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CHEMICAL CHARACTERISTICS OF BRACATINGA HONEYDEW HONEY AND BLOSSON HONEY PRODUCED IN BOM RETIRO COUNTY-SC-BRAZIL

CARACTERÍSTICAS QUÍMICAS DE MEL FLORAL E MEL DE MELATO ORIUNDOS DO MUNICÍPIO DE BOM RETIRO SC-BRASIL

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Abstract

The honeys need to be characterized and identified, so that a control can be made based on its chemical characteristics and mineral content. In order to check some floral honey and honeydew honey chemical characteristics, sampling was made in ten different apiaries in two different periods of the year. The samples were tested for protein, nitrogen, ash, pH, moisture, reducing sugars, apparent sucrose, phosphorus, potassium, calcium , magnesium, sulfur, cooper, iron, manganese and zinc content. Mineral composition values varied significantly when honeydew and floral honey were compared. Honeydew honey differed from floral honey in its higher phosphorous, potassium, cooper, manganese and zinc content. The contents of reducing sugar and total reducing sugar found in floral honey were considerably higher than those found in honeydew honey.

Palavras-chave: Chemical composition; mineral content; quality control.

Resumo

Para que um controle efetivo da qualidade dos méis seja feito, estes precisam ser caracterizados e identificados de acordo com suas características químicas e índice mineral. Com o objetivo de estudar as características do mel floral e mel de melato produzidos no município de Bom Retiro (SC), amostras de mel foram coletadas em dez diferentes apiários em duas épocas do ano. Foram determinados os teores de umidade, cinzas, proteína, açúcares redutores (AR), açúcares redutores totais (ART), sacarose, pH, nitrogênio, potássio, fósforo, cálcio, magnésio, enxofre, cobre, ferro, manganês e zinco. Os méis de melato se mostraram mais ricos em minerais que os méis florais,

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notadamente quanto aos teores de fósforo, potássio, cobre, manganês e zinco. Os méis de melato também apresentaram maiores teores de cinzas e proteína, e menores teores de açúcares redutores e açúcares redutores totais.

Palavras-chave: Composição química; Conteúdo mineral; Controle de qualidade.

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1. Introduction

Honey, a natural product synthesized by bees, can be categorized based on the origin of the collected substrate. Floral honey is derived from the nectar of blossoms, whereas honeydew honey is produced from plant secretions or the excretions of sap-feeding insects, such as aphids, that consume phloem sap from living plant tissues (MAPA, 2000; MERCOSUL/GMC, 1999). Both types undergo similar enzymatic processing by bees during honey production. However, honeydew honeys exhibit significant differences from floral honeys and among themselves, attributable to variations in the ingested sap and the enzymes introduced by the sap-feeding insects (ORTH et al., 2024; SHAABAN, 2020).

In literature, honeydew honeys are reported to be common in several countries, being produced from the exudates of sap-sucking insects that Interact with various botanical species. Examples include the aphid *Rhopalosiphum padi* on sorghum (*Sorghum bicolor*) in Egypt (FARAG et al., 2024), the scale insect *Ultracoeslostoma assimile* on southern beech (*Nothofagus* ssp.) in New Zealand (CHESSUM et al., 2022), the brown planthopper *Nilaparvata lugens* and green leafhopper *Naphotettix cincticeps* in rice (*Oryza sativa*) in China (ZHU et al., 2020) and the scale insect *Marchalina hellenica* in grecian fir (*Abiens cephalonica*), allepo pine (*Pinus halepensis*) and calabrian pine (*Pinus brutia*) in Greece (BACANDRITSOS, 2004; GOUNARI et al., 2006).

Brazil's vast territory encompasses diverse climatic regions (equatorial, tropical, semi-arid, highland tropical, and subtropical), which contribute to the production of various types of honeydew honey (CAMPOS et al., 2000; 2003). In the state of Santa Catarina, a notable example is the bracatinga (*Mimosa scabrella* Benth) honeydew honey, characterized by high free acidity, elevated electrical conductivity, significant antioxidant capacity, and low glucose content, setting it apart from floral honeys (BRUGNEROTTO et al., 2019; MARTINS-MANSANI et al., 2021; REBOLLAR & BAUMGARTEN, 2019; WOLFF et al., 2024). Its distinctive qualities have garnered increasing international appreciation, and it has been recognized with a denomination of origin certification, underscoring its cultural and economic significance in southern Brazil (DORTZBACH et al., 2020; VIEIRA et al., 2021).

Bracatinga honeydew honey is produced by Apis mellifera bees from the sugary excretions of the scale insect Stigmacoccus paranaensis Foldi (Hemiptera: Coccoidea) (ORTH et al., 2024; WOLFF et al., 2015), which feeds on the sap of the bracatinga tree (Mimosa scabrella Benth) (MARTINS-MANSANI et al., 2021; ORTH et al., 2024; WOLFF et al.,2024), a leguminous species native to the high-altitude regions of southern Brazil, particularly in the Serra Catarinense area of Santa Catarina (MAZUCHOWSKI et al., 2014; ZAMBONIM & VIEIRA, 2024; WOLFF et al.,2024). These scale insects inhabit the subcortical layers of bracatinga trees,

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extracting large volumes of phloem sap to meet their nutritional needs. The excess sugars are excreted as honeydew onto the tree's bark and leaves, serving as a carbohydrate-rich resource for honeybees (MARTINS-MANSANI et al., 2021; ORTH et al., 2024; WOLFF et al., 2024).

The dark coloration observed on trees and plants associated with honeydew sources is attributed to the proliferation of sooty mold fungi (Capnopodium spp) on the surplus pseudo-nectar exudate over the plant and sometimes even the ground (DORTZBACH et al., 2024). Particles of sooty mold fungi (vulgarly known for the fumagina) are typically found in honeydew honey and serve as indicators in the identification and authentication of honeydew (LIMA, 1942). This pseudo nectar covered of fumagina is collected by bees during the summer months, a period characterized by a relative scarcity of floral nectar compared to spring. This seasonal behavior underscores the adaptability of bees in sourcing alternative carbohydrate-rich exudates to sustain their colonies and continue honey production (BRUGNEROTTO et al., 2019; MAZUCHOWSKI et al., 2014; RICCE et al., 2024; WOLFF et al., 2024).

The characterization and authentication of honeydew honeys are essential to ensure quality control and meet the stringent demands of international markets. Honeydew honeys exhibit distinct properties compared to blossom honeys. These differences necessitate specific analytical approaches for accurate identification and quality assessment (BERGAMO et al., 2018; BERGAMO et al., 2019).

The main objective of this work is to characterize chemical characteristics (ash, moisture, nitrogen, pH, protein, reducing sugar, sucrose) and mineral content (calcium, cooper, iron, magnesium, potassium, zinc) of honeydew honey produced by *Apis mellifera* in Bom Retiro-SC-Brazil.

2. Material and Methods

Sampling and sample preparation - A total of 20 honey samples, derived from ten different apiaries located in the municipality of Bom Retiro (Santa Catarina, Brazil), were collected and used in this study. The samples were randomly harvested at two different times of the year from each apiary (Table 1). Bracatinga honeydew honeys were obtained during periods of high exudate production, whereas blossom honeys were harvested during periods of low exudate production (BERGAMO et al., 2019). The honey samples, if free of granulation, were mixed thoroughly by stirring. If granulated, the samples were heated 30 minutes, tightly covered, in a water bath at 60ºC (CAMPOS et al., 2001).

Honey mineralization - For the mineral analysis, honey samples were first mineralized. The mineralization was made by 2:1 hydrogen peroxide (H2O2) and perchloric acid (HClO4) digestion at 220ºC for 3 hours (McDANIEL, 1992).

Phosphorous determination - For the phosphorous determination, approximately 0.5 g of mineralized honey were weighed accurately and dissolved 1:100 in distilled water. A further 2 mL of 0.25% ammonium metavanadate (NH4VO3) and 2 mL of 5% ammonium molybdate ([NH4]2MoO4) were added. After 15 minutes, the colour was measured in Analyser colorimeter at 660 nm (MIYAZAWA et al., 2009).

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Copper, iron and zinc determination - For the copper, iron and zinc determination, approximately 0.5 g of mineralized honey were weighed accurately and dissolved 1:100 in distilled water. The copper, iron and zinc content were measured by atomic absorption spectrophotometry, with atomisation by acetylene flame, in Perkin Elmer model Analyst 100 atomic absorption spectrophotometer (MIYAZAWA et al., 2009).

Table 1 – Botanical and geographical information of apiaries and sampling.

SAMPLE *	APIARY	TYPE OF HONEY	BOTANICAL ORIGIN	SAMPLING DATE	APIARY LOCATION	ALTITUDE
H1	1	honeydew	*M. scabrella*	December 4 th	27º 52' 07" S	924 m
B1		blossom	*Multiflower*	April 15 th	49º 32' 46" W	
H2	2	honeydew	*M. scabrella*	December 4 th	27º 50' 10" S	993 m
B2		blossom	*Multiflower*	April 15 th	49º 29' 27" W	
H3	3	honeydew	*M. scabrella*	05 december	27º 49' 53" S	1.193 m
B3		blossom	*Baccharis dracunculifolia*	18 april	49º 23' 16" W	
H4	4	honeydew	*M. scabrella*	05 december	27º 50' 23" S	914 m
B4		blossom	*Eucayptus sp.*	19 april	49º 29' 32" W	
H5	5	honeydew	*M. scabrella*	05 december	27º 51' 17" S	980 m
B5		blossom	*Multiflower*	16 april	49º 29' 15" W	
H6	6	honeydew	*M. scabrella*	06 december	27º 53' 28" S	950 m
B6		blossom	*Multiflower*	20 april	49º 48' 12" W	
H7	7	honeydew	*M. scabrella*	06 december	27º 48' 43" S	896
B7		blossom	*Multiflower*	15 april	49º 33' 01" W	
H8	8	honeydew	*M. scabrella*	07 december	27º 45' 21" S	926 m
B8		blossom	*Baccharis dracunculifolia*	16 april	49º 31' 31" W	
H9	9	honeydew	*M. scabrella*	07 december	27º 49' 39" S	1,141 m
B9		blossom	*Multiflower*	20 april	49º 29' 20" W	
H10	10	honeydew	*M. scabrella*	07 december	27º 50' 05" S	944 m
B10		blossom	*Multiflower*	20 april	49º 29' 36" W	

* Each sample is mean of three replicates.
H – Bracatinga honeydew honey; B – Blossom honey.

Calcium and magnesium determination - For the calcium and magnesium determination, approximately 0.5 g of mineralized honey were weighed accurately and dissolved 1:100 in distilled water and 1:50 in 2.5% lanthanum solution. The calcium and magnesium content were measured by atomic absorption spectrophotometry, with atomisation by acetylene flame, in Perkin Elmer model Analyst 100 atomic absorption spectrophotometer (MIYAZAWA et al., 2009).

Potassium determination - For the potassium determination, approximately 0.5 g of mineralized honey were weighed accurately and dissolved 1:100 in distilled water. The potassium content was measured by flame spectrophotometry (gas GLP) in Analyser spectrophotometer (MIYAZAWA et al., 2009).

Nitrogen and protein determination - The nitrogen content was determined by the Microkjeldahl method (Hart, 1971). The protein content was determined by the

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Lund reaction (PREGNOLATTO & PREGNOLATTO, 2008).

Ash determination - For the ash determination, approximately 10 g of each honey sample were weighed accurately in crucibles, burned and heated in muffle at 600°C overnight (PREGNOLATTO & PREGNOLATTO, 2008).

Moisture determination - For the moisture determination, approximately 4 g of each honey sample were weighed accurately in crucibles, and the moisture content was taken as weight loss after heating at 105°C for 6 hours (PREGNOLATTO & PREGNOLATTO, 2008).

pH determination - The pH was measured by electrometric method in Digimed pH meter with combined calomel / glass electrode as described by PREGNOLATTO & PREGNOLATTO, 2008.

Reducing sugars (AR), total reducing sugars (ART) and sucrose determinations - Reducing sugars (AR), total reducing sugars (ART) and sucrose concentrations were determined by high-performance liquid chromatography (HPLC) in a Dionex DX300 ionic chromatograph with pulsed detection of carbohydrates in gold detector electrode and a Cabopack PA1 column using 100 mmol L-1 sodium hydroxide (NaOH) as the eluent, flow of 1 mL min-1 and sample volume of 20□L (MARIANO-DA-SILVA et al., 2011).

Statistical analysis - Variance analysis (F-test) was used to analyse the variables, following a randomized blocks delineation in crossed model, with triplicate. The averages comparisons were made by multiple comparison Tukey method (PIMENTEL-GOMES, 2000).

4. Results and Discussion

Floral and honeydew honeys are distinguished by their markedly different botanical and entomological origins, which justifies the establishment of specific regulatory standards for each type (MAPA, 2000; MERCOSUL/GMC, 1999). According to these regulations, a minimum of 65% reducing sugars is required in honey. The results of the chemical analyses (Tables 2 and 3) show that, although the reducing sugar and total reducing sugar contents in honeydew honey were considerably lower than those in floral honey, both types met the minimum regulatory requirement. In contrast, sucrose levels were significantly higher in honeydew honey, further highlighting the compositional differences between these two honey classes.

According to Brazilian legislation (MAPA, 2000), the maximum permissible sucrose content in honey is 6%, and both the analyzed honeydew and floral honey samples complied with this standard. Sucrose concentrations exceeding 8% are often indicative of premature harvesting, wherein sucrose has not yet been fully hydrolyzed into glucose and fructose by the enzyme invertase (SERAGLIO et al., 2021).

According to Brazil's legislation (MAPA, 2000) the maximum sucrose value permitted is 6%, and both analyzed honeydew honey and floral honey meet these standards. A higher concentration of sucrose (over 8%) often indicates an early harvest of the honey, that is, a product where sucrose has not yet been totally turned into glucose and fructose through invertase (SERAGLIO et al., 2021).

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Table 2 - Nitrogen (N), pH, sucrose, protein, reducing sugars (AR), total reducing sugars (ART) and moisture concentrations to honey samples.

SAMPLE*	Moisture (g $100g^{-1}$)	N (mol kg^{-1})	protein (mL)	sucrose (g $100g^{-1}$)	AR (g $100g^{-1}$)	ART (g $100g^{-1}$)	pH
H1	13.4ghi	0.06b	0.50b	2.3b	71.2a	74.0abc	4.16b
H2	15.0ab	0.06b	0.50b	2.3b	70.7abc	73.3abcd	4.17b
H3	14.5cd	0.06b	0.50b	3.0ab	71.2a	74.4ab	4.15b
H4	15.0ab	0.05b	0.50b	2.6ab	71.2a	74.1abc	4.15b
H5	15.3a	0.05b	0.51b	2.9ab	71.6a	74.6ab	4.10b
H6	14.9abc	0.05b	0.50b	2.6ab	71.2a	73.9abc	4.17b
H7	14.1de	0.06b	0.52b	3.0ab	71.5a	74.8ab	4.14b
H8	15.2a	0.06b	0.50b	2.5ab	71.2a	74.0abc	4.11b
H9	14.9abc	0.06b	0.51b	2.3b	70.9ab	73.5abc	4.14b
H10	14.9abc	0.06b	0.51b	2.4b	70.5abc	73.1abcd	4.17b
B1	13.8efg	0.16a	1.40a	4.7ab	56.6e	61.4e	4.84a
B2	13.9ef	0.16a	1.42a	4.2ab	66.7cd	71.1cd	4,95a
B3	13.2hi	0.16a	1.41a	4.8a	64.9d	70.1d	4,96a
B4	13.5fgh	0.16a	1.40a	4.6ab	70.4abc	75.3a	4.86a
B5	14.7bc	0.16a	1.40a	3.9ab	66.8bcd	70.9cd	4.87a
B6	13.1hi	0.16a	1.41a	4.3ab	68.3abcd	72.8abcd	4,95a
B7	14.0e	0.16a	1.40a	4.1ab	67.6abcd	72.0bcd	4.88a
B8	13.9ef	0.16a	1.40a	3.9ab	67.7abcd	71.8bcd	4.95a
B9	13.2hi	0.16a	1.40a	3.9ab	67.9abcd	72.0bcd	4.94a
B10	13.1i	0.16a	1.40a	4.3ab	68.0abcd	72.1abcd	5.02a
S.D.**	0.887	1.403	1.403	19.408	1.661	1.256	1.293
D.M.S.***	0.45374	0.00552	0.00552	2.40356	4.13873	3.28376	0.21331

* Each sample is mean of three replicates

** Standard derivation (%)

*** Minimum significant mean difference

[a-d] Means with different superscript letters in the same column are significantly different ($P < 0.01$) according the F and Tukey testes.

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Table 3 – Ash, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), cooper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) contents in honey samples.

	ash	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
SAMPLE*	%	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})	(mmol kg^{-1})
H1	0.20ef	6.47b	23.11b	5.07a	4.25a	6.34a	41.97bc	413.36a	73.11a	31.00c
H2	0.15ef	3.13c	17.99d	4.91a	3.56a	6.24a	37.17cd	327.37c	72.51a	30.90c
H3	0.18ef	6.56b	20.47c	5.07a	4.25a	6.31a	41.69bc	371.25b	73.30a	46.24b
H4	0.18ef	6.56b	17.91d	4.99a	3.84a	6.13a	37.17cd	247.96e	73.42a	46.24b
H5	0.21ef	6.04b	22.94b	5.07a	4.13a	6.57a	40.05bcd	414.13a	72.87a	30.91c
H6	0.07f	3.33c	17.91d	4.91a	3.84a	6.13a	35.79d	327.74c	73.23a	35.94c
H7	0.11f	3.55b	20.81c	5.07a	4.39a	6.31a	42.79b	371.45b	73.1a	46.54b
H8	0.07f	6.67b	17.99d	4.99a	3.98a	6.33a	38.26bcd	248.25e	73.42a	46.24b
H9	0.16ef	6.57b	20.55c	5.07a	4.11a	6.41a	42.79b	371.31b	73.29a	46.19b
H10	0.13ef	6.54b	18.25d	4.91a	3.71a	5.92a	39.63bcd	248.24e	72.57a	45.99b
B1	0.22ef	12.81a	103.09a	4.99a	4.25a	6.13a	124.39a	245.49e	n.d.b	60.62a
B2	0.34de	13.34a	102.92a	2.58b	3.98a	6.13a	124.67a	289.51d	n.d.b	61.54a
B3	0.46cd	12.80a	102.58a	2.49b	3.98a	6.24a	125.49a	247.83e	n.d.b	61.79a
B4	0.90a	12.91a	103.09a	5.07a	4.11a	6.24a	125.21a	248.65e	n.d.b	61.54a
B5	0.54bcd	13.02a	102.84a	4.99a	4.11a	6.18a	123.84a	245.69e	n.d.b	60.01a
B6	0.69ab	13.23a	102.75a	2.58b	3.84a	6.33a	124.25a	289.68d	n.d.b	61.39a
B7	0.61bc	12.91a	102.33a	2.49b	3.84a	6.54a	123.44a	247.97e	n.d.b	61.64a
B8	0.56bc	12.91a	103.44a	5.07a	3.98a	6.34a	124.66a	248.86e	n.d.b	61.38a
B9	0.75ab	13.24a	102.41a	4.99a	4.11a	6.34a	124.80a	247.99e	n.d.b	61.90a
B10	0.56bcd	13.45a	102.67a	2.58b	3.84a	6.33a	124.39a	248.97e	n.d.b	61.78a
S.D.**	17.425	4.438	0.580	6.041	10.039	7.304	1.804	0.583	1.579	4.016
D.M.S.***	0.25611	1.51331	1.28194	0.95808	1.45094	1.65883	5.34541	6.20880	2.08189	1.90872

n.d. not detectable;
* Each sample is mean of three replicates
** Standard derivation (%)
*** minimum significant mean difference

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BOGDANOV et al. (2018), analyzing an extensive database, proposed a minimum reducing sugar concentration of 60% for floral honey and 45% for honeydew honey. According to the same authors, honeydew honey may contain up to 15% sucrose, whereas floral honey presents a maximum sucrose content of 6%. This distinction in reducing sugar and sucrose concentrations between floral and honeydew honeys is well established. BERGAMO et al. (2019) analyzed 16 samples of Bracatinga honey and 25 samples of multifloral honey from the state of Santa Catarina, reporting average concentrations of 36.29% fructose and 23.75% glucose.

SERAGLIO et al. (2021), analyzing six Bracatinga honey samples collected in Santa Catarina, reported average glucose and fructose contents of 36.3% and 23.9%, respectively. AZEVEDO et al. (2021), examining honeydew honey samples from five municipalities in the Catarinense Plateau, found fructose concentrations ranging from 33.1% to 52% and glucose concentrations between 23.7% and 32.2%. SILVA et al. (2022), analyzing 22 honeydew honey samples from the Catarinense Plateau, reported glucose values ranging from 22.4% to 30.5% and fructose concentrations between 30.0% and 37.7%.

CAMPOS et al. (2003) reported reducing sugar concentrations ranging from 65.44% to 77.11% in floral honey and from 55.73% to 67.20% in honeydew honey. The honeydew samples analyzed in the present study originated from Rancho Queimado, Santa Catarina.

The variation observed in these values may be attributed to the degree of maturity of the honeys, as more mature honeys tend to exhibit lower fructose and glucose contents (COSTA et al., 2024; SERAGLIO et al., 2021).

Protein concentration varied considerably when honeydew and floral honey were compared. Honeydew tended to present a significantly higher concentration, although all recorded values were in agreement with Brazilian legislation: 0.6 to 3.0 ml (MAPA, 2000).

This trend was not observed by KOMATSU et al. (2002). These authors analyzed 94 samples of wild honey and found, in most samples, concentrations that do not meet those established by the Brazilian legislation.

According to BATH (1999), the variation in protein concentrations occurs due to the origin of this honey (floral origin or exudation). These authors found averages of 0.036 and 0.65 in Helianthus and Eucalyptus, respectively. MARCHINI et al. (2005) found variations from 0.23% to 0.49% in 121 samples of wild and eucalyptus honeys from the State of São Paulo. MORETI et al. (2009) found, in the state, variations from 0.118% to 0.706%, while ARRUDA et al. (2004), working with 21 samples from Chapada do Araripe found values from 0.118% to 0.254%.

pH values vary significantly when honeydew and floral honey were compared. The honey is naturally acid (WELKE et al., 2008), and as it had been described by CAMPOS et al. (2001), honeydew tended to show a higher value of pH than those found in floral honey. Consequently, 90% of honeydew analyzed does not meet the values proposed by the Brazilian legislation (MAPA, 2000) which proposes pH being between 3.30 and 4.60.

This trend was also observed by BENTABOL-MANZANARES (2011), that working with the 24 honeydew honey samples and 53 samples of floral honey, found rates ranging from 3.89 and 5.27 and 3.68 and 4, 54, respectively.

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This difference in acidity between honeydew and floral honey derives from floral honey being richer in glucose. This monossacharide is converted, through the action of D-glucose oxidase enzyme, into gluconic acid, which comprises 70 to 90% of honey organic acids (ALSHAREEF et al., 2022; SAHIN et al., 2020).

Humidity concentrations found did not vary significantly in the results obtained from both honeydew and floral honey. All values found are in agreement with those required by Brazil (MAPA, 2000) and MERCOSUL (MERCOSUL/GMC, 1999) standards which demand a maximum of 20%.

Ash concentrations, reflected in the mineral composition (ARRUDA et al., 2004), varied considerably in both honeydew and floral honey. Honeydew presented values significantly higher. However, all values found in this paper met MERCOSUL (MERCOSUL/GMC, 1999) standards which require a maximum of 0.6% to floral honey and 1.2% honeydew.

BOGDANOV et al. (2018), after analyzing the results of several papers, had already noticed that floral honey has a lower concentration of ash than honeydew honey. CAMPOS et al. (2001), measured ash in floral honey and bracatinga honey observing values of 0.13 and 0.28%. MORETTI et al. (2009) measured ash in 52 samples of floral honey from Ceará State and found values of 0.013 to 0.670%.

MARIANO-DA-SILVA et al. (2011), speculate that the ash content is higher in honeydew honey compared to nectar honey due to the composition of the exudates collected by bees. The authors reported ash concentrations ranging from 0.0825% to 0.2445% in floral honey, whereas honeydew honey derived from plant exudates exhibited higher ash levels, ranging from 0.2553% to 1.0405%.

Calcium, sulfur and magnesium concentrations did not vary when floral honey and honeydew were compared. MARCHINI et al. (2005) e COSTA et al. (2024) presented concentrations of calcium similar to those found in the present paper. However, PAMPLONA (1989), analyzing both floral honey and honeydew honey observed concentrations of the three minerals being a little lower than those found in the present paper, while he did not observe any important variation among concentrations of calcium, he did observe higher contents of brimstone.

DOS-SANTOS et al. (2008) studying samples of floral honey produced in three different regional climates in the southwest Bahia (semi-arid, Atlantic and transitorial forest zones) found concentrations of calcium and magnesium lower than those reported in this paper.

SERAGLIO et al. (2021), AZEVEDO et al. (2021) e BERGAMO et al. (2018) analisando amostras de mel de melado oriundos do planalto catarinense mensuraram concentrações de cálcio e magnésio abaixo das encontradas no presente estudo.

Iron concentrations were higher in some of the honeydew samples, while in others, concentrations were the same as those found in floral honey. No reason for this variation has been found, since according to studies (PAMPLONA, 1989), honeydew should present higher concentration of iron, one of the reasons why this kind of honey has a darker color. PAMPLONA (1989) observed contents varying from 0.0632 to 0.2526 mmol kg-1 in floral honey, and from 0.0368 to 1.7634 mmol kg-1 in honeydew. These values may seem somewhat divergent since the values found in the present study were 3,300 times as higher in floral honey, and approximately 500 higher in honeydew.

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The unusual iron concentrations found can be a regional characteristic and deserve to be studied in future works. Furthermore, the dark color from this kind of honeydew honey is due to high iron contents (CAMPOS et al., 2001; 2003).

The phosphorus, potassium, copper and zinc concentrations were higher in honeydew in every analyzed sample, while manganese is lower. This trend was also observed by BERGAMO et al. (2018), although the mineral concentrations reported by these authors were higher than those found in the present study. Potassium concentrations agree with those reported by AZEREDO et al. (1998), AZEVEDO et al. (2021), PAMPLONA (1989) and MARCHINI et al. (2005). The phosphorus concentrations were higher while the copper and zinc concentrations were lower than those reported by MARCHINI et al. (2005).

As it can be observed above, the concentrations of minerals found in honey are considerably variable, being modified by factors related to bees, apiarist, climate, soil and flora (BOGDANOV et al., 2018). In this way, concentrations found in honey from a certain region, will not be the same as in other regions. Based in this, KEK et al. (2017) proposed classifying honey by geographic regions, regarding its mineral composition.

The higher phosphorus, potassium, cooper and zinc content makes the bracatinga honeydew honey better than floral honey as an important potential source of these minerals. The higher mineral content is important for human nutrition, as well as for blood chemistry.

5. Conclusion

Ash, pH, nitrogen, protein and sucrose present higher values in honeydew than in flower honeys, while reducing sugars are lower; moisture values are similar in the 2 groups. All values found comply with those required by Brazil and MERCOSUR standards, with the exception of honeydew pH values.

Mineral composition values varied significantly when honeydew and floral honey were compared. Bracatinga honeydew honey differed from floral honey in its higher phosphorous, potassium, cooper, manganese and zinc content. This differed mineral compound could, still, be used to classify this kind of honey.

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