CHEMICAL FUNCTIONAL PASTING PROPERTIES OF FLOURS FROM PLANTAIN, MESQUITE SEED AND RICE BRAN

ABSTRACT:

The goal of the study was to see whether plantain flour could be blended with rice bran and mesquite flour to producecomposite flour that might be included in the diet of some people with health issues. According to the findings, the chemical composition of the top-rated enriched composite flour showed 10.41 to 14.70 % moisture, 3.37 to 11.70 % protein, 62.79 to 80.74 % carbohydrate, 1.35 to 1.71 % ash, 3.68 to 0.37 % fibre and 0.30 to 0.58 % fat. Mineral composition showed calcium 3.08 to 4.00 mg/100g, potassium 5.03 to 6.65 mg/100g, zinc 0.038 to 0.053 mg/100g, iron 0.029 to 0.038 mg/100g and sodium 0.51 to 0.80 mg/100g. Functional properties showed swelling capacity 3.85 g/g to 4.26 g/g, bulk density 0.40 to 0.44 g/cm^3, solubility 6.94 to 17.35 % , water absoption capacity 58.00 to 59.80 %. Therefore, adding up to 30% of rice bran and mesquite flour to the composite flour mix would enhance its nutritional value.

Keywords: Nutritional-composition, Functional, Minerals, Plantain, Mesquite-seed, Rice-bran

INTRODUCTION:

Using wheat flour only is one of the main baking constraints. Ayo *et al*. (2010) suggest that investigation should be conducted into substitute local flour sources for baking, such as millet, sorghum, cassava, African breadfruit, plantain, acha, and many more, due to the nation's limited capacity to provide the nation's high demand for wheat flour. Utilized in baking, snacking, and supplementary food formulations, composite flour derived from plantain, cassava, soybean, and other locally grown crops (Sanni and Eniola, 2004). Attempts have been made to promote the incorporation of composite flour, which completely or partially substitute wheat flour in baked goods with flours derived from locally cultivated crops with high-protein seeds. This reduces the need for imported wheat and produces items that are higher in protein (Olaoye *et al.*, 2006). Olaoye *et al.*, (2006) defined composite flour technology as the technique of combining other types of flour in a measured amount with other ingredients, such as cereals and legumes, to generate high-quality food products and replace wheat flour entirely or partially in baked goods and pastries. Composite flour is done with the aim of improving the nutritional composition as well as promoting the utilization of locally available food crops. Composite flour from mixture of cereal, legume or tuber have been found to produce better nutritional values than flour from single food crop (Udeh et al., 2023).By using composite flour, we may lessen our reliance on importing wheat for biscuit production, preserve foreign exchange, and engage our youth in constructive activities (Emojorho et al., 2023b, Aphiar et al, 2024)From a nutritional perspective, it is beneficial to consume mixtures of cereals and legumes as it provides a balance in diet (Anene et al., 2023). While cereal is rich in cysteine and methionine, it lacks some essential amino acids, such as lysine, and is therefore not able to provide all the nutrients required for adequate nutrition (Anene et al., 2023).Pulses, which are dietary supplements to a cereal-based diet and include beans, black gram, pigeon pea, soy bean, African yam bean, groundnuts, and lentils, complete the amino acid profile (Anene et al., 2023) Emojorho et al., 2023 reported that orange seeds are rich in nutrients and can be mixed with cereal in food processing to improve its nutritive quality.

A 100 g edible amount of plantains can give up to 120 kcal of energy, making them a good source of nutrients for both human and animal consumption (Edinformatics, 2006). In contrast to many other foods, the plantain mostly gets its energy from carbohydrates, with fat making up a small portion of its energy content. In this region of the world, rice bran—which is thrown away as a waste product during the rice milling process—contains 20% oil, 15% protein, 50% carbohydrates (mostly starch), 9% ash, 45%–65% nitrogen free extract, and a wealth of B vitamins and minerals. Nonetheless, it is a great source of dietary fibre overall, which ranges from 20% to 51%, including gum, pectin, and beta-glucan (Jiang and Wang, 2005). Additionally abundant in antioxidants such as polyphenols, carotenoids, vitamin-E gamma oryzanol, and tocotrienol, rice bran aids in avoiding oxidative damage to DNA and bodily tissues. According to Ling *et al*. (2002), feeding rice bran fraction significantly reduced atherosclerotic plaque. Furthermore, one of the most dangerous health issues in many areas of the nation, particularly in developing nations like Nigeria, is protein energy malnutrition (PEM) (Ojiako et al., 2010). Malnutrition is less likely in mesquite-baked items with high protein levels. In accordance with Aremu et al. (2006), mesquite seeds are an excellent source of protein, containing 38-40% of all the amino acids required for optimal body growth and maintenance. It also contains high levels of nutrients, antioxidants, and vitamins, including isoflavones, which help regulate menopause, decrease cholesterol, and prevent cancer. Because cereal proteins are low in lysine, adding legumes to cereal diet could increase its nutritional value (Hooda and Jood, 2005). Because mesquite seed has higher lysine content, it can be used to enhance cereals in baked goods. Because mesquite protein is less expensive than expensive meat protein, it is regarded as the best source of protein, particularly for vegetarian diets (Aremu et al., 2007). This study looks at the functional, pasting, and chemical makeup of rice bran flour, matured green plantain flour, and mesquite composite flours.

MATERIALS AND METHOD

Source of Materials

The study sourced its ripe green plantains and mesquite seeds from a local market in Ozoro, Delta State, Nigeria, and its parboiled rice bran from a rice mill located in Abakiliki, Ebonyi State, Nigeria. They were brought to the lab for processing and usage right away.

Sample preparation

After being sliced into distinct bunches, the plantain head was defingered. According to Mepba et al. (2007), the fingers were cleaned, peeled, sliced thinly, and blanched for three minutes. After dipping, the slices were drained and dried in a Gallenkamp hot box oven made of aluminum foil, set to 50 ^{o}C for 15 hours with a fan setting of 1. Slices of dried plantain were ground into flour using an Attrition mill made in Yamaha, Japan. To get rid of bad and stone seeds, the Mesquite seeds were separated. After adding boiling water and letting them sit for seven days, the seeds were dehulled, baked for ten hours at 40 degrees Celsius, and then coarsely crushed using a Kenwood food processor. The rice bran was ground into flour using an Attrition mill (Yamato, Japan).To achieve a homogeneous particle size, the flour made from plantains, mesquite, and rice bran was evenly sieved through a 60 mm size screen. It was then sealed in an airtight container until needed.

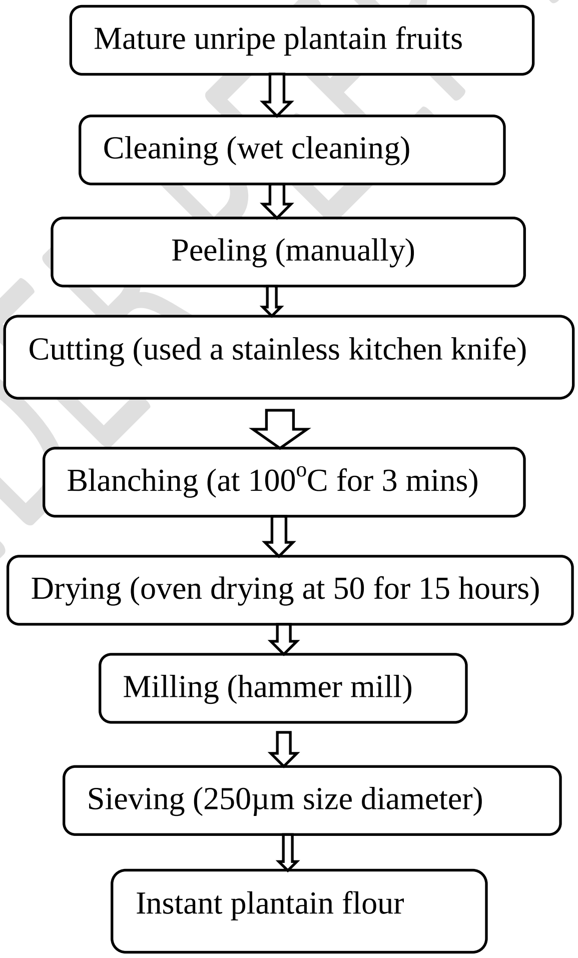

Figure 1: Flow Chart for the production of instant plantain flour

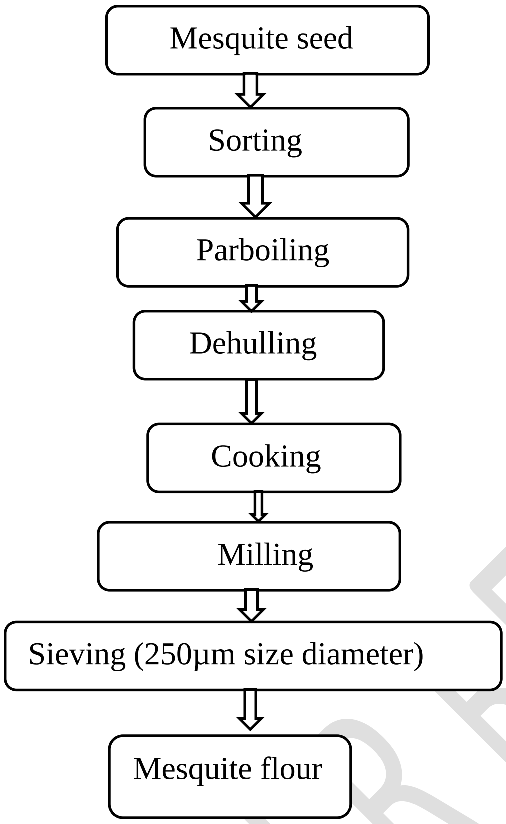

Figure 2: Flow Chart for the production of mesquite flour

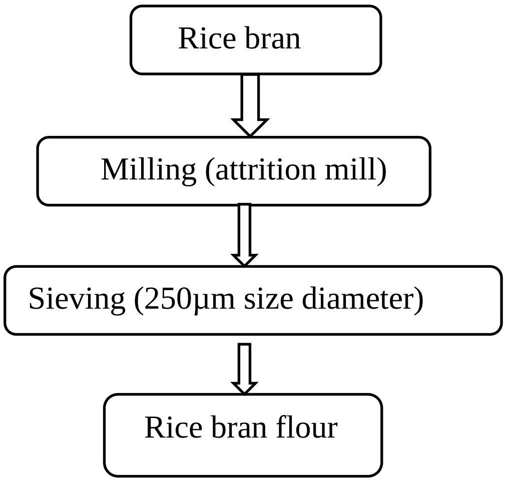

Figure 3: Flow Chart for the production of rice bran flour

Determination of Proximate Composition

Using the established procedures of (AOAC, 2005), the following parameters were measured: moisture content, crude protein, fat content, ash content, and crude fiber content. The difference approach was used to determine the overall percentage carbohydrate content, as stated by (Onyeike et al., 1995).

Determination of Functional Properties

Water Absorption Capacity

Tester and Morrison's (1990) approach was used to measure the flour samples' swelling capacity, while Narayara and Narasinga's (1989) method was used to determine the bulk density. A modified version of Coffmann and Garcia's (1977) approach was employed to ascertain the lowest concentration of gelation. The flour's solubility was assessed using Leach et al.'s (1959) method.

Pasting Properties

The RVA (Rapid Visco Analyzer) was used to evaluate the samples' pasting qualities. In accordance with the RVA handbook, Newport Scientific Australia (1998), samples were evaluated for pasting temperature, peak paste viscosity, time to peak, temperature at peak, breakdown of hot and cold paste viscosity, set back, and final viscosity.

Mineral Elements Determination: Ca, Fe, Zn, K, and Na were measured using a Spectrum Lab 22 flame photometer and a Young Lin flame Atomic Absorption Spectrophotometer (AAS) model 8010, following the procedure outlined by Khan and Zeb (2007).

Statistical Analysis: The data were analyzed using SPSS (a statistical software for the social sciences). All data were subjected to ANOVA, and the means were separated using Duncan's Multiple Range Test (DMRT). The data was shown as mean ± standard error. Differences were judged significant if the probability was less than 5% ($P \leq 0.05$) for both data sets.

RESULTS AND DISCUSSION

Proximate compositions of flour blend

The carbohydrate content of the flour samples ranged from 62.79 to 80.74 %. The control sample (TNC) has much higher carbohydrate content (80.74) than the other samples, which have lower or reduced carbohydrate contents, according to the proximate analysis of the samples. This may result from the dough mixture's propensity to absorb more oil than dough prepared exclusively from plantain flour and the rising percentage of composite flour, which has higher levels of protein, fiber, and fat (Abioye et al., 2011).

Sample TNC had the lowest moisture content among the samples, which ranged from 10.41 to 14.70% (Table 1). Due to the fact that mesquite and rice bran absorb moisture from baked goods, the flour's moisture content rises as supplementation increases. However, because protein has a strong affinity for moisture, the higher moisture content linked to composite flour may be the result of an increase in protein content (Alobo, 2006). Given that excessive moisture content promotes microbiological growth and spoiling, it may be an indication of a short self-life for composite flour.

The protein content of the flour samples ranged from 3.37 to 11.70 %.. Given that mesquite flour has a greater protein level (23.6%) than plantain flour (3.37%) and rice bran (13.5%), the mesquite portion of the blended flour may be the cause of the increase in protein content. According to Aremu *et al.* (2007), mesquite seed is a great source of protein and a supplement to cereal protein that is lysine-limited. Mesquite flour addition increases the food product's protein content both in terms of quantity and quality, which makes it a powerful weapon in the fight against protein energy deficiency (Hegstad, 2008). The samples' protein contents ranged from 3.37 to 11.70%, with sample T2 (11.70) having the greatest protein content and sample TNC (control) having the lowest.

Rice bran and mesquite flour had a higher fiber content (about 18%) than plantain flour, which is why there was a significant ($p < 0.05$) increase in fiber content. As supplementation rose, so did the flour's fiber level. The blended flour's higher percentage of rice may be the cause of the increased fiber content. Because of this, rice bran has a higher fiber content than both plantain flour and mesquite. Adult men and women should consume 38 and 25 grams of fiber per day, respectively (IOM 2002). The fiber in rice bran is made up of mostly insoluble fiber and a comparatively small amount of soluble fiber (7–13%). While insoluble fibers aid in the treatment of constipation and lower the risk of colon cancer and diverticular disease, soluble fibers are useful in lowering total blood cholesterol and inducing satiety (Islam et al, 2007; AOAC, 2000). In humans, crude fiber supports the health of the digestive and metabolic systems. Since cellulose and lignin make up crude fiber, measuring it provides an index for assessing dietary fiber, whose effectiveness has been linked to a number of gastrointestinal conditions (Schneeman, 2002). Fiber reduces the risk of colon cancer by increasing intestinal motility, which lengthens the transit time for bile salt derivatives such deoxycholate, which are potent chemical carcinogens (Eddy et al., 2007).

The flour's fat content varied from 0.30 to 0.58%, with sample treatment T2 flour having the highest quantity (0.58%). The addition of rice bran flour may possibly be the cause of the rise in fat content (van Hoed et al., 2006). The range of ash contents was 1.34 to 1.71%, with sample treatment T1 exhibiting the highest value.Because ash is the inorganic residue left over after water and organic components are removed with heating with the aid of an oxidizing agent, the amount of ash in food material can be used to determine the mineral elements in the food (Sanni et al., 2008). The flour samples had energy levels ranging from 300.82 to 339.14 kcal. In comparison to the flour blends, it was found that the sample TNC had the highest energy value.

Mineral compositions of flour: These are the inorganic materials that make up a specific amount of any dietary component, and the ash content of the biscuits used in this study provided an approximation of the total mineral content. In the composite flour with greater substitution of mesquite flour, there was an increase in the concentration of calcium (Ca) and potassium (K) (Table 2). Given that rice bran has a higher mineral content than plantain and mesquite flour, the rise in mineral contents may be the result of the rice portion of the blended flour. All of the mineral elements included in the flour exhibit a significant difference ($p \leq 0.05$) according to the results.

Table 1- Proximate of Flour blends on dry basis (%)

	Moisture (%)	Protein(%)	CHO (%)	Ash (%)	Fibre (%)	Fat (%)	Energy(kcal)
T_1	14.70 ± 0.07^{a}	8.40 ± 0.08^{b}	65.92 ± 0.20^{c}	1.71 ± 0.00^{a}	8.96 ± 0.03^{c}	0.46 ± 0.00^{b}	300.82 ± 20.00^{d}
T_2	14.00 ± 0.04^{ab}	11.70 ± 0.03^{a}	62.79 ± 0.04^{e}	1.56 ± 0.01^{b}	9.37 ± 0.06^{a}	0.58 ± 0.04^{a}	303.18 ± 20.00^{c}
T_3	14.20 ± 0.03^{ab}	8.40 ± 0.10^{b}	66.52 ± 0.01^{c}	1.54 ± 0.03^{b}	8.85 ± 0.03^{c}	0.49 ± 0.03^{ab}	306.19 ± 20.00^{b}
T_4	13.80 ± 0.04^{b}	11.60 ± 0.06^{a}	63.43 ± 0.14^{d}	1.42 ± 0.00^{c}	9.21 ± 0.06^{b}	0.54 ± 0.01^{ab}	304.98 ± 20.00^{bc}

T_5	$14.30±0.01^{ab}$	$7.80±0.04^{c}$	$67.45±0.01^{b}$	$1.54±0.04^{b}$	$8.57±0.04^{d}$	$0.34±0.04^{c}$	$304.06±20.00^{bc}$
TNC	$10.41±0.71^{c}$	$3.37±0.10^{d}$	$80.74±0.47^{a}$	$1.35±0.00^{d}$	$3.68±0.08^{e}$	$0.30±0.01^{d}$	$339.14±20.00^{a}$

*Values are means of triplicate determination (±SD).
Mean values in the same column with the same superscript of alphabet are not significantly different at $P \leq 0.05$.

Key:

B T_1 - 20% mesquite flour + 30% rice bran flour + 50 % plantain flour.
T_2 - 30% mesquite flour + 30% rice bran flour + 50% plantain flour.
T_3 - 20% mesquite flour + 20% rice bran flour + 60% plantain flour.
T_4 - 30% mesquite flour + 10% rice bran flour + 60% plantain flour.
T_5 - 10% mesquite flour + 20% rice bran flour + 70% plantain flour.
T_{NC} - Flour made by 100% plantain flour.

The calcium content ranged from 3.08 to 4.00 mg/100g with T_2 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) having the highest calcium content of 40 mg/100g and T_3 (20% mesquite flour + 20% rice bran flour + 60% plantain flour) having the lowest calcium content of 3.04 mg/100g.The potassium content ranged from 5.03 to 6.65 mg/100g with T_5 (10% mesquite flour + 20% rice bran flour + 70% plantain flour) having the highest potassium value of 6.65 mg/100g and T_2 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) having the lowest potassium content of 5.03 mg/100g. The zinc content ranged from 0.038 to 0.053 mg/100g with T_5 (10% mesquite flour + 20% rice bran flour + 70% plantain flour) recording the highest zinc value of 0.053 mg/100g and T_2 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) having the lowest zinc content of 0.038 mg/100g. The iron content ranged from 0.029 to 0.038 mg/100g with T_5 (10% mesquite flour + 20% rice bran flour + 70% plantain flour) recording the highest iron value of 0.038 mg/100g and T_2 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) having the lowest iron content of 0.033 mg/100g. The sodium content ranged from 0.51 to 0.80 mg/100g with T_2 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) recording the highest sodium value of 0.80 mg/100g and T_3 (30% mesquite flour + 30% rice bran flour + 50% plantain flour) having the lowest sodium content of 0.51 mg/100g.

Pasting Properties: The amylograph pasting characteristics of the various wheat samples at varying substitution levels are displayed in Table 3 below, which was obtained using the rapid visco analyser (RVA) on the six samples that were utilized to produce the biscuit samples. The mesquite seed has extremely little carbohydrates, which causes the gel strength to be poor during subsequent substitution. The peak viscosity of the flour sample ranged from 112.57 to 330.25, and the values rose as the amount of supplementation increased. As indicated in Table 3, sample treatment TNC (control) had the highest peak viscosity of 330.25 RVU, which was significantly different from other flour blends. Sample treatment T2 had the lowest peak viscosity of 112.57 RVU. With TNC having the highest value, the ultimate viscosity ranged from 139.67 to 339.33, suggesting that during heating, a highly viscous paste may emerge. The cooked sample's final viscosity is displayed (Chinma et al., 2009).

Table 2- Mineral compositions of Flour (mg/100g)

	Ca	K	Zn	Fe	Na
T_1	3.85 ± 0.42^{b}	5.81 ± 0.04^{c}	0.040 ± 0.03^{bc}	0.033 ± 0.01^{ab}	0.66 ± 0.03^{a}
T_2	4.00 ± 0.03^{a}	5.03 ± 0.28^{d}	0.038 ± 0.03^{c}	0.029 ± 0.04^{b}	0.80 ± 0.06^{a}
T_3	3.08 ± 0.42^{d}	6.02 ± 0.07^{b}	0.046 ± 0.04^{ab}	0.032 ± 0.01^{ab}	0.51 ± 0.03^{a}
T_4	3.32 ± 0.03^{b}	5.85 ± 0.28^{c}	0.050 ± 0.03^{a}	0.035 ± 0.03^{ab}	0.58 ± 0.00^{a}
T_5	3.91 ± 0.03^{b}	6.65 ± 0.42^{a}	0.053 ± 0.01^{a}	0.038 ± 0.03^{a}	0.59 ± 0.03^{a}

*Values are means of triplicate determination (±SD). Mean values in the same column with the same superscript of alphabet are not significantly different at $P \leq 0.05$.

Key: T_1 - 20% mesquite flour + 30% rice bran flour + 50 % plantain flour.
T_2 - 30% mesquite flour + 30% rice bran flour + 50% plantain flour.
T_3 - 20% mesquite flour + 20% rice bran flour + 60% plantain flour.
T_4 - 30% mesquite flour + 10% rice bran flour + 60% plantain flour.
T_5 - 10% mesquite flour + 20% rice bran flour + 70% plantain flour.

Pasting temperature, which can have an impact on energy consumption costs, is defined as the temperature at which flour viscosity starts to increase while cooking (Isikli and Karababa, 2005). Pasting temperature offers the information needed to cook a specific sample. Due to the accompanying breakdown in viscosity, the holding period—also known as shear thinning, holding strength, hot paste viscosity, or trough—is the time during which the sample is subjected to mechanical shear stress and a constant temperature (typically 95 oC). It gauges the paste's resistance to breaking down during cooling and is the lowest viscosity value in the RVA profile's constant temperature phase (Newport scientific, 1998). For the samples, this varied from 97.28 to 243.00 RVU. According to Ragaee et al. (2006), there is frequently a breakdown viscosity during this time. According to Zaidhul et al. (2006), it is a sign of the starch gel's stability or breakdown during cooking. According to Newport Scientific (1998), the breakdown is thought to be an indicator of the paste stability or granule disintegration level. The setback or viscosity of cooked paste is represented by the viscosity following chilling to 50 oC. This phase is characterized by the retrogradation or reorganization of starch molecules. It has a propensity to becoming harder as resistance to enzymatic attack rises. It affects digestibility as well. The cooked sample was measured using the setback value, which varied from 55.26 to 156.33 RVU, with TNC having the highest value. Higher setback values are synonymous to reduced dough digestibility (Shittu *et al*., 2001) while lower setback during the cooling of the paste indicates lower tendency for retrogradation (Sandhu *et al*., 2007).

Table 3- Pasting property of flour blends

Pasting property of flour blends							
Sample	Peak1 (RVU)	Through1 (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak time (min)	Temperature (^{0}C)
T_1	118.68 ±2.00^e	108.67±1.28^e	5.52± 1.88^b	145.75±2.10^d	55.26±2.10^d	5.51±0.02^a	88.55±0.01^a
T_2	112.57±1.52^f	97.28±1.11^f	9.38±2.00^b	139.67±2.02^f	53.89±1.00^d	5.63±0.12^a	88.78±0.24^a
T_3	138.17±1.00^d	129.00±1.54^d	8.05±0.83^b	162.00±2.16^d	58.00±1.57^{cd}	5.60±0.10^a	89.02±0.47^a
T_4	165.00±2.25^b	158.23±2.00^b	6.89±0.52^b	195.00±2.52^b	64.73±2.26^b	5.48±0.02^a	88.52±2.00^a
T_5	154.26±1.95^c	142.00±1.89^c	8.93±1.52^b	170.26±1.50^c	59.76±2.00^c	5.62±0.10^a	89.28±0.70^a
TNC	330.25±1.00^a	243.00±1.00^a	87.25±0.42^a	399.33±0.00^a	156.33±0.00^a	5.56±0.01^a	89.20±0.75^a

*Values are means of triplicate determination (±SD).
Mean values in the same column with the same superscript of alphabet are not significantly different at P ≤ 0.05.

Key:
T_1 - 20% mesquite flour + 30% rice bran flour + 50 % plantain flour.
T_2 - 30% mesquite flour + 30% rice bran flour + 50% plantain flour.

T_3 - 20% mesquite flour + 20% rice bran flour + 60% plantain flour.
T_4 - 30% mesquite flour + 10% rice bran flour + 60% plantain flour.
T_5 - 10% mesquite flour + 20% rice bran flour + 70% plantain flour.
T_{NC} - Biscuit made by 100% plantain flour.

Functional Properties of flour blends

When it comes to food ingredients, functionality is defined as any attribute that determines how useful the meal is. Basic functional characteristics of proteins, such as their ability to retain water and fat, define their quality (Abioye et al., 2011). Table 4 lists the functional characteristics that dictate how these composite flours are applied and used in the creation of different food products. The bulk density values were observed to range from 0.40 to 0.44 g/cm3, decreasing as the amount of rice bran and mesquite flour substituted increased. The densest substituted sample was 100% plantain flour. The bulk density is primarily influenced by the flour's density and particle size. It is crucial for deciding how to handle materials, package goods, and apply wet processing in the food industry. As mesquite flour substitution increases, the need for packaging decreases (Adebowale et al., 2008). The addition of mesquite flour to plantain flour provides a strong water binding capacity to the plantain flour, which increases the reconstitution and textural ability of the plantain flour. (Adebowale et al., 2008). The water absorption capacity of the composite flour increased with mesquite flour substitution due to an increase in protein content. Any food substance's ability to swell is found to rise with an increase in water absorption capacity, which subsequently improves solubility. The flour blends' solubility levels varied from 6.94% to 17.35% (Table 4). Lipids may cause flours to have a decreased capacity to absorb water, which could limit swelling and, as a result, solubility (Mepha et al., 2007). Biscuits can be made using the flour blends with the maximum swelling power (T5). The flours' swelling power ranged from 3.67 to 4.26%. This study uses a composite flour that is free of gluten. Substituting mesquite flour reduced the swelling capacity.The formation of a protein-amylose complex in native starches and flours may be the reason of reduced swelling power.

Table 4- Functional property of flour blends

	Swelling (g/g)	**Bulk Density (g/cm^3)**	**Solubility (%)**	**Water Absorption (%)**	**Least gelation concentration (%)**

T_1	3.85±0.04^{b}	0.40±0.03^{a}	9.86±0.48^{c}	58.00±0.44^{c}	4.96±0.22^{cd}
T_2	3.47±0.03^{c}	0.41±0.02^{b}	6.94±0.10^{e}	59.80.±0.12^{a}	4.01±0.20^{d}
T_3	4.08±0.05^{ab}	0.42±0.01^{a}	8.25±1.48^{d}	58.10±0.20^{c}	6.05±0.20^{c}
T_4	4.20±0.20^{a}	0.42±0.03^{a}	12.98±0.12^{b}	59.50±0.06^{b}	6.17±0.21^{b}
T_5	4.26±0.02^{a}	0.44±0.00^{a}	17.35±0.01^{a}	59.40±0.10^{c}	6.58±0.33^{a}

*Values are means of triplicate determination (±SD).

Mean values in the same column with the same superscript of alphabet are not significantly different at $P \leq 0.05$.

Key:

T_1 - 20% mesquite flour + 30% rice bran flour + 50 % plantain flour.

T_2 - 30% mesquite flour + 30% rice bran flour + 50% plantain flour.

T_3 - 20% mesquite flour + 20% rice bran flour + 60% plantain flour.

T_4 - 30% mesquite flour + 10% rice bran flour + 60% plantain flour.

T_5 - 10% mesquite flour + 20% rice bran flour + 70% plantain flour.

The level of swelling is dependent on the temperature as well as the availability of water, the species of starch as well as carbohydrates with proteins (Sui et al., 2006).The ability of flour to form gel, which provides a structural matrix for storing water and other water soluble elements like sugars and flavors, is known as least gelation capacity. Depending on the proportions of its structural components, such as proteins, carbs, and fats, it can differ from one flour to the next (Sathe et al., 2002). Protein concentration increases improve the binding force interaction, which raises flour's gelling ability; the lower the LGC value, the higher the flour's gelling ability (Lawal et al., 2004).

Conclusion

Due to its physicochemical characteristic and chemical properties of the composite flour, it can be used as a functional meal or other item in diet plans that help diabetes patients achieve their desired weight.It has been demonstrated that biscuits made using flour blends of plantain, mesquite, and rice bran are healthy and gluten-free, thus those with celiac disease may also request them. The biscuit may be an excellent source of energy, minerals, and protein. According to the study, rice bran and mesquite can be substituted in biscuit recipes up to 30%.Sample T4 was the best of all the replacement levels since the 10% substituted flour produced a product that performed well and exceeded the all-plantain biscuit without negatively impacting the biscuit's sensory characteristics. This functional biscuit is a potential diet option for patients with diabetes, obesity, and celiac disease because it is more nutritious than whole plantain biscuits. Malnutrition will therefore be less common if a mesquite baked product has a high protein content.It is best to promote the production of baked products using flours enhanced with rice bran and mesquite seeds.

References

Abioye, V.F., Ade-Omowaye, B.I.O. and Adesigbin, M.K. (2006). Effect of Soy Flour Fractions on some Functional and Physicochemical Properties of Plantain Flour In: (O.A. T. Ebuehi, ed), pp. 142-143

Abioye, V.F., Ade-Omowaye, B.I.O., Babarinde, G.O, and Adesigbin, M.K. (2011). Chemcial, Physico-Chemical and Sensory Properties of Soy-Plantain flour. Afr. J. Food Sci., 5 (4): 176-180

Abioye, V.F., Ade-Omowaye, B.I.O., Babarinde, G.O. and Adesigbin, M.K. (2011). Chemical, physico-chemical and sensory properties of soy-plantain flour. African Journal of Food Science, 5(4):176–180

Adebowale, A.A., Sanni, L.O. and Onitilo, M.O. (2008). Chemical composition,and pasting properties of tapioca grits from different cassava varieties and roasting methods. Afr. J. Food Sci., 2: 077-082

Alobo, A. P. (2006). Effect of Sesame seed on millet biscuit. *Plant Food for Human Nutrition*, 64, 21–27.

Anene, M.N., **Emojorho E.E**., Chiedu ,U.C. and Anyaiwe, U.C (2023). Chemical functional physical and sensory properties of flour and idli produced from blends of rice (Oryza sativa), african yam bean (Sphenostylis sternocarpa) and pigeon pea (Cajanus cajan). Horticult Int J. 2023;7(4):149–157. DOI: 10.15406/hij.2023.07.00289

Anene, M.N., **Emojorho E.E.,** Chiedu ,U.C. and Anyaiwe, U.C (2023b). Rheological, micronutrients and microbial quality of idli produced from blends of rice (Oryzasativa), african yam bean (sphenostylissternocarpa) and pigeon pea (cajanuscajan). Global scientific Journals 11 (11) 1941 - 1962.

AOAC. (2005). Official Methods of Analysis. 19th Edn. Association of Official AnalyticalChemists, Washington, DC., USA.

Aphiar, A., **Emojorho, E.E**., Anene, M.N., Udeh, C.C., Nwosu , A.N., Ochimana, T.O. (2024).Chemical, functional, physical and microbial properties of snack from blends of rice, bambara groundnut incorporated with african egg plant leaves (anara). Global scientific journal, 12 (1): 2790-2811

Aremu M.O, Olonisakin, A., Atolaye, B.O., Ogbu, C.F: (2006). Some nutritional and functional studies of *Prosopis africana*. Electronic J Environ Agric Food Chem, 5(6): 1640-1648.

Ayo, J. A., Ikuomola, D. S., Esan, Y. O., Onuoha, O. G., Ayo, V. A. and Eleke, V. (2010).Effect of added defatted Beniseed on the quality of Acha-based biscuits. *Continental Journal Food Science and Technology*, 4, 7–13.

Chinma, C.F, Adewuyi, A.O. and Abu, J.O (2009). Effect of germination on the chemical functional pasting properties of flour from brown and yellow varieties of tigernut. Food research International. 42(8): 1004-1009.

Coffmann, C. W. and Garciaj, V. (1977). Functional properties and amino acid content of a protein isolate from mung bean flour. International Journal of Food Science and Technology, 12:473 - 484.

Eddy, N. O., Udofia, P. G., and Eyo, D. (2007). Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference. *African Journal of Biotechnology*, *6*(20), 2415–2418.

Edinformatics. (2006). Education for the information age. July 12, 2006, Pp.4.

Elleuch, M., Bedigian. D., Roiseux, O., Besbes, S., Blecker, C. and Attia, H. (2011). Dietary fiberand fiber-rich by product of food processing: characterisation, technological functionality and commercial application: a review. Food Chemistry, 124: 411–421.

Emojorho, E. E., Okonkwo, T.M. and Eze, J.I. (2023b). Chemical physical shelf-life and sensory properties of biscuits produced from defatted and undefatted debittered orange seed flours. Fruits 78(1), art. 02 Fruits 78(1-10).

Emojorho, E.E, Anene M.N. and Udeh C.C. (2023). Minerals Vitamins and Anti-Nutritional Properties of Biscuits Produced from Defatted and Undefatted Debittered Orange Seed Flours. American Journal of Food Sciences and Nutrition, 5(2) 67 – 82

Foster, T.J. (2011). Natural structuring with cell wall material. Food Hydrocolloids 25: 18281832.

Hegstad, H.G. (2008). Nutrition and Health benefits of soyabean .soy Protein Quality Evaluation report. Food and Agriculture Organization of the United Nations, Food and Nutrition Paper No. 71, Rome, Italy.

Hooda, S., and Jood, S. (2005). Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. *Food Chemistry*, 90, 427 435.

Institute of Medicine - IOM. The Dietary Reference Intakes: Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington: Institute of Medicine of the Nacional Academy Press, 2002

Isikli, N.D. and Karababa, E.A. (2005). Rheological characterization of fenugreek paste (cemen). J. Food Eng., 69:185-190.

Islam, T., Chowdhury, A., Islam, M. and Islam, S. (2007). Standardization of Bread Preparation from Soy Flour. Int. J. Sustain. Crop Prod., 2(6): 15-20.

Jiang, Y. and Wang, T. (2005). Phytosterols in cereal by-products. Journal of the American Oil Chemists' Society, 82 (6) (2005), pp. 439-444.

Khan, I. K. and Zeb, A. (2007). Nutritional Composition of Pakistani Wheat varieties J. Zhejiang. Univ. Sci. B.8(8):555-559.

Lawal O.S, and Adebowale K.O. (2005). Physicochemical characteristics and thermal properties of chemically modified Jack bean *(Canavaliaensiforms*) Starch. Carbohydrate Polym., 60: 331-341.

Lawal, O., Adebowale, K. and Oderinde, R. (2004). Functional properties of amylopectin and amylose fractions isolated frombambarra groundnut (Voandzeia Subterranean) starch. African Journal of Biotechnology, 3(8): 399-404.Available at:https://doi.org/10.5897/ajb2004.000-2082.

Leach, H. W., McCowen, L. D., and Scotch, T. J. (1959). Structure of starch granule 1. Swelling and solubility patterns of various starches. *Cereal Chemistry*, 36, 534–544.

Ling, W. H., Wang L. L. and Ma, J. (2002). Supplementation of the black rice outer layer fraction to rabbits decreases atherosclerotic plaque formation and increases antioxidant status. J. Nutr. 132(20):20-26.

Mepba, H. D., Eboh, L., and Nwaojigwa, S. U. (2007). Chemical composition, functional andbaking properties of wheat-plantain composite flours. *African Journal ofAgriculture, Nutrition and Development*, *7*(1), 1–22.

Narayara, K. and Narasinga, R. M. (1989). Effect of partial hydrolysis on winged bean (*Psophcocarustetragonolobus*) flour. Journal of Food Science, 49:944 - 947.

Newport Scientific (1998). Applications manual for the Rapid Visco Analyzer usingthermocline for windows. Newport Scientific Pty Ltd., ½ Apollo Street, Warriewood NSW 2102, Australia, pp. 2-26.

Ojiako, O.A., Igwe, C.U., Agha, N.C., Ogbuji, C.A., Onwuliri, V.A. (2010). Protein and Amino acidcompositions of *Sphenostylis stenocarpa*, *Sesanum indicum*, *Monodora myristica* and *Afzelia Africana* seeds from Nigeria. Pakistan J Nutr, 9(4): 368-372

Olaoye, O.A., Onilade, A.A. and Idowu, O.A. (2006). Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. Afr. J. Biotechnol., 5(11): 1102 1106.

Onyeike, E.N., Olungwe, T. and Uwakwe, A. A. (1995). Effect of Heat Treatment and Defatting on the Proximate Composition of Some Nigerian Local Soup Thickeners. Food Chemistry 53:173-175.

Regaee, S. and Abdel-Aai, E.M (2006). Pasting properties of starch and protein in selected cerealsand quality of their food products. Food Chem., 95: 9-18.

Sandhu, K.S, Singh, N. and Malhi, N.S. (2007). Some properties of corn grains and their flours I: Physicochemical, functional and chapatti-making properties of flours. Food Chem., 101: 938-946.

Sanni, L., Adebowale, A., Awoyale, W., and Fetuga, G. (2008). Quality of garri (roasted cassava mash) in Lagos State, Nigeria. Nigerian Food Journal, 26, 125-134.

Sanni, S. A., and Eniola, S. A. (2004). Sensory characteristics of plantain-wheat biscuits. In G. O. Adegoke, L. O. Sanni, K. O. Falade, and P. I. Uzo-Peters (Eds.), Proceeding of 28th Annual Conference/AGM of Nigerian Institute of Food Science and Technology, University of Ibadan, Ibadan, Nigeria. Lagos, Nigeria: Nigerian Institute of Food Science and Technology.

Sathe, S.K., Ponte, I.G., Rangnekar, P.D. and Salunkhe, D.K. (2002). Effects of addition of great northern bean flour and protein concentrates on the rheological properties of dough and baking quality of bread. Cereal Chemistry; 58: 97-100.

Schneeman, B. O. (2002). Gastrointestinal physiology and functions. *British Journal of Nutrition*, *88*(2), 159–163.

Shittu, T.A., Lasekan, O.O., Sanni, L.O. and Oladosu, M.O. (2001). The effect of drying methods on the functional and sensory characteristics of pukuru- a fermented cassava product. ASSET- An Intern. J., 1(2): 9-16.

Sui, Z., Lucas, P.W. and Corke, H. (2006). Optimal cooking time of noodles related to their notch sensitivity. Journal of Texture Studies 37, 428–441

Tester, R.F. and Morrison, W.R. (1990). Swelling and gelatinization of cereal starches. I. Effects of amylopectin, amylose and lipids, Cereal Chemistry 67 (1990), pp. 551–557

Udeh C. C., Malomo S. A., Ijarotimi O.S., **Emojorho E. E.** and Arogundade T.J. (2023).Physicochemical, Nutritional and Functional Properties of Composite Flour Blends from Whole Wheat, Sweet Potato, Defatted Peanut and Rice Bran. European Journal of Nutrition & Food Safety Volume 15, Issue 12, Page 41-55

Van Hoed, V., Depaemelaere, G., Villa Ayala, J., Santiwattana, P.,Verhé R.D. (2006) Influence of chemical refining on the major & minor components of rice bran oil. JAOCS 83: 315-321

Villanueva-Suarez, M.J., Redondo-Cuenca, A. and Rodrı´guez-Sevilla, M.D. and de las Heras M. (2003). Characterization of nonstarch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: comparative study. Journal of Agricultural and Food Chemistry 2003; 51: 5950–5955.

Zaidhul, I.S.M, Hiroaki, Y., Sun-Ju, K., Naoto, H. and Takahiro, N. (2006). RVA study of mixtures of wheat flour and potato starches with different phosphorus contents. Food Chemistry, doi:10.1016/j.foodchem.2006.06.056