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Article

Characterization and Sensory Profile of Cookies Made with Whole Beet Flour

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ABSTRACT

Beets are currently being used in the development of new products due to the presence of natural colorants (betalains), the antioxidant properties of these pigments, and other compounds such as flavonoids and carotenoids. Therefore, among the products developed is the cookie, which is a product obtained by kneading and baking a dough made from flour. Among its varieties, cookies stand out, widely consumed in the daily lives of Brazilians. Given this, this study aimed to develop, characterize, and verify the acceptability of cookies produced with different proportions of whole beet flour (0%, 10%, 15%, and 25%). Physical-chemical, microbiological, and sensory parameters were evaluated. The physical-chemical analyses performed were: water content, water activity, pH, total titratable acidity (TTA), total soluble solids (TSS), ash, lipids, and proteins. The sensory test of acceptance and purchase intention was conducted with 94 judges, who evaluated the following attributes: color, appearance, aroma, flavor, crunchiness, overall impression, and purchase intention. The physicochemical parameters indicated that the addition of beet flour can add nutritional value to the food, and the cookies were found to be in compliance with microbiological standards. The cookie formulations had an acceptability index of over 70%. Formulation F3, with 25% beet flour, was considered to have excellent nutritional parameters (lipids, proteins, and ash), while formulation 2, with 15% beet flour, was the most accepted by the judges. Given the results, the relevance of this work for the food agroindustry can be emphasized, as it can contribute to technological innovation in relation to nutritionally enriched food products with good sensory acceptance when whole beet flour is added.
Keywords: acceptability; *Beta vulgaris* L.; development of new products.

RESUMO

A beterraba atualmente tem sido utilizada na elaboração de novos produtos devido à presença de corantes naturais (betalaínas), as propriedades antioxidantes destes pigmentos e outros compostos como flavonoides e carotenoides. Portanto, dentre os produtos elaborados tem-se o biscoito que é um produto obtido pelo amassamento e cozimento adequado de uma massa feita à base de farinhas. Entre suas variedades destaca-se o cookie, amplamente consumido no cotidiano dos brasileiros. Diante disso, esse estudo

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teve como objetivo elaborar, caracterizar e verificar a aceitabilidade de cookies produzidos com diferentes proporções de farinha de beterraba integral (0%, 10%, 15% e 25%). Foram avaliados os parâmetros físico-químicos, microbiológicos e sensorial. As análises físico-químicas realizadas foram: teor de água, atividade de água, pH, acidez total titulável (ATT), sólidos solúveis totais (SST), cinzas, lipídeos e proteínas. O teste sensorial de aceitação e intenção de compra, foi conduzida com 94 julgadores onde foram avaliados os atributos: cor, aparência, aroma, sabor, crocância, impressão global e intenção de compra. Os parâmetros físico-químicos indicaram adição de farinha de beterraba, pode agregar valor nutricional do alimento, os biscoitos apresentaram em conformidades com padrões microbiológicos. As formulações de biscoito apresentaram índice de aceitabilidade superior a 70%. A formulação F3, com 25% de farinha de beterraba, foi considerada como formulação com excelentes parâmetros nutricionais (lipídeos, proteínas e cinzas), enquanto a formulação 2 com 15% de farinha de beterraba foi a mais bem aceita pelos julgadores. Diante dos resultados pode-se enfatizar a relevância desse trabalho para a agroindústria de alimentos, em razão de poder contribuir para a inovação tecnológica em relação produtos alimentícios enriquecidos nutricionalmente e boa aceitação sensorialmente, quando adicionados da farinha de beterraba integral.
Palavras-chave: aceitabilidade; *Beta vulgaris* L.; elaboração de novos produtos.

Introduction

Beetroot (*Beta vulgaris* L.) belongs to the Chenopodiaceae family. It is a tuberous vegetable with a purplish-red color due to the presence of betalains, which are pigments responsible for providing the color of beetroot and are components that have antioxidant potential (Crocetti et al. 2016), which are divided into two structural groups, betaxanthins (which have a yellowish pigment) and betacyanins (which generate reddish and purplish colors, with beetroot being the main source of this pigment (Bassetto et al. 2013). According to Chhikara et al. (2019), the carotenoids and vitamins present in beets can help reduce the risk of developing cardiovascular diseases, such as hypertension, and also act as an anticarcinogen, in addition to having antioxidant, anti-inflammatory, and healing properties. This vegetable also has many nutritional characteristics, mainly high levels of potassium and magnesium, as well as being low in sodium, which helps promote greater performance in the human body (Székely & Máté, 2022).

According to the agricultural census of the Brazilian Institute of Geography and Statistics (2018), beetroot is one of the most cultivated vegetables in Brazil. In 2018, approximately 134,969 thousand tons were produced throughout the country. This tuber can be widely used for various purposes, such as in the technology industry. One example of its applicability is the use of betalains, a plant pigment responsible for providing the red-purple coloration, which can be found in considerable quantities in beets (Bangar et al. 2022). The application of this vegetable in the production of new food products can be an effective strategy to promote consumption due to its nutritional value and color, for example: flour for addition to products such as cookies, breads, and cakes (Crocetti et al. 2016).

Cookies are products obtained by kneading and baking dough that can be prepared with flours, starches, fermented or unfermented, and other food substances (National Commission for Food Standards and Norms, 1978). They come in a wide variety of sizes, shapes, colors, and even fillings. Among these countless varieties, cookies emerged, defined as a baked cereal-based product with high levels of fat and sugar, usually made with wheat flour (Ferreira et al. 2020).

The acceptability of products such as cookies is something that is very present in Brazilian society. In 2023, the cookie industry in Brazil earned R$ 32.5 billion, with a consumption of 1.5 million tons by Brazilians, according to the Brazilian Association of Cookie Industries (Ribeiro, 2024). This consumption is greatly favored by several factors, including their long shelf life, convenience, and diversity of flavors. The largest consumer groups for cookies are children and teenagers, who are attracted by the sweet taste, crunchiness, and attractive appearance of these products.

There are studies in the literature on the addition of beet flour to cookies (Brunatti et al. 2023; Duarte et al. 2022), with limited applications, given that wheat flour is commonly used in sweet baked goods. However, due to the growing global demand for food, there is a constant search for new alternative food sources and

technological advances, aiming both to reduce product costs and to meet nutritional demands more effectively. As reported in the studies by Lupatini (2011) and Silveira et al. (2016), who studied fruit waste flours. In this scenario, the use of vegetable flours as an ingredient plays a significant role in the food industry (Santana et al. 2017), in addition to replacing other white and refined flours, such as the most common, wheat flour.

In this context, whole beet flour can be added to the production of products such as cookies. The study conducted by Jesus et al. (2023) proves that cookies with added beet flour have a considerable percentage of protein, dietary fiber, and minerals. According to Xavier (2021), the nutritional appeal of products marketed in the cookie sector is growing, which explains why cookies have been reformulated using, for example, rice flour or bran, oat flour, fruit residue flour, legume residue flour, and other sources that promote nutritional improvement and quality. Given this, beet flour can be added in different proportions and can enhance the sensory and nutritional characteristics of cookies. Therefore, this study aimed to develop, perform the physical-chemical characterization, and verify the acceptability of cookies enriched with whole beet flour (*Beta vulgaris* L.).

Materials and Methods

Obtaining raw materials

The beets were purchased from a local supermarket chain in the city of Pau dos Ferros-RN and transported to the Federal Institute of Education, Science, and Technology of Rio Grande do Norte (IFRN)/Pau dos Ferros Campus, located in the city of Pau dos Ferros, Rio Grande do Norte.

To process the beets, they were first washed to remove surface dirt and then sanitized with a 200 ppm sodium hypochlorite solution, in which they were immersed for 15 minutes. After this time, the beets were cut into relatively small pieces and processed in an industrial blender, resulting in a homogeneous beet paste.

The beet pulp was dried in an air-circulating oven at a temperature of 80°C, with a layer thickness of 0.5 cm and an air speed of 1.0 m/s. The beet pulp was spread evenly in a thin layer on rectangular stainless steel trays (24.5 x 16.5 cm). During drying, the trays were weighed at regular intervals until a constant mass was obtained, with a drying time of 460 minutes. The dried beet pulp was then removed from the trays, crushed in an industrial blender to obtain flour, and immediately packaged in metallized plastic bags with a zip lock closure system.

Obtaining cookie-type biscuits

The ingredients for the cookies were purchased at local supermarket chains and specialty stores in the city of Pau dos Ferros, Rio Grande do Norte. Table 1 shows the cookie formulations and the proportions of the ingredients, as well as the respective percentages 10 (25g), 15 (37.5g), and 25 (62.5g) % of beet flour used for each formulation. The ingredients in the formulations are in grams, as we considered beet flour as an added ingredient in the formulation. Therefore, to define the percentages of flour mentioned above, calculations were based only on whole wheat flour and not on the other ingredients. The percentages of whole beet flour were determined through laboratory tests considering a uniform dough with the appropriate consistency for cookies.

Table 1 - Cookie formulations with added beet flour and different ingredient proportions.

Ingredients	Formulations			
	F0 (control)	F1 (10%)	F2 (15%)	F3 (25%)
Whole beet flour (g)	0	25	37.5	62.5
Whole wheat flour (g)	250	250	250	250
Brown sugar (g)	120	120	120	120
Refined sugar (g)	90	90	90	90
Egg (g)	50	50	50	50
Butter (g)	180	180	180	180
Baking soda (g)	0.25	0.25	0.25	0.25
Salt (g)	0.25	0.25	0.25	0.25
Vanilla essence (g)	2	2	2	2
Baking powder (g)	1.4	1.4	1.4	1.4
Chocolate chips (g)	100	100	100	100

F0= 0% beet flour; F1= 10% beet flour; F2= 15% beet flour; F3= 25% beet flour.

Source: Prepared by the authors, 2024.

The ingredients were weighed on an analytical scale and then homogenized in a mixer until a uniform consistency was obtained. Initially, the sugar, butter, and egg were beaten for 20 seconds. Then, the vanilla essence, baking soda, salt, and baking powder were added and beaten for 30 seconds. Next, the beet flour and whole wheat flour were added and mixed until a homogeneous dough was obtained, beating for 60 seconds. Finally, the chocolate chips were added and beaten for 10 seconds. For each formulation, 100 cookies were obtained.

The cookies were shaped by hand and each cookie weighed approximately 7.0 grams. They were placed on parchment paper inside round aluminum molds, as shown in Figure 1.

a b c d

Figure 1 - Cookies F0 (a), F1 (b), F2 (c), and F3 (d) before baking. Source: Prepared by the authors, 2024.

They were then baked in an electric oven at 180°C for about 14 minutes. Once they reached room temperature, they were stored in polyethylene packaging, as shown below in Figure 2.

Figure 2 - Cookies F0, F1, F2, and F3, respectively, stored in plastic packaging. Source: Prepared by the authors, 2024

Characterization of the cookies

The cookies were characterized according to the parameters of total soluble solids (°Brix), water content (%), water activity, pH, total titratable acidity (%) in citric acid, ash (%) and lipids (%) and proteins according to methodologies from the Adolfo Lutz Institute (2008).

The results were evaluated using analysis of variance, and the means were compared using Tukey's test at a 5% probability level, using the Assistat statistical program (Silva and Azevedo, 2016).

Microbiological analysis

Microbiological evaluation was performed on the cookies (F0, F1, F2, and F3) one day after preparation. The microbiological parameters of the cookies were analyzed for the presence of total coliforms (MPN/mL) and thermotolerant coliforms (MPN/mL), in addition to the standard count on mold and yeast plates (CFU g-1), as recommended by the American Public Health Association (Salfinger & Tortorello, 2001).

For coliform analysis, the cookies were crushed and homogenized prior to sample dilution. The following dilutions were performed: 10^{-1}, $10^{(-2)}$ and 10^{-3}. The dilutions were used for all microbiological analyses.

For total and thermotolerant coliform analyses, 1 mL aliquots of each dilution were inoculated in series of three tubes containing 9 mL of Lauryl Sulfate Tryptose (LST) broth, with an inverted Durhan tube and e (presumptive test). The tubes were incubated at 35 °C for 24-48 hours. After the incubation period, it was observed that the test was not positive for coliforms, as no gas formation occurred.

For mold and yeast analysis, cookie samples from formulations (F0, F1, F2, and F3) were incubated on solid Potato Dextrose Agar (PDA) medium acidified with tartaric acid (1%), previously contained in three plates corresponding to each dilution. Plating was performed using the spread plate technique. The plates were then incubated in Biochemical Oxygen Demand (BOD) at 28°C for 2 to 5 days. Therefore, with the results of the microbiological analyses, the parameters for cookies or butter products described by Brasil (2022) were compared and considered.

Sensory analysis

The research project (CAAE No. 82123724.9.0000.0225) was approved by the ethics committee with Opinion No. 7,241,771. Those responsible for the research presented it to the participants, who were students and staff from the Pau dos Ferros campus of the Federal Institute of Education, Science, and

Technology of Rio Grande do Norte (IFRN), located in the city of Pau dos Ferros, Rio Grande do Norte. The project and the free and informed consent form (FICF) were presented and signed by the participants. The sensory analysis was performed in the sensory analysis laboratory of the aforementioned campus. The evaluation attributes were: color, appearance, aroma, flavor, crunchiness, and overall impression, using a structured nine-point hedonic scale (0-9 points), ranging from I disliked it very much (1) to I liked it very much (9).

The 94 untrained judges received four samples of the cookie weighing 7 grams each, in 50 mL disposable cups coded with random three-digit numbers, served at room temperature. Along with the sample, mineral water at room temperature was served so that the judges could cleanse their palates between samples, avoiding interference from both. Each taster was asked to indicate on the evaluation form their preference in relation to the requirements evaluated using a structured five-point scale ranging from liked it very much (5) to disliked it very much (1). Purchase intention was measured using a 5-point scale: (1) definitely would not buy to (5) definitely would buy (Dutcosky, 2013).

Acceptability index

The Acceptability Indices (AI) for each sensory acceptance attribute were calculated according to Equation 1, in which: M – overall average score obtained for the attribute; and N – number of points on the hedonic scale (Dutcosky, 2013).

$$IA\ (\%) = \frac{M}{N} * 100 \qquad \text{Eq.1}$$

Statistical analysis

The experimental data obtained in the sensory analysis of the cookies was evaluated using a completely randomized design, with four cookie samples, and 94 judges evaluated the following attributes: color, appearance, aroma, flavor, crunchiness, overall impression, and purchase intention. Data analysis was performed using the Assistat version 7.7 program (Silva and Azevedo, 2016).

Results and Discussion

Characterization of cookie-type biscuits

Table 2 shows the results obtained from the physical-chemical analyses performed on the different cookie formulations with different amounts of beet flour added.

For water content, all formulations showed statistical differences, mainly due to the gradual replacement of beet flour, which has low water content. Regarding Aw, F0 and F3 were statistically different from F1 and F2 (Table 2), which showed higher values. The water content found in the samples ranged from 1.56% to 4.18%, values that differ considerably from the 6.12% value found by Teixeira et al. (2017), who also worked with beet flour-based cookies. The difference between the studies consulted may be mainly due to the different baking times and the times taken to prepare the cookies.

The water activity values found range from 0.32 to 0.41 (Table 2) and are below 0.60, which is unfavorable for the growth of contaminating microorganisms (Frias, Silva & Gava, 2008). According to Madrona & Almeida (2010), lower percentages of moisture and water activity in food products are ideal for increasing their shelf life, as low moisture can inhibit the growth of microorganisms and maintain their texture intact.

The pH values ranged from 5.90 to 6.43 (Table 2). For pH, F3 differed statistically from the other formulations, with a pH of 5.90, which can be explained by the presence of a greater amount of beet flour in the formulation. This directly affects the pH of the product, since beet is a slightly more acidic food, with a pH below neutrality. In terms of total titratable acidity, it was found that formulations F0 and F3 differed statistically from each other and also from F1 and F2. The formulation with the highest beet flour content (F3) showed higher acidity. For total titratable acidity, the variation was from 0.32 to 0.55%, with significant differences from the values in the cited study, which ranged from 2.27 to 5.20%.

Table 2 – Physical and chemical characterization of cookie-type biscuits with different beet flour contents *Different lowercase letters in the rows indicate

Parameters	Mean and standard deviation			
	F0	F1	F2	F3
Water content (%)	1.56 ± 0.06a	3.73 ± 0.17c	4.18 ± 0.09d	2.97 ± 0.10b
Water activity (Aw)	0.32 ± 0.00a	0.40 ± 0.00b	0.41 ± 0.00b	0.32 ± 0.00a
pH	6.23 ± 0.03b	6.43 ± 0.03c	6.24 ± 0.03b	5.90 ± 0.00a
Total Titratable Acidity (% citric acid)	0.32 ± 0.28a	0.43 ± 0.03b	0.48 ± 0.06b	0.55 ± 0.03c
Total Soluble Solids TSS (°Brix)	15.60 ± 0.00a	17.20 ± 0.00b	19.03 ± 0.06c	20.00 ± 0.00d
Ash (%)	1.08 ± 0.091a	1.26 ± 0.069b	1.60 ± 0.021c	1.89 ± 0.086d
Lipids (%)	23.04 ± 0.41b	24.68 ± 0.07c	22.79 ± 0.16a	23.61 ± 0.53b
Proteins (%)	1.07 ± 0.01b	1.00 ± 0.03a	1.19 ± 0.03c	1.06 ± 0.04b

statistical difference according to the Tukey test (P<0.05); identical letters do not differ significantly from each other.

Source: Prepared by the authors, 2024.

Regarding the percentage of lipids, it was observed that all formulations containing beet flour differed from each other, with F1 being the formulation with the highest average value. In addition, it was found that F3 was statistically similar to F0. Identical behavior was also observed in the protein component . The lipid content in the samples ranged from 22.79% to 24.68%. When comparing these values with the lipid content found by Teixeira et al. (2017), who also worked with beet flour-based cookies, which was 25.71%, the values were similar to those in this study. This may be related to the addition of chocolate chips, which have a high lipid content in their composition; in addition, it may also be associated with the amount of fat used in the formulation, a characteristic of this type of cookie, thus affecting the product as a whole.

The TSS values showed a significant difference for all formulations, with a noticeable increase as more beet flour was added to the formulations. The Total Soluble Solids analysis showed a variation in values from 15.60 °Brix to 20.00 °Brix, increasing as the beet flour content also increased. Dias et al. (2016), who studied cookies with added oat flour, obtained TSS values ranging from 33°Brix to 27°Brix, decreasing as the oat flour content increased. This relationship can be explained by the fact that beet is a vegetable that contains a lot of sugars (Crocetti et al. 2016). Thus, the more beet flour, the sweeter the cookie will be and, consequently, the higher its Total Soluble Solids value will be. The same relationship occurs for ash content, in which the values diverged statistically among all formulations, with F3 presenting the highest content. The ash content

values found ranged from 1.08% to 1.89% (Table 2), values that are somewhat similar to those found by Bassetto et al. (2013), in which the ash content value found was 1.55%.

For proteins, the statistical analysis showed a difference, mainly in formulations F1 and F2. The protein values, in percentage, ranged from 1.00 to 1.19 (Table 2), showing a discrepant difference in relation to the protein content found by Gouvea et al. (2023), which was 6.72%. The authors worked with beet stalk flour and other types of flour, such as oat flour, and observed that the higher the amount of beet stalk flour, decreasing the amount of other flours, the more the protein value decreased. Thus, it can be inferred that this occurs due to the low protein content present in the vegetable.

Microbiological analysis

The parameters indicated for food safety and quality in cookies include tests for total and thermotolerant coliforms, molds, and yeasts. The absence or low presence of these microorganisms, as suggested by current legislation (Brazil, 2022), are indicators of appropriate handling techniques during the preparation of cookie samples, in accordance with Good Manufacturing Practices.

Table 3 shows the results of the microbiological analysis of total and thermotolerant coliforms in the four cookie formulations with added beet flour.

Table 3 - Microbiological analysis of total and thermotolerant coliforms in cookies with beet flour.

Samples	Total coliforms at 35ºC (NMP/g)	Thermotolerant coliforms at 44.5ºC (NMP/g)
F0	<3.0	<3.0
F1	<3.0	<3.0
F2	<3.0	<3.0
F3	<3.0	<3.0

F0= 0% beet flour; F1= 10% beet flour; F2= 15% beet flour; F3= 25% beet flour. Source: Prepared by the authors, 2024.

The results obtained were less than 3.0 NMP/g for total coliforms and no thermotolerant coliforms, suggesting a production and storage environment that maintains the microbiological integrity of the product. Coliforms originate from the human intestinal tract, mammals, and birds, indicating environmental and fecal contamination in the products. The high detection of fecal coliforms suggests the presence of intestinal pathogens, mainly *Escherichia coli* (Cardoso et al., 2001), which was not observed in the present study. The products obtained presented microbiological quality in accordance with the standards required by Anvisa through Resolution No. 724, of July 1, 2022 (Brazil, 2022). This suggests adequate sanitary hygiene conditions in the sample preparation stages.

In addition, detailed analysis of the results for molds and yeasts in cookie samples with beet flour reveals crucial information about the microbiological quality of the product during preparation, indicating whether the guidelines provided by the legislation regulating Good Manufacturing Practices were met.

The results of the microbiological analysis of mold and yeast in cookie samples with added beet flour are shown in Table 4.

Formulations F0 and F3 showed similar results with $1.0x10^{1}$ UFC/g, while formulations F1 and F2 showed superior and similar results, around $5.0x10^{2}$ UFC/g. However, the legislation establishes a maximum limit of $10^{(4)}$ CFU/g for breads, cakes, cookies, biscuits, and other bakery products that are stable at room temperature. Thus, the results obtained show microbiological quality in accordance with the standards to be followed by Anvisa through Resolution No. 724, of July 1, 2022 (Brazil, 2022). Fungi are widely present in

nature and, although they can be used intentionally in food, their undesirable presence can cause several problems, as they are capable of producing a variety of enzymes that cause deterioration. In addition, some fungi, when multiplying, can produce metabolites that are toxic to human health. Extrinsic conditions such as ambient temperature and air humidity are factors that influence the development of these microorganisms in food (Garnes et al. 2022). Thus, it can be considered that the sample preparation stages presented adequate hygienic-sanitary conditions. Moreno (2016), when studying cookies made with pineapple and mango waste flour, obtained values of $6.^{4x10^3}$UFC/g and $5.^{2x10^3}$UFC/g for molds and yeasts, respectively, results that are very similar to those obtained in this study.

Table 4 - Microbiological analysis of molds and yeasts in cookies with added beet flour

Samples	Molds and Yeasts (CFU/g)
F0	$1.0x10^1$
F1	$5.5x10^2$
F2	$5.3x10^2$
F3	$1.0x10^1$

F0= 0% beet flour; F1= 10% beet flour; F2= 15% beet flour; F3= 25% beet flour. Source: Prepared by the authors, 2024.

Table 5 shows the average sensory attributes evaluated, such as color, appearance, aroma, flavor, crunchiness, overall impression, and purchase intention for the four formulations evaluated.

Table 5– Averages of the sensory attributes of the cookies

Attribute	F0	F1	F2	F3
Color	6.69±1.8 a	6.76±1.7 a	6.94±1.6a	6.95±1.7a
Appearance	6.71±1.8 a	6.76±1.7 to	7.05±1.6a	6.93±1.8a
Aroma	7.09±1.6 a	7.06±1.6 a	6.98±1.6a	7.12±1.8a
Flavor	7.21±1.9 a	7.26±1.6 a	7.18±1.5a	6.95±2.0a
Crispness	6.86±1.9 a	6.89±1.6 a	7.24±1.8a	7.13±1.9a
Overall impression	7.15±1.5 a	7.29±1.4 a	7.42±1.4a	7.07±1.9a
Purchase intention	3.89±1.0a	3.95±1.0a	3.89±1.1a	3.82±1.2a

* Means followed by the same letter are not statistically different from each other.

* F0= 0% beet flour; F1= 10% beet flour; F2= 15% beet flour; F3= 25% beet flour.

Source: Prepared by the authors, 2024.

Regarding the attributes evaluated for the sensory acceptability test of the cookies, for the color attribute, there was no statistical difference for the Tukey test (not significant), in which formulation 0, without beet flour, scored 6.69, formulation 3 with 25% beet flour scored 6.95, indicating that the color acceptability was similar to the hedonic scale criterion of "I liked it moderately" in both samples. According to the study by Faria Cardoso & Fonseca Lobo (2020) on the process of obtaining red beet pulp (Beta *vulgaris* L.) powder for the formulation of a natural dye, the importance of pigments present in beets, such as betalain, a natural pigment present in the vegetable responsible for its attractive purplish-red color, was confirmed. Given this, it can be considered that formulations containing a higher amount of beetroot flour have more intense pigmentation and are therefore more attractive to consumers. According to Vivian et al. (2022), in a study conducted on a jelly made with banana and beetroot, a positive level of acceptance was achieved, mainly in

terms of color, which was the most highly rated attribute. Therefore, with or without the addition of flour, acceptability was similar, ensuring that the color remains attractive in the visual appearance of the product.

Regarding the appearance parameter, a score of 6.71 (slightly liked) was obtained for F0, 6.76 (slightly liked) for F1, 7.05 (moderately liked) for F2, and 6.93 (slightly liked) for F3, with no statistical difference for the Tukey test. Based on this, it can be observed that the formulation with whole beet flour is similar to the formulation containing only whole wheat flour, which can be considered a positive aspect since the addition of beet flour did not impair visual acceptance, remaining similar to the original formulation. As Silva, Matos & Hackenhaar (2018) obtained satisfactory results in their study on the acceptability of cookies made from legumes and whole grains, which corroborates the idea that the partial replacement of whole wheat flour does not affect appearance.

With regard to aroma and flavor, the results for all formulations ranged from 6.98 to 7.12 (moderately liked) for aroma and from 6.95 to 7.26 (moderately liked) for flavor. In both attributes, there were no statistical differences for the Tukey test. In the aroma attribute, when compared to the study by Ramos et al. (2018), in which a sensory analysis of cookies enriched with jatoba flour was performed, the two formulations with 10% and 20% of the flour also showed no significant differences in the results. This indicates that the addition of vegetable flours, such as beet and jatoba, can be carried out without affecting this sensory aspect. Regarding the flavor attribute, formulation 1, containing 10% beet flour, obtained the highest score with 7.26, despite the high conformity with the other formulations, possibly due to the natural sweetness of beet. The use of beet flour should be done in moderate amounts so as not to cause excessive sweetness, as observed in the results. In a similar study, Lafia et al. (2020) found that cookies formulated with 40% sweet potato flour obtained an average approval rating of 8.57, which on the hedonic scale corresponds to "I liked it very much." This result shows that, even with the incorporation of high percentages of sweet natural ingredients such as beetroot and sweet potato, it is possible to achieve high levels of acceptability, provided there is a balance between the ingredients according to each formulation, since beetroot actually has an excessive amount of sugars in its composition.

Regarding the crunchiness attribute, the values obtained for formulations 0, 1, 2, and 3 were 6.86, 6.89, 7.24, and 7.13 (on the hedonic scale, 6 represents "I liked it slightly," and 7 "liked moderately") respectively, revealing a slight superiority in formulation 2, but without statistical significance for the Tukey test. According to the study by Ferreira et al. (2020), in which the sensory analysis of gluten-free cookies added and enriched with flaxseed flour showed that the formulation with 20% flaxseed flour achieved the highest acceptability. When compared to the highest value for crunchiness obtained in this study, formulation 2 with 15% beet flour, a certain correspondence can be observed. Therefore, it is worth noting that the addition of vegetable flours can bring advantages to the crunchiness attribute, but this will depend on the vegetable used as raw material. Furthermore, this may have occurred due to the variation in the particle size of the beet flour, which may have been finer in some cookies and coarser in others during processing, as well as the influence of baking time, resulting in changes in crispness.

Regarding the overall impression, samples F0, F1, F2, and F3 had mean values of 7.15, 7.29, 7.42, and 7.07, respectively, with no statistical differences for the Tukey test between the samples evaluated. On the hedonic scale, both are classified as "moderately liked." These results indicate a generally positive evaluation among the different formulations. Like Coelho et al. (2024) in their study on the preparation of cookies with added pollen, similar results were also obtained for this sensory attribute. Thus, these results show that partial changes in ingredients, such as beet flour and pollen, contribute nutritionally but without altering sensory attributes, such as overall impression.

For purchase intention, all formulations were rated above 3.00 (might buy/might not buy), indicating an intermediate position on the scale, but with a tendency toward greater acceptability. The specific results were: formulation 0 with 3.89, formulation 1 with 3.95, formulation 2 also with 3.89, and formulation 3 with 3.82. Similar data were mentioned by das Chagas et al. (2020) in their study, which conducted a sensory analysis of cookie-type biscuits with partial replacement of wheat flour with tamarillo flour, resulting in uncertainty among the judges with average scores also around "might buy/might not buy," but with no discrepancy between the control biscuit formulation and the test formulations. Thus, it can be deduced that to improve purchase intention, an improvement in the formulation of the cookies in question can be made.

Acceptability index

Figure 3 shows the acceptability index of the sensory attributes of cookies with added beet flour.

In terms of acceptability, formulation 2, with the addition of 15% beet flour, presented the highest acceptability of the attributes of color (77.07%), appearance (78.36%), crunchiness (80.47%), and overall impression (82.46%). Meanwhile, in terms of aroma (79.06%), formulation 4, with 25% beet flour, obtained the highest value, and in terms of flavor (80.70%), formulation 2, with 10% beet flour added, also obtained the highest value. However, all formulations, F0, F1, F2, and F3, had an acceptability index (AI) above of 70% in all attributes. According to Dutcosky (2013), this index classifies products with good sensory acceptance. Soares et al. (2020) performed a sensory analysis of banana cookies and cookies with banana peel and obtained equivalent results with 70.99% and 83.37%, respectively, also characterizing them as accepted products. Another study conducted by Bassetto et al. (2013) on cookies with added beet peel waste flour obtained an acceptance value of 82%, a similar result compared to this study.

In this sense, beet flour can be a promising alternative to enrich both the nutritional and sensory characteristics of foods, such as cookies, which are widely consumed in the daily lives of Brazilians.

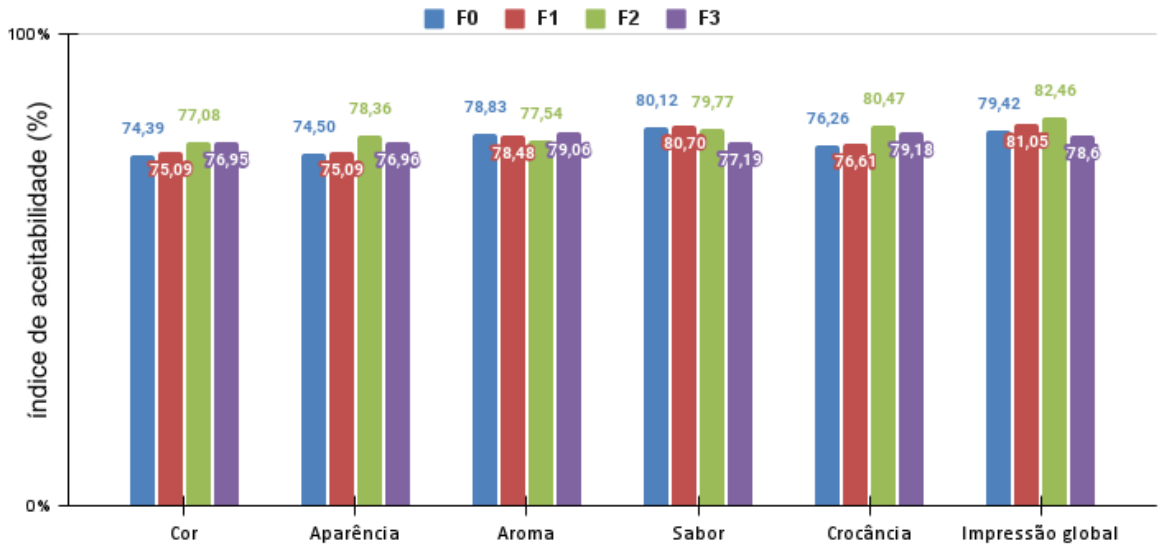

Figure 3 - Graph showing the acceptability index of the four cookie formulations made with whole beet flour. * F0 = 0% beet flour; F1 = 10% beet flour; F2 = 15% beet flour; F3 = 25% beet flour. Source: Prepared by the authors, 2024.

Conclusion

It can be concluded that making cookies from whole beet flour can be a good alternative for its use. In addition, the addition of beet flour in different proportions can greatly add to the nutritional value of the

food. In this study, this addition showed favorable results when used as a partial replacement for wheat flour in the production of cookies. Therefore, it can be stated that the formulation that presented the best physicochemical characteristics was formulation 3, which contains 25% beet flour. Therefore, it is advisable to certify the quantity of bioactive compounds present in the cookies in order to identify their stability under certain processing conditions.

The formulation that was best accepted sensorially was formulation 2 (15% beet flour). The partial replacement of whole wheat flour with up to 15% beet flour can be carried out without causing significant changes in sensory characteristics.

In this context, the results of this study may enable further research, contribute significantly to the validation of the information presented, and encourage changes in the formulation and consumption of nutritionally enriched and sensorially attractive bakery products.

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