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Quality of stingless bees honey *Melipona fasciculata* and *Melipona flavolineata* produced in the municipality of Curuçá, Pará, Amazon, Brazil

Qualidade dos méis de abelha sem ferrão *Melipona fasciculata* e *Melipona flavolineata* produzidos no município de Curuçá, Pará, Amazônia, Brasil

Calidad de las mieles de abejas sin aguijón *Melipona fasciculata* y *Melipona flavolineata* producidas en el municipio de Curuçá, Pará, Amazonía, Brasil

Lorena Géssica Carvalho do Vale*[1]; Emília do Socorro Conceição de Lima Nunes[2]; Juan Viana Moreira[3]; Fábio Willians Tavares de Souza[4]; Sandra Cristina de Ávila[5]; Patrícia Ribeiro Maia[6]; Carlos Alberto Martins Cordeiro[7]; Francisco Plácido Magalhães Oliveira[8]

[1] Médica Veterinária pela Universidade Federal do Pará (UFPA)

[2] Médica Veterinária e Doutora em Higiene Veterinária, Processamento e Tecnologia de Produtos de Origem Animal pela Universidade Federal Fluminense (UFF). Professora do curso de Medicina Veterinária da Universidade Federal do Pará (UFPA)

[3] Médico Veterinário e Residente no Programa de Medicina Veterinária Preventiva pela Universidade Federal do Pará (UFPA)

[4] Farmacêutico e Mestrando pelo Programa de Pós-Graduação em Saúde Animal na Amazônia pela Universidade Federal do Pará (UFPA)

[5] Zootecnista e Pós-Doutora em Ciências Agrárias pela Le Recherche Agronomique pour le Développement. Professora do curso de Medicina Veterinária da Universidade Federal do Pará (UFPA)

[6] Engenheira Agrônoma e Doutora em Ciências Agrárias pela Universidade Federal Rural da Amazônia. Professora do curso de Medicina Veterinária da Universidade Federal do Pará (UFPA)

[7] Engenheiro Químico e Doutor em Produção Vegetal pela Universidade Estadual do Norte Fluminense (UENF). Professor do curso de Engenharia de Pesca da Universidade Federal do Pará (UFPA)

[8] Engenheiro Agrônomo e Doutor em Ciências Biológicas (Botânica) pelo Instituto Nacional de Pesquisas da Amazônia (INPA). Professor do curso de Medicina Veterinária da Universidade Federal do Pará (UFPA)

***Autora correspondente:** lorena.gessica90@gmail.com

ABSTRACT

The objective of this study was to analyze the microbiological and physicochemical aspects of honey from stingless bees *Melipona fasciculata* (Uruçu-cinzenta) and *Melipona flavolineata* (Uruçu-amarela) produced in Curuçá, Pará, and to conduct a comparative analysis between the honeys of these bee species. The municipality of Curuçá is relevant for research on meliponiculture due to most of its territory being located within the Marine Extractivist Reserve Mãe Grande. In 17 honey samples (five from M. fasciculata and 12 from M. flavolineata), three microbiological tests and 11 physicochemical tests were conducted. The results of the two bee species were compared with each other as well as with the official standards established in the legislation for stingless bee honey by the Agricultural Defense Agency of the State of Pará and with data from the scientific literature. Most of the results from the physicochemical and microbiological tests were within the limits of the legislation and scientific recommendations. It can be concluded that the honeys from both bee species studied do not significantly differ from each other.

keywords: Honey; Physicochemistry; Microbiology; Yellow stingless bee; Gray stingless bee.

RESUMO

O objetivo deste estudo foi analisar os aspectos microbiológicos e físico-químicos de méis de abelhas sem ferrão *Melipona fasciculata* (Uruçu-cinzenta) e *Melipona flavolineata* (Uruçu-amarela) produzidos em Curuçá, Pará, e também realizar uma análise comparativa entre os méis dessas espécies de abelhas. O município de Curuçá se torna relevante para a pesquisa sobre a meliponicultura por conta da maioria do seu território estar inserido na Reserva Extrativista Marinha Mãe Grande. Em 17 amostras de méis (cinco de *M. fasciculata* e 12 de *M. flavolineata*) foram realizados três testes microbiológicos e 11 testes físico-químicos. Os resultados das duas espécies de abelhas foram comparados entre si e também com os padrões oficiais existentes na legislação de mel de meliponíneos da Agência de Defesa Agropecuária do Estado do Pará e com dados da literatura científica. A maioria dos resultados dos testes físico-químicos e microbiológicos estava dentro do limite da legislação e recomendação científica. Pode-se concluir que os méis de ambas as espécies de abelhas estudadas não diferem entre si significativamente.

Palavras-chave: Mel; Físico-química; Microbiologia; Uruçu-amarela; Uruçu-cinzenta.

RESUMEN

El objetivo de este estudio fue analizar los aspectos microbiológicos y físico-químicos de las mieles de abejas sin aguijón *Melipona fasciculata* (Uruçu-cinzenta) y *Melipona flavolineata* (Uruçu-amarela) producidas en Curuçá, Pará, y también realizar un análisis comparativo entre las mieles de estas especies de abejas. El municipio de Curuçá se vuelve relevante para la investigación sobre la meliponicultura debido a que la mayor parte de su territorio está inserto en la Reserva Extractivista Marina Mãe Grande. En 17 muestras de miel (cinco de *M. fasciculata* y 12 de *M. flavolineata*) se realizaron tres pruebas microbiológicas y 11 pruebas físico-químicas. Los resultados de las dos especies de abejas se compararon entre sí y también con los estándares oficiales existentes en la legislación de miel de meliponinos de la Agencia de Defensa Agropecuaria del Estado de Pará y con datos de la literatura científica. La mayoría de los resultados de las pruebas físico-químicas y microbiológicas estaban dentro del límite de la legislación y de las recomendaciones científicas. Se puede concluir que las mieles de ambas especies de abejas estudiadas no difieren significativamente entre sí.

Palavras Clave: Miel; Físico-química; Microbiología; Uruçu amarilla; Uruçu gris.

INTRODUCTION

The rearing of native bees is an activity that can be integrated into agricultural production, enhancing productivity and positively impacting native vegetation (Menezes, Mattietto and Lourenço 2018). For this reason, it is an activity often chosen by smallholder farmers, as it does not require highly sophisticated management techniques or significant time investment. In Pará, most small-scale producers manage to incorporate small meliponaries for bee rearing, producing high-quality honey for human consumption.

Meliponiculture, the practice of rearing native bees, is still a relatively unexplored field. Studies on the occurrence of native bees in the Amazon region remain scarce, particularly those addressing the various species, their geographical distribution, ecological importance, pollen identification, production, and quality of *Melipona* products. Most of the research published in this area to date focuses primarily on the occurrence of specific indigenous bee species, including *M. fasciculata* and *M. flavolineata* (Mercês *et al.* 2013; Menezes, Mattietto and Lourenço 2018; Oliveira, Meirelles Filho and Meirelles 2020; Oliveira *et al.* 2023). However, these studies provide limited data on production, management technologies, quality control, and commercialization of *Melipona* products.

The growing commercial demand for meliponiculture products necessitates increased production of honey and its derivatives to meet various applications in pharmacological, cosmetic, and food formulations. Most *Melipona* producers remain concentrated in smallholder agriculture or small cooperative and association groups. These groups produce and sell honey and its derivatives locally without certification. Honey from native bees plays an economically significant role for these producers, being traded above the market price for honeys.

The market for *Melipona* products is highly promising, especially for their use in cosmetics, pharmaceuticals, and food formulations, due to their unique biological and physicochemical properties. Among these, honey has the highest commercial demand as it is considered a functional food with antimicrobial, antioxidant, anti-inflammatory, antiviral, and wound-healing properties (Borges *et al.* 2021).

Of all hive products, honey from native bees exhibits unique characteristics and is experiencing growing large-scale demand, making meliponiculture a potentially economically viable activity (Pereira *et al.* 2020).

Thus, the rearing of native bees is crucial for increasing productivity, improving the quality and diversity of *Melipona* products, and boosting production. However, information on their parameters, particularly physicochemical ones, remains insufficient and is yet to be regulated by the Brazilian Ministry of Agriculture, Livestock, and Supply.

It is essential that research provides further data on native bee products, especially honey, which is the most consumed and valued product in the market. The production technology and intrinsic properties of honey from native bees differ significantly from those of Brazilian apiculture honey (Parpinelli *et al.* 2021). However, it is still common to use the parameters established in national legislation for *Apis mellifera* honey (Brasil 2000; Brasil 2003).

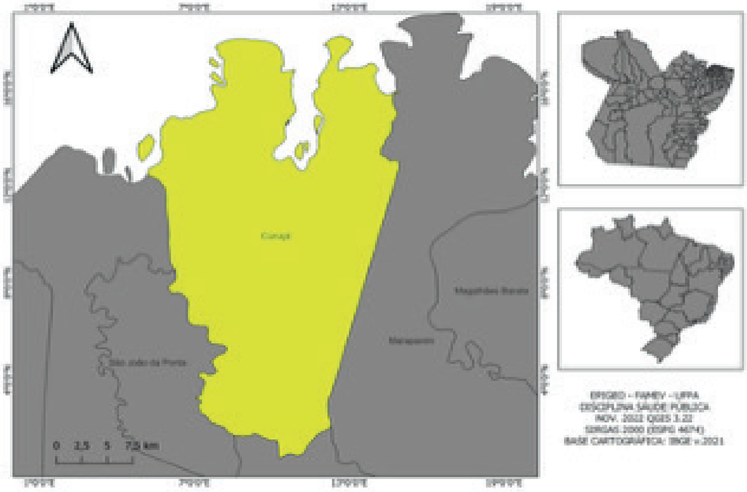
Microbiological and physicochemical parameters for native bee honey are currently addressed only in state legislation (Amazonas, Bahia, and Pará). Federal regulations, on the other hand, provide standards only for *Apis mellifera* honey under (Brasil 2000; Brasil 2003), along with additional data available in the scientific literature. Native bee honey is less sweet, more acidic and fluid, and has a variety of flavors. These characteristics give it a distinctive status, attracting particular interest in Brazilian gastronomy (Oliveira, Meirelles Filho and Meirelles 2020). Thus, studies on the characteristics of *Melipona* honey can aid in defining its identity and ensuring quality.

The objective of this study was to analyze the microbiological and physicochemical quality of honey from native bees *M. fasciculata* and *M. flavolineata* to conduct a comparative analysis between the honeys of native bees.

MATERIAL AND METHODS

To contribute to the quality requirements of honey produced by native bees, this research was conducted in the Curuçá municipality (Figure 1), located in the Northeastern Pará Mesoregion, within the Salgado Microregion. Curuçá has approximately 40,584 inhabitants, with most of its territory included in the "Marina Mãe Grande" Extractive Reserve. This municipality, situated along the coast of Pará, features extensive mangrove areas and a significantly altered terra firme forest due to anthropogenic activity (Oliveira, Meirelles Filho and Meirelles 2020). These characteristics may influence the properties of honey, making Curuçá a relevant site for meliponiculture research.

Figure 1. Map showing the location of the municipality of Curuçá in the Mesoregion of Northeast Pará and in the Microregion of Salgado in the state of Pará.



Source: Personal archive

Seventeen honey samples (five samples from *M. fasciculata* and twelve samples from *M. flavolineata*) were collected by the producers between October and December 2023 (Amazonian summer).

After collection, the samples were stored in 100 mL bottles (Figure 2), refrigerated (in a cooler with ice), and transported to the laboratories of the Institute of Veterinary Medicine, Federal University of Pará – Castanhal *Campus*, for laboratory analysis.

Figure 2. Samples of honey from *M. fasciculata* and *M. flavolineata* bees originating from the municipality of Curuçá, Pará.

Source: Personal archive

Physicochemical analyses were performed in duplicate at the Animal Nutrition Laboratory for the following determinations: acidity, Brix degree, moisture, pH, ash content, water-insoluble solids, reducing sugars, total sugars, sucrose, Lugol test, and Fiehe test (Louveaux, Maurizio and Vorwohl 1978; Brasil 2000; Bogdanov 2002; Instituto Adolfo Lutz 2008; Pará 2021; Oliveira *et al.* 2023).

Microbiological evaluation was also performed in duplicate at the Laboratory of Food Hygiene and Quality, including the following determinations: mold and yeast count, enterobacteria count, and coagulase-positive *Staphylococcus* count (Bogdanov 2002; Brasil 2003; Pará 2021). Macroscopic and microscopic standards for honey, as officially established (Brasil 2000), were considered.

Physicochemical Analyses

Acidity

The acidity test determined the degree of acidity present in the honey. It was conducted using a method based on the neutralization of the sample. A total of five grams of honey was used, to which 75 mL of distilled water was added. Three drops of phenolphthalein were then added, and the sample was titrated with 0.01N sodium hydroxide (NaOH) until it turned pink.

Brix

The Brix test determined the content of water-soluble solids (sugars) present in the honey. The measurement was performed using a refractometer after diluting the sample with distilled water due to the honey's density. The dilution ratio was 1:3 (1 part honey to 3 parts water) to enhance visualization on the refractometer. The values observed on the refractometer were then multiplied by three to obtain the Brix value for each sample.

Moisture

The moisture test determined the moisture content, the water content in the honey. It was calculated by subtracting the Brix value from 100, thus obtaining the moisture content for each sample.

pH

The pH test determined the honey's pH using a pH meter calibrated with buffer solutions of pH 4.0 and 7.0.

Ash Content

The ash test indicated the amount of minerals present in the honey. It was determined by weighing two grams of honey from each sample, which were first charred and then placed in a muffle furnace at 550°C for 5 hours. The samples were then cooled in a desiccator and weighed.

Insoluble Solids in Water

The insoluble solids in water test indicated the purity level of the honey by identifying any wax residues and other impurities. It was determined by weighing 20-gram samples, which were diluted in a small amount of distilled water at 80°C, then filtered through filter paper previously dried at 105°C. Finally, the filter papers were washed with distilled water, placed in the oven at 135°C for one hour, and weighed.

Total Sugars

The total sugar test indicated the amount of sugar present in the honey. These sugars include both reducing and non-reducing sugars. The test was performed by weighing five grams of honey, adding 100 mL of distilled water, and withdrawing 10 mL of this dilution. Then, another 100 mL of distilled water was added, followed by 1 mL of hydrochloric acid. The mixture was heated in a water bath for 30 minutes, then neutralized with sodium hydroxide to a pH of 6.5 to 7.0. Afterward, the solution was placed in a burette and titrated with Fehling A (5 mL) and Fehling B (5 mL) solutions on a heated plate at 300°C until the solution turned brick-red.

Reducing Sugars

The reducing sugars test indicated the amount of reducing sugars present in the honey, which are responsible for the flavor, color, and texture. The test was performed by weighing a five gram sample, adding 100 mL of distilled water, and transferring it to a burette. The solution was then titrated with Fehling A (5 mL) and Fehling B (5 mL) solutions on a heated plate at 300°C until the solution turned brick-red.

Sucrose

The sucrose test indicated the amount of sucrose present in the honey to evaluate the honey's maturation (transformation into glucose and fructose). It was determined based on the total sugar and reducing sugars results, and the decrease in total sugar values relative to reducing sugars, which resulted in the sucrose value for each sample.

Lugol Test

The Lugol test indicated whether the honey had been adulterated with the addition of starch (commercial glucose). It was performed by weighing a 10-gram sample, adding 10 mL of distilled water, followed by 1 mL of Lugol's solution, and observing the color change to red-violet.

Fiehe Test

The Fiehe test indicated whether the honey had been adulterated with the addition of commercial glucose or improper heating. It was performed by weighing a five gram sample, adding five mL of ether, and mixing until two layers were formed after resting. The ether layer was then transferred to another container, five drops of resorcinol were added, and the color change to cherry red was observed within five to 10 minutes.

Microbiological analyzes

Mold and Yeast Count

The mold and yeast analysis was performed by counting colonies on dextrose potato agar acidified with 10% tartaric acid, incubated at 25°C for five to seven days.

Enterobacteria Count

The *Enterobacteria* analysis was performed by counting colonies on violet red bile glucose agar, incubated at 37°C for 24 hours, followed by confirmation of typical colonies through the oxidase test.

Positive Coagulase Staphylococcus Count

The Positive Coagulase *Staphylococcus* analysis allowed for the counting of typical and atypical colonies on Baird-Parker agar supplemented with egg yolk and potassium tellurite, incubated at 37°C for 48 hours, followed by confirmation of typical and atypical colonies through the coagulase test.

Statistical Analysis

All data obtained in the study were organized in an Excel spreadsheet, and an Analysis of Variance (ANOVA) test was performed. The means were compared using the Student t test with a 5% significance level. The results were compared with the standards for each test according to the honey state legislation (Pará 2021) and scientific literature, using descriptive statistics.

A Principal Component Analysis (PCA) statistical correlation was performed using R software based on the obtained results. The PCA was conducted to identify the main sources of variation in the dataset. Before the PCA, the normality of the variables was verified using the Anderson-Darling test, and multicollinearity was assessed through the Variance Inflation Factor (VIF).

RESULTS

To ensure the quality of honey and other native bee products, as well as to promote sanitary defense and food safety, it is necessary to consolidate national regulations with official parameters for honey and native bee products (Pereira *et al.* 2020). However, to date, only state-level legislation exists regarding the identity, quality, and physicochemical and microbiological requirements. Recently, the Pará State Agricultural Defense Agency officially published the Technical Regulation of Identity and Quality for Honey from Stingless Native Bees (*Hymenoptera, Apidae, Meliponini*) (Pará 2021), which includes some specific parameters for native bee honey.

The consolidation of regulations with official parameters is crucial as it contributes to the implementation of technical assistance, specific policies, professionalization of producers, incorporation of new technologies, increased production, legalization of the activity, and product certification. This process adds value to these products and provides greater opportunities for commercialization with enhanced safety and quality (Oliveira, Meirelles Filho and Meirelles 2020; Pereira *et al.* 2020).

The results of the physicochemical analyses, including acidity, Brix degree, moisture content, pH, ash content, total sugar, reducing sugars, sucrose, Lugol test, and Fiehe test, for all honey samples analyzed from both bee species, are presented in Table 1.

Table 1. Results (averages) of the physicochemical analyses of honey from native bees in Curuçá, Pará.

Tests	*M. flavolineata*	*M. fasciculata*	P-value	Legislation (Limits)*
Acidity (mEq)	33,82	32,21	0,82	Maximum 80 mEq
Brix	85,53	84,36	0,77	--
Humidity (g.100 g^{-1})	14,47	15,64	0,77	Maximum 40 g.100 g^{-1}
pH	4,02	4,34	0,65	From 2,9 to 4,5
Ashes (g.100 g^{-1})	0,3	0,2	0,93	Maximum 0,6 g.100g^{-1}
Insoluble solids (g.100 g^{-1})	2,68	2,22	0,61	Maximum 0,1 g.100 g^{-1}
Total sugar	16,16	16,93	0,55	--
Reducing sugars (g.100 g^{-1})	13,75	14,26	0,39	Minimum 50 g.100 g^{-1}
Sucrose (g.100 g^{-1})	2,46	2,66	0,79	Maximum 6 g.100 g^{-1}
Lugol's test	Negative	Negative	-	Negative **
Fiehe test	Negative	Negative	-	Negative **

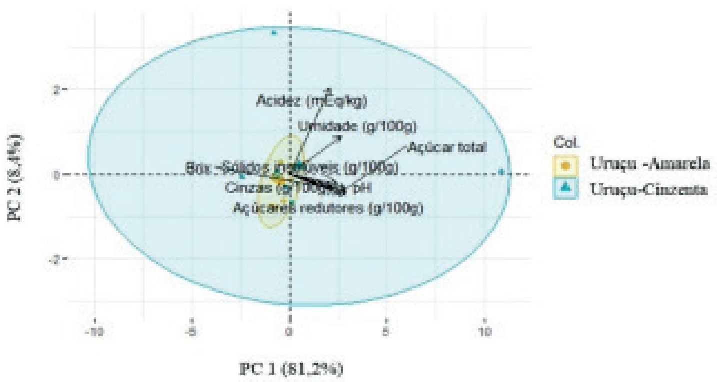
* Pará 2021
** Recommendation from the Manual of the Adolfo Lutz Institute 2008
-- There is no official limit for this studied parameter

Source: Personal archive

It was observed that there were no statistical differences between the honeys of the two bee species regarding the studied physicochemical parameters. Most of the results complied with the current state legislation. Deviations were observed only in the parameters of insoluble solids in water, which suggest that the honeys of both bee species may contain hive and comb residues. Such findings do not impede their consumption or commercialization but indicate that the honeys may not have been filtered after harvesting, leaving residues of natural components from the honey production process, which are officially acceptable under macroscopic criteria.

Based on these results, a statistical correlation was conducted, as shown in Figure 3. A Principal Component Analysis (PCA) was performed to identify the primary sources of variation in the dataset. Before the PCA, variable normality was assessed using the Anderson-Darling test, and multicollinearity was evaluated via the Variance Inflation Factor (VIF). The results indicated that the variables did not follow a normal distribution and exhibited multicollinearity, common issues in real-world data. To ensure equal contribution among variables, the data were scaled before proceeding with the PCA.

Figure 3. Statistical correlation through Principal Component Analysis of the results of the analyses in the honey of *M. fasciculata* and *M. flavolineata* bees from Curuçá, Pará.



Source: Personal archive.

The PCA revealed that the first Principal Component (PC1) explained 81.21% of the total variance, while the second Principal Component (PC2) accounted for 8.44%, totaling approximately 89.64% of the variance explained by the first two components. Measurements of sugars, acidity, and insoluble solids were identified as the primary variables distinguishing the different groups within the dataset.

Regarding microbiological analyses, no statistical differences were found between the honeys of the two studied bee species (Table 2). The results of the microbiological analyses met the official standards established for Melipona honey concerning molds and yeasts. Although *Staphylococcus* Coagulase Positive and *Enterobacteria* showed no growth of typical colonies (not included in official standards), their levels were within expected ranges for food testing manuals.

Table 2. Results of the microbiological analyses of honey from native bees in Curuçá, Pará.

Tests	*M. flavolineata*	*M. fasciculata*	P-value	Legislation (Limits)
Molds and yeasts (CFU.g^{-1})	58,5 x 102	1,00 x 102	0,09	Maximum 1,0x104 CFU.g^{-1}*
Coagulase + *Staphylococcus*	0,00	0,00	-	Without an official standard
Enterobacteria	0,00	0,00	-	Without an official standard

* Pará 2021

Source: Personal archive.

Despite the samples being within the legal limit for fungal growth, it was observed that honeys from *Melipona fasciculata* presented significantly higher fungal growth compared to those from *M. flavolineata.* However, this level remains acceptable under the honey standards for Melipona established by state legislation.

DISCUSSION

When comparing the studied honey samples, it was observed that *M. flavolineata* honey presented a slightly higher acidity level than *M. fasciculata* honey. A study conducted with honey from *Scaptotrigona sp.* in Belterra (Pará) and *Tetragonisca angustula* from Ilha Grande, in the municipality of Angra dos Reis (Rio de Janeiro) (Lira *et al.* 2014) reported acidity levels of 81.01 mEq and 71.68 mEq, respectively, which are significantly higher than the values found in the honeys from Pará. Based on the results of that study, the author explains that variations in acidity (low or high) may result from geographic origin and ecological diversity factors, such as the composition of organic acids present in nectar, the mineral content in the honey, soil type, climatic conditions, and seasonality (Lira *et al.* 2014) under which the honey was produced. The author emphasizes that acidity has an inverse relationship with pH. Generally, honey from native bees exhibits higher acidity than that of *Apis* bees, which is associated with moisture content (Lira *et al.* 2014). High moisture content can promote microbiological activity and trigger fermentation, even when pH levels are high (Lira *et al.* 2014).

The Brix level indicates a higher sugar content in *M. flavolineata* honey, significantly greater than that reported in the Maranhão lowlands in a study on *M. fasciculata* honey (Fernandes, Silva and Rosa 2020), where the Brix level was 72.79%. This value is lower than those found in the honey from Pará. Such differences can be attributed to various geographic and ecological factors (Fernandes, Silva and Rosa 2020).

The result of the moisture test shows that the honey from *M. fasciculata* has a slightly higher moisture content than *M. flavolineata*. Moisture is very important for honey because it affects viscosity, flavor, maturity, crystallization, and mass. In the study of honeys from *Scaptotrigona sp*. from Belterra (Pará) and *Tetragonisca angustula* from Ilha Grande, Angra dos Reis (Rio de Janeiro) (Lira *et al.* 2014), the moisture levels were higher (27.15 and 29.00 g.100g^{-1}, respectively) compared to the honeys from Curuçá (Pará). These differences may be related to the period of collection. In Curuçá, honey is typically harvested throughout the Amazonian summer (the less rainy period), which occurs between July and December, a period that favors a lower moisture content. In contrast, honey from Belterra is harvested at the end of the Amazonian summer and during the rainy season (specifically in March). During the Amazonian summer, it was observed that the honeys from *M. fasciculata* were more fluid than those from *M. flavolineata*. The authors of the study from Belterra and Angra dos Reis further emphasize that when the moisture content is above the limit stipulated by regulations, the honey becomes susceptible to deterioration, as higher water content in the environment favors the multiplication of microorganisms (Lira *et al.* 2014).

Considering the pH test result, it was found that honey from *M. flavolineata* has a lower pH than honey from *M. fasciculata*, meaning it is slightly more acidic, a trend also seen in the acidity test. A study of honeys from *M. flavolineata* and *M. fasciculata* from the Mosqueiro District and Castanhal (Pará) (Oliveira *et al.* 2023) showed that there is a difference in pH between these species (pH = 3.4 and 3.9, respectively) for honeys from the Mosqueiro District, as well as for honeys from Curuçá (with *M. flavolineata* honey being more acidic than *M. fasciculata*). This can be explained by these regions being coastal. In the municipality of Castanhal, the pH of *M. flavolineata* honey is higher (4.66) than that of *M. fasciculata* (3.4), with *M. fasciculata* honey being more acidic, which is the opposite result of Curuçá and Mosqueiro. The pH of honey is influenced by the pH of the nectar due to the flower origin, soil, and also the mandibular secretions of the bees when mixed with the nectar during transport to the hives (Oliveira *et al.* 2023).

The result suggests a higher ash content in *M. flavolineata* honey. This result may indicate adherence to Good Manufacturing Practices during honey collection. A study conducted with honey from native bees, *Tetragonisca angustula*, *Melipona quadrifasciata* and *Melipona obscurior* in the Vale do Itaquari region (Rio Grande do Sul) (Vieira *et al.* 2023) found ash content ranging from 0.1 to 0.3 $g.100g^{-1}$. The author noted that the ash content in honey can be influenced by soil, climate, the producer, the bees, the botanical origin, and the flowering period. The slight difference in ash content between the honeys from Curuçá, Pará and those from the study conducted in Rio Grande do Sul (Vieira *et al.* 2023) may be explained by environmental influences, as the municipalities are in different regions of Brazil. There is a slight difference between the species of bees from Curuçá honey. Honeys from *M. flavolineata* had a lighter color, while those from *M. fasciculata* were slightly darker. This characteristic may be due to the amount of ash.

In the total sugar test, there is a slightly higher value for *M. fasciculata* honey compared to *M. flavolineata*. In a study with honey from native bees *Melipona* from Manaus and Itacoatiara (Amazonas) (Souza *et al.* 2004), the total sugar content was much higher (70.6 g/100g). The authors attribute this to the floral diversity present in the honey. Possibly, due to this variety, the total sugar content in the honey analyzed in that study was higher compared to the honeys from Curuçá, Pará. In honey from *Melipona compressipes* (Fonseca *et al.* 2006), the reducing sugar content also varied and was much higher than that found in Pará (65.28 to 75.90 g/100g).

Regarding the sucrose test, it was observed that *M. fasciculata* honey contains a slightly higher amount of sucrose than *M. flavolineata* honey, indicating that sucrose has not yet been fully converted into glucose and fructose. Even though *M. fasciculata* honey has a bit more sucrose, both species' honey samples show similar amounts of sucrose, suggesting that the honey was not fully matured. When honey is fully matured, sucrose is absent, and fructose and glucose are predominant. A study with honey from native bees *Melipona seminigra* (Silva *et al.* 2024) showed a sucrose result of 0.18%, indicating that the honey was much more mature than the honeys from Pará, as it had a much lower sucrose value, and most of it had already been transformed into fructose and glucose. The author emphasizes that sucrose is a non-reducing sugar, usually present in smaller quantities in honey. When found in higher amounts, it may indicate that the honey is either not yet mature or has been adulterated. Sucrose is affected by an enzyme called invertase, which transforms it into fructose and glucose.

According to the results of the Lugol test, all the samples from both species were not adulterated with syrup. Likewise, based on the results of the Fiehe test, all the samples were not adulterated by heating the honey.

In studies with honey from native bees *Melipona quadrifasciata*, *Scaptotrigona depilis*, and *Tetragonisca angustula* in Santa Catarina, Rio Grande do Sul, and Rondônia (Silva *et al.* 2024), mold and yeast growth was observed in different honey samples (9.4x104 to 1.3x105 CFU/g and 3.0 CFU/g, respectively), with the first two values being much higher than those in our study. These differences are likely due to microorganisms commonly found in honey molds and yeasts are the microorganisms that pose the greatest risk to honey quality because they can survive in acidic conditions, and the sugar does not prevent their proliferation (Fernandes, Silva and Rosa 2020).

In a study (Mercês *et al.* 2013) with honey from native bees *Tetragonisca angustula* and *Plebeia sp.* from the municipalities of Serrinha and Cruz das Almas (Bahia), the result was negative for the development of *Staphylococcus* and enterobacteria, which are similar to the findings in Curuçá. The possible explanation for this microbiological finding is that *Staphylococcus* and *Enterobacteria* generally do not develop in acidic environments, and the honey collection technique met the hygiene requirements for food.

CONCLUSIONS

In the comparison between the honey from native bees (*M. flavolineata* and *M. fasciculata*) from the municipality of Curuçá, Pará, it is observed that these honeys are indeed similar in relation to the analyzed physicochemical aspects. Some of these parameters affect the taste, viscosity, and color of the honeys, which are important features for differentiating them. This study highlights acidity, pH, reducing sugars, sucrose, ash content, and moisture. It can be concluded that the honey from *M. flavolineata* is more acidic, reflected in its acidity level and pH. It is not fully matured, which is evident in the amount of reducing sugars and sucrose. Additionally, it is lighter and more viscous, reflected in its ash and moisture content. Microbiological analyses show similarity between the bee species regarding the fungus count in their honey.

CONFLICT OF INTEREST

There is no potential conflict of interest between the author(s) and any public or private entity that could compromise the credibility of the publication, the author(s), and science itself.

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