'MIEL DE ANGELITA': NUTRITIONAL COMPOSITION AND PHYSICOCHEMICAL PROPERTIES OF *Tetragonisca angustula* HONEY

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SUMMARY

Pre-Hispanic cultures that lived in territories of Central and South America practiced meliponiculture, extracting and processing honey and other products from several stingless bee species. Colonization of these territories introduced beekeeping of Apis mellifera*, and practically eliminated meliponiculture. Nevertheless, honey of the species* Trigona angustula *(Latreille, 1811), called 'miel de angelita' (or 'little-angel honey') has retained a place in the traditional market, with about ten times the cost of* A. mellifera *honey. Due to its scarcity and to the fact that it is popularly considered to have medicinal properties. Although there are noticeable differences between miel de angelita and common* A. mellifera *honeys, the lack of objective quality standards has often allowed falsification. Thus, assessment of its physicochemical properties is of interest. In this study, the main nutritional and physicochemical characteristics were analyzed in 44 samples from seven regions of Colombia. Results showed a major composition of 24.3 ±2.3% moisture, 23.5 ±6.4% glucose, 30.1 ±5.4% fructose and 4.2 ±2.4% disaccharides (sucrose and maltose). The honeys presented 0.205 ±0.070% ash, 155.0 ±65.1ppm Na, 576.6 ±177.6ppm K, 199.6 ±63.4ppm Ca, 56.0 ±27.5ppm Mg, 5.8 ±2.3ppm Fe, 0.9 ±0.3ppm Cu, and 19.6 ±8.3 Zn. Free acidity, hydroxymethylfurfural (HMF) content, pH, conductivity, specific rotation, diastase activity and color (on the Pfund scale) were also assessed. This study constitutes the basis for establishing quality standards of this valuable honey in Colombia.*

Introduction

Pre-Hispanic cultures that lived in different territories of Central and South America practiced meliponiculture (comprising many species of the tribe Meliponini) since times that have not been well established, mainly for extraction and processing of honey, and for application of the cerumen in metalwork. The colonization of America, during the fifteenth and sixteenth centuries introduced beekeeping of *Apis mellifera* and minimized this practice, almost extinguishing meliponiculture. More recently, the 'africanization' of *A. mellifera* and the growing demand for natural foods and health care products have played an important role in the renewal of interest in native bee species, the attempt to recover traditional knowledge about them and to characterize their possible functional and therapeutic features under a bioprospective approach.

The geographic location of Latin America and its megabiodiversity are ideal for beekeeping, which is a highly sustainable activity and an interesting opportunity to identify products, mostly yet-to-be-discovered, with unique features. Only in Colombia, it is estimated that the number of native bee species is far more than 900 (Freitas *et al*., 2009).

Honeys of stingless bee species are also known as 'pot honeys' since many of the species of the tribe Meliponini store both pollen and honey in egg-shaped beeswax pots. Meliponiculture is growing; products, such as honey of the species *Trigona angustula*, called '*miel de angelita*' (or 'little-angel honey') retain a place in markets associated to folk medicine in countries such as Venezuela, Colombia and Ecuador, and a significantly higher cost compared to *Apis mellifera* honey, reaching over ten times its price, due to its scarcity, its pleasant flavor and the attributed bioactive properties, specially for treatment of respiratory and eye infections (Nates-Parra, 2001a; Vit *et al*., 2004; Rosso and Nates-Parra, 2005). *T. angustula* is one of the better known and most widely distributed stingless bees in Latin America, and can be found from nearly 2000masl down to the sea level (Table I). Worker bees of this species are small, ~4mm long, with a slender body, yellow belly and shiny black head and thorax; their hind legs are characterized by shiny black shins, which have a small pollen basket (Nates-Parra, 2001b).

Although practically no reliable data on the marketing of honey of native bees in Latin America is available, the main supply of this product is related to naturist stores and beekeeper-consumer retailing. Beekeepers generally take care of few nests without making economic use of them, often expressing a desire to use them as a source of income, but at the same time showing lack of technical knowledge on breeding techniques and colony maintenance.

PALABRAS CLAVE / Honey / 'Miel de Angelita' / Physicochemical Characteristics / *Trigona angustula* / Stingless Bees /

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MIEL DE ANGELITA: COMPOSICIÓN NUTRICIONAL Y PROPIEDADES FISICOQUÍMICAS DE LA MIEL DE *Trigona angustula*

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RESUMEN

Las culturas prehispánicas que habitaron territorios de Centro y Suramérica practicaron la meliponicultura, empleando miel y otros productos de varias especies de abejas sin aguijón. Posteriormente, la colonización de dichos territorios introdujo la crianza de Apis mellifera *y prácticamente anuló la meliponicultura. A pesar de esto, la miel de la especie* Tetragonisca angustula *(Latreille, 1811), conocida como 'miel de angelita', ha conservado un lugar en el mercado tradicional con precios de hasta diez veces el de la miel común, debido a su escasez y a que popularmente se le atribuyen propiedades medicinales. Aunque existen diferencias notorias entre la miel de angelita y la miel común, la falta de estándares objetivos ha permitido la ocurrencia de prácticas de falsificación, haciendo de interés la determinación de sus propiedades fisicoquímicas. En este estudio, 44 muestras de siete regiones de Colombia fueron analizadas por sus principales características nutricionales y fisicoquímicas, encontrándose una composición de 24,3 ±2,3% de humedad, 23,5 ±6,4% glucosa, 30,1 ±5,4% fructosa y 4,2 ±2,4% disacáridos (sacarosa y maltosa); 0,205 ±0,070% cenizas, y en minerales: 155,0 ±65,1ppm Na; 576,6 ±177,6ppm K; 199,6 ±63,4ppm Ca; 56,0 ±27,5ppm Mg; 5,8 ±2,3ppm Fe; 0,9 ±0,3ppm Cu; y 19,6 ±8,3ppm Zn. Fueron determinados la acidez libre, el contenido de hidroximetilfurfural (HMF), el pH, la conductividad eléctrica, la rotación específica, la actividad diastásica y el color. Este estudio constituye la base para el establecimiento de una norma de calidad para este producto en Colombia.*

MEL DA JATAÍ: COMPOSIÇÃO NUTRICIONAL E PROPRIEDADES FISICOQUÍMICA DE MEL DE *Trigona angustula*

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RESUMO

As culturas pré-hispânicas que habitaram territórios de Centro e América do Sul praticaram a meliponicultura, empregando mel e outros produtos de varias espécies de abelhas sem ferrão. Posteriormente, a colonização de ditos territórios introduziu a criação de Apis mellifera *e praticamente anulou a meliponicultura. Apesar disto, o mel da espécie* Tetragonisca angustula *(Latreille, 1811), conhecida como 'mel da Jataí', tem conservado um lugar no mercado tradicional com preços de até dez vezes o do mel comum, devido a sua escassez e a que popularmente se lhe atribuem propriedades medicinais. Ainda que existam diferenças notórias entre o mel de angelita e o mel comum, a falta de padronização objetiva tem incentivado práticas de falsificação, tornando de interesse a determinação de suas propriedades físico-químicas. Neste estudo, 44 amostras de sete regiões de Colômbia foram analisadas por suas principais características nutricionais e físico-químicas, encontrando-se uma composição de 24,3 ±2,3% de umidade, 23,5 ±6,4% glicose, 30,1 ±5,4% frutose e 4,2 ±2,4% dissacarídeos (sacarosa e maltosa); 0,205 ±0,070% cinzas, e em minerais: 155,0 ±65,1ppm Na; 576,6 ±177,6ppm K; 199,6 ±63,4ppm Ca; 56,0 ±27,5ppm Mg; 5,8 ±2,3ppm Fe; 0,9 ±0,3ppm Cu; e 19,6 ±8,3ppm Zn. Foram determinadas a acidez libre, o conteúdo de hidroximetilfurfural (HMF), o pH, a condutividade eléctrica, a rotação específica, a atividade diastásica e a cor. Este estudo constitui a base para o estabelecimento de uma norma de qualidade para este produto na Colômbia.*

Technological and environmental issues related to factors such as complex ecosystem interactions, susceptibility of some native bee species to human practices and the relatively low yields of the nests in terms of honey production, must be studied and overcome, in order to effectively make meliponiculture a feasible activity, based on the knowledge about biology of native bees, their environment and the characteristics of their products. This study is aimed at characterizing the honey of *T. angustula* with a focus on bromatology and authenticity, and provides feasible quality indicators for this product. Furthermore, it represents the basis of a future official standards for this product.

Material and Methods

Samples

Forty-four samples of honey from *Trigona angustula* Latreille (1811) (Hymenoptera: Apidae) were extracted from nests by beekeepers or project staff during the years 2009 and 2010, in seven departments of Colombia: Magdalena (17), Santander (19), Cundinamarca (2), Sucre (2), Caldas (1), Cauca (1), and Tolima (2). Sterilized syringes were used for extraction and then kept in sterilized vials which were closed, sealed and sent directly to the Laboratory of Physicochemical Analysis of Foodstuff at ICTA, Universidad Nacional de Colombia, where they were stored at ~-20°C prior to analyses. Table I provides general information and location of the nests.

Physicochemical analyses

Because of the relatively low amount of *miel de angelita* that can be extracted at once from the nest without damaging the colony, samples sent to the laboratory were small (usually <20g). Thus, the physicochemical parameters of the samples were performed in order of importance and according to the availability of samples. In Tables II-IV, the number of samples used for each parameter is indicated.

Moisture. Water content was evaluated by refractometry, measuring the refraction index according to method 969.38B (AOAC, 2005) with an instrument ABBE (Euromex, Netherland) at 20°C. Water content was calculated from a Chataway table (Chataway, 1935). Results are expressed in g/100g.

Sugars. Glucose, fructose and disaccharides (sucrose plus maltose) were quantified by HPLC according to a methodology based on methods 979.23 and 983.22 (AOAC, 2005), using a chromatographer CO-2065 (Jasco, Japan) with refraction index detector RI-2031 (Jasco, Japan), a calcium resin cationic exchange column MetaCarb Ca 111 Plus (Varian A5205, USA). The mobile phase was ultra pure degasified water; the column was maintained at 80°C and

TABLE I
LOCATION OF THE NESTS OF *T. angustula*

Department	Locations of the nests (municipality)	Mean altitude (masl)	Approximate global position
Caldas	Canáan (Victoria)	750	05°19'N 74°54'W
Cauca	-	1760	02°26'N 76°37'W
Cundinamarca	Bosachoque (Fusagasugá)	1728	04°20'N 74°21'W
Magdalena	San Pedro (Ciénaga)	400	11°02'N 74°15'W
	Minca (Santa Marta)	700	11°14'N 74°12'W
	Lourdes María (El Retén)	22	10°37'N 74°16'W
Santander	Riofrío (Girón)	777	07°04'N 73°10'W
	Casiano Bajo (Floridablanca)	925	07°13'N 73°04'W
	Santa Bárbara	1925	07°05'N 73°01'W
	La Roca (Socorro)	1230	06°28'N 73°16'W
Sucre	Colozó	137	09°29'N 75°21'W
Tolima	-	1200	04°26'N 75°13'W

the detector at 45°C, with a flow rate of 0.5ml·min^{-1}. Standards of glucose, fructose, maltose and fructose were from Sigma-Aldrich. Results are expressed in g/100g.

Ash. This parameter was determined according to method 920.181 (AOAC, 2005). Samples of 5g were pre-calcinteed until smoke release stopped. The sample was then placed in a muffle and calcinated at 600°C until constant weight. Results are expressed in g/100g.

Minerals. The mineral elements were quantified according to method 979.23 (AOAC, 2005). Samples of 5g were pre-calcinated and calcinated following the same procedure described for ash content determination. The crucible was then washed with a water:HCl solution and then transferred into a 100ml glass container. This solution was heated to boiling and filtered, transferring the contents into a 50ml flask. An atomic absorption spectrometer AA240 (Varian Inc., USA) was used in order to assess mineral contents using the following wavelengths: 599nm for Na, 285nm for Mg, 422.7nm for K, 213.9nm for Zn, 327.4nm for Cu, and 248.3nm for Fe. Results are expressed in mg·kg^{-1} or ppm.

pH and free acidity. This parameter was assessed by neutralization of acids, according to method 962.19 (AOAC, 2005). A sample of 10g of honey was dissolved in 75ml of degasified ultra pure water in a 250ml glass container. A pHmeter electrode (T70 Mettler Toledo, Switzerland) was submerged in the solution and initial pH was recorded at 20°C; the solution was stirred and then titrated with NaOH 0.05N until pH 8.5 was reached. Results are expressed in meq·kg^{-1}.

Diastase activity. This was assessed according to the method of Schade, described in Bogdanov *et al.* (1997). A 20% honey solution (10ml) reacted with a 2% starch solution, mixed at 40°C, and time was measured as the absorbance (660nm) of the colored complex formed by 0.5ml of the mixture and an aqueous diluted triiodide solution was recorded with a spectrophotometer UV/VIS V-530 (Jasco, Japan). From a plot of absorbance *vs* time, the time at which absorbance reached 0.235 was interpolated and divided by 300. Results are expressed as diastase number (DN).

Hydroximethilfurfural (HMF). This compound was quantified by spectrophotometry according to White, as described by Bogdanov *et al.* (1997), by means of the UV absorbance determination at 284nm. In order to avoid interferences from other compounds at this wavelength, the difference between absorbance of an aqueous honey solution and the same solution after adding bisulphite is determined. The content of HMF is calculated by the difference between the two solutions, this latter being measured at 336nm. Results are expressed as mg·kg^{-1} or ppm.

Specific rotation. The method used is described in Bogdanov *et al.* (1997). Angular rotation of an aqueous solution clarified and filtered is measured with a polarimeter Polax-2L (Atago, Japan). An aliquot of ~10g of dry substance was dissolved in distilled water for 30s, after which 10ml of Carrez I solution were added and mixed for 30s. Then, 10ml of Carrez II solution were added and also mixed during 30s. The volume was completed to 100ml in a flask using distilled water. One day later, this solution was filtered and introduced in a 2dm polarimeter tube, where the measurement was carried out at 20°C.

Color. It was measured by photometry using a Pfund C-221 colorimeter (Hanna Instruments, USA), placing a plastic cuvette (four transparent sides), calibrated to provide results in the Pfund scale. The data was registered and results expressed in mm Pfund in a scale that goes from 0mm Pfund (water white) to 150mm Pfund (dark amber).

Electrical conductivity. This parameter was evaluated according to Bogdanov *et al.* (1997), by measuring an aqueous 20% honey solution at 20°C, using a conductometer T70 (Mettler Toledo, Switzerland). Results are expressed is µS·cm^{-1}.

Statistical analysis

Physicochemical analyses were carried out in triplicate for each sample (the relative standard deviation of an individual sample should not be greater than 11% in order to be considered valid). Results are expressed as mean ± standard deviation for all the samples analyzed. Data were processed using Microsoft Excel 2007.

Results and Discussion

Main composition: water and sugars

Honey from *T. angustula*, just as *A. mellifera* honey, is mostly composed by simple reducing and non-reducing sugars (mainly fructose, glucose, sucrose and maltose), water and ash. Their relative amounts depend largely on many variables, e.g. the maturity achieved in the hive, the harvesting season, climatic and geographic factors and others that affect the availability of flora, etc. (Bijlsma *et al.*, 2006).

The mean concentration of these components is presented in Table II. Honey from *T. angustula*, as well as other stingless bees, shows higher moisture values than *A. mel-*

TABLE II
WATER AND SUGAR CONTENT OF *T. angustula* HONEY

Parameter	Moisture (g/100g)	Glucose (g/100g)	Fructose (g/100g)	Disaccharides* (g/100g)
Mean ±SD	24.3 ±2.3	23.5 ±6.4	30.1 ±5.4	4.2 ±2.4
Number of samples	44	41	41	41

* Sucrose plus maltose.

lifera honey. This causes a greater tendency of *miel de angelita* to be spontaneously fermented, which is not necessarily an undesirable process, but is usually not under the control of beekeepers (Vit, *et al*., 1994, 2004). Nevertheless, among all the stingless bees whose honeys have been studied, *T. angustula* produces one of the honeys with lowest moisture (Souza *et al*., 2006). Although unusually high moistures were found (up to 30.6%) for some particular samples, the standard deviation is considerably low, less than 10% of the mean value, making moisture a promissory distinction criterion and quality parameter for detecting adulteration and counterfeiting.

In the present study fructose, glucose, and the sum of sucrose and maltose were quantified. These are the most concentrated sugars present in *A. mellifera* honey and they also represented a large proportion of the solid constituents of *miel de angelita* (Table II). Variability in the concentration of sugars is large, as it can be observed in the values of standard deviation in Table II. However, some tendencies can be noticed; for example, the F/G (fructose/glucose) ratio showed that fructose is predominant over glucose in a considerable proportion (1.3 ±0.2). Similar results have been reported in various studies (Torres *et al*., 2004; Souza *et al*., 2006).

It was found that, unlike in the case of *A. mellifera* honey, the total amount of sugars quantified for *miel de angelita* added to the moisture leads to an average of around 80% of the total composition of the samples, leaving nearly a fifth of it unexplained, thus suggesting that the concentration of other disaccharides and oligosaccharides (as well as other organic compounds) can be much more significant than it is for *A. mellifera* honey. The mean value of the sum of fructose and glucose, the main reducing sugars present in honey, was 52.9 ±9.8g/100 g, so the total concentration of reducing agents is expected to be just slightly greater. The present results do not completely match those reported by Torres *et al.* (2004) for honeys of this species, also from Colombia, indicating greater values of both fructose (36.1-37.6g/100g) and glucose (29.8-31.8g/100g), and are in partial agreement to the values gathered by Souza *et al.* (2006) from different studies, which indicate that mean reducing sugars of *T. angustula* honey from Brazil, Mexico and Venezuela varied from 58.0 to 70.0g/100g. On the other hand, the present results agree with those of Anacleto *et al*. (2009), who found a mean reducing sugars concentration of 55.5 ±2.7g/100g in a study conducted with 20 samples of this type of honey in São Paulo, Brazil.

TABLE III
ASH AND MINERAL CONTENT OF *T. angustula* HONEY

	Ash (g/100g)	Na (mg·g^{-1})	K (mg·kg^{-1})	Ca (mg·kg^{-1})	Mg (mg·kg^{-1})	Fe (mg·kg^{-1})	Cu (mg·kg^{-1})	Zn (mg·kg^{-1})
Mean ±SD	0.205 ±0.070	155.0 ±65.1	576.6 ±177.6	199.6 ±63.4	56.0 ±27.5	5.8 ±2.3	0.9 ±0.3	19.6 ±8.3
Number of samples	12	9	9	9	9	9	9	9

Ash and minerals

The content of ash and the minerals profile of honeys depend strongly on the botanical origin, as well as on the bee species (Vit *et al*., 1994, 2004, 2005; Vit, 2005; Souza *et al*., 2006). Table III presents the concentration of ash and some minerals for Colombian honeys of *T. angustula*. Mean content of ash was 0.205 ±0.07g/100g, ranging from 0.059 to 0.309g/100g, for the samples analyzed. All the samples meet the standard proposed by Vit *et al*. (2004) to the *Codex Alimentarius*, consisting in a maximum of 0.5g/100g for honeys from *A. mellifera*, *Melipona* sp., *Scaptotrigona* sp. and *Trigona* sp.).

For all the samples whose mineral profile was assessed, the most concentrated mineral element quantified was potassium (576.6 ±177.6ppm) whereas the less concentrated one was copper (0.9 ±0.3ppm). Other minerals in increasing order are iron, zinc, magnesium, sodium and calcium. This order of concentrations is the same found for Colombian *A. mellifera* honey (Zuluaga and Díaz-Moreno, 2010). Both ash and minerals profile should be more extensively revised as parameters for detecting counterfeiting and for differentiating from honeys of other species.

Physicochemical quality parameters

Other physicochemical analyses are useful to establish the identity and quality of honey according to the botanical, geographical and entomological origin. Knowledge about these characteristics provides tools to the regulatory organisms for preventing falsifying and for carrying out more objective market surveillance. These physicochemical characteristics are pH, acidity, hydroxymethylfurfural (HMF) content, diastase activity, specific rotation, electrical conductivity and color, among other parameters that have been studied for several varieties of honeys from *A. mellifera*, and, in general, to a lesser extent for honeys from stingless bees. Due to the difference between *A. mellifera* and species of the tribe Meliponini, their honeys frequently show remarkable variations regarding these parameters, which is a positive aspect considering that most of the adulteration of honeys as *miel de angelita* is done with *A. mellifera* honey, which is cheaper and more common. However, this can also become a regulatory issue for marketing, because honeys from stingless bee species often fall outside the legal definition of 'honey'. Thus, clearly, a particular legal framework needs to be established.

Efforts have been made (Vit *et al*., 2004; Souza *et al*., 2006), but with regard to Colombia and *T. angustula* there is yet very little knowledge in this area (Torres *et al*., 2004; Quicazán *et al*., 2009). Table IV shows the results for color, pH, acidity, diastase activity, HMF, conductivity and spe-

TABLE IV
PHYSICOCHEMICAL QUALITY PARAMETERS OF *T. angustula* HONEY

Parameter	Color (Pfund)	pH	Free acidity (m$_{eq}$·kg^{-1})	Diastase activity (DN)	HMF (mg·kg^{-1})	Conductivity (µS·cm^{-1})	Specific rotation $[\infty]_D^{20}$
Mean ±SD	49 ±19	4.2 ±0.3	39.2 ±22.9	16.7 ±9.2	1.3 ±2.1	658 ±57	2.6 ±1.3
Number of samples	23	12	12	8	6	2	3

cific rotation of *miel de angelita*.

Color was assessed using the Pfund simplified scale, developed originally for *A. mellifera* honey. The color of *miel de angelita* ranged from white to light amber, in accordance to the consideration that these honeys are usually lighter than *A. mellifera* honey. The free acidity varied in a wide range (18.3-105.1meq·kg^{-1}) with a mean value of 39.2 meq·kg^{-1}, which is consistent to the fact that acidity of most of the stingless bee honeys is higher as compared with *A. mellifera* honey. It should be noticed that the current official quality standard in Colombia requests a maximum value of 50meq·kg^{-1} for *A. mellifera* (Colombia, 2010), in agreement to most of the quality standards for honey that are nowadays in force. The large standard deviation observed suggests a high dependence of the acidity on the botanical/geographical origin. The fact that acidity of *T. angustula* honey can be much higher than *A. mellifera* honey is also noticed as a characteristically acid flavor (Vit *et al*., 1994, 2004, 2005; de Almeida Souza *et al*., 2004; Vit, 2005; Sosa López *et al*., 2004; Zuluaga and Díaz-Moreno, 2010) but is not necessarily reflected on pH, which also varied in a wide range (3.5-4.6) but whose average remained in a value usually considered higher than that for *A. mellifera* honey. This higher acidity is caused by the spontaneous fermentation associated to the high moisture content (Vit *et al*., 1994, 2004).

The diastase activity for stingless bee honeys is usually very low (Vit *et al*., 2004; Souza *et al*., 2006), except for species belonging to the genus *Tetragonisca*. This results from the entomological origin and, specifically, the particular enzymatic profile of each bee species, and is not an index of heating or incorrect storage practice. In this study, honey from *T. angustula* was 17.7 ±5.5 DN, showing that, regarding this parameter *miel de angelita* is more like *A. mellifera* honey than other species of the tribe Meliponini, agreeing with Vit *et al.* (1998) and Souza *et al.* (2006). In Colombia, the standard for *A. mellifera* honey allows a minimum value of 8 DN, and a minimum of 7.0 can be proposed for *T. angustula* honey, which agrees with a former proposal of Vit *et al.* (2004).

HMF content, which together with diastase activity is often used as a parameter of freshness in honey, was much lower for *angelita* than the maximum value commonly accepted for *A. mellifera* honey (40ppm). From the six samples which were analyzed for HMF, four were below the detection limit of the analytical technique used. This partly differs with Torres *et al.* (2004) who found a slightly higher value of HMF for *T. angustula* (10.3ppm) than for *A. mellifera* (8.6ppm) in samples from Colombia. Grajales *et al*. (2001) (cited by Souza *et al*., 2006) reported the remarkably high value of 39.1ppm for *T. angustula* honey from Mexico, whereas other studies reported values from 4 to 10ppm (Souza *et al.,* 2006). Vit *et al.* (2004) proposed that the maximum HMF concentration standard can be kept the same as for *A. mellifera*. The results of HMF concentration found in the present study may be due to the fact that samples were sent from nests to the laboratory in a relatively short period of time, thus reducing storage effects. According to these results, an HMF standard of maximum 40ppm seems to be excessively high and thus 'permissive' for miel de angelita, however further studies are recommended in order to assess the storage effect on HMF, as well as all the other quality parameters of *T. angustula* and other stingless bee honeys.

Electrical conductivity (658 ±57µS·cm^{-1}) was found to be quite different (around ten times lower) than the value reported by Vit *et al.* (1998) for Venezuelan *T. angustula* honey (7320 ±230µS·cm^{-1}), but it was similar to the value reported by Santiesteban-Hernández *et al*. (2003; cited by Souza *et al*., 2006) for Mexican honeys of this species (780µS·cm^{-1}). Considering the low number of samples from which this parameter was measured, further studies need to be carried out in order to set an electrical conductivity standard, which is relevant since this easy-to-assess parameter can replace ash content as a quality indicator, the latter being more time-consuming, expensive and carries a higher error.

Specific rotation is a property that has not been widely explored for honeys from stingless bees, probably because of the relatively large amount of sample that is required. In this study it varied from 1.5 to 4.1, with an average of 2.3, so they are predominantly dextrorotary, showing that, in spite of the few samples assessed for this parameter, it becomes a potential differentiation criterion, especially from *A. mellifera* of Colombia, as these honeys always retain a levorotary character (Zuluaga and Díaz-Moreno, 2010). The fact that specific rotation is related to the concentration of levorotary (as fructose) and dextrorotary (as glucose) compounds indicates that there are other not yet quantified sugars and other compounds with optical activity in *miel de angelita*.

Conclusion

Although the main composition and nutritional characteristics of *miel de angelita* are similar to those of regular honey, this product displays particular physical and chemical features that make the physicochemical assessment a potential tool to differentiate them from honeys of the species *A. mellifera* and for detecting adulteration and falsification. It is necessary to extend the study of quality parameters, in particular of properties such as specific rotation, that can provide a fast indication of authenticity. Further studies to be aimed at the assessment of the storage effects on all the parameters are recommended, specially those that are associated to freshness, such as pH, acidity, diastase activity and HMF content. We foresee that this study will boost the drafting of a quality standard regulation for *miel de angelita* in Colombia, thus contributing to protect fair trade and stimulating meliponiculture in this region.

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