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ELABORATION AND CHARACTERIZATION OF GLUTEN-FREE PIZZA AND COOKIE DOUGHS WITH BANANA WASTE FLOUR: ALTERNATIVES TO CELIACS

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ABSTRACT

The present study aims to evaluate the nutritional composition and acceptability of gluten-free pizza and cookie dough produced with banana (Musa ssp.) waste (bract)to improve their nutritional quality and reduce banana farming waste production. Bract flour was analysed for centesimal composition, water activity, minerals (Fe, Na and K) and color. For pizza dough elaboration, rice, sweet tapioca and bract flours were used. For cookieselaboration, cassava starch and bract flours were used to replace wheat flour. The centesimal composition and the phenolic compounds content were determined, and the sensory analyses were performed for both formulations. The results showed that bract flour presentsa high dietary fiber and minerals content and a lowcaloric value. Sensory analysis revealed the formulations acceptance and an even better evaluation for the cookies. The results suggested that banana bract flour may be included in gluten-free bakery products to improve their nutritional quality.

1.Introduction

Wheat products manufacture occurs predominantly due to thegluten proteins technological characteristics, whose hydration provides viscoelastic properties to the batter that incorporate gases during fermentation (Sciarini et al. 2010). On the other hand, some individuals are gluten intolerant (Fritz & Chen, 2017). In this context, the unique treatment for celiac disease (CD), a chronic immune-mediated enteropathy triggered by genetically predisposed individuals' exposure to dietary gluten, is agluten-free (GF) diet (Farage et al. 2018; Verma et al. 2017).

As the diet for celiacs is considered repetitive and restrictive, the food industry has invested in improving the gluten-free foods production to please consumers making the new products sensorially similar to those containing gluten. International studies show that 1% of the world population is celiac andaccording to the Brazilian Federation of Celiac Associations (Fenacelbra), around 2 million people in Brazil are affected by the disease (PRATESI and GANDOLFI, 2005). According to Farias (2009), the foods with the highest demand for transformation by the industry to be included in the celiac diet are bread, chocolate, pasta in general (spaghetti and gnocchi), pizza and sausages (sausageand mortadella). Despite this, there is a lack of raw materials for their preparation.

When compared to conventional products, GF products generally present higher fat and sugar content, as well as lower protein and dietary fiber amounts (El Khoury et al. 2018; Fry et al. 2018). Due to their lower structural quality, these products are often less attractive in terms of appearance, taste, aroma and texture (El Khoury et al. 2018). Techniques, such as the use of dietary fibersare applied to improve their properties, affecting the dough and starch cohesion properties (Aprodu & Banu, 2015; Gao et al. 2018).

There is a trend among consumers for healthier foods and a demand for sustainable production by the agro-industrial waste recovery and reuse (Vialta et al. 2010). Some studies have revealed the relevant nutrition potential fromsuch waste including vitamins, minerals, fiber and bioactive compounds (Gawlik-Dziki, 2012).

According to Shah et al. (2005), banana cultivation (Musa spp.) generates approximately 220 tons of waste per hectare. The banana inflorescence is formed by male flowers with their respective bracts (Sheng et al. 2010). Since it has no market value in Brazil, it is discarded as banana waste (Sheng et al. 2011). The bract is dietary-fiber-rich and presentskey antioxidant properties due to the presence of bioactive compounds (Padam et al. 2012). According to Basumatary & Nath (2018), banana bract presents an excellent phenolic compound content playing a significant role in free radical inhibition processes (Fawole et al. 2012).

Thus, the gluten-free pizza and cookie doughs formulating addedwith banana bract flour may facilitate the consumption of a potentially functional ingredient; adding value to this waste, in addition to improving the nutritional quality of the products without significantly affecting the sensory attributes, hence the need to evaluate this effect and the acceptance level.

2.Materials and methods

2.1.Banana bract flour, pizza and cookie doughs elaboration

Banana (Musa spp.) bracts were obtained from the Federal University of Grande Dourados (UFGD – Campus II) organic vegetable garden, Dourados -MS, Brazil. Harvesting took place in the mornings, between August 2017 and March 2018.

The preparations were done at the UEMS Food Laboratory - Naviraí Campus. The flour was elaborated according to methodology described by Borges & Mendonça (2019). The bracts were removed from the inflorescence, washed in tap water, and then cut into standardized sizes with an approximate 1 cm thickness. Afterward, they were weighed and immersed in a 200 $mg.L^{-1}$ sodium hypochlorite solution for 15 minutes. After that, they were bleached and immersed in a 0.5% citric acid solution for 1 minute, placed in aluminum containers (30 cm x 40 cm) and oven-dried at 65 ºC for 18 hours. The milling was performed in a blade mill, obtaining 60-mesh size flour. The flour was stored in dark glass bottlespreviously sanitized and stored at 4 °C, until its use.

The other essential ingredients were purchased from local markets in the municipality of Naviraí-MS. The ingredients and their concentrations were defined by preliminary sensory tests, maintaining the formulations main characteristics, as per Tables 1 and 2.

For the pizza dough preparation, baker's yeast was hydrated with sugar and warm water (50 ml). The other dry ingredients were added and homogenized with eggs and the remaining water. Olive oil and a pre-prepared mixture were added tothe other ingredients until asmooth-structured homogeneous dough was obtained. The doughs were cut into equal parts, placed on 23 cm diameter aluminum forms and baked in a gas oven for 20 minutes at 180 °C.

For the cookies preparation, pre-tests were carried out to determine the banana bract flour and cassava starch concentrations. The methodology by Silvia et al. (1998) was used, with adaptations. The dry ingredients were homogenized with eggs and butter until smoothing. The dough was divided into portions, laminated at 5 mm thickness and cut into a 30 mm diameter. Uniform circumference discs were weighed before baking in an automatic electric oven for 15 minutes at 200 °C.

Table 1. Pizza formulations with variation of banana bract flour and mixed gluten free flour.

Ingredients	Pizza P1	Pizza P2	Pizza P3
Sugar (g)	5.00	5.00	5.00
Water (ml)	142.00	142.00	142.00
Extra Virgin Olive Oil (ml)	15.00	15.00	15.00
Banana Bract Flour (g)	30.00	30.00	50.00
Mixed GF Flour (g)	450.00	246.00	450.00
Biological yeast (g)	10.00	10.00	10.00
Eggs (g)	30.00	30.00	30.00
Salt (g)	3.50	3.50	3.50

Mixed GF flour composed of rice flour (50%) and sweet tapioca flour (50%).

Table 2. Cookie formulations with variation of banana bract flour and cassava starch.

Ingredients	Cookie C1	Cookie C2	Cookie C3
Brown Sugar(g)	75.00	75.00	75.00
Refined Sugar (g)	100.00	100.00	100.00
Baking Soda(g)	5.00	5.00	5.00
Cocoa Powder 50% (g)	10.00	10.00	10.00
Banana Bract Flour (g)	10.00	10.00	15.00
Cassava Starch Flour (g)	250.00	200.00	225.00
Butter w/ salt (g)	75.00	75.00	75.00
Eggs(g)	15.00	15.00	15.00

2.2.Banana bract flour characterization

Banana bract flour centesimal composition analysis was performed in triplicate, as follows: moisture by the desiccation mass loss gravimetric method in an oven at 105 ºC; ash by incineration method in muffle at 550 °C (AOAC, 2005); crude protein by Micro-Kjeldahl method (AOAC, 2011), using 5.75 as a nitrogen conversion factor into plant proteins (Brazil, 2001) and lipids by Bligh & Dyer (1959) method. Total dietary fiber and soluble and insoluble fractions were performed by theenzymatic method (AOAC, 2000), and water activity performed by hygrometer (Labuza, 1975).

Carbohydrates were determined by the difference of the values found for moisture, ash, protein, lipid and total dietary fiber in 100g of product (AOAC, 1995). The total caloric value was calculated using lipids (9.03 kcal/g), protein (4.27 kcal/g) and carbohydrates (3.82kcal/g)as parameters (Merrill & Watt, 1973).

Samples were digested in a microwave oven using nitric acid, and the macro minerals (Fe, Na, K) were determined by atomic absorption spectrophotometry and the results expressed as mg 100 g^{-1} sample and standard deviation (Aquino et al. (2014, Xu et al. 1988). Color analysis was evaluated by the CIELAB system in terms of L, a* and b* colorimetric coordinates (Gonnet, 1998). The average results were expressed as percentage ± standard deviation.

2.3.Pizza and cookie doughs characterization

Centesimal composition analyses were performed on the three formulations of both products using the methods previously described for moisture, ash, lipids, proteins and carbohydrates. Total phenolic compounds determination was performed by Follin-Ciocauteau method with modifications proposed by Asami et al. (2003), in triplicate. Extracts were prepared with a 70% ethanol (v/v) extraction solution. 200 µl aliquots of extract, 60 µl Follin-Ciocauteau reagent and 2 mL sodium carbonate solution (7% w/v) were taken. The readings were taken at a 720 nm wavelength. The results were expressed as mg gallic acid equivalent (GAE) / g dry matter.

2.4.Pizza and cookiedoughssensory analysis

The sensory analysis was performed with the UEMS Human Ethics Committee approval under opinion # 1,858,034/2016. The formulation tests were performed at the UEMS Food Laboratory / Naviraí Campus, with 100 randomly chosenuntrained (19-59 years old) (male and female) adult tasters.

The samples were presented in coded disposable plastic plates on trays with a glass of water and a napkin. The pizzas were prepared with industrialized tomato sauce, mozzarella cheese and oregano. For the evaluation, the structured nine-point hedonic scale was used (Dutcoski, 2013).

2.5. Statistical Analysis

The results were expressed as average ± standard deviation (SD) and the triplicate measurements of pizza and cookie doughs were submitted separately to the analysis of variance (ANOVA) and Tukey test at a 5% significance level ($p \leq 0.05$) using the STATISTICA 7.0 software (Statsoft, 2004).

3.Resultsanddiscussions

3.1.Banana bract flour characterization

The physicochemical and color analysis results are shown in Table 3. The result for moisture content is in accordance with the Brazilian Law (Brazil, 2005), which establishes a 15g-100g maximumlimit forproduct. The water activity results (0.454 ± 0.04) ensure greater product stability (Cecchi, 2003).

The ash content was higher than that obtained for green banana flour (2.27%) (Medeiros et al., 2010). Both ash and protein contents (9.98 ± 0.13%) were lower than those for dehydrated banana inflorescence (14.4 ± 0.64% and 14.5 ± 0.40%, respectively). On the other hand, lipids contentwas higher (6.27 ± 0.24%) when compared with the same study (4.04 ± 0.07%) (Fingolo et al., 2012).

The results for total dietary fiber (56.14 ± 2.41%) and insoluble fiber (50.32 ± 1.35%) were higher than those found by Scorsatto et al. (2017) in eggplant flour, 39.2% and 28.83% respectively. Bhaskar et al. (2012) obtained highertotal fiber, soluble and insoluble fraction results (65.6 ± 1.3; 7.3 ± 0.2% and 58.3 ± 1.0%, respectively) for dehydrated banana inflorescence.

Banana bract flour is classified as high fiber content (Brazil, 2012)and to achieve this classification it must contain 6g of fiber per 100g.Therefore, it is a potential product to achieve the dietary recommendation since the fiber intake by the population is below the recommended one (Grooms et al. 2013). Both the amount of carbohydrates and the caloric valuewere lowerthan those forwatermelon rind flour (65.95 ± 0.04% and 317.88 ± 0.04 Kcal, respectively) (Cristo et al. al., 2018).

Borges et al. (2009), analyzed green banana flouras having higher potassium content (1,180 mg 100 g – 1) and lower iron content (17.80 mg 100 g – 1) than the bract flour. For color,the L* value shows the luminosity and the higher this value, the lighter the sample thus, the flour tended to darken. Fora*, a positive value was obtained, which indicates an even greater darkening. According to Takatsui (2011), when a* and b* coordinates approach zero, the colors are neutral.

Table 3. Characterization and color analysis of banana bract flour

Composition	%±DP
Moisture	3.86±0.11
Water Activity (Aw)	0.454±0.04
Ash	10.46±0.02
Proteins	9.98±0.13
Lipids	6.27±0.24
Total Fiber	56.14±2.41
Soluble fiber	5.82±2.28
Insoluble fiber	50.32±1.35
Carbohydrates	12.42±0.53
VC (kcal/100g)	150.40±10.63
Fe	65.22 ± 0.95
Na	294.46 ± 3.97
K	322.04 ± 2.53
L*	33.66±0.11
a*	4.28±0.06
b*	1.98±0.11

Data were presented as mean ± standard deviation (SD). VC: Caloric value.
The theoretical calculation was performed for carbohydrates and caloric value (Kcal/100g).

3.2. Pizza and cookie doughs characterization

According to the Brazilian Institute of Geography and Statistics (IBGE, 2011), wheat-based pizza dough formulations contain an approximate 39.79%moisture content. Moisture contents are related to product crispness, an important sensory attribute that, is reduced at high moisture levels (Guimarães & Silva, 2009). When evaluating the results for doughs, all formulations were below this content level.

For the cookie formulations, a significant statistical difference in moisture content between C3 and the other formulations could be observed due to the higher bract flourcontent. According to the Brazilian Health Regulatory Agency (ANVISA), the maximum moisture content for cookies must be 15% w / w (BRAZIL, 2005). Thus, the cookies are in accordance with Brazilian law.

For pizza dough`s ash, protein and lipid content, the highest averages obtained for the P2 formulation were inversely proportional to the mixed flour concentration. One of the reasons was the other ingredients concentration in P2 formulation.

The three pizza dough formulations had a lower protein content compared to wheat-based pizza dough, with an 8.22% averageprotein content (IBGE, 2011). According to the Brazilian Food Composition Table (TACO, 2011), wheat flour has a 9.8g / 100g protein average content and, as already described, banana bract flour has an 9.98g / 100g average protein content (Table 4), making the amount of the latter necessary for the dough preparation lower than that of wheat flour. Rice flour and sweet flour were used as replacements for wheat flour, both presenting reduced 8.4g / 100g and 0.4g / 100g protein valueson a dry basis, respectively (TACO, 2011). These values may justify the results found for protein levels on formulations when compared to a wheat-based pizza formulation.

Pizza (P2) formulation obtained a lipid average similar to the findings from Monteiro (2013) on pizzas made with rice, yam and quinoa flours with 4.74% to 6.17% averages. However, all samples presented lower lipid contents than those reported by IBGE (2011) for wheat-based pizza (11.35%).

Carbohydrate contents showed a significant statistical difference between the three pizza samples. El-Beltagi et al. (2017) evaluated pizza doughs with partial wheat flour replacement by three different chickpea flour or carp fish powder concentrations, which present higher protein and carbohydrate contents. However, a lower ash contents was observed, mainly due to the high ash contents in banana bract flour.

For cookie formulations, C2 showed a lower ash value (1.55 ± 0.08), since it has a lower banana bract flouramount. C1 and C3 formulations achieved similar results to the study by Freitas et al. (2014), who evaluated gluten-free cookies added with pumpkin seed flour and baru seed flour obtaining 1.93g / 100g and 1.76g / 100g, respectively.

There was no statistical difference forthe cookies' protein, lipid and carbohydrate contents($P \geq 0.05$). Mariani et al. (2015) prepared gluten-free cookies from rice bran, rice flour and soy flour and obtained higher protein values (11.16 - 14.22g / 100g) and lower lipids (20.29 - 22.13g / 100g) and carbohydrates (37.27 - 48.20g / 100g) values. These results may be due to the energetic and non-protein characteristics of the ingredients used in the formulations.

From the results, the pizza dough with the lowest flour content showed the highest phenolic compoundscontent, mainly due to the highest concentration of products used, however, no statistical differences were seen in the pizza samples. For cookies, C3 formulation with the highest banana bract flour content presented the highest phenolic compoundscontent, which was statistically different ($P \leq 0.05$) from the other samples, confirming the considerable phenolic compounds contentin banana bract flour.

One of these products benefits was the good nutritional composition, obtaining a higher fiber and phenolic compounds content and a lower carbohydrate content.

Several studies have shown that the consumption of antioxidant substances in a daily dietproduces an effective protective action against the natural oxidative processes in the body, preventing diseases and delaying the body`s aging process. Also, adequate fiber intakeappears to reduce the risk of chronic diseases development such as coronary artery disease, stroke, hypertension, diabetes mellitus and some gastrointestinal disorders, among other health benefits.

Table 4. Characterization of pizza dough and cookie biscuits.

Sample	Moisture (g/100g)	Ash (g/100g)	Proteins (g/100g)	Total Lipids (g/100g)	Carbohydrates (g/100g)	Phenolics Compounds (mg EAG/100g
P1	28.63±0.31^{b}	2.49±0.08^{b}	0.62±0.01^{b}	3.73±0.09^{b}	64.53±0.23^{a}	72.08±0.20^{a}
P2	28.63±0.31^{b}	3.80±0.06^{a}	0.75±0.02^{a}	5.71±0.12^{a}	61.24±0.50^{b}	98.58±0.22^{a}
P3	28.49±0.31^{ab}	2.33±0.02^{c}	0.61±0.03^{b}	3.44±0.01^{c}	58.51±1.00^{c}	87.36±0.11^{a}
C1	7.31±0.15^{a}	1.70±0.05^{a}	0.43±0.23^{a}	34.16±15.31^{a}	56.40±15.48^{a}	195.21±0.41^{b}
C2	7.64±1.33^{a}	1.55±0.08^{b}	1.02±0.60^{a}	31.90±8.81^{a}	57.88±8.53^{a}	307.29±0.65^{b}
C3	2.78±1.51^{b}	1.80±0.02^{a}	0.89±0.15^{a}	38.04±9.80^{a}	56.50±8.91^{a}	471.21±0.20^{a}

Date were present as mean ± standard deviation (SD). The pizza dough formulations were analyzed separately from the cookie formulations. The averages in the same column. followed by different letters. differ statistically from each other by Tukey test at 5% probability.

[1]P1 Pizza Dough: 450g mixed GF flour and 30g bract flour; P2: 250g of mixed GF flour and 30g of bract flour; P3: 450g of mixed GF flour and 50g of bract flour.

[2] Cookie C1: 250g of cassava starch flour and 10g of bract flour; C2 200g of cassava starch flour and 10g of bract flour; C3 225g of cassava starch flour and 15g of bract flour.

Table 5. Averages of sensory acceptability and purchase intention of the pizza doughs of the cookie biscuits added banana flour

Sample		Color	Aroma	Texture	Flavour	Global Impression
Pizza Dough	P1	6.21±1.85[a]	6.88±1.68[a]	6.42±1.79[a]	6.68±1.69[a]	6.56±1.72[a]
	P2	5.76±1.72[a]	6.47±1.60[ab]	5.99±1.62[ab]	6.46±1.68[ab]	6.25±1.69[ab]
	P3	5.83±1.71[a]	6.00±1.84[b]	5.73±1.65[b]	5.96±1.73[b]	5.72±1.66[b]
Cookie	C1	6.88±1.63[a]	7.04±1.52[ab]	6.93±1.55[b]	6.69±1.69[b]	6.80±1.54[b]
	C2	7.09±1.58[a]	6.90±1.62[b]	7.06±1.36[ab]	6.84±1.77[b]	7.12±1.57[ab]
	C3	6.98±1.58[a]	7.49±1.33[a]	7.53±1.34[a]	7.78±1.32[a]	7.38±1.26[a]

Data were presented as mean ± standard deviation (SD). The pizza dough formulations were analyzed separately from the cookie formulations. The averages in the same column. followed by different letters. Differ statistically from each other by the Tukey test at 5% probability.
1 P1 Pizza Pasta: 450g mixed flour and 30g bract flour; P2: 250g of mixed flour and 30g of bract flour; P3: 450g of mixed flour and 50g of bract flour.
2 Cookie C1: 250g of manioc starch flour and 10g of bract flour; C2 200g of manioc starch flour and 10g of bract flour; C3 225g of manioc starch flour and 15g of bract flour.

3.3. Pizza and cookiedoughs sensory analysis

Sensory analysis is a critical factor for new products acceptance or rejection(Sivakumar et al. 2010). Changes in the modified foods sensory characteristics are expected, such as in the dough structure with the gluten removal (Padalino et al. 2016). The sensory analysis results are shown in Table 5.

Taste and texture are the determining factors in choosing pizza dough (Bingham et al. 2011). Gluten-free pizza dough formulations added with banana bract flour received between 5.57 ("neither liked nor disliked") and 6.88 ("slightly liked")on average for all hedonic attributes. Such results were similar to those obtained by Russo et al. (2012), who developed pizza doughs added with whole wheat flour and different flaxseed flour concentrations, with aroma, taste, texture and color attributesclassified as "slightly liked". The exceptions occurred for the "flavor" attribute, where the formulation added with 5% flaxseed flour was classified as "moderately liked" and for the "texture" attribute, where the formulation added with 7.5% flaxseed flour was classified as "neither liked nor I disliked it".

No significant statistical difference was observed in the "color" attribute among the pizza dough samples. Pizza dough P3 formulation added with 450g mixed flour and 50g banana bract flour was the least accepted among the tasters, receiving the lowest averages for the "aroma, texture, taste and overall impression" attributes. A significant difference (P ≤0.05) was observed among the

P1 samples elaborated with the lowest banana bract flourconcentration, were the most accepted.

According to Lambert et al. (2006), the main cookie quality attributes are appearance, taste and texture. All cookieformulations were well-accepted by the tasters, with hedonic averages ranging from 6.69 ("liked slightly") to 7.78 ("liked moderately"). C3 formulation with the highest banana bract flour content was the highest ranked, except for the “color” attribute that showed no statistical difference among the formulations.

The cookies producedhad higher averages than those obtained by Queiroz et al. (2017) who developed gluten-free cookies with potato starch and coconut flour, with averages ranging from 6.0 (“like”) to 7.0 (“like”) for sensory attributes. The study by Giovanella et al. (2013), who developed gluten-free cookies added with quinoa flour and potato starch, obtained similar results in terms of taste, texture and overall impression.

4. Conclusions

In this study, further discussions were sought on the production of new, affordable, and easily accessible gluten-free products. The banana bract flour (Musa ssp.) analysisrevealed its considerable nutritional value and may be considered a significant nutritional supplement based on the dietary fiber content.

This study showed the feasibility of using a little known flour such as banana bract flour, as a wheat flour replacementon gluten-free foods production. It was seen that both pizza and cookie doughsadded with bract flour had a good response from tasters, with an overall acceptance above 65%, showing that it staste would not be a problem for products elaboration. It has shownitspotential as a raw material for new products, soit further testsshould be performed for it to enter the market in the future.

The gluten-free pizza and cookie doughs development added with banana bract flour has allowed obtaining more nutritious products with higher fiber and phenolic compounds and lower carbohydrate content. Sensory analysis showed that the formulations were accepted, with the best evaluation for cookie samples.

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