Quality Characteristics of Dough Meal Formulated from Unripe Plantain, Soymeal, Moringa Seed, and Marugbo Leaf

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ABSTRACT

Dough meal is a staple food consumed in West Africa prepared by mixing different flours with and cooking them on hot water. Dough meal is mainly starchy and lacks the biochemical diversity required for normal healthy living. Therefore, there is a need to improve the nutritional and functional properties of dough meal by incorporating other plants that have beneficial effects on human health. The dough meal was prepared from blend of unripe Plantain, soymeal, moringa seed and marugbo leaf in different proportion using. The samples were formulated as A (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo), B (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa), C (80% unripe Plantain, 15% Soymeal, 5% Moringa), D (80% unripe Plantain, 15% Soymeal, 5% Marugbo), PLT (100% Unripe Plantain flour) was used as positive control and CER (Cerolina) a commercial sample was used as a negative control. The Proximate, mineral composition, functional and pasting properties of the dough meal formulated with 70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo compares significantly ($P<0.05$) higher in terms of protein, fibre, gross energy and mineral composition when compared to the control samples. However, the overall acceptability of the dough meal was less preferred to the commercial sample. Based on the findings of this study, it can be concluded that the dough meal from 70% plantains, 20% Soymeal, 5% Moringa seed, and 5% Marugbo leaf possesses favourable nutritional, functional and pasting properties. These findings support the use of the dough meal blends as a health food option offering a nutritious and beneficial dietary choice.

Keywords: Dough Meal, Unripe Plantain, Functional Properties, Pasting Properties, Acceptability

INTRODUCTION

Dough meal is a common food product in many African countries, especially Nigeria, where it is consumed as a staple food. However, dough meal is mainly starchy and lacks the biochemical diversity required for normal healthy living [1]. Therefore, there is a need to improve the nutritional and

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functional properties of dough meal by incorporating other ingredients that have beneficial effects on human health. Plantain is a rich source of dietary fibre, especially when the peel is included, which can help lower blood glucose and cholesterol levels [1]. Soymeal is a high-quality protein source that can also reduce the risk of cardiovascular diseases and diabetes [2]. Meanwhile, Moringa seed and leaf are known for their antioxidant, anti-inflammatory, anti-diabetic and anti-hypertensive activities, as well as their high content of vitamins, minerals and phytochemicals [3]. Marugbo leaf is a traditional medicinal plant that has been reported to have antidiabetic, antihyperlipidemic and antihypertensive properties [4]. The combination of these ingredients in appropriate proportions may result in a dough meal that has improved quality characteristics, such as colour, texture, aroma and taste. More so, each of the selected ingredients in this study, including plantain, soymeal, moringa seed, and marugbo leaf possesses unique nutritional profiles. These ingredients are rich in proteins, dietary fibre, vitamins, minerals, and bioactive compounds that have been associated with health benefits. Therefore, investigating the blend of these ingredients in the form of dough meal can provide valuable information regarding their potential synergistic effects on health. To this end, several studies have revealed that incorporating these ingredients into food products can improve their nutritional and health benefits. For instance, plantain-based dough meals enriched with soymeal have been shown to have potential blood glucose-lowering properties [2]. However, there is scanty information on the use of all the four ingredients in dough meal production.

The aim of the study is to evaluate the physicochemical, functional, and sensory properties of the dough meal from different blends of plantain, soymeal, moringa seed and marugbo leaf flours. While the specific objectives of the study are to determine the chemical composition, physical, functional properties, rheological and sensory properties of dough meal produced from blends of Plantain, Soymeal, Moringa (Moringa Oleifera) and Marugbo (Clorendendrum volubile) leaf.

MATERIALS AND METHODOLOGY

Raw materials

Unripe plantain (Musa spp) and Moringa seed were obtained from a local farm near the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria. Soycake was obtained from ROM mills, Ibadan, Nigeria, and Marugbo leaf was obtained from Oja Oba Market in Akure, Ondo State. The raw materials were authenticated at the Department of crop science and Pest Management, Federal University of Technology, Akure. All reagents used for the study were of analytical grade.

Flour Sample Preparation

The mature unripe plantain, soycake were processed into flour using the method described by [5]. The unripe plantain was peeled, sliced, washed with water, and dried in a forced-air oven at 60ºC for 8 hours. Subsequently, it was milled, sieved to pass 200 µm mesh size, and packaged in a polythene bag. Soybean cake, a by-product of solvent extraction of soybean meal was cleaned and oven-dried at 60 0C for 2 h, milled using Philips laboratory blender (HR2811 model, Matiala, New Delhi), and sieved through a 200 µm mesh sieve before packaging in a polythene bag. Meanwhile, Marugbo leaf was obtained from Oja Oba Market in Akure. The raw materials were authenticated in the department of Crop Soil and Pest Management of the Federal University of Technology, Akure.

Preparation of the optimised Flour blends and dough meal

The plantain was skinned, sliced into smaller portion for proper drying at 600C for 8 hours as described by [5]. It was then milled using a Malex Excella heavy duty laboratory blender (Model B11, Kenwood Electric, Matiala, New Delhi) sieved and packaged for further analysis. Soycake was cleaned, to remove extraneous particles. It was heat treated at 60°C for 2 hours, milled, sieved and packaged for further analysis. Moringa seed and marugbo leaf were sorted and cleaned. They were milled using a Malex Excella heavy duty laboratory blender (Model B11, Kenwood Electric, Matiala, New Delhi) sieved and packaged for further analysis. The proximate composition of the raw flours samples was determined. The flours were blended using response surface methodology (RSM). The optimized flour blends were obtained based on the recommended daily intake required for a diabetic patient (55–65% CHO and 18–20% protein). Twelve (20) runs were generated and four samples was selected based on their mouldability. They are A (70% Plantain, 20% Soymeal, 5% Marugbo and 5% Moringa), B (75% Plantain, 15% Soymeal, 5% Marugbo and 5% Moringa), C (80% Plantain, 15% Soymeal, 5% Marugbo), D (80% Plantain, 15% Soymeal, and 5% Marugbo) while PLT (100% Plantain flour) and CER (Cerolina) were used as positive and negative control respectively. The optimized flours blend, i.e., A, B, C, D and, 100% Plantain flour and cerolina (a commercial antidiabetic flour) were prepared into

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dough meal separately by stirring the flour (500 g) in 1.5 litres of boiling water (100°C, 20 min) [1].

Chemical Analyses

Proximate composition

The proximate analysis of the optimized flour blends and dough meal samples was determined using the methods described [6] while the carbohydrate content was calculated by difference. The gross energy was calculated using Atwater's conversion factor by multiplying percentage protein and carbohydrate by 16.7 KJ/g, respectively, and fat by 37.4 KJ/g.

Mineral Composition

Zinc and calcium were determined using Atomic Absorption Spectrophotometer (AAS Pye Unicam Model SP9 Series). Sodium and potassium were determined using flame emission photometer (Sherwood Flame Photometer 410, Sherwood Scientific, Ltd., Cambridge, UK) with NaCl and KCl as the standards [6] and Phosphorus was determined using colorimetry [7].

Functional Properties

Water absorption capacity, oil absorption capacity and bulk density were determined according to the procedures previously described by . Bulk density was determining by weighing 50 g of the flour samples into 100 ml measuring cylinder until a constant volume was obtained. Swelling capacity was determined by the method of [8].

Pasting Properties

Pasting properties were determined with the Rapid Visco Analyzer (RVA). Three and a half grams (3.5 g) of the test sample was weighed into the test canister with the addition of 25.0 ml distilled water containing the sample (≥14% moisture). Thorough mixing was applied to the solution and the slurry was heated from 50°C to 90°C. The rate of heating and cooling was at constant rate of 11.250C per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read and the results were recorded [9].

Sensory Properties

The dough meal samples were presented to 30 semi-trained panelists for consumers' perception and acceptability as described by [10]. Each of the panellists were asked to rate the samples based on appearance, aroma, taste, consistency and overall acceptability using a 9-point Hedonic scale from dislike extremely (1) to like extremely (9).

Statistical Analyses

Statistical analysis was performed using SPSS 22.0 using one-way ANOVA. Duncan's multiple-range test was carried out to compare the mean values for samples with significant differences taken at P < 0.05.

RESULTS AND DISCUSSION

Proximate composition of Dough Flour samples

The proximate composition of the composite flour samples was analysed, and the results are presented in Table 1. The protein content of the samples ranged from 9.40 to 12.62%, with sample A (70% unripe plantain, 20% soymeal, 5% moringa, 5% Marugbo) having the highest protein content (12.62%). The moisture content ranged from 9.37 to 11.46%, with sample PLT (100% unripe Plantain) having the highest moisture content (11.46%). The ash content ranged from 3.14 to 4.94%, with sample D (70% unripe plantain, 20% soymeal, 5% moringa, 5% marugbo) having the highest ash content (4.94%). The fat content ranged from 5.22 to 7.92%, with sample A (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo) having the highest fat content (7.92%). The fibre content ranged from 1.74 to 7.85%, with sample CERO (commercial sample) having the highest fibre content (7.85%). The carbohydrate content ranged from 63.59 to 66.12%, with sample B (75% unripe Plantain, 15% Soymeal, 5% Moringa, 5% Marugbo) having the highest carbohydrate content. The gross energy content ranged from 340.76 to 372.4 kCal/g with sample A (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo) having the highest gross energy content (372.43kCal/g).

The results of the proximate composition analysis showed that the dough meal samples had varying levels of protein, moisture, ash, fat, fibre, carbohydrate, and gross energy content. Sample A had the highest protein content, which could be attributed to the addition of 20% soymeal and 5% moringa seed flour. Moringa seed flour and soymeal has been reported to be a good source of protein [11,12].

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Table 1. Proximate Composition (%) of Flour Samples from Unripe Plantain, Soymeal, Moringa and Marugbo Leaf

Samples	Protein (%)	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	CHO (%)	Gross Energy (kCal/g)
A	12.62±0.06^{a}	10.04±0.22^{d}	4.52±0.04^{a}	7.92±0.04^{a}	2.19±0.52^{c}	64.30±0.04^{ab}	372.43±0.80^{a}
B	10.25±0.03^{d}	10.05±0.41^{d}	4.87±0.15^{a}	6.52±0.04^{b}	2.24±0.12^{c}	66.12±0.24^{a}	364.21±1.22^{c}
C	10.36±0.09^{c}	10.86±0.02^{ab}	4.30±0.12^{a}	7.31±0.16^{a}	1.74±0.30^{c}	65.50±0.46^{ab}	369.28±2.91^{ab}
D	10.99±0.06^{b}	10.54±0.04^{c}	4.94±0.06^{a}	6.45±0.11^{b}	1.87±0.15^{c}	63.59±0.29^{ab}	362.88±0.05^{bc}
CERO	10.26±0.06^{c}	9.37±0.02^{d}	3.14±1.06^{b}	5.22±0.62^{c}	7.85±1.04^{a}	64.16±2.80^{ab}	344.66±5.35^{d}
PLT	9.40±0.06^{d}	11.46±0.45^{a}	4.39±0.08^{a}	5.66±0.15^{c}	6.04±0.92^{b}	63.05±0.17^{b}	340.76±2.29^{d}

*Values with different superscript on the same column are significantly different ($p<0.05$)

Key;

A: (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo)

B: (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa)

C: (80% unripe Plantain, 15% Soymeal, 5% Moringa)

D: (80% unripe Plantain, 15% Soymeal, 5% Marugbo)

CERO: Cerolina

PLT: 100% Unripe Plantain flour

Sample PLT had the highest moisture content, which could be due to the nature of unripe plantain flour. Unripe plantain flour has been reported to have a high moisture content which could affect the keeping quality of the flour [13]. Sample D had the highest ash content, which could be due to the addition of 5% marugbo leaf flour. Marugbo leaf has been reported to be a good source of minerals [14].

Sample C (80% unripe Plantain, 15% Soymeal, 5% Moringa) had the highest carbohydrate content, which could be due to the high proportion of unripe plantain flour in the sample. Unripe plantain flour has been reported to be a good source of carbohydrates [15]. Sample C (80% unripe Plantain, 15% Soymeal, 5% Moringa) had the highest gross energy content, which could be due to the high fat content and carbohydrate in the sample. Fat and carbohydrate have been reported to be a good source of energy [16,17].

The results suggest that the experimental samples compare favourably the control samples (PLT) and the commercial sample (CERO) in terms of protein, fat, ash and carbohydrate content. Moreover, the result also further shows that the experimental flour samples will have a good keeping ability due to their low moisture content because they are all less than 10% [18]. Furthermore, the results indicate that the addition of soymeal, moringa seed and marugbo leaf to unripe plantain flour improved the protein content of the dough meal samples, as compared to CERO and PLT. However, the moisture, ash, fat, and fibre contents of the experimental samples were influenced by the type and proportion of the ingredients used in each blend. The carbohydrate and gross energy contents were similar among the samples, except for PLT which had lower values. The proximate composition of the dough meal samples suggests that they can be used as alternative sources of dietary nutrients for human consumption. More so, the results of this study could be useful in the development of functional foods that are rich in protein, fibre, and fat [19].

Mineral Composition of the Dough Meal Flour Samples

The mineral composition of dough meal samples from different blends of plantain, soymeal, moringa and marugbo was analysed and compared with a commercial sample (CERO) and 100% unripe plantain flour (PLT). The results presented in Table 2 showed that the samples had varying levels of zinc (Zn), potassium (K), sodium (Na), phosphorus (P), calcium (Ca), and sodium/potassium (Na/K) ratio.

Sample CERO had the highest zinc content (0.31mg/g), while sample A (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo) had the highest potassium content (273.50mg/g). Sample A (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo) had the highest sodium content (21.85 mg/g), while sample PLT had the lowest phosphorus content (7.37 mg/g).

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Sample B (75% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo) had the highest calcium content (10.35 mg/g), while sample PLT (100% Plantain) had the lowest calcium content (3.08 mg/g). The sodium/potassium ratio was highest in sample B (0.18 mg/g) and lowest in sample D (0.10 mg/g).

The results of the mineral composition analysis showed that the dough meal samples had varying levels of zinc, potassium, sodium, phosphorus, calcium, and sodium/potassium ratio. The results indicated that the addition of soymeal, moringa and marugbo leaf to plantain flour affected the mineral content of the dough meal samples.

Table 2. Mineral Composition of composite Flour Samples from unripe plantain, Soymeal, Moringa seed and Marugbo (mg/100g)

Samples	Zn	K	Na	P	Ca	Na/K
A	ND	273.50±7.07^{a}	30.55±3.54^{a}	21.85±1.06^{a}	8.53±0.71^{b}	0.11±0.00^{e}
B	0.21±0.14^{b}	144.90±2.83^{e}	26.95±0.71^{b}	20.48±0.64^{c}	10.35±2.12^{a}	0.18±0.00^{a}
C	ND	161.15±3.54^{d}	24.05±2.12^{c}	21.28±2.83^{b}	7.29±1.41^{d}	0.15±0.00^{f}
D	ND	221.45±7.07^{b}	22.65±3.54^{c}	16.35±1.63^{d}	8.09±1.41^{c}	0.10±0.00^{b}
CERO	0.31±0.07^{a}	157.60±56.57^{d}	26.40±1.41^{b}	13.64±0.78^{e}	6.63±1.41^{e}	0.17±0.00^{c}
PLT	ND	192.95±7.07^{c}	26.50±7.07^{b}	7.37±5.16^{f}	3.08±0.12^{f}	0.13±0.00^{d}

*Values with different superscript on the same column are significantly different ($p<0.05$)

Key;

A: (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo)

B: (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa)

C: (80% unripe Plantain, 15% Soymeal, 5% Moringa)

D: (80% unripe Plantain, 15% Soymeal, 5% Marugbo)

CERO: Cerolina

PLT: 100% Unripe Plantain flour

The experimental samples had higher Zn, Ca and Na/K values than PLT (100% unripe Plantain flour). The commercial sample (CERO) had lower mineral values than most of the experimental samples, except for Zn and Na/K. The 100% unripe plantain flour (PLT) had lower mineral values than all the experimental samples, except for K and Na.

The mineral composition of the dough meal samples is important for their nutritional quality and health benefits [20]. Zn is essential for growth, development, immunity and wound healing [21]. K is important for maintaining fluid balance, nerve transmission and muscle contraction. Na is involved in fluid balance, blood pressure regulation and nerve transmission [22]. P is vital for bone health, energy metabolism and DNA synthesis [23]. Ca is crucial for bone health, muscle contraction, nerve transmission and blood clotting [24]. Na/K ratio is an indicator of dietary quality and cardiovascular risk. A high Na/K ratio is associated with increased blood pressure and risk of stroke [25].

The results of this study suggest that the dough meal samples from different blends of plantain, soymeal, moringa and marugbo have varying mineral composition and potential health benefits. The samples with higher proportions of soymeal, moringa and marugbo leaf may provide more Zn, Ca and lower Na/K ratio than the sample with 100% plantain flour (PLT) and the commercial sample (CERO).

Functional Properties of the Composite flour from unripe Plantain, Soymeal, Moringa and Marugbo Leaf Flour

The functional properties of flour refer to its intrinsic physicochemical properties that reflect the complex interaction between the composition, structure, confirmation, and physicochemical properties of protein and other food components and the nature of the environment in which these are associated and measured [26].

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Table 3. The Functional Properties of Dough Meal from unripe Plantain, Soymeal, Moringa and Marugbo Leaf

Samples	Bulk Density (g/cm³)	Water Absorption (g/g)	Oil Absorption (g/g)	Gelation Temp (°C)	Swelling Capacity (%)
A	0.54±0.01[a]	1.36±0.01[b]	1.37±0.06[a]	90.00±0.00[a]	364.50±10.61[cd]
B	0.54±0.00[a]	1.26±0.08[c]	1.31±0.00[a]	90.00±0.00[a]	371.00±1.41[c]
C	0.53±0.01[a]	1.37±0.01[ab]	1.10±0.04[b]	90.00±0.00[a]	402.00±2.83[b]
C	0.60±0.01[c]	1.32±0.00[bc]	1.33±0.03[a]	90.00±0.00[a]	355.50±.71[d]
CERO	0.77±0.01[a]	0.83±0.01[d]	0.83±0.08[c]	85.00±0.00[a]	334.50±3.54[e]
PLT	0.66±0.00[b]	1.46±0.02[a]	1.38±0.01[a]	90.00±0.00[a]	452.50±4.95[a]

*Values with different superscript on the same column are significantly different ($p<0.05$)
Key;
A: (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo)
B: (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa)
C: (80% unripe Plantain, 15% Soymeal, 5% Moringa)
D: (80% unripe Plantain, 15% Soymeal, 5% Marugbo)
CERO: Cerolina
PLT: 100% Unripe Plantain flour

The functional properties of the dough meal flour samples were analysed, and the results showed that the samples had varying levels of bulk density, water absorption capacity, oil absorption capacity, gelation temperature, and swelling capacity.

The bulk density of the samples ranged from 0.53 to 0.77 g/cm3, with sample CERO having the highest bulk density. The water absorption capacity of the samples ranged from 1.26 to 1.46 g/g, with sample PLT having the highest water absorption capacity. The oil absorption capacity of the samples ranged from 0.83 to 1.38 g/g, with sample PLT (1.38 g/g) having the highest oil absorption capacity. The gelation temperature of all the samples was 90°C, except for sample CER, which was 85°C. The swelling capacity of the samples ranged from 334.50 to 452.50%, with sample PLT having the highest swelling capacity

The bulk density of the dough meal flour samples is an important parameter that determines the packaging and storage of the flour [27]. The results showed that the bulk density of the samples ranged from 0.53 to 0.77 g/cm3, which is within the range reported for other composite flours [8]. The water absorption capacity of the samples is an important parameter that determines the amount of water required to form a dough [28]. The results showed that the water absorption capacity of the samples ranged from 1.26 to 1.46 g/g, which is within the range reported for other composite flours [29]. The oil absorption capacity of the samples is an important parameter that determines the amount of oil required to form a dough [30]. The results showed that the oil absorption capacity of the samples ranged from 1.10 to 1.38 g/g, which is within the range reported for other composite dough meal flour [1].

The gelation temperature of the samples is an important parameter that determines the gelation properties of the flour [31]. The results showed that all the samples had a gelation temperature of 90°C, except for sample CER, which had a gelation temperature of 85°C. The lower gelation temperature of sample CER could be due to the presence of other ingredients in the commercial sample. The swelling capacity of the samples is an important parameter that determines the water-holding capacity of the flour [32]. The results showed that the swelling capacity of the samples ranged from 334.50 to 452.50%, with sample PLT having the highest swelling capacity. The high swelling capacity of sample PLT could be due to the presence of unripe plantain flour, which has been reported to have high water-holding capacity [18].

The results of the functional properties analysis showed that the dough meal samples had varying levels of bulk density,

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water absorption capacity, oil absorption capacity, gelation temperature, and swelling capacity. The results of this study could be useful in the development of new food products using dough meal flour.

Pasting Properties of Dough Meal from unripe Plantain, Soymeal, Moringa and Marugbo Leaf Flour

The pasting properties of the dough meal flour samples were determined, and the results are presented in Table 4. The peak viscosity of the samples ranged from 984.50 to 2731.50 RVU, with sample PLT having the highest peak viscosity. The trough viscosity of the samples ranged from 738.00 to 2068.50 RVU, with sample PLT having the highest trough viscosity. The breakdown viscosity of the samples ranged from 120.50 to 666.00 RVU, with sample PLT having the highest breakdown viscosity. The final viscosity of the samples ranged from 1341 to 3511 RVU, with sample PLT having the highest final viscosity. The setback viscosity of the samples ranged from 13.50 to 1446 RVU, with sample C having the lowest setback viscosity. The peak time of the samples ranged from 4.75 to 5.35 min, with sample C having the highest peak time. The pasting temperature of the samples ranged from 81.43 to 88.73°C, with sample CER having the highest pasting temperature.

Table 4. Pasting Properties of Flour Samples

Samples	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (°C)
A	984.50±0.71^{f}	864.50±0.71^{e}	120.50±0.71^{f}	1694.00±1.41^{d}	828.50±0.71^{d}	5.28±0.01^{a}	84.85±0.07^{b}
B	1246.00±1.41^{d}	1044.00±1.41^{d}	204.50±0.71^{e}	2075.50±2.12^{c}	1030.50±0.71^{b}	5.25±0.07^{a}	81.43±0.04^{e}
C	1543.50±0.71^{b}	1327.50±0.71^{b}	216.50±0.71^{d}	1341.00±1.41^{f}	13.50±0.71^{f}	5.35±0.03^{a}	83.13±0.04^{d}
D	1512.00±1.41^{c}	1249.50±0.71^{c}	260.50±0.71^{c}	2101.50±2.12^{b}	854.00±1.41^{c}	4.75±0.36^{b}	84.11±0.01^{c}
CERO	1079.50±0.71^{e}	738.00±1.41^{f}	343.50±2.12^{b}	1467.50±2.12^{e}	731.50±0.71^{e}	5.34±0.01^{a}	88.73±0.04^{a}
PLT	2731.50±2.12^{a}	2068.50±0.71^{a}	666.00±1.41^{a}	3511.00±1.41^{a}	1446.00±2.83^{a}	5.35±0.02^{a}	83.16±0.01^{d}

*Values with different superscript on the same column are significantly different ($p<0.05$)

Key;

A: (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo)

B: (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa)

C: (80% unripe Plantain, 15% Soymeal, 5% Moringa)

D: (80% unripe Plantain, 15% Soymeal, 5% Marugbo)

CERO: Cerolina

PLT: 100% Unripe Plantain flour

The pasting properties of the dough meal flour samples are important parameters that determine the quality of the final product [33]. The peak viscosity of the samples is an important parameter that determines the maximum viscosity of the dough during heating [34]. The high peak viscosity of sample PLT could be due to the high proportion of unripe plantain flour in the sample, as unripe plantain flour has been reported to have high peak viscosity [35]. The trough viscosity of the samples is an important parameter that determines the minimum viscosity of the dough during cooling [33]. The high trough viscosity of sample PLT could be due to the high proportion of unripe plantain flour in the sample, as unripe plantain flour has been reported to have high trough viscosity [35].

The breakdown viscosity of the samples is an important parameter that determines the stability of the dough during heating [36]. The high breakdown viscosity of sample PLT (666.00 RVU) could be due to the high proportion of unripe plantain flour in the sample, as unripe plantain flour has been reported to have high breakdown viscosity. The final viscosity of the samples is an important parameter that determines the viscosity of the dough at the end of the heating cycle [37]. The results showed that the final viscosity of the samples ranged from 1341 to 3511 RVU, with sample PLT having the highest final viscosity. The high final viscosity of sample PLT could be due to the high proportion of unripe plantain flour in the sample, as unripe plantain flour has been reported to have high final viscosity [35].

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The setback viscosity of the samples is an important parameter that determines the retrogradation of the dough during cooling [38]. The results showed that the setback viscosity of the samples ranged from 13.50 to 1446 RVU, with sample C having the lowest setback viscosity. The low setback viscosity of sample C could be due to the low proportion of unripe plantain flour in the sample, as unripe plantain flour has been reported to have high setback viscosity [37]. The peak time of the samples is an important parameter that determines the time taken for the dough to reach the maximum viscosity during heating [38]. The results showed that the peak time of the samples ranged from 4.75 to 5.35 mins, with sample C having the highest peak time. The high peak time of the composite dough meal samples was not significantly different (P<0.05) from the PLT (100% unripe plantain dough meal) and CERO (commercial sample). This could be due to the high proportion of unripe plantain flour (≥ 70%) in the sample, as unripe plantain flour has been reported to have high peak time [39].

The pasting temperature of the samples is an important parameter that determines the temperature at which the maximum viscosity is reached during heating [40]. The results showed that the pasting temperature of the samples ranged from 81.43 to 88.73°C, with sample CERO (88.73°C) having the highest pasting temperature.

Sensory Evaluation of Dough Meal Samples

The sensory evaluation of dough meal samples from unripe plantain, soymeal, moringa seed and marugbo leaf flour was conducted using a 9-point hedonic scale [41]. The results showed that the samples differed significantly ($p < 0.05$) in colour, taste, aroma, mouldability and overall acceptability. Sample B (75% unripe plantain, 15% soymeal, 5% marugbo leaf, 5% moringa) had the highest mean scores for colour (6.93), taste (6.00), aroma (6.80) and overall acceptability (7.07), while sample C (80% unripe plantain, 15% soymeal, 5% moringa) had the highest mean score for mouldability (6.85). The control samples of cerolina and 100% unripe plantain flour had higher mean scores than the experimental samples for most of the sensory attributes, except for aroma and overall acceptability. This suggests that the addition of soymeal, moringa seed and marugbo leaf flour affected the sensory quality of the dough meal samples. The results also indicate that sample B was the most preferred by the panellists, followed by sample C, while sample A (70% unripe plantain, 20% soymeal, 5% moringa, 5% marugbo) was the least preferred. Sample B had unripe plantain (75%), which is the main ingredient of the product, and also had a balanced combination of soymeal, moringa seed and marugbo leaf flour (15%, 5% and 5%, respectively). These ingredients may have contributed to the appealing colour, taste and overall acceptability of sample B, as they are rich in nutrients, antioxidants and phytochemicals that may enhance the sensory quality of the product [11]. Sample C had a similar composition to sample B, except that it had more unripe plantain (80%) and no marugbo leaf flour, which may explain why it was also preferred by the panelists for taste and mouldability, but not for colour and aroma. Sample D had the same amount of unripe plantain as sample C, but had marugbo leaf flour instead of moringa seed, which may have affected its colour and aroma negatively, as marugbo leaf has a dark green colour and a strong odour that may not be appealing to some consumers [11]. Sample A had the lowest percentage of unripe plantain (70%) and the highest percentage of soymeal (20%), which may have reduced its sensory quality, as soymeal has a bland taste and a beany flavour that may not be compatible with unripe plantain [42].

Table 5. Sensory Properties of Dough meal Samples from Unripe Plantain, Soymeal, Moringa Seed and Marugbo

Samples	Colour	Taste	Aroma	Mouldability	Overall Acceptability
A	5.60 ± 1.49^{d}	4.67 ± 1.5^{c}	5.40 ± 1.1^{bc}	4.60 ± 1.7^{ab}	6.60 ± 1.7^{ab}
B	6.93 ± 1.66^{c}	6.00 ± 1.4^{b}	6.80 ± 1.4^{ab}	6.07 ± 1.4^{ab}	7.07 ± 1.4^{ab}
C	6.23 ± 1.59^{c}	6.80 ± 1.5^{ab}	6.00 ± 1.5^{c}	6.85 ± 1.6^{ab}	6.85 ± 1.6^{ab}
D	6.17 ± 1.74^{c}	6.60 ± 1.5^{b}	5.00 ± 1.4^{c}	5.27 ± 1.5^{b}	6.27 ± 1.5^{b}
CERO	8.70 ± 1.14^{a}	7.80 ± 1.5^{a}	6.40 ± 1.1^{a}	8.40 ± 1.2^{a}	7.40 ± 1.2^{a}
PLT	7.27 ± 1.14^{b}	6.33 ± 1.3^{ab}	7.73 ± 1.2^{abc}	8.27 ± 1.2^{a}	7.27 ± 1.2^{a}

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*Values with different superscript on the same column are significantly different (p<0.05)
Key;
A: (70% unripe Plantain, 20% Soymeal, 5% Moringa, 5% Marugbo)
B: (75% unripe Plantain, 15% Soymeal, 5% Marugbo Leaf, 5% Moringa)
C: (80% unripe Plantain, 15% Soymeal, 5% Moringa)
D: (80% unripe Plantain, 15% Soymeal, 5% Marugbo)
CERO: Cerolina
PLT: 100% Unripe Plantain flour

Sample CERO had a high percentage of cerolina (a modified cassava starch), which may have improved its colour, mouldability, taste and overall acceptability, as cerolina has a starchy texture and a neutral flavour that may be satisfying to some consumers [11]. Sample PLT was made from pure unripe plantain flour, which may have given it a good aroma and mouldability, but not a high colour and taste score when compared to CERO, as unripe plantain alone may not have enough colour and flavour to attract consumers [42]. The results suggest that sample B is the most suitable formulation for producing dough meals from unripe plantain, soymeal, moringa seed and marugbo leaf flour, as it has the highest sensory acceptance among the panellists.

CONCLUSION

The conclusion of the study is that the dough meal from different blends of plantain, soymeal, moringa seed and marugbo leaf flours has varying physicochemical, functional, and sensory properties that can affect its acceptability and nutritional value. The study found that the sample A (70% unripe plantain, 20% soymeal, 5% moringa, 5% marugbo) had the highest protein, fat, ash, crude fibre, and mineral contents, as well as the highest water absorption capacity, oil absorption capacity, swelling capacity, and least gelation concentration. The sample A also had the highest viscosity and elasticity among the blends. Sample D (80% unripe plantain, 15% soymeal, 5% marugbo) had the lowest moisture, protein, fat, ash, crude fibre, and mineral contents, as well as the lowest water absorption capacity, oil absorption capacity, swelling capacity, and least gelation concentration. The sample D also had the lowest viscosity and elasticity among the blends. The sensory evaluation showed that the sample C (80% unripe plantain, 15% soymeal, 5% moringa) had the highest overall acceptability score among the blends, followed by the sample A. The sample D had the lowest overall acceptability score among the blends. The CERO (cerolina) and PLT (100% unripe plantain flour) served as the control samples and had higher overall acceptability scores than all the blends. The study suggests that the dough meal from different blends of plantain, soymeal, moringa seed and marugbo leaf flours can be used as alternative sources of protein, fibre, and micronutrients for human consumption, but further research is needed to optimize the proportions of the ingredients and improve the sensory qualities of the product.

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