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# Chemical Composition and Pasting Properties of Banana (*Musa paradisiaca Linn.*), Bambara Groundnut (*Vignasubterranea*) and Pawpaw (*Carica papaya*) Flour Blends

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## Abstract

This study investigates the chemical composition and pasting properties of flour blends made from Banana, Bambara groundnut and Pawpaw mixed at different ratios. The proximate composition results revealed that moisture content ranged from 10.18 to 11.09%, ash content 3.71 to 5.05%, fat content 6.27 to 10.19%, fibre content 2.03 to 2.73%, protein content 7.39 to 19.30% and carbohydrate content 53.74 to 69.16%. Supplementation of banana flour with bambara groundnut and pawpaw flour improve the protein and fat content of the flour samples. The result for the pasting showed that sample D (35% Banana, 50% Bambara groundnut and 15% Pawpaw flour) had the highest value for peak viscosity, trough viscosity, final viscosity and setback viscosity. Antioxidant capacity of the flour blends was assessed using DPPH% and FRAP assays. The results showed that the sample D had the highest DPPH (19.28%) and the sample E (40% Bambara, 40% Banana, 20% Carica papaya) had the highest FRAP value (43.58 mgGAE/g). These findings show the potential of utilizing banana,bambara groundnut and pawpaw flour blends to enhance dietary intake of essential nutrients and provide functional food products with superior antioxidant properties, contributing positively to overall health and nutrition.

**Keywords:** Proximate, Antioxidant, Pasting, Banana, Bambara Groundnut.

## Introduction

The use of composite flour to produce baked goods would help to lessen total dependence on imported wheat. Composite flour as an innovative flour has attracted much attention in research as well as food product development (Hasmadi*et al.,* 2018; Emmanuel *et al.,* 2019). Composite flour has been defined as a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour (Awolu*et al*., 2016). Composite flour technology is important because of the advantage of reducing the huge amount of money spent on wheat flour importation, coupled with the prospects of the utilization of underutilized crops (Alugee*et al*., 2016). Formulation of composite flours therefore meant to enhance economic and nutrition and this necessitates continuous search for wheat supplements.

Banana (*Musa sapientum*) is a popular dietary staple due to its versatility and good nutritional value. The ripe banana is a soft and delicate with a post-harvest shelf life of 5- 10 days. Banana is a store house of minerals, vitamins and carbohydrates. It contains potassium, calcium, magnesium, iron, zinc etc. Vitamins A, B, C, $B_6$(Adeniji*et al*., 2007). Presence of iron in banana helps to boost the production ofhaemoglobin. This helps persons who suffer from anemia. Banana contains potassium which could help to balance sodium potassium level and reduce hypertension or high blood pressure. Banana flour is a type of gluten-free flour made from green or unripe bananas (*Musa spp*.). It has gained popularity as a nutritious alternative to traditional wheat flour due to its unique nutritional composition and potential health benefits. Banana flour is particularly high in dietary fiber, including resistant starch. Resistant starch has been associated with improved gut health and blood sugar regulation (Adeniji*et al*., 2007).

Bambara groundnut (*Vignasubterranea* [L.] Verdc.) is a nutritionally rich grain legume crop indigenous to Africa. Bambara groundnut represents a cheap protein-rich source that can improve the food and nutrition security status of rural households (Azman*et al.,*2019). Nutritional analysis of the carbohydrate, fat, protein and mineral content reveals that bambara groundnut produces an almost balanced diet. It contains 64.4% carbohydrate, 6.5% fat, 23.6% protein, and 5.5% fibreas well as minerals such as K (11.44-19.35 mg/100 g), Fe (4.9-48 mg/100 g), Na (2.9-12.0 mg/100 g), and Ca (95.8-99 mg/100 g), (Paliwal*et al.,* 2021). The high fiber content helps regulate blood sugar levels, making it beneficial for people with diabetes. Bambara groundnuts contain polyphenols and flavonoids, which help in reducing oxidative stress and lowering inflammation in the body.

The papaya (*Carica papaya Linn.*) is fruit rich in antioxidant and an important source of bioactive compounds. Papaya is rich in vitamin C, which strengthens the immune system and helps the body fight infections. The enzyme papain, found in papayas, helps break down proteins, improving digestion and alleviating bloating and indigestion. Papaya is rich in antioxidants like vitamin A and C, which support skin health and help reduce signs of aging. Papaya contains antioxidants such as flavonoids, which have anti-inflammatory effects, helping reduce inflammation in the body. Some people may be allergic to papaya, particularly due to the enzyme papain.Pawpaw consumption is one of the causes of significant loss of food value; therefore, new aspects on the use of its waste as by-products, or in the production of food additives, or even the incorporation of its flour in food have aroused great interest because these are products of high nutritional value and their use may be economically viable (Chen *et al*., 2017).

There is limited research on the use of bambara groundnut and pawpaw flour blended with banana flour. The objectives of this study is to determine the proximate composition, antioxidant properties and pasting characteristics of banana, bambara groundnut and pawpaw flour blends

## Material and Methods

### Source of raw materials

The banana and bambara groundnut were obtained from "OjaBisi" in Ado Ekiti, while the pawpaw was obtained from a local farm near The Federal Polytechnic, Ado Ekiti, Ekiti State, Nigeria.

## Methods

### Production of Banana flour

The Banana flour was prepared according to the method described by Daramola and Osanyinlusi (2006). The unripe banana was washed, peeled and sliced thinly, then dried in hot air oven at 60 $^{o}$Cfor 12hours, milled into flour using attrition mill, sieved with mesh size 0.25mm and packaged in high density polyethylene nylon.

### Production of pawpaw flour

The unripe matured pawpaw was washed, peeling with manually with stainless steel knife, sliced thinly and spread on oven tray and dried at 60$^{o}$C for 12hours. The dried pawpaw was milled in attrition mill and sieved with mesh size 0.25mm. The pawpaw flour was then packaged in high density polyethylene nylon and store.

### Production of Bambara groundnut flour

The Bambara groundnut seeds were cleaned to remove the unwanted materials and washed with water very well. The beans were soaked in water for 24hours to soften the seed-coat and it was dehulled manually and washed thoroughly. The bean seeds were boiled for 10mins, drained and dried in hot air oven at 60$^{o}$C for 24hours. The dried bean seeds were milled in attrition mill and sieved with mesh size 0.25mm. The flour was packaged in high density polyethylene nylon and stored.

### Formulation ratio

The flour blends were mixed at different ratio: 100% Banana (sample A) was used as control, 25% banana, 70% Bambara groundnut and 5% pawpaw (Sample B), 30% banana, 60% Bambara groundnut and 10% pawpaw (Sample C), 35% banana, 50% Bambara groundnut and 15% pawpaw (Sample D) and40% banana, 40% Bambara groundnut and 20% pawpaw (Sample E).

## Analysis

### Proximate analysis

The moisture content, protein, fat, crude fibre and ash were determined according to the method of AOAC(2016), while Carbohydrate content was determined from the percentage difference of the other proximate indexes as follows; %carbohydrate = 100 - (%fat +%protein + %moisture +%ash + %fibre).

### Evaluation of pasting characteristics

Pasting characteristic of the flour blend was determined according to the method of Ross *et al.,* (1987). Rapid visco analyzer (RVA) series 4 (RVA; series 4, Newport Scientific P.T.V., Warriewood, Australia) with the aid of thermocline for Windows (version 1.1. Software, 1996) provided by the instrument manufacturer was used for the analysis.

### Antioxidants activities

FRAP was determined as described by Aderinola*et al*., (2018) and DPPH was determined as described by Agunbiade*et al.,* 2022,

## Results and Discussion

### Proximate Composition of Banana, Bambara groundnut and Pawpaw Flour Blends

The result of the proximate composition of banana, bambara groundnut and pawpaw flour blends is showed in Table 1. The moisture content of the samples ranged from 10.18 to 11.09%. Sample A(100% banana flour), exhibited the lowest moisture content. The slight increase in moisture content across samples B, C, D, and E could be attributed to the increased proportion of Bambara groundnut and pawpaw flour, which may retain more water during processing.Adebowale*et al*. (2012) reported that composite flours with leguminous content, Bambara groundnut, typically exhibit higher moisture content due to the hygroscopic nature of legumes. Similarly, Akubor*et al*. (2017) reported moisture content within a comparable range for banana-groundnut blends. The low moisture content of control and composite flour blends is a good indication of microbiological stability of the flour during storage and can also lead to a reduction in the stalking tendency in baked goods (Orhevba and Mbamalu, 2017). These results were comparable to the moisture content of 11.3-11.6% reported by Kaptso*et al.,* 2015.

The ash content ranged from3.71 to5.05%. Sample B (25% banana, 70% Bambara groundnut and 5% pawpaw flour), showed the highest ash content, while sample C, with a reduced amount of Bambara groundnut, had the lowest. The ash content is crucial for determining the mineral composition of the blends, and Bambara groundnut, known for its mineral richness, likely contributes to the higher ash content. The variation in ash content could alsobe linked to the processing method and the quantity of Bambara groundnut and pawpaw flour used.

The fat content ranged from 6.27 to 10.19%. There was increase in fat content in blends with Bambara groundnut. Bambara groundnut is known to contain healthy fats, particularly unsaturated fatty acids, which contribute to the increased fat content in these blends. The higher fat content makes these blends suitable for energy-dense food formulations, particularly for weaning foods and nutritional supplements. Diets with high fat content show significant contribution to the energy needs of humans because one gram of fat or oil will yield about 368 kJ/gkcal of energy when oxidised in the body (Ayo *et al.,* 2014).

The fiber content of the samples varied between 1.84 and 2.73% and there was a significant difference ($p< 0.05$) among all the samples. Sample C (60% Bambara groundnut and 10%

pawpaw flour), showed the highest fiber content. This is likely due to the fiber-rich nature of Bambara groundnut and pawpaw, both known for their dietary fiber content. Studies by Adebowale*et al*. (2012) and Akubor*et al*. (2017) demonstrated that adding leguminous crops such as Bambara groundnut and fruits like pawpaw to flour blends increased fiber content, contributing to the overall health benefits of the composite flour.However, the availability of fibre in food is known to have beneficial effect since it has physiological effects in the gastrointestinal tract (Etiosa and Chika, 2017).

There was a significant increase in the protein content of composite flour samples from7.39 (control) to 19.30% (sample B: 25% Banana, 70% Bambara groundnut and 5% Pawpaw flour). The increase in the protein content of composite flours with the quantity of BGN flour added is because BGN is a complete balanced food high in protein content rich with lysine and methionine (Abdualrahman, 2019).The protein content of the sample increased as the percentage of the Bambara groundnut increased in the flour blends. Bambara groundnut is a rich source of plant-based protein, and this is responsible for the increase in protein content across the blends. Similar observations were obtained by Ojinnaka*et al*. (2013), who reported that the protein content in composite flours containing Bambara groundnut ranged between 15% and 20%. This confirms that the inclusion of Bambara groundnut significantly enhances the protein quality of the flour blend, making it a suitable option for addressing protein-energy malnutrition in developing countries.

The carbohydrate content across the samples ranged from 53.74 to 69.16%. Sample A, composed of 100% banana flour, had the highest carbohydrate content due to the naturally high carbohydrate content of bananas. The reduction in carbohydrate content in samples with higher Bambara groundnut and pawpaw proportions is likely due to the higher fat and protein contents in these materials, which displace carbohydrates. This trend aligns with previous findings. According to Ayo *et al*. (2010), composite flours that incorporate leguminous crops like Bambara groundnut typically have lower carbohydrate content due to the higher protein and fat content.

**Table 1: Proximate Composition of Banana, Bambara groundnut and Pawpaw Flour Blends**

| Samples | Moisture (%) | Ash (%) | Fat (%) | Fibre (%) | Protein (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| A | $10.18\pm0.05^{e}$ | $4.83\pm0.03^{c}$ | $6.27\pm0.02^{e}$ | $2.17\pm0.02^{c}$ | $7.39\pm0.09^{e}$ | $69.16\pm0.40^{a}$ |
| B | $11.09\pm0.02^{a}$ | $5.05\pm0.06^{a}$ | $10.19\pm0.10^{a}$ | $2.50\pm0.03^{b}$ | $19.30\pm0.20^{a}$ | $51.87\pm0.70^{e}$ |
| C | $10.58\pm0.12^{c}$ | $3.71\pm0.02^{e}$ | $9.15\pm0.0^{c}$ | $2.73\pm0.03^{a}$ | $17.63\pm0.14^{b}$ | $56.20\pm0.30^{c}$ |
| D | $10.64\pm0.08^{b}$ | $4.92\pm0.02^{b}$ | $9.89\pm0.0^{b}$ | $1.84\pm0.01^{e}$ | $17.25\pm0.15^{c}$ | $55.47\pm0.40^{d}$ |
| E | $10.28\pm0.22^{d}$ | $4.15\pm0.04^{d}$ | $7.40\pm0.07^{d}$ | $2.03\pm0.06^{d}$ | $14.38\pm0.11^{d}$ | $61.77\pm0.50^{b}$ |

Mean values ± standard deviation along the same column with different superscript are significantly different from each other ($p<0.05$)

Keys:

A: 100% Banana flour

B: 25% Banana, 70% Bambara groundnut and 5% Pawpaw flour

C: 30% Banana, 60% Bambara groundnut and 10% Pawpaw flour

D: 35% Banana, 50% Bambara groundnut and 15% Pawpaw flour

E: 40% Banana, 40% Bambara groundnut and 20% Pawpaw flour

## Pasting properties of banana, bambara groundnut and pawpaw flour blends

The result of the pasting properties of banana, bambara groundnut and pawpaw flour blends is showed in Table 2. Peak viscosity ranged from 1604 cP - 2885 cP. It indicates the water-holding capacity and swelling power of starch granules before they rupture under heat. Sample A (100% Banana flour) has the lowest peak viscosity (1604 cP), while Sample D (35% Banana, 50% Bambara groundnut and 15% Pawpaw flour), has the highest peak viscosity (2885 cP). The increase in peak viscosity in samples B, C, D, and E suggests that the addition of Bambara groundnut increases the swelling power of the starch, likely due to the higher amylose content in legume starches. Awolu and Olofinla (2016) reported that legume-enriched flour blends tend to exhibit higher peak viscosities compared to 100% banana or other cereal-based flours due to the higher starch granule integrity in legumes.Ikegwu*et al.* (2010) reported that a high peak viscosity correlates with starch water binding ability.

Trough viscosity is the lowest viscosity after the peak and represents the ability of the paste to withstand breakdown during heating and shear. Sample A (100% Banana flour) has the lowest trough viscosity (1482 cP), while Sample D (35% Banana, 50% Bambara groundnut, and 15% Pawpaw flour) has the highest (2179 cP). The higher trough viscosity in legume-rich blends suggests better stability during heating. The higher stability of Bambara groundnut-containing blends was also noted by Ayo *et al*. (2010), who found that the protein and lipid components in legume starches provide structural integrity to the paste during heating.

Breakdown viscosity is the difference between peak viscosity and trough viscosity. It indicates the ease with which the starch granules disintegrate under heat. The value ranged from 122 cP to 837 cP. Sample C (30% Banana, 60% Bambara groundnut, 10% Pawpaw flour) had the highest breakdown viscosity (837 cP), indicating that this sample had more fragile starch granules. Sample A had the lowest breakdown viscosity (122 cP), reflecting higher paste stability in 100% banana flour. A lower value was observed by Ivo *et al,*(2024)for swallow meal form blends of broken rice and Bambara groundnut flour.

Final viscosity reflects the re-association of starch molecules after cooling and is a measure of the gel strength of the paste. It ranged between 2203 cP to 3420 cP. Sample D exhibited the highest final viscosity (3420 cP), followed by Sample E (40% Banana, 40% Bambara groundnut and 20% Pawpaw flour) (3253 cP), indicating that blends with higher Bambara groundnut and pawpaw flour tend to form stronger gels. Sample B (25% Banana, 70% Bambara groundnut, 5% Pawpaw flour) had the lowest final viscosity (2203 cP). Final viscosity trends are consistent with those observed by Abioye*et al*. (2011), who found that legume-enriched flour blends form firmer gels due to the interaction between starch and protein during cooling.

Setback viscosity is the difference between final viscosity and trough viscosity. It represents the tendency of starch to retrograde, or gel, upon cooling. Sample D showed the highest setback viscosity (1241 cP), suggesting that it has the highest tendency for gelation. Sample B exhibited the lowest setback viscosity (656 cP). Legume-based flours typically show higher setback viscosity, indicating stronger gel formation during cooling, which was also observed by Ivo *et al,* (2024).

Peak time indicates the time it takes to reach the peak viscosity, which is a reflection of the rate of starch gelatinization. The peak time ranged from 4.93 to6.27 minutes**.** Sample A took the longest time to reach peak viscosity. Banana-based flours typically take longer time to reach peak viscosity due to their slower gelatinization process compared to legume-based blends.

Pasting temperature represents the temperature at which the starch granules begin to swell and gelatinize. The pasting temperature ranged from 83.05to 86.45°C. The higher pasting temperature in blends with more Bambara groundnut suggests that these samples require more energy for gelatinization, likely due to the denser structure of legume starches. This observation is consistent with Ayo *et al*. (2010), who noted that composite flours containing legumes generally exhibit higher pasting temperatures due to the structural properties of legume starch.

**Table 2: Pasting properties of Banana, Bambara groundnut and Pawpaw flour blends**

| Samples | Peak Viscosity (cP) | Trough Viscosity (cP) | Breakdown Viscosity (cP) | Final Viscosity (cP) | Setback Viscosity (cP) | Peak Time (min) | Pasting Temperature ($^oC$) |
|---|---|---|---|---|---|---|---|
| A | $1604.00^e$ | $1482.00^e$ | $122.00^e$ | $2268.00^d$ | $786.00^d$ | $6.27^a$ | $83.05^c$ |
| B | $2107.00^d$ | $1547.00^d$ | $560.00^d$ | $2203.00^e$ | $656.00^e$ | $5.00^c$ | $86.30^b$ |
| C | $2821.00^b$ | $1984.00^c$ | $837.00^a$ | $2961.00^c$ | $977.00^c$ | $4.93^d$ | $86.45^b$ |
| D | $2885.00^a$ | $2179.00^a$ | $706.00^b$ | $3420.00^a$ | $1241.00^a$ | $4.93^d$ | $84.75^a$ |
| E | $2750.00^c$ | $2135.00^b$ | $615.00^c$ | $3253.00^b$ | $1118.00^b$ | $5.13^b$ | $84.70^a$ |

Mean values standard deviation along the same column with different superscript are significantly different from each other ($p<0.05$)

Keys:

A: 100% Banana flour

B: 25% Banana, 70% Bambara groundnut and 5% Pawpaw flour

C: 30% Banana, 60% Bambara groundnut and 10% Pawpaw flour

D: 35% Banana, 50% Bambara groundnut and 15% Pawpaw flour

E: 40% Banana, 40% Bambara groundnut and 20% Pawpaw flour

## Antioxidant Activities of Banana, Bambara groundnut and Pawpaw flour blends

The antioxidant activities of banana flour, bambara groundnut flour and pawpaw flour blends is showed in Table 3. DPPH ranged from 12.75% to 19.28%. DPPH (2,2-diphenyl-1-picrylhydrazyl) assay measures the ability of antioxidants to neutralize free radicals by donating hydrogen. Sample D (35% Banana, 50% Bambara groundnut and 15% Pawpaw flour) had the highest DPPH value. This suggests that Bambara groundnut and pawpaw flour, significantly contributes to free radical scavenging.100% Banana flour sample demonstrates notable antioxidant activity, primarily due to its inherent phytochemicals.

The Ferric Reducing Antioxidant Power (FRAP) activity measures the antioxidant capacity to reduce ferric ions ($Fe^{3+}$) to ferrous ions ($Fe^{2+}$). A higher FRAP value indicates stronger antioxidant power. The FRAP values range from 32.64 to 43.58 mgGAE/g. There are significantly different ($p<0.05$) in the values obtained for all the samples while sample E (40% Banana, 40% Bambara groundnut and 20% Pawpaw flour) exhibits the highest FRAP value. Addition of Bambara groundnut and pawpaw flour to banana flour increased the FRAP content of the flour blends. 100% banana flour sample had the lowest FRAP value and this suggests that banana on its own does not have the same potency in reducing iron as the blends. These findings suggest that consumption of BGN complemented product could offer some health benefits because they contain a lot of antioxidants reducing power.

**Table 3: Antioxidant Activities of Banana, Bambara groundnut andPawpaw flour blends**

| SAMPLE | DPPH (%) | FRAP (mgGAE/g) |
|---|---|---|
| A | $17.28\pm0.25^{b}$ | $32.64\pm0.40^{d}$ |
| B | $12.75\pm0.12^{d}$ | $40.78\pm0.91^{b}$ |
| C | $13.88\pm0.10^{c}$ | $39.28\pm0.36^{c}$ |
| D | $19.28\pm0.32^{a}$ | $32.68\pm0.28^{d}$ |
| E | $13.94\pm0.08^{c}$ | $43.58\pm0.20^{a}$ |

Mean values ± standard deviation along the same column with different superscript are significantly different from each other ($p<0.05$)

Keys:

A: 100% Banana flour

B: 25% Banana, 70% Bambara groundnut and 5% Pawpaw flour

C: 30% Banana, 60% Bambara groundnut and 10% Pawpaw flour

D: 35% Banana, 50% Bambara groundnut and 15% Pawpaw flour

E: 40% Banana, 40% Bambara groundnut and 20% Pawpaw flour

## Conclusion

The result revealed that increasing the proportion of Bambara groundnut and pawpaw flour in banana-based blends enhances the protein, fat, and ash content and antioxidant properties. The higher protein and fat content make the blends suitable for energy-dense food products and for combating malnutrition. Sample D (35% Banana, 50% Bambara groundnut and 15% Pawpaw flour) appears to the best among other samples and due to its pasting properties it could be used for food product formulation.

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