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Article

Physico-chemical and sensory characterization of bread based on green banana *(Musa spp.)* flour

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Abstract: The banana (*Musa spp.*) is a tropical fruit with excellent sensory characteristics in terms of aroma, flavor and texture, consumed worldwide and exploited in most tropical countries. Green banana flour is rich in flavonoids, which protect the gastric mucosa, has a high content of resistant starch, which acts in the body as a dietary fiber and thus has health benefits, and is an alternative option for bakery products, reducing waste of both the peel and the pulp. The aim of this study was to develop bread formulations with partial substitution of wheat flour with green banana flour (FBV), thus increasing the nutritional, technological and sensory value. 4 formulations, (A), standard sample; (B), bread with 10% FBV; (C), bread with 15% FBV and (D), bread with 20% FBV. Physico-chemical quality was assessed in terms of moisture content by drying at 105ºC, ash by incineration, fat by the Soxhlet method, protein by the biuret method, carbohydrates by difference calculation and calorific value by sum calculation and sensory analysis by affective methods. The data was evaluated using the RStudio 4.2.1 DCC statistical package. There were no significant differences in moisture content, lipids and calorific value. Differences were evident in the ash and protein content. Sensory acceptance of the standard formulation was 82.22%. The results obtained show that green banana flour can be used as a partial substitute for wheat flour to produce breads with functional properties.

Keywords: Green Banana Flour; Bread, Resistant Starch, Quality Control.

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1. Introduction

Bread can be considered a popular food, eaten as a snack or with meals. This product is made from wheat flour and/or the partial incorporation of other flours, with added liquid, resulting from the fermentation process or not, and may contain other ingredients, as long as they do not de-characterize the products. They can have different toppings, fillings, shapes and textures [1].

One of the factors that limits the shelf life of bakery products, especially breads, is ageing, which occurs due to the retrogradation of starch and the reduction of moisture that contributes to increasing the firmness of the crumb, giving the product a dry feel when eaten. These factors, combined with the need to reduce operating costs and expand the market, have led bakeries to develop new methods of producing dough in general [2].

Bananas are one of the most important fruits in the world, both in terms of production and commercialization. For many countries, as well as being a complementary food in the population's diet, it has great social and economic relevance, serving as a source of income for many farming families, generating jobs in the countryside and in the city, contributing to the development of regions [3].

The green banana has been considered an ideal product for industrialization due to its high content of resistant starch (17-18%) and low concentration of sugars [4], as well as high amounts of total dietary fiber, especially hemicellulose, minerals such as potassium, calcium, magnesium, iron and vitamins A, B1, B2 and C [5].

Bananas (*Musa spp*.) are an important crop for millions of people in developing countries. Its carbohydrate content ranges from 22 to 32 per cent of the fruit's weight and is an excellent source of energy. It contains many minerals, including calcium (8 mg/100 g), potassium (385 mg/100 g), magnesium (30 mg/100 g) and phosphorus (22 mg/100 g), as well as vitamins A (68 μg/100 g), B6 (470 μg/100 g) and C (11.7 mg/100 g) [6].

The resistant starch (RA) present is a natural component of the diet, and its current consumption is around 3g/person/day. It is found in unprocessed foods such as grains, raw potatoes, green bananas, and botanically has various functional properties when applied to food and other industrial sectors. It is an abundant, renewable and biodegradable raw material that can be extracted with high purity through simple industrial processes, and is easily converted into various substances by chemical and biochemical processes [7].

Green banana starch has great potential; in addition to its digestive and functional properties, it has applications in food processing, which makes its production commercially viable [8].

Similarly, (FBV) helps to reduce the risk of chronic diseases such as hypertension, diabetes mellitus, colon cancer, obesity, coronary heart disease and some gastrointestinal disorders, including constipation [9].

Thus, the research was carried out with the aim of producing bread with the partial substitution of wheat flour by green banana flour (FBV) as an alternative for increasing FBV in the production chain of foods with functional qualities in bakery, contributing in a similar way to the prevention of risks of more common diseases such as hypertension, cancer, obesity and diabetes.

2. Materials and Methods

2.1. Area

This study was conducted at the laboratory of the Higher Polytechnic Institute of Gaza (ISPG), located in Chókwè district, administrative post of Lionde. According to [10], the Chókwè district is located in the south of Gaza province, on the middle course of the Limpopo River, with the Limpopo River to the north separating it from the districts of Massingir, Mabalane and Guijá, the Bilene, Chibuto and Xai-Xai districts to the south, the Bilene and Chibuto districts to the east and the Magude and Massingir districts to the west.

2.2. Purchase of raw material

30kg of green bananas, 2kg of wheat flour, 1kg of sodium chloride (salt) and sugar, 250g of fresh biological yeast and 1 litre of vegetable oil were bought from a supermarket in Chókwè city, packed in plastic bags and taken to the Agro-Processing laboratory at the Higher Polytechnic Institute of Gaza.

2.3. Flour production stages

The production of flour (Figure 1) continued with the removal of the bunches, followed by washing and sanitization, which consisted of 3 stages: (i) first wash, (ii) sanitization in a 200 ppm sodium hypochlorite solution for 10 minutes and (iii) second wash and weighing on an analytical scale (ADAM Nimbus®).

The bananas were then peeled manually, separating the pulp and peel, and immersed in a solution of natural bioactive agent (citric acid at 5.0 g/L). While still in the solution, the banana flesh was cut into 0.5 cm thick slices. The banana slices were then placed on stainless steel trays and left in an oven (Eco Therm) at 50ºC for 20 to 28 hours until constant weight. Once they had dehydrated, they were ground into flour using a mortar and pestle. The banana flour was packed in 750g glass jars so as not to favour moisture absorption and to retain the aroma of the flour. The jars containing the flour were stored in a cool, dry place during the analyses.

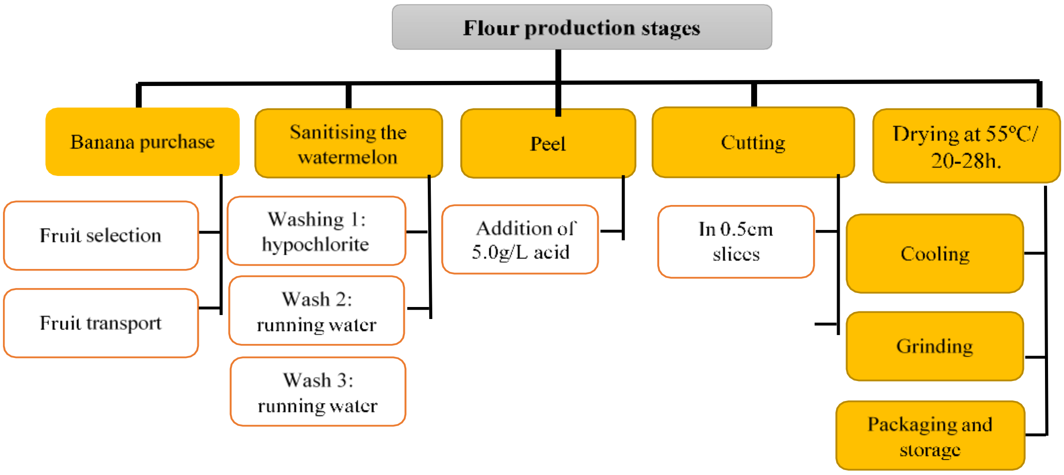

Figure 1. Production organization for green banana flour. (Source: Authors.)

2.4. Flour yield

The yield was determined using equation 1, according to [8].

$$\mathbf{R = \frac{F}{P} * 100} \quad (1)$$

Where:

R - Yield (%);
F - Quantity of flour obtained (g);
P - Amount of banana pulp (g).

2.5. Bread production

Bread formulations (Table 1) were developed by partially replacing wheat flour with FBV: (A) Standard, with 100% of wheat flour; (B) 90% of wheat flour and 10% of green banana flour; (C) 85% of wheat flour and 15% of green banana flour and (D) 80% of wheat flour and 20% of green banana flour.

Table 1. Green banana (*Musa ssp.*) bread formulations.

Ingredients (%)	**Samples**			
	A	**B**	**C**	**D**
Wholemeal flour	100	90	85	80
Green banana flour	0	10	15	20
Sodium chloride	2	2	2	2
Sucrose	5	5	5	5
Fresh biological yeast	3	3	3	3
Water (mL)	57-60	57-60	57-60	57-60
Oil (mL)	3	3	3	3

Source: Andrade et al., (2018).

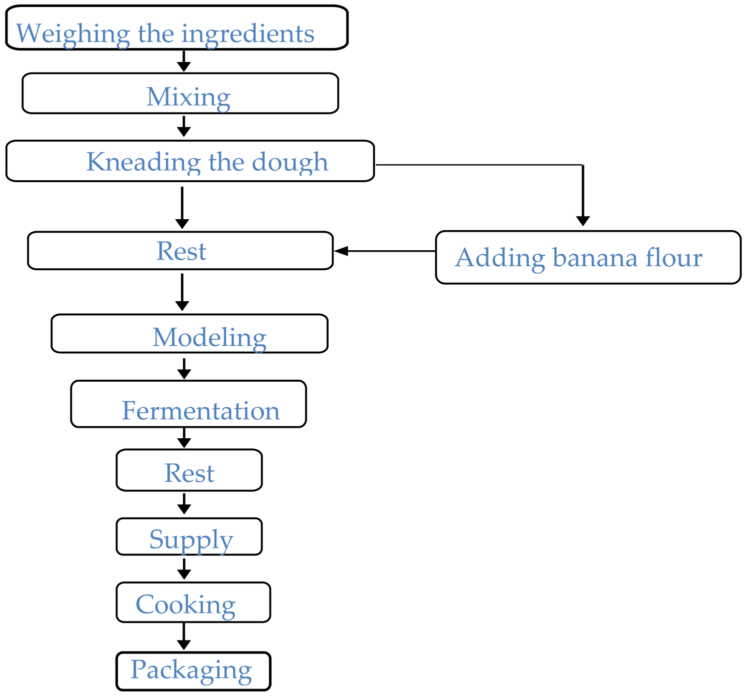

Figure 2. Production flowchart for green banana bread. (Source: Authors.)

After measuring the mass (g) of each ingredient on an analytical balance (ADAM Nimbus®), and they were mixed (with the addition of water) at a temperature of 38°C, measured in a 100 mL beaker. The difference in volume in each treatment was due to their addition to the dough until mixing was complete and the gluten net study developed. The dough was manually homogenized for 10 to 15 minutes, then divided into units of 50±1g each. The loaves were moulded into a circular shape, placed on an oven tray and subjected to fermentation and left to rest for 30 minutes at room temperature. After fermentation was complete, the loaves were baked at 180°C for 40 minutes. The loaves were then cooled to room temperature (25°C) and then wrapped in plastic polythene.

2.6. Physico-chemical analyses

The physicochemical composition of the green banana flour and bread formulations was analyzed in terms of moisture, fat, protein, ash, carbohydrate and calorific value.

2.6.1. Moisture content

Moisture was determined by loss on drying. To do this, 5g of the sample was weighed into petri dishes and placed in an oven with circulating air at 105° C for 2 hours, after which it was cooled to room temperature for 30 minutes and weighed again. After reaching a constant weight, the moisture content was calculated using equation 2.

$$\frac{(\text{Plate weight} + \text{sample}) - \text{Final weight}}{\text{Sample weight}} * 100 = \%\ \text{moisture content} \quad (2)$$

2.6.2. Fat content

5g of the sample was weighed on an analytical balance, placed on filter paper in the shape of a cone and inserted into the fat extractor tube. 250mL of diethyl ether was added to 500mL volumetric flasks which had previously been dried in an oven at 105° C for 30 minutes, cooled to room temperature and weighed, and then placed in the heating hood

(60^{o} C) to facilitate the extraction of the fat contained in the sample. The extracted fat was deposited in the flask, which was dried and weighed again after the extraction process. Having weighed the flask with the fat, the amount of fat in the bread was determined using equation 3.

$$\frac{(\text{weight} + \text{fat}) - \text{balloon weight}}{\text{sample Weight} * 100} = \%\ \text{fat} \quad (3)$$

2.6.3. Ash

On an analytical balance, 5g of the sample were weighed in porcelain crucibles and placed in a muffle furnace at 550°C until the verification of complete incineration of the organic matter into inorganic, shown by a white powder. The crucibles were then transferred to an oven at 105ºC for 30 minutes with emphasis on lowering the temperature, followed by weighing them with the sample. Expression 4 was used to determine the percentage of sample incinerated.

$$\frac{(\text{Crucible weight} + \text{incinerated sample}) - \text{Crucible weight}}{\text{Sample weight}} * 100 = \%\ \text{incinerated residue} \quad (4)$$

2.6.4. Protein

Protein assay was based on the Biuret method, where extracts prepared in the proportion of 10g of sample to 90 mL of distilled water were mixed with 200 mL of Biuret reagent and left in a dark place for 30 minutes to give a purple complex color, followed by an absorbance reading at 540nm on a spectrophotometer previously calibrated with distilled water. The protein content of the samples was then determined by extrapolation using a calibration curve made up of casein in proportions of 0 to 10 mg/ml.

2.6.5. Carbohydrates

The carbohydrate content was determined using the difference calculation method. To do this, the moisture content, fat, ash and protein in 100g of the sample was added up and subtracted from the maximum (100%), as shown in equation 5.

$$\text{Carbohydrates}\ (\%) = 100 - (\%\ \text{Moisture} + \%\ \text{Fat} + \%\ \text{Ash} + \%\ \text{Protein}) \quad (5)$$

2.6.6. Calorific value

The calorific or energy value of the samples was determined by the sum calculation method, using the factors: (4) for proteins and carbohydrates and (9) for lipids. Equation 6 was used to determine the calorific value.

$$\text{Calorific value} = \text{lipids}*9 + \text{carbohydrates}*4 + proteins*4 \quad (6)$$

2.6.7. Sensory Analyze

Sensory tests were carried out on the bread formulations in order to assess the product's acceptability. The tests were carried out by 50 untrained tasters who expressed their opinions on taste, color, consistency, appearance, texture and overall impression. The acceptability test was applied using a nine-point structured hedonic scale, ranging from "1" (extremely disliked) to "9" (extremely liked). The acceptability index was assessed using equation 7, suggested by [34]. This equation considers that the sample has been accepted when it reaches 70%.

$$\mathbf{IA}\ (\%) = \frac{\mathbf{A} * \mathbf{100}}{\mathbf{B}} \quad (7)$$

Where:

A - Average score obtained for the product;
B - Maximum score given to the product.

2.6.8. Statistical analyze

The analysis of variance (ANOVA) was carried out using the general linear model (GLM), using the statistical package RStudio 4.2.1. In the event of significant effects, the difference between the experimental units was evaluated using the Tukey test at a 5% level.

3. Results and Discussions

3.1. Green banana flour yield

Table 2 shows the initial mass of the raw material and the loss rate. The green banana pulp selection stage had a loss rate of 50%, related to peeling and removing damaged parts of the banana. The drying stage is related to the loss of water in the product, which is negligible. In the crushing or grinding stage, the loss was 0.175kg. This phenomenon may be correlated with the ability of the fibers present in the green pulp to absorb water.

Table 2. Yield (R) and loss index (IP) of green banana pulp flour.

Raw materials	Stage	Mass (kg)	Loss (kg)	IP (%)	R (%)
Pulp	Reception	10	-	-	-
	Selection	5	5	50	-
	Dehydration	1,650	3,35	-	-
	Crushing	1,475	0,175	10,60	29,5

IP= Loss index; R= Yield. (Source: Authors.)

The yield of green banana flour was 29.5%, a quantity corresponding to 1.475kg obtained after dehydrating and grinding the banana corresponding to 5kg. Similar result to that of the present study was reported by [8] with a yield of around 29.8% when they produced FBV in an industrial tray dryer at 40°C for approximately 24 hours. Lower results were reported by [12] in their study on banana flour: product development and its physicochemical and functional characterization, obtaining a yield of 25.6% for green bananas. On the other hand, [13] reported a higher yield than the present study, 33.9%, in their study on biscuits produced with banana flour: chemical, physical and sensory evaluation.

3.2. Centesimal composition of green banana flour

The centesimal composition of green banana flour (FBV) is shown in Table 3.

Table 3. Centesimal composition of green banana flour.

	Parameters					
Sample	**Moisture**	**Ashes**	**Protein**	**Lipids**	**Carbohydrates**	**Calorific value**
FBV	8,52	0,96	2,84	0,67	87,01	384.16kcal

Source: Authors.

The moisture content of the flour obtained was higher (8.52) than the results reported by [14], around 7.55%; 7.80% and 7.20%, respectively.

The protein content obtained in the present research was revealed by [15], (4.7%) and by [13] in the range of 4.5%. Lower results were proposed by [16] (0.53%), when evaluating the effect of Moisture and temperature on the processing of green banana flour (*musa acuminata*, group AAA) by thermoplastic extrusion, by [13], around 1.89% protein, and also by [17] when evaluating six samples of green banana flour, obtained protein contents of between 1.24%.

The lipid content was 0.67%, results that agree with those obtained in this research were reported by [8], around 0.6% protein, and by [18] reported a lipid content of 0.69 for green banana flour, in their study on the elaboration of cheese bread added with green banana flour: physical and sensory characteristics.

The ash content was found to be in the range of 0.96%; similar results were reported by [19] in their study on the physical parameters and concentrations of resistant starch in frozen bread with the addition of green banana flour, with an ash content of around 0.94%. Higher results than those obtained in this research were reported by [12] in their study on banana flour: product development and its physicochemical and functional characterization, obtaining 2.79% mineral residue, and by [16] around 2.0% ash, in their study on green banana flour.

The result for carbohydrates was 87.01%, which is close to the value reported by [15] of 88.9%. Lower value than that found in this study was reported by [13] in which they described a carbohydrate content of 83.4% for FBV, and by [19], who obtained a carbohydrate content of around 73.71%, and also by [20] around 76.53% of carbohydrates, when evaluating honey breads made with flour from different varieties of green banana. In the evaluation carried out by [16], they obtained a value in the range of 91.7%, higher result than that obtained in the present study. The calorific value of the FBV was around 384.16kcal, a result higher than that reported by [15] (373kcal) per 100g.

3.3. Centesimal composition of the bread produced

The centesimal composition of the breads produced is shown in Table 4.

Table 4. Physico-chemical characteristics of breads made from 100% whole wheat flour and (10, 15 and 20% FBV).

	Formulations			
Parameters	**A**	**B**	**C**	**D**
Moisture	38,62±0,38^{c}	39,06±0,57^{c}	41,20±0,23^{b}	42,70±0,76^{a}
Ashes	1,63±0,19^{b}	2,07±0,17^{ab}	1,68±0,18^{ab}	2,13±0,16^{a}
Lipids	2,51±1,13^{a}	1,53±1,79 ^{a}	2,74±0,81 ^{a}	2,29±1,06 ^{a}
Protein	2,64±0,43 ^{a}	0,89±0,88^{ab}	0,96±0,91^{ab}	0,47±0,00^{b}
Carbohydrates	54,6	56,45	53,42	52,41
Calorific value	251,55±0,11^{a}	243,13±0,01^{b}	242,18±0,11^{c}	232,13±0,05^{d}

Means±standard deviation followed by the same letters on the same line do not differ significantly from each other at the 5% significance level. A, standard sample; B, bread with 10% FBV; C, bread with 15% FBV and D, bread with 20% FBV.

3.3.1. Moisture content

The moisture content of the formulations ranged from 38.62±0.38 to 42.70±0.76 per cent. The highest moisture content (42.72%) was observed in formulation D with 20% green banana flour. High moisture content in the formulations with partial substitution of wheat flour with green banana flour may be related to the protein content, starch composition and low level of lipids, since these components are hydrophilic and have the ability to bind more water molecules.

In the assessment made by [21] in their study on the production of green banana flour (*Musa spp*) for application in wholemeal bread, they obtained 38.8% moisture for the standard bread, and a significantly greater variation for the breads with the incorporation of FBV in which they varied in the range of 40.5 to 42.1%, results in agreement with those obtained in the present research.

Lower results (15, 17, 40 and 18%) than those obtained in the present study were reported by [20] in their study when producing honey breads made with green banana flour, obtained moisture ranging from 17.40% for the standard bread, 15% moisture for bread with 15% FBV, and 18% for the formulation with 30% FBV, and by [22] in their study on physicochemical, microbiological and sensory evaluation, microbiological and sensory evaluation of bread enriched with green banana flour with and without peel, in the range of 14.81% for standard bread, 17.29 and 20.22% for bread with 10 and 15% of FBV, respectively, also by [23] when evaluating the centesimal composition of banana bread, obtained moisture content ranging from 19.65 to 20.30%. This variation in the increase of moisture content in bread may be associated with the increase in water absorption in its composition.

3.3.2. Ash content

The ash content of the samples evaluated ranged from 1.63±0.19 to 2.13±0.16%. The lowest (1.63%) mineral residue content was evident in the standard sample. The highest (2.13%) ash content was seen in the 20% Green Banana Flour (FBV) sample. Statistically, the treatments (B and C) did not differ significantly ($p > 0.05$) from each other. There were significant differences ($p < 0.05$) between treatments (A and D).

Lower results than those obtained in this study were reported by [24] in their study on the physicochemical and sensory evaluation of breads produced with partial substitution of wheat flour with green banana flour, obtained ash contents in the range of 1.15% for standard bread, 1.03% for bread with 8% FBV and bread with 12% FBV had 1.10% ash, and by [22] in their study on the physicochemical, microbiological and sensory evaluation of breads enriched with green banana flour with and without peel, microbiological and sensory evaluation of breads enriched with green banana flour with and without peel, found mineral residue of 0.9 and 1.04% for breads produced with the incorporation of 10% and 15% green banana flour, this differentiation in terms of fixed mineral residue content may be associated with the composition and variety used.

In the research carried out by [21] to produce green banana flour (*Musa spp*) for use in wholemeal wheat bread, they reported fixed mineral residue levels in the range of 3.5% for the control treatment, 3.6% for the formulations with the addition of 10% and 15% FBV and 3.8% for the formulation with 20% FBV, results above those obtained in the present research.

Results in agreement with those of the present research were reported by [25] in his study on obtaining green banana flour for application in food products, he obtained a variation of 1.80% for the bread incorporated with 40% Green Banana Flour, and 2.08% for the bread produced with 60% Green Banana Flour.08% for bread made with 50% FBV and for bread made with 60% green banana flour, the ash content was 2.14%, and [20] in their study on honey breads made with green banana flour, obtained a fixed mineral residue ranging from 1.30 to 1.60%, and [23] when assessing the centesimal composition of banana bread, obtained a fixed mineral residue of 1.63%.

3.3.3. Content of lipids

The lipid content of the formulations ranged from 1.53 to 2.74, with the highest values being observed in formulations C (2.74), A (2.51) and D (2.29), with no significant differences between them.

Similar results to those found in the present research were reported by [21] producing green banana flour (*Musa spp*) for application in wholemeal wheat bread, with 2.29% lipids in breads incorporating 15% and 20% green banana flour (FBV).

Higher values were revealed by [20] 9.99 and 10.04%) of lipids, in their study on breads, in the formulations incorporated with 15 and 30% of green banana flour respectively, by [25] (5.8, 8.33 and 6.11%) of lipids, when developing bread formulations incorporated with 40, 50 and 60% of FBV, in their study on obtaining green banana flour for application in food products, and by [24] in their research on the physicochemical and sensory evaluation of breads produced with partial substitution of wheat flour with green banana flour, obtained 3.33% lipids for the standard sample, 2.97% for the bread with 8% FBV and 2.95% for the bread with 12% green banana flour, and by [26] when carrying out their study on the effect of fortifying bread with green banana, obtained lipids ranging from 10.4 to 10.7%, and also by [23] in the range of 7.91 to 9.04% lipids, when carrying out their study with the aim of evaluating the centesimal composition of banana bread.

3.3.4. Protein content

The results obtained for protein indicated that the treatment formulations ranged in average from 0.47±0.00 to 2.64±0.43 per cent. Statistically, the treatments (B and C) did not differ significantly ($p > 0.05$) from each other. Significant differences ($p < 0.05$) were found between treatments (A and D).

Higher results than those found in this research were reported by [21] (11.3%, 10.9% and 10.1%) in terms of protein content in bread formulations with the addition of 10%, 15% and 20% of FBV, by [27] in his study on the use of Solanum tuberosum L. peel flour in the preparation of wholemeal bread, around 12.9% lipids, and by [24], when producing bread with 8 and 12% substitution of wheat flour with green banana flour, obtained lipids of around 9.95 and 9.11%, and also [26] around (11.1 to 17.6%), when developing their study on the effect of fortifying bread with green banana, obtained protein ranging from 10.4 to 10.7%, and also by [23] in the range of 13.16 to 14.29% protein.

3.3.5. Carbohydrate content

The lipid content of the formulations ranged from 52.41 to 56.45, with the highest values being observed in formulations B (56.45), A (54.4) and C (53.42), with no significant differences between them.

In his study on obtaining green banana flour for use in food products, [25] reported a carbohydrate value of 53.30 per cent for bread made with 40 per cent green banana flour, 47.86 per cent for bread made with 50 per cent green banana flour and 50.02 per cent for bread made with 60 per cent green banana flour, values close to those reported in this study. Results in agreement with those obtained in the present research were reported by [24] in their research on the physicochemical and sensory evaluation of breads produced with partial substitution of wheat flour by green banana flour, with 56.52% of carbohydrates for the standard bread, and by [20] when evaluating honey breads made with green banana flour, revealed carbohydrates of around 53.64% for the standard sample, and also by [23] in the range of 53.32 to 56.48% carbohydrates, their study aiming to evaluate the centesimal composition of banana bread.

Lower results than those obtained in this study were described by [26] when they analyzed the effect of fortifying bread with green bananas, at around 37.7 to 39.2% carbohydrates.

Higher values than those obtained in this research were reported by [21] when producing green banana flour (*Musa spp*.) for application in wholemeal bread, obtaining 82.5% for the control bread, 83.0% for the bread with 10% and 83.9% of FBV, respectively.

3.3.6. Calorific value

The calorific content of the formulations produced showed a significant difference ($p < 0.05$), with 251.55kcal for the standard formulation; 243.13kcal for the bread with 10% more FBV; 242.18kcal for the formulation with 15% FBV and 232.13kcal for the formulation with 20% more FBV. It was found that as the concentration of green banana flour in the formulations increased, there was a decrease in calorific content. The variations observed in the calorific value of the formulations produced are justified by the low protein, lipid and carbohydrate value, a phenomenon that directly influences calorific value.

Higher results than those obtained in this research were reported by [25] in his study on obtaining green banana flour for use in food products, around 273.61 kcal for bread incorporated with 40% FBV; 299.25 kcal for bread with 50% FBV and 292.75 kcal for bread with 60% Green Banana Flour, and by [26] in their study on the effect of fortifying bread with green banana obtained calorific values of around 294.3 to 323.6 kcal. FBV has a large proportion of resistant starch in its composition, so its use as an ingredient in food expands the variety of products with a low glycaemic index.

3.4. Sensory analysis

Table 5 shows the results of the sensory analysis based on the 9-point hedonic scale.

Table 5. Formulations of bread made from green banana flour (FBV).

	Attributes					
Formulations	**Appearance**	**Texture**	**Aftertaste**	**Aroma**	**Color**	**Flavor**
A	7.68±1.75^{a}	6.96±1.95 ^{a}	7.12±1.75 ^{a}	7.12±1.78^{a}	8.08±1.39^{a}	7.46±1.82a
B	5.6±1.97^{b}	5.92±1.77b	6.34±1.99 ^{ab}	6.16±2.23a	5.18±2.12b	6.58±1.90a
C	5.92±1.88^{b}	5.74±1.99b	6.08±2.07 ^{b}	6.44±1.93a	5.68±1.78b	6.48±1.83a
D	5.72±2.17^{b}	6.3±2.06^{ab}	6.42±2.03ab^{a}	6.62±2.04^{a}	5.5±2.15^{b}	6.52±2.15^{a}

Means±standard deviation followed by the same letters in the same column do not differ significantly from each other at the 5% significance level. A, standard sample; B, bread with 10% FBV; C, bread with 15% FBV and D, bread with 20% FBV.

3.4.1. Appearance

The appearance attribute indicated scores ranging from 5.6 to 7.68, with formulation A providing the highest score (7.68) with significant differences (p <*0.05*) between the other formulations.

Results in agreement with those obtained in the present study were reported by [7] in his study aimed at analyzing the physico-chemical and sensory composition of cakes made with rice flour and green banana flour, in the range of 7.74 in the standard sample, 7.26 in the sample incorporating 20% of FBV, the cake incorporating 35% of FBV had a score of 7.08, and the formulation with 50% of FBV had the lowest score of 6.56, at the extremes of "I liked it slightly, and by [28] in their study on the development and sensory acceptance of products made with green banana flour, found a score of 7.07 for the bread samples, and also by [23] in their study to assess the centesimal composition of banana bread, obtained a score of 5.90 for the appearance attribute.

3.4.2. Texture

The results obtained for texture showed that formulations A and D had the highest scores of 6.96 and 6.30 with significant differences between them, followed by a non-significant variation in relation to formulations B and C with scores of around 5.74 to 5.92. Statistically, the formulations (B and C) did not differ significantly (p>0.05) from each other.

Similar values to those of the present study were reported by [7], who obtained scores of around 7.46 and 6.90 for the standard cake and the cake with 20% FBV, 6.74 for the cake with 35% FBV, and by [28] in their study on the development and sensory acceptance of products made with green banana flour, obtained a score of 6.90 for the bread. In the evaluation carried out by [22] in their study on the physico-chemical, microbiological and sensory evaluation of bread enriched with green banana flour with and without peel, they found scores of 8.06 for the standard sample, 7.70 for the sample with 10% FBV and 6.22 for the bread with 15% FBV, higher results than those obtained in this study.

3.4.3. Aftertaste

The highest score (7.12) was observed in formulation A and D with (6.42). Statistically, the formulations (B and D) did not differ significantly (p >0.05) from each other. Significant differences were observed in formulations (A and C).

In the study carried out by [29] on the sensory analysis of bread rolls enriched with FBV as a substitute for wheat flour, in percentages of 10 and 20% as a substitute for wheat flour, he obtained a score of 7.2 for the standard bread; 6.8 for the bread replaced by 10% FBV and a score of 6.4 for the formulation with 20% FBV, results similar to those found in the present study. The study by [30] found that the best ratio was 15% partially added flour and 85% wheat flour.

3.4.4. Aroma

No significant differences (*p >0.05*) were found between the samples. This finding is probably related to the lower variability in the concentrations of the ingredients in the formulations, which had no effect on their volatile compounds.

Similar results to those found in the present study were revealed by [24] in their study on the partial substitution of wheat flour with green banana flour, obtained scores ranging from 6.82-7.50, and also [31] reported scores in the extreme range of 6.34-6.58, when making bread with added flour from cassava waste. As well as those found by [23] around 6.35 to 7.30, when developing their study with the aim of evaluating the centesimal composition of banana bread.

3.4.5. Color

The results obtained in this area indicated that formulation A obtained the highest score (8.08), followed by formulation C with a score of 5.68, formulation D with 5.50 and the lowest score was given to formulation B with an average of 5.18. Statistically, the formulations (B, C and D) did not differ significantly (p >0.05) from one another.

[22] found that the standard formulation and the bread with 10% FBV scored between 7.98 and 7.64 respectively for the color attribute, and the bread formulation with 15% FBV scored 5.90, which was probably due to the amount of green banana flour, which may have influenced the darker colors of the bread and the lower scores, similar results were found in this study.

Similar results were reported in the study of [7], in relation to color, who described that the standard sample scored (7.76), the cake with 20% FBV (7.54) and (7.42) for the cake with 35% FBV. The cake with 50% FBV scored the lowest, at 6.74, and was classified as "I liked it slightly". [21] reported that in terms of color, the greater the addition of green banana flour, the lower the scores given by the evaluators, due to the darker color.

3.4.6. Flavor

The scores ranged from 6.48 to 7.46. Formulation A (7.46) scored highest, followed by formulation B with an average of around 6.58. There were no significant differences (*p>0.05*) between formulations A, B, C and D.

Results in agreement with those obtained in the present study were revealed by [22], who obtained scores of around 7.08 for bread with 10% green banana flour and 5.44 for the formulation with 15% Green Banana Flour, and by [18], when adding FBV at concentrations of 0, 4, 8, 12, 16 and 20% to bread, obtained scores of around 6.90 for standard bread, 6.6 for bread incorporating 4% green banana flour and 6.28 for bread with 8% FBV, and also by [2], who made two formulations of bread, obtained 6.63 to 7.18, classified at the extremes "I liked it slightly and I liked it moderately", respectively. This is in line with [15], who observed that the aroma and flavor were not influenced by the addition of green banana flour.

Lower results than those obtained in this research were proposed by [28] in their study on the development and sensory acceptance of products made with green banana flour, with a score of 5.13 in the "neither liked nor disliked" range.

3.5. Overall assessment

Figure 3 shows the results of the overall assessment of the bread formulations.

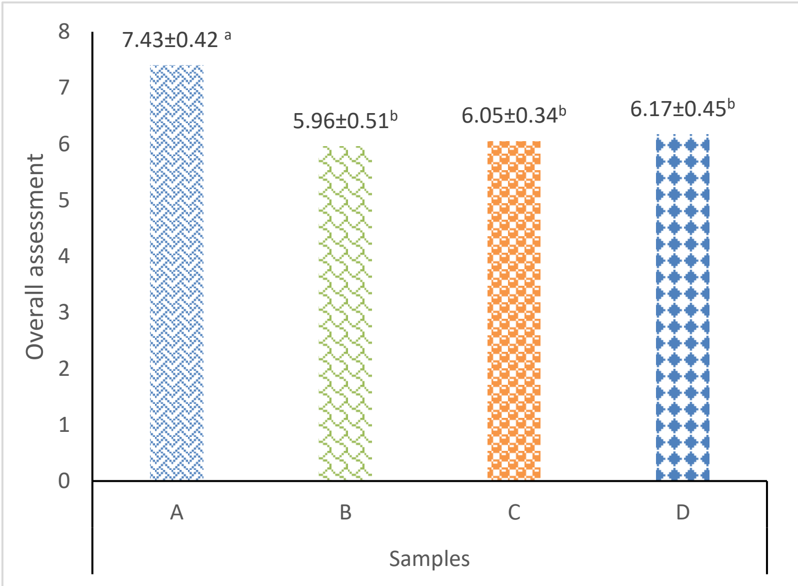

Figure 3. Overall assessment of the bread made from green banana flour. Means±standard deviation followed by the same letters in the same column do not differ significantly from each other at the 5% significance level. A, standard sample; B, bread with 10% FBV; C, bread with 15% FBV and D, bread with 20% FBV.

The highest score was given to formulation A (7.43), followed by formulation D with a score (6.17); formulation C with (6.06) and the lowest score was given to formulation B (5.95) where the tasters' classification of its attributes centred on "neither liked nor disliked".) Statistically, the formulations (B, C and D) did not differ significantly ($p>0.05$) from one another.

Similar results to those obtained in the present study were reported by [30], in the range of 7.00 for bread formulations with 10% FBV and 6.80 for bread with 15% green banana flour, and by [7] in his study on analyzing the physicochemical and sensory composition of cakes made with rice flour and green banana flour, obtained 7.40 for the standard cake, 7.16 for the cake incorporated with 20% FBV and 6.86 for the cake added with 50% FBV. These formulations scored "I liked it moderately" and "I liked it slightly". Similar results to those described above were reported in the study by [29], when he carried out a sensory analysis of bread rolls enriched with FBV as a substitute for wheat flour, in percentages of 10 and 20% as a substitute for wheat flour.

3.6. Purchase intent

Figure 4 shows the results of the bread formulation preference test.

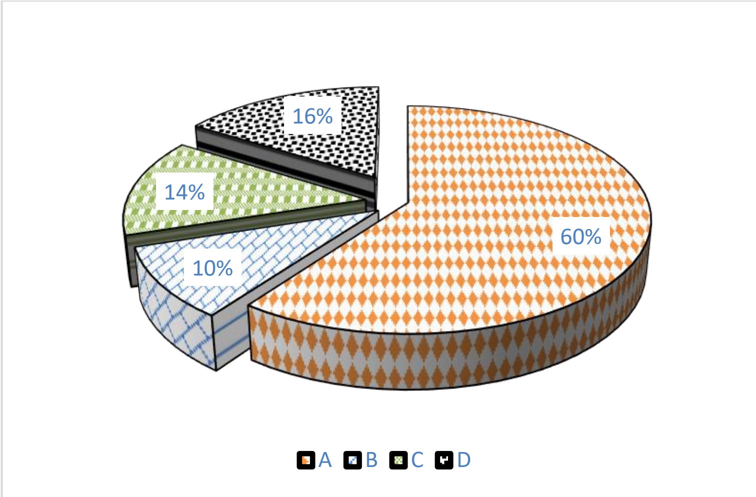

Figure 4. Purchase intention test for bread made from green banana flour. (A), standard sample; (B), bread with 10% BFP; (C), bread with 15% BFP and (D), bread with 20% BFP.

Formulation A of the standard loaf stood out as the best formulation in the purchase intention test, as 60 per cent of the tasters rated it "would buy".

In the study by [21] on the production of green banana flour (*Musa* spp.) for application in wholemeal bread, they found that for the control bread, 70% of the tasters revealed that they would "often buy" and 56% of the tasters revealed that they would buy the bread with 15% FBV. [9] made biscuits based on rice flour with 20 and 30 per cent green banana flour added, and obtained the result "might buy and or might not buy", while the biscuit sample produced with rice flour, cinnamon and 10 per cent (FBV) obtained an evaluation close to "might buy".

3.7. Acceptance rate

Figure 5 shows the results of the acceptability test for green banana flour bread.

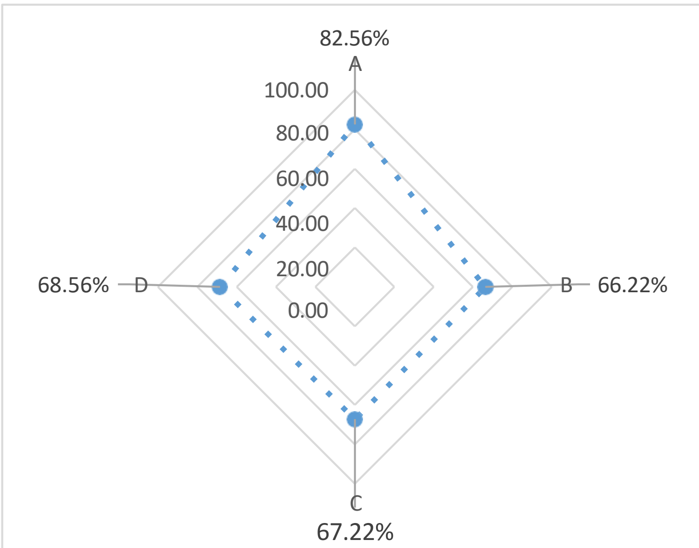

Figure 5. Bread acceptability index. (A), standard sample; (B), bread with 10% BFP; (C), bread with 15% BFP and (D), bread with 20% BFP.

The acceptability index of the bread formulations produced indicated that the best formulation was A with 82.22%, which was in the ideal range for acceptance (AI) as it was ≥70%. Low acceptability indices (AI) were observed in formulations B, C and D with acceptance indices of 66.22%, 67.22% and 68.58% respectively.

Similar results to those obtained in formulation A of the present study were reported by [11] in his study on food sensory analysis, that for a given product to be considered accepted in terms of its sensory properties, it must achieve an acceptance index equal to or greater than 70 per cent. The same was reported by [33] in his study on food sensory analysis, that the acceptability index that a product must present must be greater than 70%, indicated as the minimum value for good acceptance in the consumer market.

In the evaluation carried out by [21], they reported an acceptability index of 88.7% for standard bread and 82.1% for bread incorporating 15% Green Banana Flour. [22], in their study on the physicochemical, microbiological and sensory evaluation of bread enriched with green banana flour with and without peel, revealed an acceptability index of 86.44% for the standard bread formulation, 81.16% for the formulation incorporating 10% FBV and 67.77% for the bread formulation incorporating 15% Green Banana Flour, similar results were obtained in the present study.

5. Conclusions

The process of obtaining green banana flour (FBV) yielded a final product of 29.5%. There were no significant differences between the formulations developed in terms of moisture content, lipids and calorific value. There were differences in the ash and protein contents. Sensorially, formulation A, which contained 1200g of wheat flour, stood out in terms of purchase intention.

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Conflicts of Interest: The authors declare no conflict of interest.

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