Physicochemical profile of honeys from different species of stingless bees from western Pará, Brazilian Amazonia

Perfil físico-químico dos méis de diferentes espécies de abelhas sem ferrão do Oeste do Pará, Amazônia Brasileira

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ABSTRACT
Stingless honey is a product with a peculiar flavor and quality and its consumption is increasing both as food and as therapeutic and medicinal purposes, particularly in rural communities. This work evaluates the physicochemical profile of different stingless honeys from the Brazilian Amazonia. We analyzed 13 honey samples of the species *Melipona interrupta*, *Scaptotrigona* aff. *xanthotricha*, *Melipona* sp., *Melipona seminigra* and *Scaptotrigona polystica* from different communities in western Pará State, Brazil. We evaluated the physicochemical parameters of moisture, pH, total acidity, electrical conductivity, ash, hydroxymethylfurfural, diastatic activity, total soluble solids, reducing sugar, and apparent sucrose. The physicochemical profiles showed differences between the species studied, despite coming from the same geographical region. Most parameters comply with limits established from the Identity and Quality of Socially Stingless Honey, from the State of Amazonas. Our results contribute to other studies that investigate and qualify honeys from this region, particularly honeys from *Scaptotrigona* aff. *xanthotricha*, whose physicochemical characteristics are still little known in the Brazilian Amazonian region.

Keywords: *Melipona interrupta*, *Scaptotrigona* aff. *xanthotricha*, *Melipona* sp., *Melipona seminigra*, *Scaptotrigona polystica*.

RESUMO
O mel de abelha sem ferrão é um produto de sabor e qualidade peculiar, com ascensão no mercado consumidor, sendo consumido tanto como alimento, quanto para fins terapêuticos e medicinais, particularmente em comunidades rurais. Este trabalho tem por objetivo avaliar o perfil físico-químico dos diferentes méis de abelhas sociais sem ferrão do Oeste do Pará, Amazônia. Foram analisadas 13 amostras de méis das espécies *Melipona interrupta*, *Scaptotrigona* aff. *xanthotricha*, *Melipona* sp., *Melipona seminigra* e *Scaptotrigona polystica*, obtidas em diferentes comunidades do Oeste do Pará, Amazônia. Os parâmetros físico-químicos avaliados foram umidade, pH, acidez total, condutividade elétrica, cinzas, hidroximetilfurfural, atividade diastásica, sólidos solúveis totais, açúcar redutor e sacarose aparente. Houve diferenças no perfil físico-químico entre as espécies estudadas, apesar de serem de uma mesma região geográfica. A maioria dos parâmetros se enquadram naqueles estabelecidos na Identidade e Qualidade do Mel de Abelha Social sem Ferrão, do Estado do Amazonas. Nossos resultados se somam aos de outros estudos na busca de conhecer e qualificar os méis dessa região, particularmente os méis de *Scaptotrigona* aff. *xanthotricha*, cujas características físico-químicas ainda são pouco conhecidas na região Amazônica.

Palavras-chave: *Melipona interrupta*, *Scaptotrigona* aff. *xanthotricha*, *Melipona* sp., *Melipona seminigra*, *Scaptotrigona polystica*.
1 INTRODUCTION

Stingless bees produce rare honey, which has gained attention in recent years, due to its particular characteristics and exotic flavor (CHUTTONG et al. 2016; DA SILVA et al. 2013; RAMÓN-SIERRA et al. 2015; SOUSA et al. 2016a). This honey is also rich in sugars with nutritional properties (KWAKMAN et al. 2010; JAGANATHAN et al. 2011; WATANABE et al. 2014).

Honey quality and composition has an intimate relationship with the bee species and the nectar collected from different plant species. Each bee produces a distinct honey in terms of organoleptic, physicochemical characteristics, as honey features are influenced by geographic space, climate, techniques and period of collection, processing and conservation (ESTEVINHO et al. 2016; ARAÚJO et al. 2017).

The Amazonia stands out for its diverse flora, combined with a wide diversity of climate and bees species (LEMOS et al. 2017) with an array of stingless bee honeys, with unique sensory qualities. Therefore, meliponiculture has gained relevance, generating economic benefits, especially in food supplementation (BELÉM et al. 2011; MARINHO et al. 2013).

In western Pará State, Brazilian Amazonia, rearing of social sting bees (apiculture) is promising; nevertheless, there is considerable potential for rearing stingless bees of the Meliponini tribe (meliponiculture). Rayol and Maia (2013) identified 197 honey producers in this region and 68% produce stingless bee honey; however, they do not know the physicochemical composition of the honey produced by their bees (RAYOL and MAIA, 2013). Studies that characterize honeys of these species are relatively recent for the establishment of their identities and quality standards. Therefore, our study aimed to evaluate the physicochemical profile of different stingless honeys from western Pará, Brazilian Amazonia.

2 MATERIAL AND METHODS

2.1 SAMPLES

We obtained 13 honey samples from stingless bees directly from producers in two municipalities in the western of Pará State, Amazonian region, Brazil: Santarém and Belterra (Table 1). The samples were collected from October to December in 2017, during the main flowering in the region, where average temperature is 33 ºC and relative humidity is 70-90%. The honeys were collected by suction directly from hives of predominant species in each municipality, using disposable syringes. Then, samples were stored at approximately 7 ºC in sterile glass bottles and properly labeled before testing.
2.2 PHYSICOCHEMICAL ANALYSES

The physicochemical analyses followed the quality parameters established by the Brazilian legislation (BRAZIL, 2000) for honey, recommended by the Ministry of Agriculture, Livestock and Supply (MAPA). Moisture was determined by refractometry, pH, total acidity, hydroxymethylfurfural (HMF) according to AOAC (1990), electrical conductivity (SANCHO et al. 1991), total soluble solids content (IAL, 2005), diastatic activity (Göthe scale) e reducing sugars and apparent sucrose (CAC, 1990). The ash content (Moraes; Texeira, 1998) and color according to Vidal; Fregosi (1984).

2.3 STATISTICAL ANALYSES

Statistical analyses were performed using the software Minitab16 (Minitab, State College, PA, USA). Experimental results were obtained as the mean ± standard deviation (SD) of three parallel measurements. The data were submitted to the analysis of variance (ANOVA) followed by the Tukey test to compare data obtained for different honey samples. Mean values with p <0.05 were considered statistically significant. As different factors influence stingless honey composition, the principal component analysis (PCA) was used to assess the importance of each physicochemical characteristic studied on the total variation available (MARDIA et al., 1979). The characteristics with a correlation

### Table 1. Identification of stingless bee species and geographical description of municipalities of sampling.

| SAMPLES | POPULAR NAME   | SCIENTIFIC NAME                  | PLACE   | LATITUDE (S) | LONGITUDE (W) |
|---------|----------------|----------------------------------|---------|--------------|---------------|
| A       | Pinto caído    | *Scaptotrigona polysitica*       | Santarém| 02°25′10.4″  | 55°12′44.2″   |
| B       | Uruçu amarela  | *Melipona sp.*                   | Santarém| 02°25′10.4″  | 55°12′44.2″   |
| C       | Jandaira       | *Melipona interrupta*            | Santarém| 02°25′10.4″  | 55°12′44.2″   |
| D       | Uruçu boca de renda | *Melipona seminigra*          | Belterra| 02°38′10.7″  | 054°56′02.2″  |
| E       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°38′15.0″  | 054°56′27.6″  |
| F       | Pinto caído    | *Scaptotrigona polysitica*       | Belterra| 02°37′58.6″  | 054°56′14.6″  |
| G       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°38′15.0″  | 054°56′27.6″  |
| H       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°37′58.6″  | 054°56′14.6″  |
| I       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°38′10.7″  | 054°56′02.2″  |
| J       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°38′10.7″  | 054°56′27.6″  |
| L       | Canudo         | *Scaptotrigona aff. xanthotricha*| Belterra| 02°37′58.6″  | 054°56′14.6″  |
| M       | Jandaira       | *Melipona interrupta*            | Santarém| 02°32′19″    | 054°52′14″    |
| N       | Jandaira       | *Melipona interrupta*            | Santarém| 02°32′19″    | 054°52′14″    |
above 70% were discarded using the criterion proposed by Joliffe (1973), ignoring the variable with the highest coefficient in each component with an eigenvalue lower than 0.70.

3 RESULTS AND DISCUSSION

Average values of physicochemical characterization of stingless bee honeys from the western region of Pará State complied with the Brazilian legislation for honey (BRAZIL, 2000), except for the parameters of moisture and ash (Table 2). This legislation regards honey of the *Apis mellifera* species; however, it has also been used for studies on stingless bee honeys (ANACLETO et al. 2009; CARVALHO et al. 2009; NASCIMENTO et al. 2015). Our results demonstrated that only ashes did not show conformity with the threshold recommended by Ordinance No. 253 of the Agency for Agricultural and Forestry Defense of the State of Amazonas, which regulates identity and quality of social stingless honey (ADAF/AM, 2016).

Moisture of samples varied from 24.0 to 28.37%, showing a statistical difference (p<0.05) between each other. Souza et al. (2004) found similar results for stingless bee honeys from Amazonas (*Melipona rufiventris paraensis* -23.9%; *Melipona seminigra merrillae* -27.0%; and *Melipona compressipes manaosensis* -25.3%). Similar results were observed in stingless honeys from other regions in Brazil, *Scaptotrigona bipunctata* (24.5 to 25.0%) in Ceará State (OLIVEIRA and SANTOS, 2011), *Melipona fasciculata* Smith (21.44 to 27.51%) in the Cerrado of Maranhão (HOLANDA et al. 2012), *Melipona subnitida* Smith (22.2 to 24.4%) in the Paraiba State (SILVA et al. 2013a), *M. subnitida* Duke (23.9 to 28.9%) in the Northeast semi-arid (SOUSA et al. 2016b), *Melipona bicolor*, *Scaptotrigona bicunctata*, *Melipona quadriasciata*, *Melipona marginata*, *Tetragonisca angustula*, *Melipona mondury*, *Melipona raflvestris mondory*, *Tetragona clavipes*, *Melipona scutellaris*, *Trigona fusciennis* (23.1 to 43.5%) in Santa Catarina State (BILUCA et al. 2016), and *T. angustula* (25.0 to 25.5%) in Paraná State (BRAGHINI et al. 2017).

Stingless honeys have high moisture levels and consequently high water activity in their composition, regardless of the region where it comes from, and moisture is one of the main physicochemical parameters that differs it from *A. mellifera* honey. Therefore, conservation techniques after harvest are recommended for stingless bee honey, such as refrigeration, dehumidification, and pasteurization to increase its shelf life (CAMARGO et al. 2017).

The moisture content is one of the most important parameters that influence honey quality, as it changes the physicochemical and sensory properties, such as viscosity, crystallization, color, flavor, aroma, specific gravity, solubility, and conservation (CAMARGO et al. 2017). Moisture values were above the threshold recommended by national (BRAZIL, 2000) and international (FAO, 2001).
legislations (maximum 20%); nevertheless, within 23-35%, which are values recommended for stingless honey in Amazonas (ADAF/AM, 2016).

The pH of samples ranged from 3.59 to 6.85 with an average 4.29. The results for pH corroborate with LEMOS et al. (2017), SOUSA et al. (2016b), and BILUCA et al. (2016). The authors evaluated stingless bee honeys and found a difference between the samples, due to different floral sources and bee species with values from 3.07 to 6.69, from 3.1 to 5.3, and from 3.3 to 6.6, respectively. The pH is of great importance during honey extraction and storage, since low pH inhibits the presence and growth of microorganisms, ensuring quality to honey as a food product thus increasing its shelf life (SILVA et al. 2016). In addition, the pH can be correlated with other authenticity parameters to verify honey adulterations (RIBEIRO et al. 2014).

Values of the total acidity index ranged from 1.40 to 23.05 meq kg\(^{-1}\), showing a significant difference between samples. Total acidity corresponds to the balance of organic acids in honey. The high total acidity index refers to fermentation of sugars and alcohols that form acids through the action of microorganisms over time (SILVA et al. 2016). All samples presented total acidity levels within the legislation standards (BRAZIL, 2000), Codex Alimentarius (FAO, 2001), where the maximum total acidity is 50 meq kg\(^{-1}\) and for stingless bee honeys is 80 meq kg\(^{-1}\) (ADAF/AM, 2016). Therefore, the samples did not show evidence of fermentation.

Higher levels were found for Melipona sp. (Jandaíra) from the Cruzeiro do Sul region, Acre State, Brazil, ranging from 30.5 to 60.8 meq.kg\(^{-1}\) (DO VALE et al. 2018) and in Melipona spp. from the Amazonian region, northern Brazil, by Silva et al. (2013b), with values ranging from 8.24 to 76.72 meq kg\(^{-1}\).
Table 2. Physicochemical parameters of stingless bee honeys from the western region of Pará State, Amazonia, Brazil (mean ± standard deviation, n = 3).

| Samples | Moisture (%) | pH         | Total Acidity (mEq kg⁻¹) | Electric conductivity (μS cm⁻¹) | Ashes (%) | HMF (mg kg⁻¹) | Diastatic Activity (Gothe Scale) | Total Soluble Solids (°Brix) | Reducing sugars (%) | Apparent Sucrose (%) | Color       |
|---------|--------------|------------|---------------------------|-------------------------------|-----------|--------------|-------------------------------|-----------------------------|---------------------|---------------------|-------------|
| A       | 28.37 ± 0.05ᵃ | 6.85 ± 0.15ᵃ | 1.80 ± 0.20ᵈ             | 1025.00 ± 4.90ᵈ              | 0.60 ± 0.00ᶠ | 0.40 ± 0.22ᵈ | 23.10                        | 68.00 ±0.16ʰ          | 73.24 ± 0.13ᵉᶠ     | 0.89 ± 0.1ᵇᶜᵈ     | Amber       |
| B       | 28.37 ± 0.05ᵃ | 4.65 ± 0.00ᵇ | 4.15 ± 0.05ᶠ             | 645.25 ± 1.76¹              | 0.39 ± 0.00ᵉ | 0.80 ± 0.55ᵈ | 21.40                        | 70.10 ±0.08ᵍ          | 84.77 ± 0.35ᵃ       | 2.04 ± 0.33ᵃᵇᶜ    | Light Amber  |
| C       | 27.00 ± 0.00ᵇ | 6.85 ± 0.02ᵃ | 1.40 ± 0.10ᵉ             | 714.30 ± 0.33ᵇ              | 0.40 ± 0.00ᵉ | 1.00 ± 0.66ᵈ | 12.00                        | 71.10 ±0.08ᵉ          | 74.45 ± 0.27ᵈᵉᵃ     | 1.19 ± 0.26ᵇᶜᵈ     | Light Amber  |
| D       | 25.10 ± 0.24ᵈ | 3.68 ± 0.01ᵈ | 11.50 ± 0.10ᶜ             | 788.35 ± 4.78ᵏ              | 0.45 ± 0.01ᵈ | 0.30 ± 0.22ᵈ | 1.60                         | 74.15 ±0.04ᵇ          | 68.09 ± 1.49ʰ       | 2.23 ± 1.41ᵃᵇ     | Amber       |
| E       | 24.70 ± 0.08ᵈᵉ | 3.90 ± 0.00ᶜ | 9.90 ± 0.10ᵈ             | 1154.50 ± 3.67ᵃ              | 0.67 ± 0.01ᵇ | 13.62 ± 7.33ᵇ | 7.50                         | 74.80 ±0.00ᵃ          | 78.19 ± 0.91ᵇ       | 1.75 ± 0.86ᵃᵇᶜᵈ   | Amber       |
| F       | 24.60 ± 0.08ᵃ  | 3.93 ± 0.01ᶜ | 9.65 ± 0.25ᵈ             | 1044.00 ± 7.35ᶜ              | 0.61 ± 0.01ᶜ | 31.64 ± 16.88ᵃ | 8.30                         | 73.70 ±0.08ᵇ          | 76.13 ± 0.00ᵃᵈᶜ     | 3.27 ± 0.00ᵃ       | Amber       |
| G       | 24.00 ± 0.00 Decimal | 3.95 ± 0.02ᶜ | 9.60 ± 0.40ᵈ             | 1157.50 ± 11.84adera         | 0.67 ± 0.01ᵇ | 5.99 ± 3.52ᶜ | 8.80                         | 75.05 ±0.04ᵃ          | 71.81 ± 0.00ᵃ       | 2.25 ± 0.00ᵃᵇ     | Amber       |
| H       | 25.80 ± 0.24ᶜ  | 3.72 ± 0.02ᵈ | 12.55 ± 0.05ᶜ             | 976.30 ± 7.51ᶠ              | 0.59 ± 0.00ᶠ | 0.35 ± 0.21ᵃ | 4.90                         | 72.80 ±0.00ᶜ          | 72.45 ± 0.65ᵃᵉ      | 0.37 ± 0.62ᵃᵇᵈ     | Amber       |
| I       | 26.97 ± 0.05ᵇ  | 3.72 ± 0.01ᵈ | 16.55 ± 0.95ᵇ             | 1098.00 ± 2.45ᵇ              | 0.69 ± 0.04ᵃ | 2.30 ± 1.34ᵈ | 5.70                         | 70.85 ±0.12ᵉᶠ         | 74.18 ± 0.54ᵉᶠ     | 2.09 ± 0.52ᵃᵇ     | Amber       |
| J       | 28.17 ± 0.05ᵃ  | 3.69 ± 0.01ᵈ | 23.05 ± 0.55ᵃ             | 1087.00 ± 2.45ᵇ              | 0.63 ± 0.00ᵇᶜ | 1.45 ± 0.79ᵈ | 6.70                         | 70.50 ±0.16ᵃᵍ         | 69.36 ± 0.47ʰ       | 2.06 ± 0.44ᵃᵇᶜ     | Amber       |
| L       | 26.90 ± 0.00ᵇ  | 3.68 ± 0.01ᵈ | 16.05 ± 0.55ᵇ             | 1001.15 ± 3.96ᵃ              | 0.61 ± 0.02ᶜ | 0.65 ± 0.36ᵈ | 4.50                         | 71.10 ±0.24ᵉ          | 77.74 ± 0.29ᵇᶜ      | 0.70 ± 0.28ᵃᵇᵈ     | Amber       |
| M       | 26.20 ± 0.16ᶜ  | 3.62 ± 0.00ᵈᵉ | 9.00 ± 0.10ᵉᵃ             | 490.95 ± 2.00ᶠ              | 0.29 ± 0.00ᶠ | 1.75 ± 0.95ᵈ | 0.30                         | 71.70 ±0.24ᵈ          | 76.13 ± 0.29ᵃᵈᵉ     | 0.27 ± 0.27ᵃᵈ       | Light Amber |
| N       | 26.97 ± 0.05ᵇ  | 3.59 ± 0.00ᵈᵉ | 8.45 ± 0.05ᵉ              | 453.95 ± 2.57ᵏ              | 0.28 ± 0.00ᶠ | 0.65 ± 0.43ᵈ | 0.30                         | 71.00 ±0.16ᵃᵉ         | 77.00 ± 0.59ᵃᵇᶜ     | 0.84 ± 0.56ᵃᵇᵈ     | Light Amber |

* Different letters in the same column differ statistically at 5% probability by the Tukey test.
The total ash content varied from 0.28 to 0.69% with a total average 0.53%. The ash content represents mineral richness in honey, often used for quality control, as it can be indicative of environmental pollution, geographic origin, and nectar of botanical species, as well as the soil type used by flowers, where nectar is collected (SANTOS et al. 2015; SOUSA et al. 2016b and SILVA et al. 2016). According to Biluca et al. (2016), K is the main mineral in stingless honey, followed by Ca, Mg, and Na, where the content of these elements varies with the bee species.

For the ash content, 46.15% of the samples (E, F, G, I, J, and L) presented a percentage higher than 0.6%, maximum value determined by the legislation (BRAZIL, 2002; ADAF/AM, 2016). The high ash content in the samples are attributed to burning practices throughout the region during the sampling period and a change in the environmental scenario, with the introduction of monoculture and the growth of livestock.

Gomes et al. (2017a) evaluated honeys of the species *Melipona compressipes manoasensis* and *M. seminigra* (Jandaíra) produced in the municipality of Santarém and found ash contents from 0.02 to 0.33%. Chuttong et al. (2016) reported the average ash content of 0.531% (pp<sup>1</sup>) for stingless honey (Apidae: Meliponini), ranging between 0.22 and 3.10% (pp<sup>1</sup>). Silva et al. (2013b) assessed honey samples from *M. fasciculata* and *M. flavoneata* from Pará State (Amazon Region, Brazil) and found values ranging from 0.02 to 0.45%.

Electrical conductivity is a common parameter in honey quality control and has a positive correlation with ash content and acidity (YÜCEL and SULTANOGLU, 2013). Values of electrical conductivity ranged from 645.25 to 1157.5 μS cm<sup>-1</sup>, showing a statistical difference between samples. Table 2 shows that 46.17% of the samples had values above 800 μS cm<sup>-1</sup>. Nascimento et al. (2015) found smaller results in honeys of *M. seminigra* (548.22 μS cm<sup>-1</sup>) and *S. xanthotricha* (621.89 μS cm<sup>-1</sup>). Do Vale et al. (2018) found values ranging from 385.0 to 484.0 μS cm<sup>-1</sup> in honeys of Melipona sp. from Cruzeiro do Sul, Acre Stae. Sousa et al. (2016b) obtained values from 300 to 670 μS cm<sup>-1</sup> for honeys of jandaíra (*M. subnitida* Ducke) and uruçú (*M. scutellaris* Latrelle) bees.

Average values of diastatic activity ranged from 0.30 to 23.10 on the Gothe scale. The diastatic activity indicates overheating and conservation of honey, corresponding to the activity of enzymes (α and β-amylases), naturally found in 1 g of honey, which can hydrolyze 0.01 g of starch in 1 h at 40 °C, expressed in units of Göthe (AHMED et al. 2013). For the diastatic activity, only 23.07% of the samples did not comply with the threshold in the legislation (BRAZIL, 2000 and FAO, 2001), with 38.46% of samples showing values ≥ 8 units on the Gothe scale and 38.46% showing values ≥ 3 units on the Gothe scale when HMF <15 mg kg<sup>-1</sup>. However, 23.07% of stingless bee honeys from the Amazonia (ADAF/AM, 2016) comply with limits of the legislation, with a maximum value of 3.0 units on the Gothe scale.
Biluca et al. (2016) found similar results that ranged from 4.3 to 49.6 Gothe units for honey *Melipona bicolor*, *S. bicunctata*, *M. quadriasciata*, *M. marginata*, *T. angustula*, *M. mondury*, *M. rufivestris mondory*, *T. clavipes*, *M. scutellaris*, and *T. fuscipennis*. The lowest value was found for the species of *S. bicunctata*, while the highest value was for the species *T. angustula*, indicating that the diastatic activity varies according to the stingless bee species. Do Vale et al. (2017) evaluated samples of *Melipona* sp. and found values ranging from 10.67 to 23.33 (Gothe scale).

Regarding the diastatic activity, 5-HMF is also a qualitative parameter that indicates overheating or inadequate storage conditions, due to monosaccharide decomposition or Maillard reaction, when honey is heated or stored, and/or inverted syrup is added (SIDDIQUI et al. 2017). The samples obtained HMF values between 0.3 and 31.64 mg kg\(^{-1}\) (Table 2). All results complied with national and international legislation that allows 40 mg kg\(^{-1}\) (BRAZIL, 2000), 40 mg kg\(^{-1}\) (ADAF/AM, 2016), and 80 mg kg\(^{-1}\) (FAO, 2001), demonstrating that all samples were adequately collected and stored, without undergoing a heating process or exposure to high temperatures.

In the Brazilian Amazonia, Lemos et al. (2017) found similar results in honeys of *Sacaptotrigona* sp. from the municipality of Belterra, with values ranging from 3.14 to 40.88. Sousa et al. (2016b) and by Silva et al. (2013a) carried out studies in hot regions and in the Brazilian semi-arid on honeys of *M. subnitida* and *M. scutellaris*. Stingless bee honeys are often suspect of adulteration due to their high HMF content (NORDIN et al. 2018). However, Biluca et al. (2014) report that stingless honey is more resistant to HMF formation than *A. mellifera* honey when subjected to heat treatment.

The TSS values in the samples ranged from 68.0 to 74.8 °Bx. Samples E and G, I, and J did not differ from each other and were statistically different from the other samples, according to the Tukey test at 5% probability. In addition, the apparent sucrose varied from 0.27% to 3.27%. Concentrations of RS in honey samples ranged from 68.09 to 84.77%, with an average value 74.88% (p<0.05). Regarding honey composition, TSS values were similar to those reported by Fernandes et al. (2018) in *M. fasciculata* honey produced in two hydrographic basins in Maranhão State (72.8 to 73.9 °Brix) and by Silva et al. (2013b) in honeys of the same species in Pará State (72.67 to 76.0 °Brix).

All samples analyzed showed minimum RS levels required by legislation and maximum contents allowed for sucrose. As quality indicators, sugars are related to honey maturation; therefore, the samples were not collected prematurely and there was no adulteration by sucrose addition.

Sousa et al. (2016b) observed that honey of *Melipona interrupta* and *Melipona* sp. had more than 90% of glucose (41.4 to 45.4%) and fructose (50.0 to 59.2%) in their constitution and 0.7 to 3.9% of sucrose. Nascimento et al. (2015) reported average values for RS and apparent sucrose in
hones of *M. seminigra* of 69, 12%, and 1.61%, and in honeys of *S. xanthotricha*, 66.32% and 1.22%, respectively. According to Escuredo et al. (2014), fructose, glucose, moisture, and their ratios are the main indicators to predict honey crystallization, where honey crystallizes faster with high glucose content and low fructose/glucose ratio. Honey with higher fructose than glucose content crystallizes slowly, such as stingless honey.

Color of honey samples varied between light amber and amber. Color is a very important sensory attribute for honey marketing, as it refers to parameters of quality, acceptance, and consumer preference. In many countries, honey is priced according to its color. Slightly light honeys generally have a higher value, while dark honeys are appreciated in certain regions (TUBEROSO et al. 2014), showing that color acceptance of honeys by consumers can vary widely (GÁMBARO et al. 2007).

The PCA is represented in Figures 1A and 1B, and Table 3. The two-dimensional plane generated between components PC1, PC2, and PC3 corresponds respectively to components PC1 and PC2 by 69% (34% in PC1 and 36% in PC2) (Figure 1A). Variability in the original dataset and PC1 and PC3 by 63% of this variability (34% in PC1 and 29% in PC3) (Figure 1B). Moisture and TSS parameters characterized PC1 (Table 3, Figures 1A and 1B).

| VARIABLES                  | F1    | F2    | F3    |
|---------------------------|-------|-------|-------|
| Moisture                  | -0.98 | -0.15 | -0.05 |
| pH                        | -0.37 | 0.12  | -0.90 |
| Total acidity             | -0.07 | 0.31  | 0.93  |
| Total Soluble Solids      | 0.96  | 0.13  | 0.17  |
| Electric conductivity     | 0.16  | 0.98  | 0.06  |
| Ashes                     | 0.11  | 0.98  | 0.11  |
| % of variance             | 34    | 35    | 29    |

Figure 1 shows the straight line defined by moisture following the opposite line to the line defined by TSS, that is, when the value of one variable increases, the value of the other variable in the opposite direction tends to decrease, both presenting properties with high discriminatory power.
Figure 1. Principal Component Analysis (PCA) of the physical-chemical profile (humidity, pH, acidity, TSS, electrical conductivity and ash) with sample distribution in PCA 1 and 2 (A) and in PCA 1 and 3 (B), according to with species, respectively.

Bandeira et al. (2018) assessed the antioxidant activity and physicochemical characteristics of honeys from the eastern Amazonian region in Brazil. The authors observed that the pH showed high and moderate positive correlations with the contents of ash (0.903) and moisture (0.620), respectively. In the PCA to evaluate the composition of phenolic acid and flavonoids in honeys exposed and protected from light, the first two axes (PC1 and PC2) explained about 65% of data variation.
Gomes et al. (2017b) used the multivariate analysis for physicochemical characterization of bee honeys in the municipalities of Cachoeira do Ararí and Salvaterra, Pará. The authors observed a variance of 87.73%, where PC1 had a strong influence between color and ash parameters and PC2 expressed correlations between acidity and moisture.

Lacerda et al. (2010) applied the multivariate analysis to honey samples from the southwestern region of Bahia State, Brazil, to correlate physicochemical characteristics with honey color and observed high discriminatory power in the identification and improvement of the pattern produced. The multivariate analysis demonstrated the relationship between colors of honeys and their physicochemical composition.

A study on the physicochemical characteristics of honey samples collected in Ceará State, Brazil, showed that electrical conductivity and apparent sucrose were the characteristics that most influenced the grouping of samples (SODRÉ et al. 2007).

Variability of PC2 associated the parameters electrical conductivity and ash, showing high discriminatory power and that the line composed by one of the properties defined between PC2 acts in the same way, when the value of a property increases, the value of another property also increases. Generally, there is a positive correlation between the color, mineral content, and electrical conductivity of honey (KARABAGIAS et al. 2014).

4 CONCLUSION

The physicochemical profile of honeys from different stingless bee species from western Pará State, Brazilian Amazonia, is distinct and complies, for the most part, with parameters established by the Identity and Quality Regulation of Social Stingless Bee, from the Amazonas State, Brazil. Our results complement other studies the investigate and qualify honeys from this region, particularly honeys of Scaptotrigona aff xanthotricha, whose physicochemical characteristics are still little known in the Brazilian Amazonia.

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REFERENCES

ADAF, Agência de defesa agropecuaria e florestal do Estado dos Amazonas (ADAF/AM). Regulamento técnico de identidade e qualidade do mel de abelha social sem ferrão, Portaria nº 253 de 31 de Outubro de 2016. Diário Oficial da União, 2016.

AHMED, M.; DJEBLI, N.; AISSAT, S.; KHIATI, B.; MESLEM, A.; BACHA, S. In vitro activity of natural honey alone and in combination with curcuma starch against Rhodotorula mucilaginosa in correlation with bioactive compounds and diastase activity. Asian Pacific Journal of Tropical Biomedicine, v. 3: p. 816-821, 2013. Doi: 10.1016/S2221-1691(13)60161-6.

ANACLETO, D. A.; SOUZA, B. A.; MARCHINI, L. C.; MORETI, A. C. C. C. Composition of Jatai bee honey samples (Tetragonisca angustula Latreille, 1811). Food Science and Technology, v. 29, p. 535-541, 2009. Doi: https://doi.org/10.1590/S0101-20612009000300013.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Official methods of analysis. AOAC Internacional, Washington, DC.2. ed. 1990. 1018 p.

ARAÚJO J. S.; CHAMBÓ E. D.; COSTA, M. A. P. C.; CAVALCANTE DA S. M. P. S.; LOPES DE CARVALHO C. A.; ESTEVINHO M.L. Chemical composition and biological activities of mono-and heterofloral bee pollen of different geographical origins. International Journal of Molecular Sciences, v. 18, p. 1-15, 2017. Doi: 10.3390/ijms18050921

BANDEIRA, A. M. P.; GOMES, V. V.; VASCONCELOS, A. A.; TAUBE, P. S.; DE BARROS, E. C.; COSTA, S. C.; LIMA, A. K. O.; BOLIGON, A. A.; WACZUK, E. P.; ROCHA, J. B. T. Antioxidant activity and physicochemical characteristics of honeys from the eastern Amazon region, Brazil. Acta Amazonica, v. 48, p. 158-167, 2018. Doi: https://doi.org/10.1590/1809-4392201702721

BELÉM, L. G.; ABSY, M. L.; SOUZA, A. C. M.; FERREIRA, M. G.; SANTOS, A. O. Análise de amostras do mel provenientes da área indígena Saterê-Mawé, Amazônia. Paper presented at: PIBIC INPA. In: XX JORNADA DE INICIAÇÃO CIENTÍFICA PIBIC INPA - CNPq/FAPEAM; 18-22 julho; Manaus (AM). 4p. 2011.

BILUCA, F. C.; BETTA, F. D.; OLIVEIRA, G. P DE.; PEREIRA, L. M.; GONZAGA, L. V.; COSTA, A. C. O.; FETT, R. 5-HMF and carbohydrates content in stingless bee honey by CE before and after thermal treatment. Food Chemistry, v. 159, p. 244-249, 2014. Doi: https://doi.org/10.1016/j.foodchem.2014.03.016
BILUCA, F. C.; BRAGHINI, F.; GONZAGA, L. V.; COSTA, A. C. O. FETT, R. Physicochemical profiles, minerals and bioactive compounds of stingless bee honey (Meliponinae). *Journal of Food Composition and Analysis*, 50: 61-69, 2016. Doi: https://doi.org/10.1016/j.jfca.2016.05.007

BRAGHINI, F.; CHIAPETTI, E.; JUNIOR, J. F. S.; MILESKI, J. P. F.; OLIVEIRA, D. F. de.; MORÉS, S.; COELHO, A. R.; TONIAL, I. B. Qualidade dos méis de abelhas africanizadas (*Apis mellifera*) e jataí (*Tetragonisca angustula*) comercializado na microrregião de Francisco Beltrão: PR. *Revista de Ciências Agrárias*, v. 40, p. 279-289, 2017. Doi: http://dx.doi.org/10.19084/RCA16039

BRASIL, Ministério da Agricultura e Abastecimento. Instrução Normativa n. 11, de 20 de outubro. Ministério da Agricultura, Pecuária e Abastecimento aprova o regulamento técnico de identidade e qualidade do mel. Brasília: *Diário Oficial da União*, 2000.

CAMARGO, R. C. R.; OLIVEIRA, K. L de; BERTO; M. I. Mel de abelhas sem ferrão: proposta de regulamentação. *Brazilian Journal of Food Technology*, v. 20, p. e2016157, 2017. Doi: https://doi.org/10.1590/1981-6723.15716.

CARVALHO, C. A. L.; SODRÉ, G. S.; FONSECA, A. A. O.; ALVES, R. M. O.; SOUZA, B. A.; CLARTON, L. Physicochemical characteristics and sensory profile of honey samples from stingless bees (Apidae: Meliponinae) submitted to a dehumidification process. *Anais da Academia Brasileira de Ciências*, v. 8, p. 143-149, 2009. Doi: https://doi.org/10.1590/S0001-37652009000100015

CHUTTONG, B.; CHANBANG, Y.; SRINGARM, K.; BURGETT, M. Physicochemical profiles of stingless bee (Apidae: Meliponini) honey from South East Asia (Thailand). *Food Chemistry*, v. 192, p. 149-155, 2016. Doi: https://doi.org/10.1016/j.foodchem.2015.06.089

CAC, Codex Alimentarius Commission. *Official methods of analysis*. v. 3, Suppl. 2, 1990.

DA SILVA, I. A. A.; DA SILVA, T. M. S.; CAMARA, C. A.; QUEIROZ, N.; MAGNANI, M.; DE NOVAIS, J. S.; DE SOUZA, A. G. Phenolic profile, antioxidant activity and palynological analysis of stingless bee honey from Amazonas, Northern Brazil. *Food Chemistry*, v. 141, p. 3552-3558, 2013. Doi: https://doi.org/10.1016/j.foodchem.2013.06.072

DO VALE, M. A. D.; GOMES, F. A.; SANTOS, B. R. C dos.; FERREIRA, J. B. Honey quality of Melipona sp. bees in Acre, Brazil. *Acta Agronomica*, v. 67, p. 201-207, 2018. Doi:10.15446/ACAG.V67N2.60836
ESCUREDO, O.; DOBRE, I.; FERNANDA-GONZALEZ, N.; SEIJO, M. C. Contribuition of botanical orig and sugar compositio of honeys on the crystalization phenomenon. *Food Chemistry*, v. 149, p. 84-90, 2014. Doi: 10.1016/j.foodchem.2013.10.097

ESTEVINHO, L. M.; CHAMBÓ, E. D.; PEREIRA, A. P. R.; CARVALHO, C. A. L de.; TOLEDO, V. A. A de. Characterization of *Lavandula* spp. honey using multivariate techniques. *PLoS One*, v. 11, p. 1-15, 2016. Doi: https://doi.org/10.1371/journal.pone.0162206

FAO. Revised codex standard for honey (No. CODEX STAN 12-1981), Rev. 1 (1987). Codex Alimentarius, 11(Rev. 2). p. 1-8, 2001.

FERNANDES, R. T.; ROSA, I. G.; CONTI-SILVA, A. C. Microbiological and physical-chemical characteristics of honeys from the bee *Melipona fasciculata* produced in two regions of Brazil. *Ciência Rural*, v. 48, p. e20180025, 2018. Doi: https://doi.org/10.1590/0103-8478cr20180025

GÁMBARO, A.; ARES, G.; GIMÉNEZ, A.; PAHOR, S. Preference mapping of color of Uruguayan honeys. *Journal of Sensory Studies*, v. 22, p. 507-519, 2007. Doi: 10.1111/j.1745-459X.2007.00125.x

GOMES, V. V.; DOURADO, G. S.; COSTA, S. C.; LIMA, A. K. O.; SILVA, D. S; BANDEIRA, A. M. P.; VASCONCELOS, A. A.; TAUBE, P.S. Avaliação da Qualidade do Mel Comercializado no Oeste do Pará, Brasil. *Revista Virtual Química*, v. 9, p. 815-826, 2017a.

GOMES, P. W. P.; REIS, J. D. E.; SILVA, D. S. C.; COSTA, A. P. A.; MALATO, B. V.; MURIBECA, A. J. B.; GOMES, P. W. P. A aplicação da técnica multivariada (PCA e HCA) em dados microbiológicos e físico-químicos de méis comercializados em Cachoeira do Ararí e Salvaterra - PA. *Scientia Plena*, v. 13, p. 1-13, 2017b. Doi: 10.14808/sci.plena.2017.069901

HOLANDA, C. A.; OLIVEIRA, A. R.; COSTA, M. C. P.; RIBEIRO, M. N de S.; SOUZA, J. L.; ARAÚJO, M. J. A. M. Quality of honey produced by *Melipona fasciculata* Smith of cerrado region from Maranhão state, Brazil. *Química Nova*, v. 35, p. 55-58, 2012. Doi: https://doi.org/10.1590/S0100-40422012000100011

INSTITUTO ADOLFO LUTZ (IAL). *Métodos físico-químicos para análise de alimentos*. São Paulo: Instituto Adolfo Lutz, 2005. 4ª ed, 2005.

JAGANATHAN, S. K.; MAZUMDAR, A; MONDHE, D.; MANDAL, M. Apoptotic effect of eugenol in human colon cancer cell lines. *Cell Biology International*, v. 35, p. 607-615, 2011. Doi: 10.1042/CBI20100118
JOLIFFE, I. T. Discarding variables in a principal component analysis. *Applicant Statistical*, v. 21, p. 21-31, 1973.

KARABAGIAS, I. K.; BADEKA, A.; KONTAKOS, S.; KARABOURNIOTI, S.; KONTOMINAS, M. G. Characterisation and classification of Greek pine honeys according to their geographical origin based on volatiles, physicochemical parameters and chemometrics. *Food Chemistry*, v. 146, p. 548-557, 2014. Doi: https://doi.org/10.1016/j.foodchem.2013.09.105

KWAKMAN, P. H. S.; VELDE, A. A. T. E.; BOER, L. D. E.; SPEIJER, D.; VANDENBROUCKE-GRAULS, C. M. J. E.; ZAAT, S. A. J. How honey kills bacteria. *The Faseb Journal*, v. 24, p. 2576-2582, 2010. Doi: https://doi.org/10.1096/fj.09-150789

LACERDA, J. J. J.; SANTOS, J. S.; SANTOS, S. A.; RODRIGUES, G. B.; SANTOS, M. L. P. Influência das características físico-químicas e composição elementar nas cores de méis produzidos por *Apis mellifera* no sudoeste da Bahia utilizando análise multivariada. *Quimica Nova*, v. 33, p. 1022-1026, 2010. Doi: https://doi.org/10.1590/S0100-40422010000500003

LEMOS, M. S.; VENTURIERI, G. C.; FILHO, H. A. D.; DANTAS, K. G. F. Evaluation of the physicochemical parameters and inorganic constituents of honeys from the Amazon region. *Journal of Apicultural Research*, ISSN: 0021-8839 (Print) 2078-6913 (Online), 2017. Journal homepage: http://www.tandfonline.com/loi/tjar20.

MARDIA, K.; KENT, J.; BIBBY, J. *Multivariate analysis*. London: Academic, 1979. 521p.

MARINHO H. A.; ABSY, M. L.; HIGUCHI, M. I. G.; ASSIS, M. G. P. *Introdução a criação de abelhas nativas sem ferrão* (Awi’a etiat wem’u moher eup imotag hap). Manaus (AM): Editora INPA, 2013.

MORAES, R. M.; TEIXEIRA, E. W. *Análise do mel*. 2 ed. Pindamonhangaba: Centro de Apicultura Tropical, IZ/SAA, 1998. 41 p.

NASCIMENTO, A. S do.; MARCHINI, L. C.; CARVALHO, C. A. L de.; ARAÚJO, D.F.D.; OLINDA, R. A de.; SILVEIRA, T.A da. Physical-Chemical Parameters of Honey of Stingless Bee (Hymenoptera: Apidae). *American Chemical Science Journal*, v. 7, p. 139-149, 2015. Doi: https://doi.org/10.9734/ACSJ/2015/17547

NORDIN, A.; SAINIK, N. Q. A. V.; CHOWDHURY, S. R.; SAIM, A. B.; BT HJ IDRUS, R. Physicochemical properties of stingless bee honey from around the globe: A comprehensive review. *Journal of Food Composition and Analysis*, v. 73, p. 91-102, 2018. Doi: https://doi.org/10.1016/j.jfca.2018.06.002
OLIVEIRA, E.N.A.; SANTOS, D.C. Análise físico-química de méis de abelhas africanizada e nativa. Revista do Instituto Adolfo Lutz, v. 70, p. 132-138, 2011.

RAMÓN-SIERRA, J. M.; RUIZ-RUIZ, C.; LUZ ORTIZ-VÁZQUEZ, E. Electrophoresis characterisation of protein as a method to establish the entomological origin of stingless bee honeys. Food Chemistry, v. 183, p. 43-48, 2015. Doi: https://doi.org/10.1016/j.foodchem.2015.03.015

RAYOL, B. P.; MAIA, R. T. F. Potencial da inserção de abelhas em sistemas agroflorestais no oeste do estado do Pará, Brasil. Revista Brasileira de Agroecologia, v. 8, p. 101-108, 2013.

RIBEIRO, R de O. R.; MÁRSICO, E. T.; CARNEIRO, C da S.; MONTEIRO, M. L. G.; JÚNIOR, C. C.; JESUS, E. F. O de. Detection of honey adulteration of high fructose corn syrup by Low Field Nuclear Magnetic Resonance (LF 1H NMR). Journal of Food Engineering, v. 135, p. 39-43, 2014. Doi: https://doi.org/10.1016/j.jfoodeng.2014.03.009

SANTOS, A.; MOREIRA, R. F.; DE MARIA, C. A. Study of the principal constituents of tropical angico (Anadenanthera sp.) honey from the atlantic forest. Food Chemistry, v. 171, p. 421-425, 2015. Doi: https://doi.org/10.1016/j.foodchem.2014.09.017

SIDDQUI, A. J.; MUSHARAF, S. G.; CLOUDHARY, M. I.; RAHMAN, A. Application of analytical methods in authentication and adulteration of honey. Food Chemistry, v. 217, p. 687-698, 2017. Doi:https://doi.org/10.1016/j.foodchem.2016.09.001

SILVA, T. M. S.; SANTOS, F. P dos.; EVANGELISTA-RODRIGUES, A.; SILVA, S. E. M da.; SILVA, G. S da.; NOVAIS, J. S de.; SANTOS, F de A. R.; CAMARA, C. A. Phenolic compounds, melissopalynological, physicochemical analysis and antioxidant activity of jandaíra (Melipona subnitida) honey. Journal of Food Composition and Analysis, v. 29, p. 10-18. 2013a. ISSN 0889-1575. Doi: https://doi.org/10.1016/j.jfca.2012.08.010

SILVA, A dos S.; ALVES, C. N.; FERNANDES, K das G.; MÜLLERD, R. C. S. Classification of Honeys from Pará State (Amazon Region, Brazil) Produced by Three Different Species of Bees using Chemometric Methods. Journal of the Brazilian Chemical Society, v. 24, p. 1135-1145, 2013b. Doi: https://doi.org/10.5935/0103-5053.20130147

SILVA, P. M da.; GAUCHE, C.; GONZAGA, L. V.; COSTA, A. C. O.; FETT, R. Honey: Chemical composition, stability and authenticity. Food Chemistry, v. 196, p. 309-323, 2016. Doi: https://doi.org/10.1016/j.foodchem.2015.09.051
SODRÉ, G. S.; MARCHINI, L.C.; MORETI, A. C. C. C.; OTSUK, I. P.; CARVALHO, C. A. L. Caracterização físico-química de amostras de méis de *Apis mellifera* L. (Hymenoptera: Apidae) do Estado do Ceará. *Ciência Rural*, v. 37, p. 1139-1144, 2007.

SOUZA, J. M.; SOUZA, E. L de.; MARQUES, G.; MEIRELES, B.; CORDEIRO, A. T de C.; GULLÓN, B.; *et al.* Polyphenolic profile and antioxidant and antibacterial activities of monofloral honeys produced by Meliponini in the Brazilian semiarid region. *Food Research International*, v. 84, p. 61-68, 2016a. Doi: https://doi.org/10.1016/j.foodres.2016.03.012

SOUZA, J. M. B de.; SOUZA, E. L de.; MARQUES, G.; BENASSI, M de T.; GULLÓN, B.; PINTADO, M. M.; MAGNANI, M. Sugar profile, physicochemical and sensory aspects of monofloral honeys produced by different stingless bee species in Brazilian semi-arid region. LWT - *Food Science and Technology*, v. 65, p. 645-651, 2016b. Doi: https://doi.org/10.1016/j.lwt.2015.08.058

SOUZA, R.C da S.; YUYAMA, L.K.O.; AGUIAR, J.P.L.; OLIVEIRA, F.P.M. (2004). Valor nutricional do mel e pólen de abelhas sem ferrão da região amazônica. *Acta Amazonica*, v. 34, p. 333-336, 2004. Doi: https://doi.org/10.1590/S0044-59672004000200021

TUBEROSO, C. I. G.; JERKOVIC, I.; SARAIS, G.; CONGIU, F.; MARIJANOVC, Z.; KUS, P. M. Color evaluation of seventeen European unifloral honey types by means of spectrophotometrically determined CIE *L*° *C*°*ab* *H*°*ab* chromaticity coordinates. *Food Chemistry*, v. 145, p. 284-291, 2014. Doi: https://doi.org/10.1016/j.foodchem.2013.08.032

VIDAL, R.; FREGOSI, E. V de. *Mel*: características, análises físico-químicas, adulteração e transformação. Barretos: Instituto Tecnológico Científico “Roberto Rios”, 1984. 95p.

WATANABE, K.; RAHMASARI, R; MATSUNAGA, A.; HARUYAMA, T.; KOBAYASHI, N. Anti-influenza viral effects of honey in vitro: potent high activity of manuka honey. *Archives of Medical Research*, v. 45, p. 359-365, 2014. Doi: https://doi.org/10.1016/j.arcmed.2014.05.006

YÜCEL, Y.; SULTANOĞLU, P. Characterization of Hatay honeys according to their multi-element analysis using ICP-OES combined with chemometrics. *Food Chemistry*, v. 1, p. 231-237, 2013. Doi: https://doi.org/10.1016/j.foodchem.2013.02.046