Chemical and Functional Properties of Pasting Producing from Plantain, Mesquite Seed Flours and Rice Bran

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The goal of the study was to see whether plantain flour could be blended with rice bran and mesquite flour to produce composite 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

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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.

1. INTRODUCTION

Using wheat flour only is one of the main baking constraints. Ayo et al. [1] 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 [2]. 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. Olaoye et al. [3] 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. This reduces the need for imported wheat and produces items that are higher in protein [3]. 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 [4]. 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 [5,6]. From a nutritional perspective, it is beneficial to consume mixtures of cereals and legumes as it provides a balance in diet, 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. 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 [7,8] 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 [9]. 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 [10]. 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. [11], 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) [12]. Malnutrition is less likely in mesquite-baked items with high protein levels. In accordance with Aremu et al. [13], 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 [14]. 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 [13]. This study looks at the functional, pasting, and chemical makeup of rice bran flour, matured green plantain flour, and mesquite composite flours.

2. MATERIALS AND METHODS

2.1 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.

2.2 Sample Preparation

After being sliced into distinct bunches, the plantain head was defingered. According to Mepba et al. [15], 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 °C for 15 hours with a fan setting of 1. Slices of dried plantain were ground into flour using hammer 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, cooked for ten hours at 40 degrees Celsius, and then coarsely milled 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 250μm size screen. It was then sealed in an airtight container until needed.
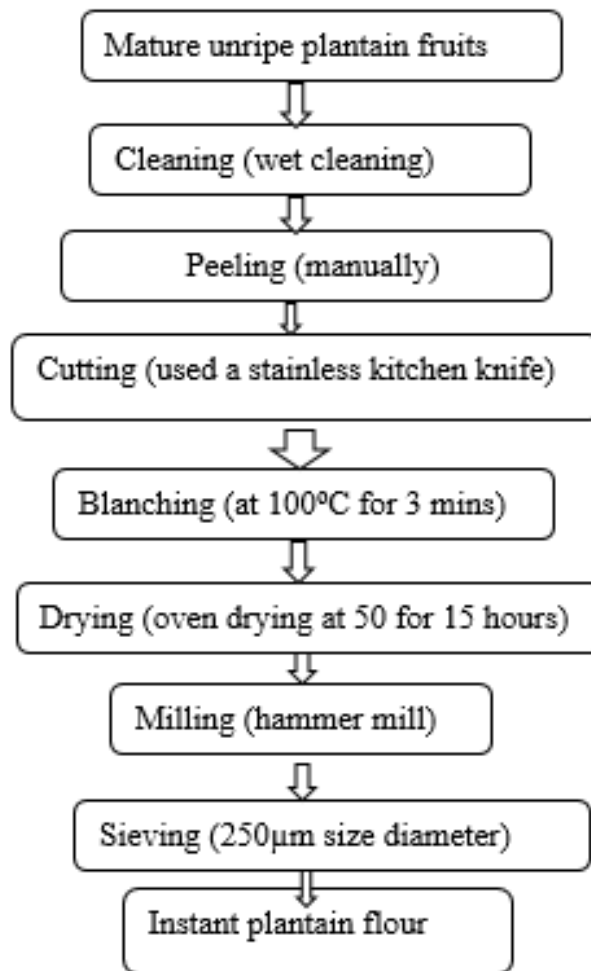

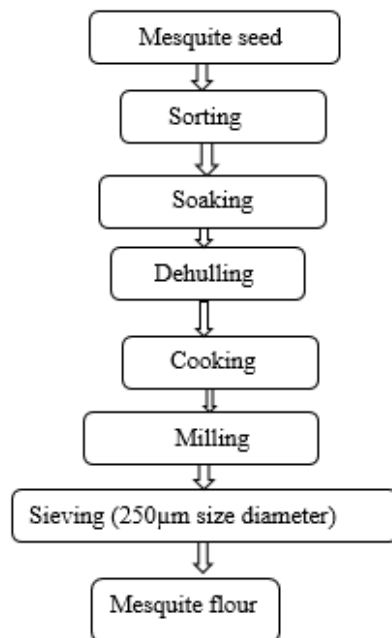**Fig. 1. Flow Chart for the production of instant plantain flour**

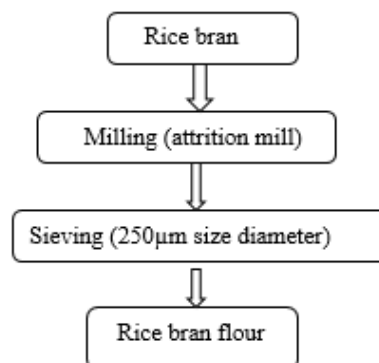**Fig. 2. Flow Chart for the production of mesquite flour**

Fig. 3. Flow Chart for the production of rice bran flour

2.3 Determination of Proximate Composition

Using the established procedures of [16], 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 [17].

2.4 Determination of Functional Properties

2.4.1 Water absorption capacity

Tester and Morrison's [18] method was used to measure the flour samples' swelling capacity, while Narayara and Narasinga's [19] method was used to determine the bulk density. A modified version of Coffmann and Garcia's [20] method was employed to ascertain the lowest concentration of gelation. The flour's solubility was assessed using Leach et al.'s [21] method.

2.4.2 Pasting properties

The RVA (Rapid Visco Analyzer) was used to evaluate the samples' pasting qualities. In accordance with the RVA handbook, Newport Scientific Australia [22], 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 [23].

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≤0.05) for both data sets.

3. RESULTS AND DISCUSSION

3.1 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 [24].

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 [25]. 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 %. 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 [26]. 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.

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 [27]. 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 [28]. 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 [29]. 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 [30].

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 [31]. 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 [32]. 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 flours 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 sodium (Na) (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.

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 T2s ample contains the lowest value of K, Zn and Fe, while T5 contains the highest value of K, Zn and Fe.

Pasting Properties: The amylograph pasting characteristics of the various samples at varying substitution levels are displayed in Table 3 below, which was obtained using the rapid visco analyser (RVA) on the 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 [33].

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 [34]. 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 [22]. For the samples, this varied from 97.28 to 243.00 RVU. According to Ragaee et al. [35], there is frequently a breakdown viscosity during this time. According to Zaidhul et al. [36], it is a sign of the starch gel's stability or breakdown during cooking. According to Newport Scientific [22], 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 53.89 to 156.33 RVU, with TNC having the highest value. Higher setback values are synonymous to reduced dough digestibility [37] while lower setback during the cooling of the paste indicates lower tendency for retrogradation [38].

3.2 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 [24] 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 [39]. 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. [39]. 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 [15]. Biscuits can be made using the flour blends with the maximum swelling power (T5). The flours' swelling power ranged from 3.47 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 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]
TNC10.41±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 ≤ 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} - Flour made by 100% plantain flour.
CHO - carbohydrate

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 ≤ 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.

Table 3. Pasting property of flour blends

Sampe	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.
RVU - Rapid Visco Units (RVU).

Table 4. Functional property of flour blends

	Swelling (g/g)	BulkDensity (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 ≤ 0.05.
Key:
T_1 - 20% mesquite flour + 30% rice bran flour + 50 % plantain flour.
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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 [40]. 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 [41]. 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 [42,43,44].

4. 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. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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