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Stingless bee honey in Brazil: A review

Mel de abelhas sem ferrão no Brasil: Uma revisão

Miel de abeja sin aguijón en Brasil: Una reseña

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Abstract
This systematic review aimed to identify and synthesize data on the physical and physicochemical characteristics of stingless bee honey produced in Brazil. A total of 231 samples were analyzed across the selected studies, with most originating from the Northeast region. Key parameters evaluated included moisture, pH, acidity, sugars, and phenolic compounds. The findings reveal significant variability among samples and consistent deviations from standards established for Apis mellifera honey, particularly in moisture content, free acidity, HMF levels, and diastase activity. These differences highlight the need for specific regulatory standards for stingless bee honey in Brazil. The unique composition of this product underscores its distinct physicochemical profile and the importance of tailored quality criteria to ensure appropriate classification, safety, and market development.
Keywords: Quality; Standardization; Quality Control.

Resumo
Esta revisão sistemática teve como objetivo identificar e sintetizar dados sobre as características físicas e físico-químicas do mel de abelhas sem ferrão produzido no Brasil. Um total de 231 amostras foram analisadas nos estudos selecionados, com a maioria originária da região Nordeste. Os principais parâmetros avaliados incluíram umidade, pH, acidez, açúcares e compostos fenólicos. Os resultados revelam variabilidade significativa entre as amostras e desvios consistentes dos padrões estabelecidos para o mel de Apis mellifera, particularmente no teor de umidade, acidez livre, níveis de HMF e atividade diastásica. Essas diferenças destacam a necessidade de padrões regulatórios específicos para o mel de abelhas sem ferrão no Brasil. A composição única deste produto ressalta seu perfil físico-químico distinto e a importância de critérios de qualidade personalizados para garantir classificação, segurança e desenvolvimento de mercado adequados.
Palavras-chave: Qualidade; Padronização; Controle de Qualidade.

Resumen
Esta revisión sistemática tuvo como objetivo identificar y sintetizar datos sobre las características físicas y fisicoquímicas de la miel de abeja sin aguijón producida en Brasil. Se analizaron 231 muestras en los estudios seleccionados, la mayoría provenientes de la región Nordeste. Los parámetros clave evaluados incluyeron humedad, pH, acidez, azúcares y compuestos fenólicos. Los hallazgos revelan una variabilidad significativa entre las muestras y desviaciones consistentes de los estándares establecidos para la miel de Apis mellifera, particularmente en contenido de humedad, acidez libre, niveles de HMF y actividad de la diastasa. Estas diferencias resaltan la necesidad de estándares regulatorios específicos para la miel de abeja sin aguijón en Brasil. La composición única de este producto subraya su perfil fisicoquímico distintivo y la importancia de criterios de calidad específicos para garantizar una clasificación, seguridad y desarrollo de mercado adecuados.
Palabras clave: Calidad; Estandarización; Control de Calidad.

1. Introduction

Stingless bees, belonging to the Meliponini tribe (Hymenoptera, Apidae, Apinae), are widely distributed across tropical and subtropical regions, including tropical America, Africa, Southeast Asia, and Australia (Hrncir, Jarau & Barth, 2016). These bees play a crucial role in the pollination of both natural ecosystems and agricultural systems, in addition to producing a type of honey with unique characteristics that differ significantly from the honey produced by Apis mellifera. The properties of stingless bee honey are influenced by a variety of factors, such as vegetation, seasonality, soil, geographic location, and climate, all of which determine the composition of the nectar collected (Da Silva, 2022; Mokaya et al., 2022; Mduda, Hussein & Muruke, 2023). These specificities confer a distinct physicochemical profile to stingless bee honey, with important implications for its quality, preservation, and commercial potential.

Despite the growing scientific and economic interest in this product, there remains a significant gap in terms of standardization and specific regulation for stingless bee honey. While international and national standards—such as those established by the International Honey Commission (IHC, 2009) and Brazilian legislation (Normative Instruction N° 11/2000) define parameters for Apis mellifera honey, the criteria for stingless bee honey remain underexplored and often unsuitable. Recent studies have shown that this type of honey presents distinct physicochemical characteristics, such as higher moisture content, elevated acidity, and a unique sugar composition, which do not conform to conventional standards (Camargo, Oliveira & Berto, 2017; Biluca et al., 2021).

This discrepancy highlights the need to establish specific parameters that account for the unique attributes of stingless bee honey, thereby ensuring its quality and safety for consumption. This systematic review aimed to identify and synthesize data on the physical and physicochemical characteristics of stingless bee honey produced in Brazil.

2. Methodology

A quantitative research was conducted regarding the quantity and percentage of articles, and qualitative in relation to the discussions (Braucks et al., 2025; Ramos & Mazalo, 2024) using simple descriptive statistics with absolute frequency values in quantity, relative frequency percentage, and mean and standard deviation values presented in the studied articles (Oliveira, 2024). The systematic review, as described by Casarin et al. (2020), follows a rigorous and reproducible method, enabling a critical analysis of the available evidence. The careful application of inclusion and exclusion criteria allows for a structured synthesis of the collected data. In this study, the review was conducted based on established methodological guidelines to ensure the validity and reproducibility of the findings.

The scope of the research encompasses studies that examine the physical and physicochemical properties of stingless bee honey in Brazil, considering only peer-reviewed scientific journal publications.

The literature search was carried out in recognized databases, including SciELO, Scopus, Web of Science, and Google Scholar. Keywords included both Portuguese and English terms, combining expressions such as “mel de abelhas sem ferrão” / “stingless bee honey”, “propriedades físicas” / “physical properties”, and “propriedades físico-químicas” / “physicochemical properties”.

Inclusion criteria comprised studies published between 2010 and 2024 that present quantitative data on physical characteristics (such as color) and physicochemical attributes (including pH, moisture content, sugars, acidity, and phenolic compounds) of stingless bee honey in Brazil. Studies focusing exclusively on microbiological or therapeutic aspects without addressing physicochemical properties, as well as duplicate publications, were excluded.

Study selection was conducted in three stages: (1) Initial screening – analysis of titles and abstracts to assess thematic relevance; (2) Full-text reading – comprehensive evaluation of articles based on the inclusion criteria; and (3) Data extraction – collection of information regarding honey collection sites, analytical methods used, and average values of physical and physicochemical parameters.

The results were analyzed based on the available scientific literature, highlighting the differences identified among samples and their potential implications for the quality of stingless bee honey. Furthermore, the data were compared to Brazilian standards and regulations for apicultural products to assess the compliance of the studied honey with national legal requirements.

3. Results and Discussion

The selected articles are summarized in Table 1. A total of 231 honey samples from different regions of Brazil were analyzed in these studies, with 62.8% originating from the Northeast region (n = 145). The remaining samples were from the South (n = 52) and North (n = 16), accounting for 22.5% and 6.9%, respectively. No studies were identified for the Central-West or Southeast regions. One article did not specify the geographical origin of the honey samples, resulting in 18 samples (7.8% of the total) with no identified provenance.

Table 1 - Summary of the selected articles: authors, geographical region, number of samples, and parameters evaluated.

Author	Region and State	Number of Samples	Parameters Evaluated in the Article
Moreira et al. (2023)	Paraíba and Bahia	2	Moisture; total soluble solids (°Brix); Hydroxymethylfurfural (HMF); instrumental color; water activity; pH; free acidity; carbohydrates.
Biluca et al. (2016)	Santa Catarina	33	Moisture; total soluble solids (°Brix); diastase activity; Hydroxymethylfurfural (HMF); pH; free acidity; carbohydrates.
Grando et al. (2023)	Paraná	7	Moisture; total soluble solids (°Brix); Hydroxymethylfurfural (HMF); instrumental color; water activity; pH; free acidity.
Santos et al. (2022)	Santa Catarina	12	Moisture; water activity; free acidity; carbohydrates.
Vale et al. (2018)	Acre	16	Moisture; total soluble solids (°Brix); diastase activity; minerals; Hydroxymethylfurfural (HMF); pH; protein; free acidity; lactic acidity; total acidity; carbohydrates.
Fernandes, Rosa & Conti-Silva (2018)	Maranhão	40	Moisture; total soluble solids (°Brix); water-insoluble solids; minerals; pH; total acidity; carbohydrates.
Sousa et al. (2013)	Rio Grande do Norte	29	Moisture; minerals; pH; protein; vitamin C; total acidity; carbohydrates.
Bana et al. (2024)	Brazil (region not specified)	18	Moisture; total soluble solids (°Brix); diastase activity; Hydroxymethylfurfural (HMF); instrumental color; water activity; minerals; pH; free acidity; lactic acidity; total acidity; carbohydrates.
Sant'ana et al. (2020)	Piauí	29	Moisture; total soluble solids (°Brix); diastase activity; Hydroxymethylfurfural (HMF); pH; vitamin C; total acidity; carbohydrates.
Araújo et al. (2023)	Rio Grande do Norte	45	Moisture; minerals; Hydroxymethylfurfural (HMF); total acidity; carbohydrates.

Source: Authors (2025).

The quality standards established by the International Honey Commission (IHC, 2009) define thresholds for the physicochemical parameters of honey. According to these guidelines, the moisture content should not exceed 20 g/100 g, while the sum of fructose and glucose must reach at least 60 g/100 g. The allowable sucrose level is up to 5 g/100 g, and free acidity must not surpass 50 meq/100 g. Furthermore, the ash (mineral) content must be below 0.5 g/100 g, and the concentration of hydroxymethylfurfural (HMF) - an indicator of thermal degradation - must remain under 40 mg/kg. A minimum diastase activity of 8 Göthe units is required, which is associated with the preservation of the honey's natural enzymes.

In Brazil, Normative Instruction No. 11 of October 20, 2000 adopts similar criteria, though with some variations. The maximum moisture content is likewise set at 20 g/100 g, while the sum of fructose and glucose must exceed 65 g/100 g - a stricter requirement than that of the IHC. The sucrose limit remains at 5 g/100 g, and free acidity at 50 meq/100 g. The allowable mineral content can reach up to 0.6 g/100 g, slightly above the IHC standard. HMF content may reach 50 mg/kg, which is more lenient than the international guideline. The Brazilian regulation also establishes a maximum of 0.1 g/100 g for water-insoluble solids, restricting the presence of impurities (Brazil, 2000).

The Malaysian Standards (2017), which are specific to stingless bee honey, present notable differences. The maximum permitted moisture content is higher (35 g/100 g), possibly reflecting local climatic conditions. Instead of a minimum threshold, the sum of fructose and glucose is capped at 85 g/100 g. The maximum sucrose content allowed is 7.5 g/100 g - higher than those set by both the IHC and Brazilian regulations. Additionally, a maltose limit of 9.5 g/100 g is specified, a parameter not addressed in the other standards. The mineral content can reach up to 1.0 g/100 g, and the HMF limit is 30 mg/kg - stricter than both the Brazilian and IHC guidelines. The Malaysian regulation also includes a pH range between 2.5 and 3.8, which is not considered by the IHC or Brazilian standards.

Finally, the study by Camargo, Oliveira, and Berto (2017) proposes regulatory parameters for stingless bee honey in Brazil, offering broader tolerances. The maximum moisture content is set at 40 g/100 g—the highest among the analyzed standards. The sum of fructose and glucose must be at least 60 g/100 g, in line with IHC criteria. The allowable sucrose content is up to 6 g/100 g, an intermediate value between Brazilian and Malaysian regulations. Free acidity is limited to 50 meq/100 g, and mineral content to 0.6 g/100 g, similar to the Brazilian norm. The maximum HMF content is set at 20 mg/kg - the most stringent among the standards reviewed. The authors also propose a pH range between 2.9 and 4.5 and include water activity values ranging from 0.52 to 0.80 - a parameter not addressed by the other regulations. Like the Brazilian legislation, they suggest a maximum of 0.1 g/100 g for water-insoluble solids.

The differences in regulatory standards highlight the diversity of quality criteria for honey across regions. Among these parameters, moisture content is one of the most critical, as it directly influences the product's stability and shelf life. Accordingly, the reviewed studies assessed the moisture content of the honey samples, enabling comparisons with both current and proposed regulatory limits.

Moisture content was evaluated in all 10 studies (100%), encompassing a total of 231 honey samples. The values ranged from 17.0% to 45.82%, with an average of 31.61% (±17.0%). This average exceeds the maximum limit of 20% established by Brazilian legislation (Brazil, 2000) and the IHC (2009). Elevated moisture content can compromise honey preservation by promoting fermentation and spoilage. However, the average observed remained below the thresholds defined by the Malaysian Standards (2017) and Camargo, Oliveira, and Berto (2017), which set maximum values of 35.0 g/100 g and 40.0 g/100 g, respectively.

Moisture content in stingless bee honey tends to be higher, as reported by Chuttong et al. (2016), who observed an average moisture level of 31 g/100 g in Southeast Asia (Thailand), and by Khongkwanmueang et al. (2020), who reported a mean of 27.0 g/100 g. In another study conducted in Thailand, Mduda, Hussein, and Muruke (2023) found variations ranging from 20.18 g/100 g to 29.7 g/100 g.

The total soluble solids content was analyzed in seven studies (70.0%), comprising 145 samples (62.77%). The values ranged from 55.20% to 77.17%, with an average of 68.78 °Brix (±4.9). This average is higher than those reported by Khongkwanmueang et al. (2020) and Mduda, Hussein, and Muruke (2023), who found mean values of 51.70 °Brix and 57.12

°Brix, respectively. Total soluble solids reflect the presence of sugars, minerals, and organic acids in honey.

Carbohydrate content was evaluated in nine studies (90.0%), encompassing a total of 224 samples (96.97%). Maltose concentration ranged from 0.6% to 7.69%, with an average of 4.97% (±3.82%). According to the Malaysian Standards (2017), the maximum permissible level for maltose is 9.7 g/100 g, and the observed values fall within this limit. Glucose ranged from 8.21% to 36.25%, with an average of 26.16% (±4.55%), while fructose varied from 25.31% to 46.50%, with a mean of 35.25% (±4.70%). In the study conducted by Mduda, Hussein, and Muruke (2023) on Tanzanian honeys, average glucose and fructose contents were 18.01 g/100 g and 28.38 g/100 g, respectively.

Sucrose concentration ranged from 1.00% to 12.53%, with a mean of 2.79% (±2.56%), which is below the maximum limits established by the IHC (2009), Malaysian Standards (2017), Camargo, Oliveira, and Berto (2017), and Brazilian legislation (Brasil, 2000). This result is desirable, as high sucrose content may indicate adulteration. In the study by Mduda, Hussein, and Muruke (2023), the average sucrose level in Tanzanian honeys was 1.05 g/100 g, ranging from 0.46 g/100 g to 2.60 g/100 g.

Reducing sugars ranged from 42.00% to 79.29%, with a mean of 60.12% (±8.65%). These values are comparable to those reported by Biluca et al. (2021), who observed a range from 58.79% to 73.01%. Additionally, the values fall within the limits established by the IHC (2009), Malaysian Standards (2017), and Camargo, Oliveira, and Berto (2017), which set minimum requirements between 60.0 g/100 g and 85.0 g/100 g. However, the observed mean is below the minimum of 65.0 g/100 g required by Brazilian legislation (Brasil, 2000).

Total sugar content ranged from 44.30% to 79.59%, with an average of 59.35% (±7.26%), higher than the means reported by Chuttong et al. (2016), at 52.00% (±21.00%), and by Khongkwanmueang et al. (2020), at 50.00% (±7.80%). These findings reinforce that stingless bee honey presents a distinct sugar profile compared to conventional honey, characterized by lower levels of fructose and glucose, higher maltose content, and reduced sucrose levels.

Mineral content was analyzed in five studies (50.0%), comprising a total of 148 honey samples. The values ranged from 0.10% to 1.10%, with a mean of 0.38% (±0.20%). These results fall within the standards set by Brazilian regulations (Brasil, 2000), the IHC (2009), Malaysian Standards (2017), and Camargo, Oliveira, and Berto (2017). Similar findings were reported by Chuttong et al. (2016) and Mduda, Hussein, and Muruke (2023), who observed an average ash content of 0.33 g/100 g in stingless bee honeys from Southeast Asia and Tanzania, respectively.

Water-insoluble solids content was assessed in one study (10.10%), involving 40 honey samples. The values ranged from 0.09% to 0.11%, with an average of 0.1% (±0.01%), aligning with the limits set by Brazilian standards (Brasil, 2000) and Camargo, Oliveira, and Berto (2017). This parameter reflects the presence of solid particles in honey, such as wax fragments and pollen grains.

Diastase activity was evaluated in four studies (40.0%), covering 96 samples. The values ranged from 3.00 to 49.69 Göthe, with a mean of 9.01 Göthe (±8.65), exceeding the minimum threshold of 8 Göthe required by both the IHC (2009) and Brazilian regulations (Brasil, 2000). This result indicates the presence of enzymes responsible for starch conversion, suggesting the honey was not subjected to excessive heating. For stingless bee honey from Southeast Asia, Chuttong et al. (2016) reported diastase levels ranging from 0.050 to 4.9 Göthe, with a mean of 1.5 (±1.6) Göthe.

HMF content was analyzed in seven studies (70.0%), totaling 150 honey samples. The values ranged from 0.80 to 57.60 mg/kg, with an average of 5.49 mg/kg (±0.37 mg/kg), remaining within the maximum limits set by international standards: 40 mg/kg by the IHC (2009), 50 mg/kg by Brazilian legislation (Brasil, 2000), 30 mg/kg by Malaysian Standards (2017), and 20 mg/kg by Camargo, Oliveira, and Berto (2017). HMF (hydroxymethylfurfural) is a marker of thermal degradation and honey aging. Chuttong et al. (2016) reported an average of 8.7 mg/kg in honey samples from Thailand, while Mduda, Hussein, and Muruke (2023) observed a mean of 23.7 mg/kg in Tanzanian honey. Zheng et al. (2025) reported relatively low HMF levels ranging from 0 to 9.64 mg/kg in Chinese stingless bee honeys. Mokaya et al. (2022) suggest that stingless bee honey exhibits resistance to HMF formation, possibly due to its higher moisture, acidity, and fructose content, as also noted by Biluca et al. (2021).

Free acidity was analyzed in six studies (60.0%), covering a total of 88 honey samples (30.20%). Values ranged from 16.20 to 139 mEq/kg, with an average of 61.89 mEq/kg (±33.53). This average exceeds the maximum limit of 50 mEq/kg established by Brazilian legislation (Brasil, 2000), the IHC (2009), and Camargo, Oliveira, and Berto (2017). Similarly, Mduda, Hussein, and Muruke (2023) reported an average free acidity of 60.67 mEq/kg in stingless bee honey from Tanzania, while Zheng et al. (2025) reported values ranging from 145.02 to 276.78 mEq/kg in Chinese honeys.

Lactonic acidity was measured in two studies (20.0%), comprising 34 honey samples (14.72%). Values ranged from 4.80 to 14.25 mEq/kg, with a mean of 9.16 mEq/kg (±2.31). Total acidity was analyzed in six studies (60.0%), involving 177 honey samples (76.62%). The observed values varied from 23.00 to 116.10 mEq/kg, with an average of 48.91 mEq/kg (±25.22). Zheng et al. (2025) reported total acidity values ranging from 166.67 to 298.51 mEq/kg in Chinese stingless bee honeys.

pH was measured in eight studies (80.0%), including 174 honey samples (75.32%). The values ranged from 2.70 to 6.56, with an average of 3.82 (±0.56). This average falls within the ranges established by the Malaysian Standards (2017) of 2.5 to 3.8 and by Camargo, Oliveira, and Berto (2017) of 2.9 to 4.5, indicating that the analyzed honeys exhibit the characteristic acidity of the product. Similar findings were reported by Chuttong et al. (2016), Khongkwanmueang et al. (2020), and Mduda, Hussein, and Muruke (2023), who found average pH values of 3.6, 3.70, and 3.66, respectively, in honeys from stingless bee species. The low pH of honey contributes to microbial inhibition, enhancing its stability and prolonging its shelf life (Lage et al., 2012).

Water activity was assessed in four studies (40.0%), covering a total of 39 honey samples (16.88%). The values ranged from 0.520 to 0.840, with a mean of 0.755 (±0.062). This average falls within the recommended range of 0.52 to 0.80 established by Camargo, Oliveira, and Berto (2017). The results are comparable to those of Mokaya et al. (2022), who reported values ranging from 0.70 to 0.77. Despite its high water activity, stingless bee honey is relatively resistant to fermentation due to its low pH and high free acidity, which inhibit microbial growth.

Protein content was examined in two studies (20.0%), involving a total of 45 honey samples (19.45%). Observed values ranged from 0.10% to 1.80%, with an average of 0.37% (±0.44%). In their study of Indonesian stingless bee honey, Agussalim et al. (2021) reported protein contents ranging from 0.17 to 1.66 g/100 g of honey. Proteins and amino acids present in honey originate from nectar, pollen, and honeydew (Da Silva et al., 2016).

Vitamin C content was analyzed in two studies (20.0%), covering a total of 58 honey samples (25.11%). The values ranged from 0.75 to 36.1 mg/100 g, with a mean of 19.37 mg/100 g (±13.65 mg/100 g). Similarly, in Thailand, Mduda, Hussein, and Muruke (2023) reported variations from 7.42 to 60.50 mg/100 g of vitamin C.

Color parameters using the CIE-LAB values L* (lightness), a* (redness-greenness), and b* (yellowness-blueness) were reported in three studies (30.0%), totaling 27 honey samples (11.67%). The average L* value was 43.78 (±5.87), ranging from 38.02 to 54.21. The a* parameter had an average of −1.49 (±2.27), ranging from −5.95 to 2.84, while the mean b* value was 13.59 (±9.66), ranging from −3.01 to 30.26. Therefore, the L* value (43.78) being ≤ 50 classifies the honey as dark, with red (a* = −1.49) and yellow (b* = 13.59) components. This is consistent with Zheng et al. (2025), who reported that Chinese stingless bee honey exhibited a darker color, with tones between yellow and green.

4. Final Considerations

Physicochemical analyses confirm the need to establish separate national standards for stingless bee honey in terms of moisture content, free acidity, diastase activity, and HMF levels, as these parameters diverged from the limits set for Apis mellifera honey. The distinctiveness of this type of honey - particularly regarding moisture content and sugar composition—reinforces the importance of regulatory frameworks tailored to its unique characteristics.

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