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Chemical and Pasting Properties of Cassava-bambara Groundnut Flour Blends

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Abstract The aim of the study was to determine the chemical and pasting properties of cassava-bambara groundnut flour blends. Cassava tubers and bambara groundnut seeds were processed into flour. The flours were also blended into different ratios from 0 to 50%. The flour samples were evaluated for their chemical and pasting properties using standard methods. Moisture content ranged from 11.25 to 12.30%, crude protein ranged from 1.74 to 19.30%, fat 0.81to 5.70%, ash content ranged from 0.51to 3.46%, crude fibre ranged from 3.19 to 5.78%, carbohydrate ranged from 60.17 to 79.57%, starch ranged from 77.96 to 87.12%, sugar ranged from 5.00 to 6.04, amylose ranged from 20.20 to 25.85% and amylopectin 74.15 to 79.80%. Sample A (100% cassava) had the highest content of amylose (25.85 %,) and starch (87.12%) while sample G (100% bambara) had the highest content of amylopectin (79.80%) and sugar (6.04%). Pasting properties of the flour samples showed that peak viscosity ranged from 3550 to 6934 RVU, trough viscosity 2030 to 2525 RVU, breakdown viscosity 1171.50 to 4408.50 RVU, final viscosity 2888.00 to 3698.00 RVU and setback viscosity 858.00 to 1313.00 RVU. Peak time and pasting temperature ranged from 3.97 to 5.13 minutes and 72.90 to 76.68°C. The inclusion of bambara flour improved the nutritional qualities of cassava flour.

Keywords: *cassava, bambara groundnut, composite flour, chemical, pasting*

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1. Introduction

Cassava (*Manihot esculenta crantz*) is a perennial vegetable propagated tuber that is grown throughout the tropics. It is a very important staple food in the diet of Nigerians as well as Africans. About 500 million people depend on cassava as a major source of carbohydrate making it the third largest source of carbohydrate for humans worldwide [1]. The world production of cassava is 960 million tons of fresh roots, 80 million produced in Africa with 34 million from Nigeria [2], indicating that Nigeria is the world's largest cassava producer. Cassava tuber has short shelf life due to the fact that it deteriorates in 3-4 days after harvest. This makes it very necessary to process into stable forms like garri, fufu, kpopogari, starch and flour.

Cassava tubers used in producing flour have very low nutritional value as they are deficient in nutrients like protein, minerals and vitamins [3] but contain about 20 to 25% starch. The awareness on the use of cassava products for industrial and domestic purposes has increased tremendously [4]. There is increased promotion of the utilization of cassava flour in food product development as a means of ensuring food security.

Bambara groundnut (*Vigna subterrenea*) belongs to the family of *Fabaceae*. Its distribution is widespread from Senegal to Kenya and Madagascar. Nigeria is one of the major producers of the crop and it is locally called Okpaotuanya by the Igbos, Epiroro (Yoruba) and Guijiya (Hausa). It is currently receiving attention by many researchers due to its tolerance to drought, pest and disease resistance, high yield and nutrient content compared to other crops [5]. Bambara groundnut is one of the five most important protein sources for many Africans [6]. Adu-Dapaah and Sangwan [7], reported that the seeds are regarded as a completely balanced food because it is rich in iron 4.9 to 48 mg, compared to a range of 2.0 to 10.0 mg for most food legumes and its protein contains lysine, and methionine.

The nutrient content of Bambara groundnut make is suitable for use in composite flour production. Composite flour is a mixture of varying proportions of non-wheat flour from tubers, cereals and legumes with or without the addition of wheat flour [8]. Composite flours have better nutritional value than flours milled from single crops [9]. Thus the production of composite flour from cassava and Bambara groundnut would have enhanced nutritional value. The utilization of flour blends from locally grown crops could be a means of addressing the problem of food insecurity and malnutrition.

The use of composite flour in food product development depends on its chemical, functional and pasting properties. The chemical composition of flour depends on the composition of the crops from which the flour was obtained and the method of processing. Flour obtained from same crop may differ in their chemical composition due to varietal differences, location and other environmental factors [10]. The chemical constituents of composite flours also affect its pasting properties.

Pasting properties is an important index for determining the cooking and baking qualities of flours. They are used to predict the pasting behaviour and ability of flour samples and are a reliable predictor of flour quality [11]. The pasting properties of a food material are the changes that occur in the food as a result of application of heat in the presence of water [12]. These changes affect the texture, digestibility and the end use of the food product. Addition of cassava flour in gluten free flours improves the resistance and extensibility of the dough during mixing and stretching [13]. Thus the study aimed at determining the chemical and pasting properties of cassava-bambara groundnut composite flour blends.

2. Material and Methods

2.1. Materials

Bambara groundnut seed (*Vigna Subterrenea*), were purchased from Mile 3 Market Port-Harcourt, Rivers State. The seeds were stored at room temperature 32°C until used. Cassava (*Manihot esculenta*) tubers (TMS 30572) were obtained from the Rivers State University Farm in Port-Harcourt. All the chemicals used for analysis were of analytical grade.

2.2. Methods

2.2.1. Preparation of Cassava Flour

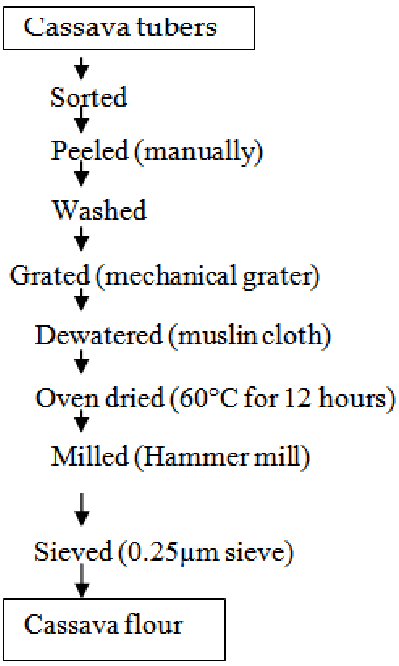

Figure 1. Production of high quality cassava flour [14]

Cassava tubers were processed using the high-grade processing method. Freshly harvested cassava tubers were sorted, peeled, washed and grated into a wet mesh. The wet mash was dewatered using a muslin cloth and the cake pulverized. The pulverized cake was oven dried at 60°C for 12 hours, milled, sieved, packed and stored at 32°C.

2.2.2. Preparation of Bambara Groundnut Flour

Bambara groundnut seed were sorted, washed and soaked in water for 24 hours at room temperature (32°C) with the water changed every 12 hours. The seeds were dehulled by manually rubbing in between the palms and fingers. After dehulling, the cotyledons were then dried, milled and sieved.

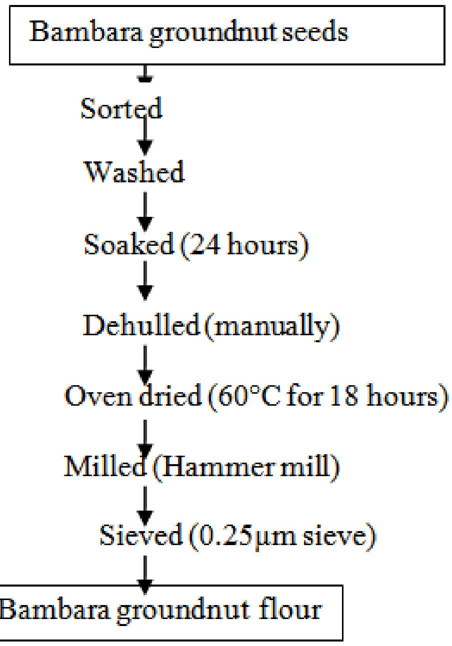

Figure 2. Production of Bambara Groundnut flour [15]

2.2.3. Cassava /Bambara groundnut Composite Flour Blends

Composite flour of Cassava and Bambara groundnut flour blends were formulated from 0-50% levels of cassava flour substitution.

2.3. Chemical Analysis

The method of AOAC [16] was used to determine the moisture, ash, protein, fat and fibre contents of the flour samples while carbohydrate was by difference. Amylose content was determined by the method described by Williams *et al.*, [17] and amylopectin calculated by difference. AOAC [18] was used for the determination of total sugar while starch was determined by the method described by Eke [19]. Pasting properties was carried out as described by Sanni *et al.*, [20] using a Rapid Visco-Analyser (RVA model 3c, New Port Science, Sydney).

2.4. Statistical Analysis

The data generated from chemical analysis and pasting properties of the flour samples were subjected to analysis of variance (ANOVA). Means were separated using new

Duncan's multiple range tests at 95% confidence level ($p < 0.05$).

3. Results

3.1. Chemical Composition of Cassava-Bambara Groundnut Composite Flour Blends

Table 1 shows the chemical composition of cassava-bambara groundnut composite flour blends. The moisture content of the flour samples ranged from 11.25% in sample G (100% Bambara flour) to 12.30% in sample D (70% cassava: 30% Bambara). Protein content increased from 1.74% in sample A (100% cassava flour) to 10.45% in sample F (50% cassava flour: 50% bambara flour). The protein content of the composite blends increased with addition of bambara groundnut flour. Fat content of the flour samples ranged from 0.81% to 5.7% with sample A (100% cassava) having the lowest value and sample G (100% bambara) having the highest value. The fat content of the composite flour blends increased with addition of bambara groundnut flour. Ash content ranged from 0.51% in sample A (100% cassava flour) to 1.55% in sample E (60%cassava flour: 40% bambara flour) while crude fibre ranged from 3.19% in sample F (50% cassava flour: 50% bambara flour) to 5.78% in sample A (100% cassava flour). Carbohydrate ranged from 60.17% to 79.57% with sample G (100% bambara flour) having the least value and sample A (100% cassava flour) having the highest value. Starch and sugar ranged 77.96 to 87.12% and 5.01 to 6.04% respectively. Sample A (100% cassava flour) had the highest content of starch and sample F (50% cassava flour: 50% bambara flour) had the least while sugar was highest in sample G (100% bambara flour) and sample B (90% cassava flour: 10% bambara flour) had the least. Amylose and amylopectin ranged from 20.20 to 25.85% and 74.15 to 79.80% respectively. Sample A (100% cassava flour) had the highest content of amylose and least content of amylopectin while sample G (100% bambara flour) had the least content of amylose and highest content of amylopectin.

The pasting properties of the composite flour blends are shown in Table 2. Peak viscosity ranged from 3550 to 6934 RVU, trough viscosity ranged from 2030 to 2525.50 RVU and breakdown viscosity ranged from 1171.50 to 4408.50 RVU. Sample A (100% cassava flour) had the highest peak, trough and breakdown viscosity while sample G (100% bambara) was lowest in peak and breakdown viscosity and sample F (50% cassava: 50% bambara) was lowest in trough viscosity. Final viscosity and setback viscosity ranged from 2888 RVU and 858 RVU respectively in sample B (90% cassava: 10% bambara) to 3698 RVU and 1265.50 RVU in sample A (100% cassava flour) and sample F (50% cassava: 50% bambara) respectively. Peak time and pasting temperature ranged from 3.97 minutes and 72.90°C respectively in sample A (100% cassava flour) to 5.13 minutes and 76.68°C respectively in sample G (100% bambara).

Table 1. Chemical Properties of Cassava/Bambara Groundnut Composite Flour Blends (%)

Samples	Moisture	Crude protein	Fat	Ash	Crude fibre	CHO	Starch	Sugar	Amylose	Amylopectin
A	$11.60^{b} \pm 0.14$	$1.74^{f} \pm 0.02$	$0.81^{d} \pm 0.01$	$0.51^{e} \pm 0.01$	$5.78^{a} \pm 0.46$	$79.57^{a} \pm 0.31$	$87.12^{a} \pm 0.01$	$5.01^{d} \pm 0.04$	$25.85^{a} \pm 0.11$	$74.15^{e} \pm 0.12$
B	$12.25^{a} \pm 0.21$	$4.37^{e} \pm 0.02$	$0.86^{d} \pm 0.01$	$1.10^{d} \pm 0.21$	$3.73^{b} \pm 0.67$	$77.66^{a} \pm 0.26$	$85.16^{b} \pm 0.14$	$5.00^{d} \pm 0.06$	$21.22^{d} \pm 0.11$	$78.78^{b} \pm 0.11$
C	$11.55^{b} \pm 0.21$	$5.25^{d} \pm 0.00$	$1.94^{c} \pm 0.03$	$1.15^{cd} \pm 0.14$	$3.50^{b} \pm 0.07$	$76.66^{ab} \pm 0.03$	$84.77^{b} \pm 0.57$	$5.50^{c} \pm 0.08$	$22.44^{c} \pm 0.11$	$77.56^{c} \pm 0.11$
D	$12.30^{a} \pm 0.28$	$8.67^{c} \pm 0.01$	$3.68^{b} \pm 0.14$	$1.45^{bc} \pm 0.07$	$3.30^{b} \pm 0.07$	$72.33^{b} \pm 0.15$	$82.75^{c} \pm 0.14$	$5.80^{b} \pm 0.08$	$21.42^{d} \pm 0.17$	$78.58^{b} \pm 0.17$
E	$11.50^{b} \pm 0.28$	$8.75^{c} \pm 0.01$	$3.95^{b} \pm 0.39$	$1.55^{b} \pm 0.07$	$3.24^{b} \pm 0.02$	$70.29^{bc} \pm 0.76$	$80.21^{c} \pm 0.00$	$5.86^{b} \pm 0.06$	$23.46^{b} \pm 0.06$	$76.55^{d} \pm 0.63$
F	$11.35^{b} \pm 0.07$	$10.45^{b} \pm 0.01$	$3.97^{b} \pm 0.01$	$1.35^{bc} \pm 0.21$	$3.19^{b} \pm 0.09$	$69.70^{c} \pm 0.38$	$77.96^{d} \pm 0.02$	$5.61^{b} \pm 0.04$	$20.33^{e} \pm 0.12$	$79.68^{a} \pm 0.12$
G	$11.25^{b} \pm 0.07$	$19.30^{a} \pm 0.42$	$5.70^{a} \pm 0.14$	$3.46^{a} \pm 0.02$	$3.60^{b} \pm 0.06$	$60.17^{d} \pm 5.33$	$82.59^{c} \pm 0.01$	$6.04^{a} \pm 0.08$	$20.20^{e} \pm 0.06$	$79.80^{a} \pm 0.06$

Means having the same superscript on the same column are not significantly different ($p<0.05$)
Key:
A= 100% Cassava flour, B=90% Cassava flour: 10% Bambara flour
C=80% Cassava flour: 20% Bambara flour, D= 70% Cassava flour: 30% Bambara flour
E=60% Cassava flour: 40% Bambara flour, F=50% Cassava flour: 50% Bambara flour
G= 100% Bambara flour

Table 2. Pasting Properties (RVU) Cassava/Bambara Groundnut Composite Flour Blends

Sample	Peak Viscosity	Trough Viscosity	Breakdown Viscosity	Final Viscosity	Setback	Peak Time(Min)	Pasting Temp (°C)
A	$6934.00^{a} \pm 87.70$	$2525.50^{a} \pm 2.12$	$4408.50^{a} \pm 85.60$	$3698.00^{a} \pm 19.80$	$1172.50^{ab} \pm 21.90$	$3.97^{d} \pm 0.50$	$72.90^{c} \pm 0.64$
B	$4356.00^{b} \pm 27.17$	$2030.00^{a} \pm 85.70$	$2326.00^{b} \pm 18.60$	$2888.00^{a} \pm 12.39$	$858.00^{b} \pm 38.20$	$4.43^{c} \pm 0.42$	$75.13^{abc} \pm 1.17$
C	$4985.00^{ab} \pm 21.20$	$2433.50^{a} \pm 19.10$	$2551.50^{b} \pm 40.30$	$3679.00^{a} \pm 55.20$	$1245.50^{a} \pm 36.10$	$4.37^{cd} \pm 0.23$	$74.80^{abc} \pm 1.70$
D	$4328.00^{b} \pm 24.10$	$2257.00^{a} \pm 83.40$	$2071.00^{b} \pm 15.80$	$3570.00^{a} \pm 10.61$	$1313.00^{a} \pm 22.60$	$4.53^{bc} \pm 0.00$	$74.28^{bc} \pm 0.04$
E	$3843.50^{b} \pm 21.90$	$2499.00^{a} \pm 25.50$	$1344.50^{b} \pm 47.40$	$3514.50^{a} \pm 44.50$	$1015.50^{ab} \pm 19.10$	$4.97^{ab} \pm 0.05$	$76.30^{a} \pm 0.56$
F	$3828.50^{b} \pm 13.40$	$2104.00^{a} \pm 4.24$	$1724.50^{b} \pm 17.70$	$3369.50^{a} \pm 0.71$	$1265.50^{a} \pm 3.54$	$4.80^{abc} \pm 0.00$	$75.98^{ab} \pm 0.11$
G	$3550.00^{b} \pm 31.10$	$2378.50^{a} \pm 16.30$	$1171.50^{b} \pm 14.80$	$3371.50^{a} \pm 29.00$	$993.00^{ab} \pm 12.73$	$5.13^{a} \pm 0.00$	$76.68^{a} \pm 0.00$

Means having the same superscript along the same column are not significantly difference ($p<0.05$)
Key:
A= 100% Cassava flour, B=90% Cassava flour: 10% Bambara flour
C=80% Cassava flour: 20% Bambara flour, D= 70% Cassava flour: 30% Bambara flour
E=60% Cassava flour: 40% Bambara flour , F=50% Cassava flour: 50% Bambara flour
G= 100% Bambara flour

4. Discussion

4.1. Chemical Composition of Cassava-bambara Composite Flour Blends

Results of the chemical composition of the flour samples revealed a decrease in moisture content with increase in substitution of bambara groundnut flour. The decrease in moisture level is an indication of an increase in storage stability of the composite blends as high moisture content in foods encourages the growth of microorganisms. Sanni *et al., [20]* noted that the lower the moisture content of a food product to be stored the better the shelf stability of such product.

The protein, fat and ash content of the flour samples increased with increase in bambara groundnut flour inclusion. These increases are due to the high protein, fat and ash content of sample G (100% bambara groundnut flour). Elochkwu *et* al., [21] also reported increase in protein, fat and ash content of cassava, bambara and cashew composite flour blends. The increase in protein and ash content of the composite flour blends indicates that substitution of cassava flour with bambara groundnut flour greatly improved the nutritional quality of the composite flour blends compared to cassava flour and other single cereal flour. The lower moisture content of the composite blends may also be due to the higher protein content of the samples. Proteins possess some functional properties such as water absorption, elasticity, foam stability and fibre formation which affect moisture content in foods [22]. The higher ash content of the composite blends indicates it would contain higher amounts of minerals.

The crude fibre content of the flour blends differed significantly from 100% cassava flour but did not differ significantly from 100% bambara groundnut flour. However the fibre content of the composite blends reduced with increased supplementation of bambara groundnut flour. This may be due to the lower fibre content of bambara groundnut flour compared to cassava flour as reported in this study. Malomo *et* al., [23] have also reported a decrease in fibre content with increasing substitution of breadfruit flour and bread nut flour. The values obtained for the fibre content of the composite blends are similar to the values (2.24 to 4.81%) reported by Ajatta *et* al., [24] for fibre content of composite blends of wheat flour, breadfruit flour and cassava starch.

Carbohydrate and starch content differed significantly ($p<0.05$) among the samples. There was also a reduction in the carbohydrate and starch content of the composite blends with increased substitution of bambara groundnut flour. This may be due to the increase in protein, fat and ash content of the flour blends. Okoye and Ezeugwu [25] reported a reduction in carbohydrate content of wheat/bambara/yellow cassava composite flour with increased addition of bambara groundnut flour.

Sugar content of the flour samples varied significantly ($p<0.05$). The sugar content of the composite blends increased with increased substitution of bambara groundnut flour. The increase may be due to the higher content of sugar in bambara groundnut flour compared to cassava flour. The sugar content of the flour samples were slightly lower than previous findings by Eke-Ejiofor and Allen [26] who reported sugar content of 2.88% for cassava flour and 2.59 to 4.16% for cassava/tigernut residue composite flour blends.

Amylose and amylopectin are polysaccharides; they are the major components of starches responsible for their behaviours [27]. There was a significant difference ($p<0.05$) in the amylose and amylopectin content of the samples. Amylose was higher in the control (100% cassava) sample than the composite blends. The values obtained in this study are within the range of 21.06 to 28.98% reported by Eke-Ejiofor and Mbaka [28] who also reported higher content of amylose in cassava flour than blends of cassava, defatted soybean and groundnut flour. Amylopectin increased with increase in protein substitution with the composite blends having higher amylopectin content than the control (100% cassava). This result is in agreement with the findings of Eke-Ejiofor [4].

4.2. Pasting Properties of the Flour Samples

Peak viscosity indicates the strength of pastes formed from gelatinization during processing in food applications [29]. The peak viscosity differed significantly ($p<0.05$) among the samples with sample A (100% cassava) having the highest peak viscosity (6934.00 RVU). The high peak viscosity of sample A could be attributed to its high content of starch and amylose. Increased substitution of bambara flour resulted in a decrease in peak viscosity of the flour samples. This indicates that the composite blends would exhibit reduced thickening ability than the control sample. Elochukwu *et al.*, [21] also reported higher peak viscosity in 100% cassava flour than blends with bambara and cashew flours.

Trough viscosity is the minimum viscosity and measures the ability of a paste to withstand breakdown during cooling. The trough viscosity of the flour samples were not significantly different ($p>0.05$) however, for sample A (100% cassava) flour had the highest value for trough viscosity. The values obtained in this study are higher than the values (1390 to 1549 RVU) reported for cassava flour by Hasmadi *et al*., [9].

Breakdown viscosity is a measure of the degree of disintegration of starch granules after heating. The breakdown viscosities of the composite blends were significantly different ($p<0.05$) from the control which had the highest value. Bambara flour substitution reduced the breakdown viscosity of the composite blends. Olapade *et* al., [30] also reported a reduction in breakdown viscosity of composite flour blends with increased substitution with bambara flour.

There was no significant difference ($p>0.05$) in the final viscosity of the flour samples. However sample A (100% cassava) had the highest value (3698 RVU) with the composite blends having lower values. This suggests that sample A will form a more viscous paste than the composite blends after cooking and cooling. High values of final viscosity are attributed to aggregation of amylose molecules in the paste [11]. The values obtained for final viscosity of the flour samples are lower that the findings of Olapade *et* al., [30] but they also reported higher final viscosity in cassava flour than the composite flours.

Setback viscosity of the flour samples varied significantly ($p<0.05$). Sample F (50% cassava: 50% bambara flour) had the highest setback. Most of the composite blends had higher setback than the control (1005 cassava). High setbacks results in lower retrogradation during cooling [31] and is associated with syneresis. Ajatta *et al*., [24] reported higher setback in composite blends of wheat, breadfruit and cassava flour than wheat flour.

Peak time measures the time at which peak viscosity occurred while pasting temperature is a measure of the minimum temperature required to cook a sample [28]. The peak time and the pasting temperature increased with increased level of bambara substitution. This suggests that the composite flours will take a longer time and would require a higher temperature to cook. These findings corroborate that of Eke-Ejiofor and Allen [26] who reported an increase in peak time and pasting temperature with increase in substitution of tiger nut residue flour with cassava flour.

5. Conclusion

The study revealed that substitution of cassava flour with bambara groundnut flour improved the nutrient content of the flour. The composite flours had higher protein, fat and ash contents with reduced carbohydrate and starch contents. The pasting properties of the composite flour blends decreased with increase in substitution of bambara flour resulting in an increase in the pasting time and temperature. Cassava flour substituted with 50% bambara flour had good nutritional properties and its use in food formulation is encouraged.

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