Cassava starch cookies made with replacement of farinaceous fraction by green banana flour

Galletas de almidón de yuca elaboradas con sustitución de la fracción farinácea por harina de plátano verde

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ABSTRACT
Changes in eating habits of the individuals have led the food industry to develop products that meet this demand. Banana is a fruit very appreciated in Brazil, but with a high loss rate, due to the absence of instruction among the manipulators. The production of banana flour can reduce these losses, because flour is made with the green fruit, which contains unique compounds with functional properties. Cassava starch cookies is a typical Brazilian food, characterized by its large volume and low weight, thus, the addition of green banana flour to these cookies may be a viable alternative. The objective of this study was to produce cassava starch cookies with substitution of the farinaceous fraction for green banana flour, to evaluate the proximate composition, and to verify the effect of the storage time on the physicochemical, sensory, and microbiological characteristics of the products. Four formulations were made, as follows: a control formulation (A1), and three different formulations containing 4% banana flour (A2), 8% banana flour (A3), and 12% banana flour (A4). The cookies were evaluated for proximate composition and the physicochemical, sensory, and microbiological characteristics in two different periods, corresponding to T1 immediately after manufacture, and T2 after 60 days of storage. All results were analyzed by Tukey's test and ANOVA at 5% probability. Significant differences (p≤0.05) were observed for moisture and
protein contents of the products. Regarding the physicochemical parameters, the samples presented significant differences (p≤0.05) for texture, color, and moisture gain, after 60 days of storage. The microbiological quality remained within the limits permitted by the current legislation, demonstrating excellent hygienic-sanitary conditions. Concerning the sensory evaluation, the samples A1 and A2 presented the higher acceptance scores, with no significant differences for the attribute crispness. Therefore, the addition of 4% green banana flour in cassava starch cookies may be a promising alternative of product diversification to attend the consumer demands, once the final product presented few changes in structure and good sensory acceptance.

**Keyword:** characterization, crispness, demand, storage, viability.

**RESUMEN**

Los cambios en los hábitos alimentarios de los individuos han llevado a la industria alimentaria a desarrollar productos que satisfagan esta demanda. El plátano es una fruta muy apreciada en Brasil, pero con un alto índice de pérdidas, debido a la falta de instrucción de los manipuladores. La producción de harina de plátano puede reducir estas pérdidas, porque la harina se hace con la fruta verde, que contiene compuestos únicos con propiedades funcionales. Las galletas de almidón de yuca son un alimento típico brasileño, caracterizado por su gran volumen y bajo peso, por lo que la adición de harina de plátano verde a estas galletas puede ser una alternativa viable. El objetivo de este estudio fue producir galletas de almidón de yuca con sustitución de la fracción farinácea por harina de plátano verde, evaluar la composición proximal y verificar el efecto del tiempo de almacenamiento en las características fisiocómicas, sensoriales y microbiológicas de los productos. Se elaboraron cuatro formulaciones, a saber: una formulación de control (A1), y tres formulaciones diferentes que contenían 4% de harina de plátano (A2), 8% de harina de plátano (A3) y 12% de harina de plátano (A4). Se evaluó la composición proximal de las galletas y las características fisiocómicas, sensoriales y microbiológicas en dos períodos diferentes, correspondientes a T1 inmediatamente después de la fabricación, y T2 después de 60 días de almacenamiento. Todos los resultados se analizaron mediante la prueba de Tukey y ANOVA al 5% de probabilidad. Se observaron diferencias significativas (p≤0,05) para los contenidos de humedad y proteínas de los productos. En cuanto a los parámetros fisiocómicos, las muestras presentaron diferencias significativas (p≤0,05) para la textura, el color y la ganancia de humedad, tras 60 días de almacenamiento. La calidad microbiológica se mantuvo dentro de los límites permitidos por la legislación vigente, demostrando unas excelentes condiciones higiénico-sanitarias. En cuanto a la evaluación sensorial, las muestras A1 y A2 presentaron las mayores puntuaciones de aceptación, sin diferencias significativas para el atributo crujiente. Por lo tanto, la adición de 4% de harina de plátano verde en las galletas de almidón de yuca puede ser una alternativa prometedora de diversificación de productos para atender las demandas de los consumidores, una vez que el producto final presentó pocos cambios en la estructura y buena aceptación sensorial.

**Palabra clave:** caracterización, crujiente, demanda, almacenamiento, viabilidad.

**1 INTRODUCTION**

One of the major challenges of food science is to meet the energy needs of population and promote positive sensory stimuli, financial sustainability, and food safety.

Changes in eating habits of the population have led to the development of products with characteristics of practicality, energy supply, fibers, and functional properties (Gouveia, 2006). Functional foods contribute
to the reduction of disease risks due to the presence of natural compounds, which when present in the body, strengthen the immune system and promote the maintenance of health and quality of life (Anjo, 2004).

Green banana flour stands out among the alternatives of functional food. The estimated banana production in the 2017 harvest is approximately seven million tons, which ranks the country among the top places in world fruit production (IBGE, 2017). The banana crop is a tropical fruit, with year-round production, has a pleasant flavor, and is considered the most consumed fruit in Brazil (Souza et al., 2011 and Asmar et al., 2013 apud Silva et al., 2015). However, banana waste reaches levels of 20 to 25% (Spricigo, 2016), due to its natural characteristics, associated with the lack of instruction of the manipulators, problems in harvesting, transport, and storage, which makes exporting difficult (EMBRAPA, 2000). The use of green bananas to make flour is one of the alternatives to reduce this waste, once its characteristic firmness and greater rigidity facilitate the manipulation and the storage. In addition, in this stage of development, the fruit present unique compounds, such as resistant starch, phenolic compounds, and antioxidants.

The great demand for functional foods has led the new product development sector to incredible advances in the last decades (Cardoso, 2016), opening space for the bakery sector, including the cassava starch cookies. Cassava starch cookies is a typically Brazilian food, popular with children mainly in school age, which is made from the scalding of cassava starch, with oil, milk, and salt, being considered an energetic and tasty food with interesting crispness characteristics. Thus, its nutritional and sensory properties allow its introduction in the infant eating habits, because it provides more energy for the accomplishment of the activities.

The addition of green banana flour in cookies formulations can provide an alternative food with functional characteristics. Thus, the objective of this study was to produce cassava starch cookies with the replacement of the farinaceous fraction for green banana flour, and to characterize the product for proximate composition, physicochemical characteristics, sensory evaluation, and microbiological characterization, aimed at evaluate the effect of the addition of green banana flour to this type of product during the storage.

2 MATERIALS AND METHODS

The cookies were prepared at Catuzo Produtos Alimentícios Ltda, located in the municipality of Bueno Brandão - MG, Brazil.
The physicochemical, microbiological, and sensory characterization was performed in the laboratories of Soils, Bromatology, Microbiology and Sensory Evaluation, respectively, at Federal Institute of Science and Technology Education of Southern Minas Gerais - Campus Inconfidentes.

2.1 COOKIES MANUFACTURE

Four formulations were made, corresponding to a standard (A1) and three formulations with the substitution of the farinaceous fraction by green banana flour in the concentrations of 4% (A2), 8% (A3), and 12% (A4).

After manufacture, the cookies were cooled, and 130 g cookies were packed in transparent polypropylene plastic packages, with dimensions of 20 cm x 40 cm and 0.06 mm thickness, identical to those used commercially. Finally, the samples were identified and stored.

2.2 SAMPLES CHARACTERIZATION

The physicochemical, sensory, and microbiological characterization were performed within 24 hours of manufacture (T1) and after 60 days of storage (T2). The proximate composition was performed only for the freshly processed samples (T1). To facilitate sampling, the samples were packed into two batches (each batch with 13 packets). The batch 1 corresponded to the samples with 1 day of manufacture, while the batch 2 corresponded to the samples with 60 days of storage. The batch 2 remained stored for 60 days protected from sunlight and humidity, which represents the conditions similar to those of retail and sale.

2.3 PROXIMATE COMPOSITION

The samples were characterized for moisture content, ash, lipids, protein, crude fiber, and carbohydrates, in triplicate, according to the methodologies described by AOAC (2005).

The percentage of moisture gain was determined after 60 days of storage using the moisture content values of T1 and T2, according to the methodology proposed by Esteller and Lannes (2005).

2.4 PHYSICOCHEMICAL CHARACTERIZATION

The samples were characterized for pH, texture (hardness and fracturability), specific volume, and color, in triplicate, according to the methodologies described below:

The pH of the samples was determined according to the methodology 017/IV of the Adolfo Lutz Institute (2008), using a benchtop meter (DIGIMED-DM-22), previously calibrated according to the manufacturer's instructions.
The texture profile of the samples was determined in a texture analyzer (TA XT2 plus), with a capacity of 50 kg, coupled to the A/WEG probe for characterization of hardness (g) and fracturability (mm). The apparatus was calibrated and pre-set with the following specifications: penetration distance of 5 mm and speed of 3 mm/s. Texture measurements were carried out in three repetitions.

The specific volume was determined by the ratio of volume (mL) and weight (mL.g⁻¹) of the cooked cookies, using the millet displacement method, as proposed by Pizzinatto and Campagnolli (1993).

The instrumental color parameters of the cookies were measured in a Colorimeter (KONICA MINOLTA - model CM-2300d) using the CIE color system (L*, a*, b*) where L* corresponds to the luminosity, varying from black to white (values from 100 to 100), a* from green to red (values from -100 to 100) and b* from blue to yellow (values from -100 to 100). The apparatus was previously calibrated with a reference white plate, and the readings were performed in triplicate on the flat bottom of the samples freshly removed from the package.

2.5 MICROBIOLOGICAL CHARACTERIZATION

The cookies were evaluated for coliforms at 45 °C, coagulase-positive staphylococci and Salmonella sp, according to the methodologies described in the Normative Instruction 62/2003 of the Ministry of Agriculture, Livestock, and Food Supply (MAPA). The coliforms were determined at 45 °C by the most probable number technique, also known as the multiple tube technique. Surface plating method was used for enumeration of coagulase-positive staphylococci, replacing the culture medium by mannitol agar. For Salmonella sp., a sequence of steps was carried out, including pre-enrichment, selective enrichment, and plating.

The results were compared with the Resolution - RDC 12 of January 2, 2001, of the National Sanitary Surveillance Agency (ANVISA), which has established the microbiological standards for food.

2.6 SENSORY EVALUATION

The participants were invited orally and through posters in the Federal Institute/Campus Inconfidentes, and the participation in the sensory evaluation was voluntary. One-hundred and twenty consumers participated in the test, corresponding to 66.67% female and 33.33% male, aged between 15 and 52 years.

The tests were performed in individual booths with natural light, and four samples (2-3 grams corresponding to one unit) were presented at room temperature (25 °C) in disposable containers coded with random 3 digit numbers, in a sequential monadic form (Stone and Sidel, 2010).
Consumers were instructed to carry out the evaluation of the samples starting from left to right, rinsing the mouth with water between the samples. The acceptance of the cookies was evaluated for the parameters appearance, aroma, flavor, texture, and overall impression, as well as the purchase intention and the ideal scaling, which determined how close the sample was to the ideal for the attribute crunchiness (Stone and Sidel, 2010; Meilgaard et al., 1999).

2.7 DATA ANALYSIS

The results were analyzed by ANOVA/Tukey's test at 5% of probability, using the statistical program Sensomaker® developed by Pinheiro et al., (2013).

3 RESULTS AND DISCUSSION

3.1 PROXIMATE COMPOSITION

The mean values of moisture, ash, lipids, proteins, fibers, carbohydrates, and moisture gain within the storage time of the samples are shown in Table 1.

<table>
<thead>
<tr>
<th>Components</th>
<th>Samples</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>2.58 ± 0.05a</td>
<td>2.16 ± 0.08b</td>
<td>1.96 ± 0.06c</td>
<td>1.79 ± 0.07c</td>
<td></td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.65 ± 0.15a</td>
<td>2.74 ± 0.09a</td>
<td>2.87 ± 0.08a</td>
<td>2.93 ± 0.31a</td>
<td></td>
</tr>
<tr>
<td>Lipids (%)</td>
<td>10.60 ± 0.20b</td>
<td>12.04 ± 0.45a</td>
<td>11.30 ± 0.09ab</td>
<td>11.32 ± 0.19ab</td>
<td></td>
</tr>
<tr>
<td>Protein (%)</td>
<td>0.60 ± 0.005d</td>
<td>0.74 ± 0.005c</td>
<td>0.78 ± 0.017b</td>
<td>0.92 ± 0.015a</td>
<td></td>
</tr>
<tr>
<td>Fiber (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.85 ± 0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates (%)</td>
<td>83.56 ± 0.37a</td>
<td>82.31 ± 0.54a</td>
<td>83.08 ± 0.18a</td>
<td>82.20 ± 0.79a</td>
<td></td>
</tr>
<tr>
<td>Moisture gain (%)</td>
<td>181.30±6.90c</td>
<td>194.80±13.70bc</td>
<td>223.90±12.50ab</td>
<td>230.90± 11.30a</td>
<td></td>
</tr>
</tbody>
</table>

Source: the author

* Means followed by the same letter in the same row do not differ from each other at p≤0.05 by the Tukey's test.

A significant difference (p≤0.05) was observed between the samples A1, A2, and A3 in relation to moisture content, which was not observed for the samples A3 and A4. Sample A1 exhibited the highest moisture content, which decreased with the addition of green banana flour, while the samples A3 and A4 showed the lowest moisture contents.

No significant difference (p≤0.05) was observed for ash and carbohydrates contents for all samples, as can be observed in Table 1.

A significant difference (p≤0.05) was observed in lipids content between the samples A1 and A2, with no difference between the samples A3 and A4. The sample A2 presented the highest lipids content among the samples.
Regarding the protein content, significant differences (p≤0.05) were observed for all samples. A gradual increase in protein content was observed with the addition of green banana flour, with the lowest level for the sample A1 and the highest level for the sample A4.

The fiber content was 0.85%, which was determined only for the sample A4, which contained the higher green banana flour concentration.

When comparing the moisture gain of the treatments T1 and T2, the sample A4 had a higher gain rate, with no significant differences (p≤0.05) from the sample A3. A higher moisture gain was observed between the standard sample and the sample containing the highest green banana flour concentration (A1 to A4), probably due to the presence of fiber, which confers a higher water absorption capacity, as reported by Giuntini and Menezes (2011).

TACO (2011) has established the proximate composition of the cassava starch cookies in the sweetened version, which contained 5.4% moisture, 0.5% ash, 1.3% proteins, 12.2% lipids, 1.2% fiber, and 80.5% carbohydrates. Thus, lipids, protein, fiber, and carbohydrates levels of the samples of this study are similar to the levels reported by TACO.

Ribeiro (2006) evaluated the effect of the composition on the sorption isotherms and the characteristics of cookies, and found 3.53% moisture, 2.23% ash, 0.05% protein, 19% lipids, and 0.32% fibers, for the formulation containing 90 to 95% water, 15% vegetable fat, and 4% salt.

Brandão (2016) evaluated cookies made with chia flour and/or seeds and found a significant (p≤0.05) increase in moisture at day 10 of storage at 40 ° for all samples.

### 3.2 PHYSICOCHEMICAL CHARACTERIZATION

Tables 2 and 3 show the results of pH, texture (hardness and fracturability), specific volume, and color (L*, a*, and b*) of the samples in the freshly processed state (T1) and after 60 days of storage (T2).

#### Table 2. Average values of pH, texture, and specific volume of the different cookies during the storage

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Hardness (g)</th>
<th>Fracturability</th>
<th>Specific Volume (mL·g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 – T1</td>
<td>4.04 ± 0.05ᵇ</td>
<td>55.96 ± 0.84ᶜ</td>
<td>3.15 ± 0.60ᵈ</td>
<td>16.92 ± 1.22ᵇ</td>
</tr>
<tr>
<td>A2 – T1</td>
<td>4.04 ± 0.03ᵇ</td>
<td>53.29 ± 2.30ᶜ</td>
<td>4.17 ± 0.28ᶜ</td>
<td>19.79 ± 1.36ᵃ</td>
</tr>
<tr>
<td>A3 – T1</td>
<td>4.04 ± 0.04ᵇ</td>
<td>52.94 ± 1.24ᶜ</td>
<td>3.33 ± 0.32ᵈ</td>
<td>13.17 ± 1.79ᵈ</td>
</tr>
<tr>
<td>A4 – T1</td>
<td>4.18 ± 0.11ᵇ</td>
<td>55.79 ± 1.28ᶜ</td>
<td>3.24 ± 0.31ᵈ</td>
<td>16.33 ± 0.79ᵇ</td>
</tr>
<tr>
<td>A1 – T2</td>
<td>3.85 ± 0.07ᶜ</td>
<td>1.555 ± 189.6ᵃ</td>
<td>8.42 ± 0.31ᵇ</td>
<td>14.30 ± 2.80ᵇ</td>
</tr>
<tr>
<td>A2 – T2</td>
<td>4.32 ± 0.07ᵃ</td>
<td>1,194.6 ± 46.3¹</td>
<td>9.97 ± 0.48ᵃ</td>
<td>17.48 ± 1.49ᵇ</td>
</tr>
<tr>
<td>A3 – T2</td>
<td>4.24 ± 0.04ᵃ</td>
<td>1,563.6 ± 105.3ᵃ</td>
<td>10.55 ± 0.35ᵇ</td>
<td>10.98 ± 1.46ᵈ</td>
</tr>
<tr>
<td>A4 – T2</td>
<td>4.32 ± 0.05ᵃ</td>
<td>1,341.8 ± 58.03ᵇ</td>
<td>8.22 ± 0.02ᵇ</td>
<td>15.67 ± 1.00ᵇ</td>
</tr>
</tbody>
</table>

Source: the author * Means followed by the same letter in the same column do not differ from each other at p≤0.05 by the Tukey's test.
Table 3. Color parameters $L^*$, $a^*$, and $b^*$ of the different cookies during the storage

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color parameters</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L^*$</td>
<td>$a^*$</td>
<td>$b^*$</td>
<td></td>
</tr>
<tr>
<td>A1 – T1</td>
<td>66.39 ± 2.73$^a$</td>
<td>1.24 ± 0.18$^{bc}$</td>
<td>17.42 ± 0.82$^a$</td>
<td></td>
</tr>
<tr>
<td>A2 – T1</td>
<td>63.36 ± 1.98$^a$</td>
<td>1.56 ± 0.33$^{abc}$</td>
<td>16.40 ± 1.33$^b$</td>
<td></td>
</tr>
<tr>
<td>A3 – T1</td>
<td>67.51 ± 0.39$^a$</td>
<td>2.03 ± 0.22$^{abc}$</td>
<td>16.83 ± 1.41$^b$</td>
<td></td>
</tr>
<tr>
<td>A4 – T1</td>
<td>64.07 ± 1.59$^a$</td>
<td>2.67 ± 0.99$^a$</td>
<td>18.51 ± 3.42$^a$</td>
<td></td>
</tr>
<tr>
<td>A1 – T2</td>
<td>67.24 ± 1.71$^a$</td>
<td>0.96 ± 0.09$^c$</td>
<td>12.01 ± 2.13$^b$</td>
<td></td>
</tr>
<tr>
<td>A2 – T2</td>
<td>64.01 ± 1.44$^a$</td>
<td>2.42 ± 0.34$^{ab}$</td>
<td>18.29 ± 2.16$^a$</td>
<td></td>
</tr>
<tr>
<td>A3 – T2</td>
<td>63.20 ± 2.16$^a$</td>
<td>1.96 ± 0.34$^{abc}$</td>
<td>14.35 ±1.36$^{ab}$</td>
<td></td>
</tr>
<tr>
<td>A4 – T2</td>
<td>64.58 ± 0.64$^a$</td>
<td>2.38 ± 0.45$^{ab}$</td>
<td>17.91 ± 1.13$^a$</td>
<td></td>
</tr>
</tbody>
</table>

Source: the author * Means followed by the same letter in the same column do not differ from each other at $p$≤0.05 by the Tukey’s test.

When comparing time zero (T1) and 60 days of storage (T2), the samples presented a significant increase ($p$≤0.05) in pH values, except for the sample A4, which presented a decrease in pH when compared to the control A1. Thus, a pH stability with storage was observed for the sample made with 12% green banana flour, as also observed in the sample A4.

No significant difference ($p$≤0.05) was observed in T1 for all samples; however, a significant difference was observed for the sample A1 in T2 when compared to the other samples, thus the banana flour may have contributed to an increase in pH.

Andrade (2013) studied cookies enriched with green banana flour, and found an increase in pH with an increase in green banana flour concentrations, with values of 6.59, 6.71, and 7.05 for the formulations containing 10%, 20%, and 30% green banana flour, respectively.

Regarding the parameter hardness, a significant difference ($p$≤0.05) was observed between T1 and T2 for all samples, which increased during 60 days of storage, with higher values for the samples A1 and A3. For the fracturability, a significant difference ($p$≤0.05) was observed between T1 and T2 for all samples, with values 2 to 3 times higher after 60 days of storage, requiring higher tensile strength, with higher values for the sample A3, with no significant differences when compared to A2 ($p$≤0.05). At the time zero (T1), the sample A1 had the lowest hardness, with no significant difference ($p$≤0.05) when compared to the samples A3 and A4.

Silva et al., (2014) evaluated hardness of chocolate filled cookies with partial replacement of hydrogenated fat by avocado pulp for 45 days of storage, and observed a significant increase in hardness ($p$≤0.05) between the control sample (time zero) and the sample containing avocado pulp after 45 days of storage.

Teixeira (2016) evaluated hardness and fracturability of cookies made with native and fermented waxy maize starch, and reported that both parameters decreased with increasing the substitution percentage. Although the control sample presented fracturability similar to the sample with the lower substitution level, it exhibited greater softness.
No significant difference (p≤0.05) was observed for the specific volume of the treatment T1 when compared to T2, thus demonstrating no changes in the cookies over time. The sample A2 had a higher specific volume, while the sample A3 had the lowest specific volume, with no significant differences (p≤0.05) when compared with A1.

According to Nunes (1999), cookies are classified according to their specific volume, as low, medium, and large specific volume, corresponding to <5.0 mL.g⁻¹; 5.0 to 10 mL.g⁻¹; and >10 mL.g⁻¹, respectively. Therefore, all samples of this study were classified as a product with high specific volume.

Dias et al., (2007) studied the fermentation and chemical oxidation of cassava starch and maize starch using artificial and solar drying and evaluated the expansion of the samples. The authors reported that cookies prepared with sour cassava starch tended to present a higher specific volume, with values varying from 3.67 mL.g⁻¹ to 15.04 mL.g⁻¹.

Montenegro et al., (2008) evaluated the specific volume of sour cassava crackers enriched with soluble and insoluble fiber, and found a gradual reduction of the specific volume with an increase in fiber content, from 5.50 mL.g⁻¹ to 2.90 mL.g⁻¹. The authors concluded that the addition of wheat fiber promoted a weakening of the cookie structure.

The parameter L * corresponds to the brightness of the cookies, and high L* values correspond to a lighter color. No significant differences (p≤0.05) were observed for this parameter during storage, as can be seen in Table 3.

In relation to the color coordinate a*, only the sample A1 presented a significant difference (p≤0.05) during storage, with a reduction from T1 to T2, thus a greater red tonality.

Similar results were observed for the b* values, since only the sample A1 presented a significant difference (p≤0.05), with a reduction from T1 to T2, thus a greater yellow tonality.

No significant differences (p≤0.05) were observed for all instrumental color parameters (L*, a*, and b*).among the samples containing green banana flour.

Oliveira and Curta (2014) evaluated the color of cookies made from biomass and green banana (Musa paradisiaca) flour and reported that the flour and biomass concentrations did not affect the parameters evaluated, with no significant difference between the samples (p ≤0.05).

3.3 MICROBIOLOGICAL CHARACTERIZATION

The results of the microbiological analyses of the samples were satisfactory in both treatments (T1 and T2), once they did not exceed the maximum limits in 25 g sample, as established by the Brazilian legislation (BRASIL, 2001) for all microorganisms evaluated. There was an absence of Salmonella sp.,
thus demonstrating excellent hygienic-sanitary conditions of the environment, equipment, ingredients, packaging, and manipulators during the manufacture of the cookies and throughout the storage period.

Oliveira and Curta (2014) analyzed the same microorganisms of this study in a gluten-free cookie made from biomass and green banana flour and found similar results.

3.4 SENSORY EVALUATION

The results of the acceptance tests, ideal scaling for crispness, and the purchase intention are shown in the tables and figures.

3.5 ACCEPTANCE TEST AND IDEAL CRISPNESS

Two acceptance tests were performed: the first test at time zero (T1) and another at 60 days after storage (T2), and the results for the attributes appearance, aroma, flavor, texture, and overall impression are shown in Table 4.

Table 4. Sensory acceptance scores and ideal crispness of the different cookies during the storage

<table>
<thead>
<tr>
<th>Sample</th>
<th>Attributes</th>
<th>Appearance</th>
<th>Aroma</th>
<th>Flavor</th>
<th>Texture</th>
<th>Overall impression</th>
<th>Ideal crispness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 – T1</td>
<td></td>
<td>7.92 ± 1.35&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.58 ± 1.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.73 ± 1.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.40 ± 1.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.67 ± 1.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.44 ± 1.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>A2 – T1</td>
<td></td>
<td>7.68 ± 1.32&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.32 ± 1.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.64 ± 1.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.62 ± 1.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.69 ± 1.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.47 ± 1.36&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>A3 – T1</td>
<td></td>
<td>6.17 ± 1.75&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.85 ± 1.64&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>7.25 ± 1.55&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.10 ± 1.68&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.00 ± 1.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.40 ± 1.34&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>5.47 ± 2.08&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.40 ± 1.72&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.57 ± 1.83&lt;sup&gt;e&lt;/sup&gt;</td>
<td>6.83 ± 1.86&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>A1 – T2</td>
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<td>8.18 ± 0.96&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>7.83 ± 1.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.22 ± 1.30&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>A2 – T2</td>
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<td>7.51 ± 1.31&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>6.84 ± 1.36&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>6.83 ± 1.59&lt;sup&gt;bc&lt;/sup&gt;</td>
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<td>6.59 ± 1.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.33 ± 1.94&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>6.70 ± 1.40&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>6.91 ± 1.69&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.63 ± 1.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.21 ± 1.53&lt;sup&gt;a&lt;/sup&gt;</td>
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</table>

Source: the author * Means followed by the same letter in the same column do not differ from each other at p≤0.05 by the Tukey's test.

For the attribute appearance, no significant difference (p≤0.05) was observed between the samples in T1 when compared to T2, with the highest values for the sample A1.

Similar results were observed for aroma, with no significant difference (p≤0.05) between the samples, with the highest scores for the samples A1 and A2, representing a higher acceptance for these attributes.

Regarding the attribute texture, a significant difference was observed between A3 in treatment T1 when compared to T2, corresponding to a lower acceptance, therefore the texture of these cookies was less accepted by consumers after 60 days of storage. No significant differences (p≤0.05) were observed between T1 and T2 for all samples.
Concerning the overall impression, no significant difference (p≤0.05) was observed for the treatment T1 when compared to T2, and the samples A1 and A2 presented the highest scores, while the samples A3 and A4 had the lower scores for this attribute.

The storage time did not affect the acceptance of the samples A1 and A2, with no significant difference for all attributes evaluated. In addition, these samples presented the highest acceptance scores.

In relation to the ideal crunchiness of the cookies, no significant differences (p≤0.05) were observed between T1 and T2, demonstrating that the crispness remained ideal after 60 days of storage. All samples had positive scores, therefore with crispness above the ideal range.

Andrade (2013) evaluated the acceptance of cookies enriched with 10%, 20%, and 30% green banana flour. The authors found significant differences among the samples for the attributes color, appearance, odor, and flavor, once the assessors reported differences in formulation with increasing the green banana flour concentration. The sample containing 10% banana flour received the highest scores for all attributes evaluated.

Fasolin et al., (2007) evaluated the acceptance of cookies produced with the substitution of wheat flour for green banana flour by children and university students. The cookies with the highest percentage of banana flour (30%) were the least accepted among children, with significant (p≤0.05) differences from the control, and the formulations containing 10%, and 20% green banana flour. Regarding the acceptance of cookies by college students, no significant differences were observed for all samples, with a greater acceptance of the cookies made with 20% green banana flour.

Brandão (2016) used the ideal scaling to evaluate the crispness of cookies made with flour and/or chia seeds. The samples containing 10% flour and 10% chia seeds (FS20) and 30% seeds (S30) showed averages closer to 0 (-0.80 and -1.15, respectively), and therefore presented crispness close to the ideal scale.

Rebouças et al., (2012) used the ideal scaling to evaluate the crispness of salted crackers with the addition of fish protein concentrate. The authors reported that no sample reached the minimum percentage of ideal crunchiness (70%), therefore they suggested improvements in the formulations. However, when assessing all regions of the ideal scaling, it was found that 54.75% of the judges responded that the cookies had the high crispness, so they were more crunchy than the ideal, suggesting an optimization in the formulation for a reduction of this attribute.

3.6 PURCHASE INTENTION

The consumers' purchase intention of the cookies made with the addition of green banana flour was evaluated at T1 (in the freshly processed state) and T2 (after 60 days of storage). For the interpretation
of the results, a positive purchase intent corresponds to the sum of the scores for "would certainly buy" and "would probably buy". The purchase uncertainty corresponded to the scores for "maybe would buy", and the negative purchase intention corresponded to the sum of the scores for the terms "probably would not buy" and "certainly would not buy."

An increase in the frequency of positive purchase intention (CC and PC) was observed for the sample A1 from T1 to T2 (80% to 83.33%). An increase in consumer uncertainty (TC) was also observed, varying from 11.67% to 12.50%. In addition, a lower frequency from 8.33% to 4.17% was observed for the negative purchase intention (PNC and CNC).

For the sample A2, there was an increase in the frequency of positive purchase intention (CC and PC) from T1 to T2 (74.17% to 76.67%). The consumer uncertainty (TC) showed a reduction from T1 to T2, ranging from 18.33% to 15.83%. No changes were observed from T1 and T2 for the negative purchase intention (PNC and CNC), corresponding to 7.5% for both treatments.

A reduction of positive purchase intention (CC and PC) was observed for the sample A3 from T1 to T2 (57.5% to 38.33%), while the frequency of purchase intention (TC) presented an increase from 32.5% to 36.67%. In relation to the negative purchase intention (PNC and CNC), there was an increase from T1 to T2 (10% to 25%).

An increase in the frequency of positive purchase intention (CC and PC) was observed for the sample A4 from T1 to T2 (38.33% to 43.32%), with a lower consumer uncertainty (TC), ranging from 33.34% to 29.16%. Concerning the negative purchase intention (PNC and CNC), a reduction in the frequency of responses was observed from T1 to T2 (28.33% to 27.49%).

Thus, the sample A1 had a higher frequency of positive purchase intention, followed by the sample A2, both at T2. Regarding the consumer uncertainty, the sample A3-T2 showed a higher frequency of responses when compared with the other samples. For the negative purchase intention, the sample A4-T1 presented a higher frequency of responses. This gradual acceptance was probably due to the greater acceptance of the freshly processed samples, as shown in Table 4.

Andrade (2013) evaluated the purchase intention of cookies enriched with green banana flour, and verified that the sample made with 30% of green banana flour had a higher purchase intention, with 47% corresponding to the term "would certainly buy", followed by the sample made with 10% flour, with 45%. The intermediate sample, containing 20% flour had greater acceptance, with 40% of responses corresponding to the term "probably would buy".

Rocha et al., (2010) evaluated the purchase intention of cookies with 20% substitution of cassava starch for algaroba (Prosopis juliflora) flour, and obtained a satisfactory result, once only 10% of the
judges stated that they probably would not buy the product, while 40% responded they would probably buy.

4 CONCLUSION

The cookies made with banana flour showed higher protein and fiber contents when compared to the control. The sample A2 presented a higher specific volume, which is desired in the cookies market. Concerning the attribute hardness, the samples A2 and A4 presented lower scores after 60 days of storage. With respect to the color parameters, no significant differences (p≤0.05) were observed for L*, a*, and b* during storage for all samples. The microbiological quality of the cookies was within the standards established by the current legislation, demonstrating excellent hygienic-sanitary conditions. The sensory acceptance test, the purchase intention test and the purchase intention of the cookies showed that the samples A1 and A2 exhibited the highest scores for all periods evaluated. Thus, the cookies made with the substitution of 4% farinaceous fraction for green banana flour may be a promising alternative, once this flour has many benefits to the human health.
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