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Application of green banana flour for partial substitution of wheat flour in sliced bread

Aplicação de farinha de banana verde na substituição parcial da farinha de trigo em pão de forma

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Abstract

The objective of this work was to develop a sliced bread product with green banana flour in order to obtain high resistant starch content and good acceptance. Four bread formulations were studied, at concentrations of 0% (control), 15%, 20% and 25% green banana flour (Terra Maranhão variety). The green banana flour (GBF) was characterized as color (L * coordinate and C * and h * parameters), and flour and bread were characterized with respect to chemical composition and total and resistant starch contents. Sensory acceptance of breads was investigated for the attributes color, flavor, aroma, texture, overall acceptance and purchase intention. The GBF presented light yellow color, with values of L * = 81.32, C * = 18.37 and h * = 89.51. The values (d. b.) for the other characteristics were: yield, 25.17%; moisture, 6.69%; ash, 1.60%; protein, 2.66%; lipids, 0.61%; total starch, 67.49%; and resistant starch, 56.29%. There was no significant difference (p > 0.05) between the breads containing GBF, and the sliced breads showed lower protein value (8.64%) than the control (10.60%) and higher resistant starch content (2.91%) compared to the control (0.65%). Addition of GBF to bread did not interfere with the moisture, ash and lipid contents of the products. Breads with concentrations of 15 and 20% GBF received acceptance higher than 90% for all sensory attributes. The use of GBF in sliced bread at the 15% and 20% levels resulted in a product with high sensory acceptance (greater than 90%) and with resistant starch content 4.2 times higher than conventional sliced bread.

Key words: Functional food. Resistant starch. Bakery.

Resumo

O objetivo desse trabalho foi desenvolver um pão de forma com farinha de banana verde visando obter um produto com elevado teor de amido resistente e boa aceitação. Foram estudadas quatro formulações de pão nas concentrações de 0% (controle), 15%, 20% e 25% de farinha de banana verde (variedade Terra Maranhão). A farinha de banana verde (FBV) foi caracterizada quanto à cor (coordenada L* e parâmetros C* e h*) e a farinha e os pães foram avaliados quanto à composição centesimal e teores de amido total e resistente. A aceitação sensorial dos pães foi realizada para os atributos cor, sabor, aroma, textura e aceitação global e escala de intenção de compra. A FBV apresentou coloração amarela clara pouco intensa, com valores de L* = 81,32, C*=18,37 e h*= 89,51. Os valores (b. u) para as demais características foram: rendimento, 23,72%; umidade, 6,69%; cinzas, 1,60%; proteína, 2,66%; lipídeos, 0,61%; amido total, 67,49%; e amido resistente, 56,29%. Não houve diferença significativa (p > 0,05)

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entre as formulações com adição de FBV, e os pães apresentaram menor valor proteico (8,64%) em relação ao controle (10,60%) e maior teor de amido resistente (2,91%) quando comparado ao controle (0,65%). A adição de FBV ao pão de forma não interferiu nos teores de umidade, cinzas e lipídeos dos produtos. As formulações com as concentrações de 15 e 20% de FBV apresentaram aceitação superior a 90% para todos os atributos sensoriais. A utilização da FBV na formulação de pão de forma, nos níveis de 15% e 20% resultou em um produto com elevada aceitação sensorial e com 4,2 vezes mais amido resistente em relação ao pão de forma convencional.

Palavras-chave: Alimento funcional. Amido resistente. Panificação.

Introduction

The banana is one of the most important foods in the world, together with rice, wheat and corn (PERRIER et al., 2011), and is very popular among consumers due to its low price, wide availability and sensory and nutritional characteristics. It is rich in carbohydrates and mineral salts such as calcium, manganese, phosphorus and potassium. The green fruit contains 70 to 80% of starch (dry base), a level comparable to that of potato and corn endosperm (ZHANG et al., 2005). Besides this, banana is rich in flavonoids (MOKBEL & HASHINAGA, 2005), which help protect the gastric mucosa, and resistant starch (RS), which is a carbohydrate that resists digestion in the small intestine of healthy individuals (ASP, 1992), but can be fermented in the large intestine by anaerobic bacteria to produce short-chain fatty acids (ENGLYST & MACFARLANE, 1986; GEE et al., 1992), thus behaving similar to dietary fiber (NUGENT, 2005).

The slow digestion of RS can also improve the glycemic and insulinemic response, with the important effect of controlling metabolic syndrome, a contributor to some of the main health problems nowadays: obesity, cardiovascular disease and diabetes. Although less effective than fiber in controlling the mentioned responses (VAN DOKKUM, 2008), RS has also been associated with reducing the levels of triglycerides and low-density lipoproteins, known as LDL cholesterol (JENKINS et al., 1998).

One of the ways of providing RS in people's diets is by adding green banana flour to various foods and dishes. This flour can be obtained by a relatively simple and inexpensive process. Green banana flour can be consumed directly or used in the preparation of breads, pastas, confectionery, dietary products and baby foods (TRAVAGLINI et al.,1993), as enrichment or for partial or total replacement of wheat flour (BORGES et al., 2009). In comparison with traditional dietary fibers such as whole grains, brans and fruit fibers, resistant starch has the advantage of improving sensorial attributes such as appearance, texture and taste of the final product, which are important for consumer acceptance (FUENTES-ZARAGOZA et al., 2010).

Bread is widely consumed throughout the world and has important nutritional constituents for food and nutrition of an individual, meeting their energy needs. In Brazil, the bread went from a complementary food for a meal itself, due to the customs of large part of population, and became the main element contributing to the intake of carbohydrates, lipids and proteins. Thus, it is a food that has the potential to become increasingly rich nutritionally, from the addition of substances of interest during its processing (VASCONCELOS et al., 2006).

In particular, the use of green banana flour to make bread can contribute to the control of chronic diseases like obesity and diabetes, by lowering the glycemic index of the products, promoted by ingestion of the resistant starch contained in this ingredient (PEREIRA, 2007).

In this context, the aim of this study was to develop a sliced bread product with green banana flour with high resistant starch content and good sensory acceptance.

Obtaining the green banana flour

Bananas of the plantain type (Terra Maranhão variety) were used in ripeness stage 1 (peel totally green), according to the Von Loesecke ripening scale (CEAGESP, 2006), grown in Presidente Tancredo Neves city, located in the Sul Baiano mesoregion of the state of Bahia, Brazil. The experimental design was completely randomized with three repetitions, with each bunch representing an experimental repetition.

To obtain the flour, the bananas (fingers) were separated from the stems using a stainless steel knife and then weighed. After that, they were washed and sanitized by immersion in a chorine solution (50 mg L^{-1} of free residual chlorine) for 10 minutes and rinsed in water to remove the excess chlorine. The fruits were peeled and cut into slices with 2-3 mm thickness and immediately immersed for 10 to 15 minutes in a solution containing 100 mg L^{-1} of citric acid and 300 mg L^{-1} of ascorbic acid to prevent enzymatic browning. After this step, the slices were placed in trays, weighed and put in a forced-air oven (Parcal model PE60, Rio de Janeiro, RJ, Brazil), at 50º C, with fixed air circulation speed of 1.5 m s^{-1} for drying.

During the drying step, the trays were rearranged several times to obtain a product with homogeneous moisture. After reaching ideal moisture, between 5 and 10% (w. b), the trays were weighed again to determine the yield. The slices were ground in a knife mill (Tecnal model TE-340, Piracicaba, SP, Brazil) with 30 mesh screen (0.59 mm) to obtain the flour.

Producing the bread

The bread was produced in a bakery located in Cruz das Almas city, Bahia. Three repetitions were performed in a completely randomized design, with four bread formulations, as reported in Table 1.

Table 1. Formulations used in the sliced bread.

Ingredients	Control Bread	Bread 15% GBF	Bread 20% GBF	Bread 25% GBF
Wheat flour	1.20 kg	1.02 kg	0.96 kg	0.90kg
Green banana flour	--	0.18 kg	0.24kg	0.30 kg
Whole UHT milk	700.00 mL	700.00 mL	700.00 mL	700.00 mL
Sugar	50.00 g	50.00g	50.00g	50.00g
Salt	20.00 g	20.00 g	20.00 g	20.00g
Powdered improver *	20.00 g	20.00 g	20.00 g	20.00g
Vegetable fat	4.00 g	4.00 g	4.00 g	4.00 g
Dry biological yeast	6.00 g	6.00 g	6.00g	6.00g

GBF- Green banana flour; *corn and/or cassava starch; stabilizers: polysorbate 80 (INS 433) and stearoyl-2-lactyl calcium lactate; and flour improvers: ascorbic acid (INS 300) and alpha amylase (INS 1100).

The ingredients were weighed and placed in a mixer (G. Paniz model BP 18 EL, Caxias do Sul, RS, Brazil) to obtain a smooth and homogeneous dough. The dough was passed through a roller laminator (G. Paniz model CLP 600), and then divided and formed into loaves with a cutter (G. Paniz model DV 30). The loaves were placed in bread pans and maintained at room temperature (22.2±5 ºC) with relative humidity of 81.5% for 10 hours for fermentation and then were baked in an industrial wood oven with steam (RR, Vila Formosa, SP), at 180 ºC for 20 minutes.

Evaluation of the physico-chemical parameters and centesimal composition

The green banana flour was analyzed for color by the instrumental parameters L* (luminosity), C* (chroma/purity or intensity of color) and h^* (hue), according to the International Commission on Illumination (CIE, 2004).

The chemical compositions of the green banana flour and bread were determined based on the levels of moisture, ashes, proteins, lipids, total starch, resistant starch and carbohydrates.

The moisture was determined by drying the bread samples in an oven at 105 ºC until constant weight, and was expressed as a percentage. The ash level was calculated by incineration in a muffle furnace (550 ºC) and was also expressed as a percentage, while the protein was measured by the Kjeldahl method, both according to the recommendations of Instituto Adolfo Lutz (2008).

The lipids were quantified by the Bligh-Dyer method. The total starch content was determined by the method proposed by Rickard and Behn (1987), and the resistant starch was quantified by the method proposed by Goñi et al. (1996). The flour yield was calculated as a percentage of the weight of the unpeeled fruits. The total carbohydrates were calculated by the difference between 100 and the sum of the percentages of moisture, ashes, lipids and crude protein (BRASIL, 2005). The total caloric value was calculated using the conversion factors of Atwater: 4 kcal g^{-1} (proteins); 4 kcal g^{-1} (carbohydrates); and 9 kcal g^{-1} (lipids) (BRASIL, 2008).

Three experimental repetitions were performed and each analysis was carried out in triplicate.

Sensory evaluation

The study was approved by the Research Ethics Committee of Maria Milza College, located in Governador Mangabeira city, state of Bahia (authorization registered under number CAAE number 17106213.1.0000.0053). Sensory acceptance and buying intention tests were conducted with 71 untrained judges, following a randomized block design. The sliced bread samples were numbered randomly with three digits for evaluation of the sensory attributes appearance, color, aroma, taste, texture and overall acceptance, on a nine-point structured hedonic scale, where the extremes were "really disliked" (1) and "really liked" (9), according to the Brazilian standard NBR 14141 (ABNT, 1998). The bread samples were presented in square pieces (4 cm x 4 cm) in individual booths under white light. The approval percentages of the sensory attributes were calculated based on the sum of the scores greater than or equal to 6.

The buying intention was evaluated before tasting (outside the booth) with whole breads and during tasting (inside the booth), based on a five-point scale, with the extremes being "certainly would buy" (5) and "certainly would not buy" (1).

Statistical analysis

The physico-chemical characteristics of the bread samples were submitted to analysis of variance and the means were compared by the Tukey test at 5% probability, using the SISVAR program (FERREIRA, 2011).

Results and Discussion

Characterization of the green banana flour

The characterization results of the GBF are presented in Table 2. The color of flour was light yellow, according to the values of L*, C* and h*. This characteristic can favor its use to make sliced bread, since it does not greatly change the color when comparing to wheat sliced bread, thus having little visual impact on consumers.

Table 2. Physico-chemical characteristics and centesimal composition of banana flour (Terra Maranhão variety).

Characteristics	Mean[1](w.d.)	Mean[1](d. b.)
L*	81.32±0.57	-
C*	18.37±0.50	-
h*	89.51±2.21	-
Moisture (%)	6.69±0.90	7.16±0.90
Ashes (%)	1.60±0.06	1.71±0.06
Protein (%)	2.66±0.04	2.85±0.04
Lipids (%)	0.61±0.12	0.65±0.12
Carbohydrates (%)	88.44±0.75	94.77±0.75
TCV (Kcal/100g)	369.89±3.98	378.98±3.98
Yield (%)[3]	23.72±0.98	25.17±0.98
Total starch (%)	67.49±0.30	72.33±0.30
Resistant starch (%)	56.29±3.47	60.33±3.47

[1]mean of three repetitions ± standard deviation; [3]calculated using unpeeled fruits; L*: luminosity; C*: chroma/purity or color intensity; h*: hue; and TCV: total caloric value.

The moisture content of the GBF was 6.6% (w.b.), in conformity with the current Brazilian standard (BRASIL, 2005), which establishes maximum moisture of 15% for flours, cereal starches and brans.

Due to its low protein content (2.66%) and absence of gluten, GBF should be used together with wheat flour to make bread. The protein percentage of wheat flours determines their classification for culinary indication, with those having protein content below 12% being classified as weak, leading to dough with low capacity to retain gas and less tolerance to mixing and fermentation (ARAUJO et al., 2008).

The level of lipids found in the GBF was low, similar to the result of Borges (2009) for flour from the Prata banana variety (0.68%) and lower than that observed by Fasolin et al. (2007) in flour from the Nanica variety (1.89%).

The total caloric value of the green banana flour was 369.89 kcal 100 g^{-1} (w. b.), lower than that measured by Borges (2009) in green banana flour from the Prata variety (373 kcal 100 g^{-1}). The consumption of 50 g of the flour would supply 9,2% of the daily calories of a diet with 2000 Kcal.

The average yield of the GBF produced from unpeeled fruits was 23.72% (w. b.) in this study, while Fasolin et al. (2007) obtained a yield of 33.97% (w. b.) for GBF prepared from peeled fruits of the Nanica variety.

The total starch content in this study (72.33%, d. b.) was lower than the value observed by Borges (2009) for flour from Prata banana, of 75.20% (d. b.). Among the factors that affect the starch content of the varieties are genetic variability and ripeness stage of the fruit. Therefore, standardization of the banana variety and the ripeness of the fruits are essential for the production of green banana flour for addition to foods. Starch is the main source of dietary carbohydrate and Brazil's Ministry of Health recommends ingesting at least 55% of this macronutrient in the total food energy intake (BRASIL, 2008).

The green banana flour tested here is an interesting alternative to provide a food rich in resistant starch to consumers. The resistant starch content obtained in this study was higher than that reported by Ramos (2009), in studying 13 banana varieties, in which the highest content obtained was for the Nam variety (40.25%).

Characterization of physico-chemical parameters and centesimal composition of the bread samples

The use of different concentrations of GBF to produce the bread did not influence the levels of moisture, ashes, lipids, total carbohydrates and caloric value (Table 3). The average moisture of the bread samples was within the maximum limit for bread prepared exclusively with common wheat flour and/or special wheat flour (durum wheat/ semolina), which is 38% according to the Brazilian standard (BRASIL, 2000). However, in the study conducted by Juarez-Garcia et al. (2006), breads containing only GBF showed significantly higher levels of moisture, ashes and proteins compared to the control product made with 100% wheat flour.

Table 3. Chemical composition[1] of the sliced breads prepared with green banana flour.

Treatments	Moist %	Ash %	Prot %	Lip %	Carb total %	TCV Kcal $100g^{-1}$	RS %
Control Bread	32.77	2.32	10.60a	1.85	52.46	268.91	0.65b
Bread 15% GBF	34.71	2.34	8.83b	1.85	52.27	261.08	2.56a
Bread 20% GBF	34.28	2.37	8.74b	2.04	52.58	263.59	2.95a
Bread 25% GBF	35.50	2.41	8.36b	2.20	52.09	259.35	3.22a

[1] in wet basis. Moist: moisture; Ash: ashes; Prot: proteins; Lip: lipids; Carb: carbohydrates; TCV: total caloric value; RS: resistant starch. Means followed by different letters differ significantly from each other at 5% probability by the Tukey test.

Although the literature demonstrates that green banana flour has a greater content of minerals than flour of other types available in the market (BORGES et al, 2009), in the levels tested in this study, the inclusion of this ingredient did not increase the quantity of ashes (minerals).

The protein content found in this study for the control bread was 10.60%, a value near that reported by Andrade et al. (2018), of 11.9%. All the bread formulations containing GBF presented lower protein value than the control. This is explained by the higher protein content of wheat flour in relation to banana flour. This decrease in protein was also observed by Ormenese (2010), Silva et al. (2014) and Andrade et al. (2018).

In the present study, the breads contained an average of 52.35% carbohydrates, equivalent to 17.45% of the recommended daily intake of 2000 kcal. This value is similar to traditional and commercial whole-grain breads, which contain 44.1% and 49.9% carbohydrates, respectively, according to the Brazilian Table of Food Composition (TACO, 2011).

The average total caloric value (TCV) obtained in this study (263 kcal) was similar to that of regular white and whole wheat bread, of 253 kcal $100g^{-1}$ (TACO, 2011).

There were no significant differences ($p>0.05$) between the three formulations with GBF regarding RS levels (Table 3), and the average content was 2.91%, which represents an increase of 2.26 g of this starch in each 100 g of bread in relation to the control bread. Juarez-Garcia et al. (2006) found that the use of GBF alone also provided a higher resistant starch content (6.74%) compared to the control bread (1%). The physiological properties of resistant starch are similar to those of dietary fiber, leading to reduction of intestinal pH and formation of short-chain fatty acids and increased fecal volume, increasing the tolerance to glucose and reducing lipid levels (PEREIRA, 2007). However, Brazilian regulations do not include this nutrient on the list of foods with allegation of functional and/or health properties (BRASIL, 2006).

Sensory evaluation of the bread samples

The results of the sensory acceptance and percentages of approval (scores from 6 to 9) of the breads prepared with GBF are presented in Table 4. There were significant differences ($p < 0.05$) between the formulations for the six attributes assessed.

Table 4. Mean hedonic scores of the bread samples prepared with green banana flour.

	Color		Texture		Flavor		Aroma		Overall Impression	
	Mean[1]	%AP [2]	Mean[1]	%AP [2]	Mean[1]	%AP [2]	Mean[1]	%AP [2]	Mean[1]	%AP [2]
Control Bread	7.88a	98.60	7.96a	98.60	7.76a	95.80	7.33a	90.10	7.89a	97.20
Bread 15% GBF	7.45ab	97.20	7.20bc	91.50	6.79bc	87.30	6.94ab	88.70	7.37ab	94.40
Bread 20% GBF	7.05bc	94.40	7.27b	91.50	7.15ab	93.00	6.91ab	85.90	7.31b	94.40
Bread 25% GBF	6.62c	83.10	6.68c	85.90	6.24c	71.80	6.57c	83.10	6.76c	84.50

(1) Mean of the hedonic scores (n = 71), according to a nine-point scale, with "really disliked" (1) and "really liked" (9) at the extremes; (2) results expressed as percentage of scores ≥ 6. Means (n = 71) followed by equal letters in the column do not differ from each other at 5% by the Tukey test.

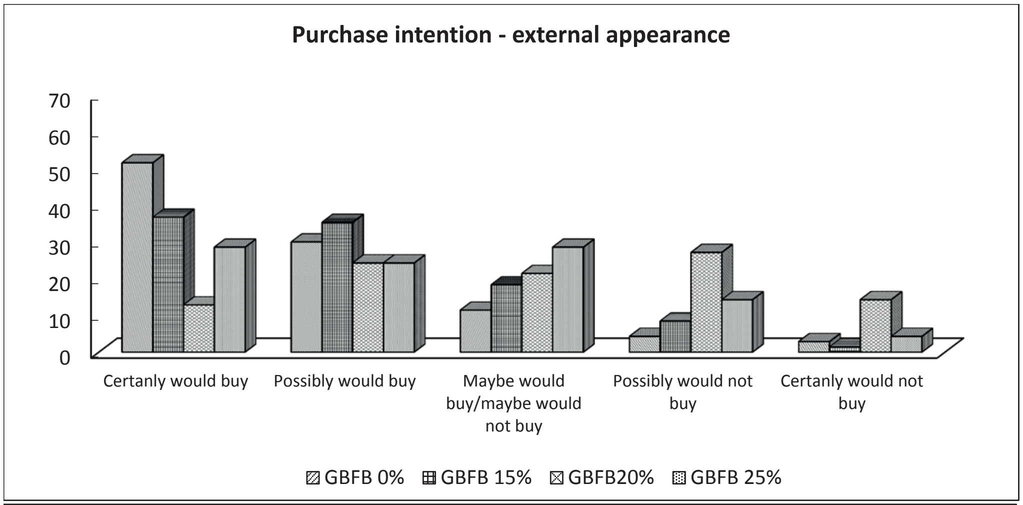
The judges preferred the texture of the control bread (Table 4). For the attributes color, aroma and overall impression, there were no significant differences ($p>0.05$) between the control and bread with 15% GBF. The flavor acceptance percentages were highest for the control bread and the formulations with 15 and 20% GBF.

The formulation with 25% GBF had lower acceptance than the control for all the attributes evaluated and this bread received hedonic classification as either "slightly liked" or "moderately liked". This formulation presented the lowest overall acceptance index (84.5%).

The formulations with 15 and 20% GBF presented similar acceptance with each other for all the attributes evaluated, and had overall acceptance index of 94.40%, showing that consumers liked the products. A different result was reported by Silva et al. (2014) when adding GBF of 8 and 12% to French bread, in which the highest sensory acceptance was found for the control bread. These authors stated that GBF negatively influenced the color and aroma of the product, but did not impair its texture and flavor, unlike observed in this study.

The results of buying intention before and after tasting are presented in Figure 1.

Figure 1. Buying intention of the breads prepared with green banana flour (Terra Maranhão variety). GBFB - green banana flour bread.



Based on evaluation of the external appearance of the breads, the sum of the categories "certainly would buy" and "possibly would buy" was highest for the control bread (81.4%) and the bread with 15% GBF (66.19%) (Figure 1A). After consuming these breads, the buying intention for the control bread increased to 84.50% while it remained the same for the bread with 15% GBF (Figure 1B).

For the bread with 20% GBF, the buying intention increased from 37.24% (Figure 1A) to 69% (Figure 1B). However, a contrary effect was observed for the bread containing 25% GBF, for which the buying intention declined after tasting the bread from 52.9% to 45% (Figures 1A and 1B).

Although the overall acceptance of the bread with GBF was lower than the control bread, it can be an appropriate product for consumers interested in healthier foods. Besides this, the breads with GBF presented greater resistant starch content and characteristics similar to those of traditional sliced bread.

Conclusion

The addition of 15% and 20% of green banana flour in the sliced bread results in a product with high sensory acceptance (greater than 90%) and with resistant starch content 4.2 times higher than conventional sliced bread.

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