# COMPOSITION OF STINGLESS BEE HONEY: SETTING QUALITY STANDARDS

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*SUMMARY*

*Compositional data from 152 stingless bee (Meliponini) honey samples were compiled from studies since 1964, and evaluated to propose a quality standard for this product. Since stingless bee honey has a different composition than* Apis mellifera *honey, some physicochemical parameters are presented according to stingless bee species. The entomological origin of the honey was known for 17 species of Meliponini from Brazil, one from Costa Rica, six from Mexico, 27 from Panama, one from Surinam, two from Trinidad & Tobago, and seven from Venezuela, most from the genus Melipona. The results varied as follows: moisture (19.9-41.9g/100g), pH (3.15-4.66), free acidity (5.9-109.0meq/Kg), ash (0.01-1.18g/100g), diastase activity (0.9-23.0DN), electrical conductivity (0.49-8.77mS/cm), HMF (0.4-78.4mg/Kg), invertase activity (19.8-90.1IU), nitrogen (14.34-144.00mg/100g), reducing sugars (58.0-75.7g/100g) and sucrose (1.1-4.8g/100g). Moisture content of stingless bee honey is generally higher than*

Meliponine honey is a valuable bee product with a long consumption tradition, to which several medical uses are attributed. Due to the scant knowledge about the product, meliponine honey is not included in the international standards for honey (CODEX, 2001) and it is not controlled by the food control authorities. Thus, there is no assurance for consumers. Since the aim of the International Honey Commission (IHC) is the establishment of quality standards of bee products other than *Apis mellifera* honey, stingless bee honey was considered, along with pollen, beewax, propolis and royal jelly.

Honey standards from Brazil (BRASIL, 2000), and Venezuela (COVENIN, 1984a, b) were established

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*the 20% maximum established for* A. mellifera *honey. Guidelines for further contributions would help make the physicochemical database of meliponine honey more objective, in order to use such data to set quality standards. Pollen analysis should be directed towards the recognition of unifloral honeys produced by stingless bees, in order to obtain standard products from botanical species. A honey quality control campaign directed to both stingless beekeepers and stingless bee honey hunters is needed, as is harmonization of analytical methods.*

only for *A. mellifera* honey, following the guidelines of international standards of the *Codex Alimentarius* Commission (CODEX, 1969, 1987, 2001). However, stingless bees produce honey as well. They differ from *A. mellifera* at the subfamily level and are known as Meliponinae (Camargo and Menezes Pedro, 1992), recently renamed as Meliponini (Michener, 2000). A new classification including the stingless bees in the subfamily Apinae, tribe Apini and subtribe Meliponina (Silveira *et al.*, 2002) continues the taxonomic debate. It is worthwhile to study the ecology of tropical bees (Roubik, 1992), at least to answer a practical question on the use intended for a stingless bee colony, because some species will be better pollinators, while others will provide higher honey, pollen or propolis yields (Kerr, 1987).

The goal of this review is to provide an overall view of a number of factors behind the proposal of quality standards for meliponine honey. This honey is produced primarily by *Tetragonisca, Melipona, Scaptotrigona, Plebeia* (in America), *Meliponula* (in Africa), *Tetragonula* (in Asia), and a few other species. Worldwide, there are around 64 genera and 500 species of stingless bees. It can be estimated that they visit about half of the tropical flora, but there are few specific studies. Like honey bees, stingless bees also collect pollen and contribute considerably to flower pollination (Heard, 1999). Although their pollen is not harvested, pollen pots are used to prepare refreshing drinks resembling lemonade, because of its sour taste (Rivero Oramas, 1972).

**Native stingless bees and stingless beekeeping in the world**

In Northern Australia, aborigines regarded very highly the honey of stingless bees. A traditional dance ("corroboree") tells the story of robbing a hive (McKenzie, 1975), and special tools were used to climb trees and extract the honey (Petrie, 1904). The bees and their honey had a very important role in ritual, mythology and social life (Akerman, 1979). Today, aboriginal communities keep stingless bees in wooden hives, honey and cerumen being the main products. Interest in the honey is expressed by tourist centers, gift shops, health food shops and restaurants that promote native foods, and the demand is expected to grow rapidly as awareness increases. Cerumen is also collected for making traditional artifacts, especially the mouthpiece of the didgeridoo, a traditional aboriginal musical instrument.

The supply of native stingless bee honey, called sugarbag in Australia, comes from a dedicated group of beekeepers with a variety of motivations, including conservation of native species and interest in using the bees for production of honey and cerumen, crop pollination and as pets. Honey production by Australian stingless bees has grown rapidly in less than 20 years (Heard and Dollin, 2000). The growth has been driven by supply from a small community of enthusiastic stingless beekeepers and a demand for bush products by a curious public.

Lack of official census for stingless bee hives has been overcome with a private virtual initiative in Brazil, by creating a group of almost 400 stingless beekeepers of native species. ABENA (Abelhas Nativas) is a virtual discussion group at http://br.groups.yahoo.com/group/Abena/ that has the purpose of exchanging experiences, buying and selling products and acquiring know-how about stingless bees. They produced a census on the number of several species of stingless bee colonies kept in Brazil, shown in Table I.

Many stingless bee hives have been described in Brazil (Nogueira-Neto, 1997). New hive designs that are suited to the extraction of honey and cerumen have been developed in Australia. Also, stingless beekeepers have their own preferences on materials

TABLE I
BRAZILIAN STINGLESS BEE 2005 CENSUS FROM ABENA*

| Species** | Common name in Brazil | Number of colonies |
|---|---|---|
| *Tetragonisca angustula* | Jataí | 1243 |
| *Melipona quadrifasciata* | Mandaçaia | 748 |
| *Plebeia* sp. | Mirim | 173 |
| *Scaptotrigona depilis* | Canudo | 155 |
| *Melipona seminigra* | Jandaira | 154 |
| *Melipona scutellaris* | Uruçú | 95 |
| *Melipona marginata* | Manduri | 84 |
| *Melipona bicolor* | Guaraipo | 71 |
| *Melipona rufiventris* | Tujuba | 51 |
| *Scaptotrigona bipunctata* | Tubuna | 41 |
| *Nannotrigona testaceicornis* | Iraí | 28 |
| *Plebeia remota* | Mirim guaçú | 12 |
| *Plebeia juliani* | Mosquito | 10 |
| *Tetragona clavipes* | Borá/vorá | 12 |
| *Frieseomelitta varia* | Moça-branca/marmelada | 11 |
| *Scaptotrigona xanthotricha* | Mandaguari | 8 |
| *Friesella schrottkyi* | Mirim Preguiça | 7 |
| *Plebeia saiqui* | Saiqui | 6 |
| *Frieseomelitta silvestri* | Moça-preta | 6 |
| *Melipona compressipes* | Jupará | 4 |
| *Geotrigona cupira / Partamona cupira* | Cupira | 3 |
| *Plebeia droryana* | Droryana | 2 |
| *Partamona subnitida* | Jataí do Chão | 1 |

* Abelhas Nativas. http://br.groups.yahoo.com/group/Abena/
** Species indications were supplied by the stingless beekeepers

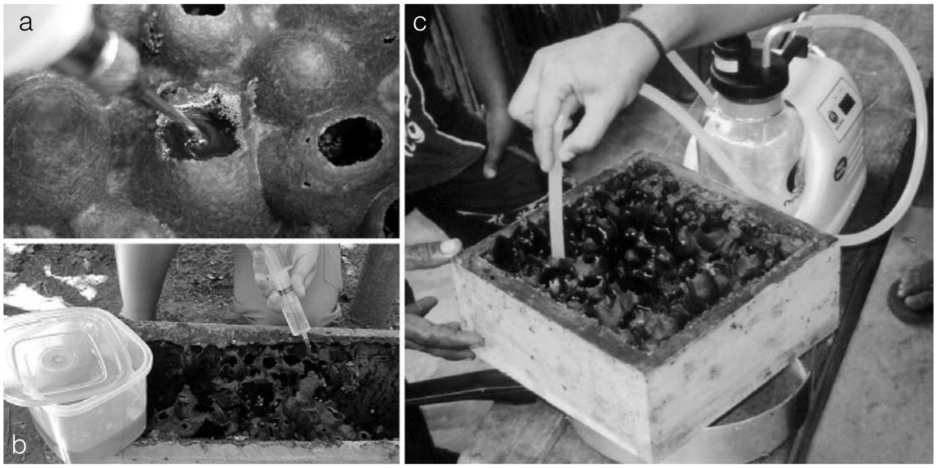


Figure 1. Stingless bee honey collection with disposable syringe (a, b) and with suction pump (c). (Souza BA) .

and their decoration, as stingless bees are treated as pets in many countries.

It must be stressed here that a rational stingless beekeeping requires the compliance with a set of principles needed for a more social conscious agriculture with reduced chemical residue, known as Good Agricultural Practices (GAP; FAO/EMBRAPA, 2002). On the other hand, forest honey is possibly more residue-free than any farm-honey, unless the farm is located in the forest. The modern collection of stingless bee honey is done with disposable syringes and, more efficiently, with a suction pump (Figure 1).

Initiatives for meliponiculture are supported in several tropical countries with interest in stingless beekeeping and honey production (Rivero Oramas, 1972; Enríquez *et al*, 2001; Medina-Camacho, 2003; Enríquez and Yurrita, 2004; Enríquez *et al*, 2005; Nates-Parra, 2005; Moreno *et al*, 2005).

In Brazil, the partnership between the Bahia Federal University with the Government of the state of Bahia and a local agency resulted in the creation of "Série Meliponicultura" (UFBA/UFRB, EAFC, ESALQ-USP), so far with four published issues (Carvalho *et al.*, 2003, 2005; Alves *et al.*, 2005a, b), whose purpose is to provide technical information on handling colonies, production costs, characteristics of the honey, etc. Besides the economic importance of these bees, there is interest in species preservation for the sustainable use of natural resources in the regions where the activity is carried out. The impact of these initiatives in Brazil is leading to the organization of stingless beekeeping through a variety of events, such as initiation and advanced courses, and the first and second Brazilian Congress of Meliponiculture, respectively held in Natal (2004) and Aracaju (2006).

However, besides the Brazilian enthusiasm for meliponiculture, great concern was recently expressed on the decline of this traditional activity in the Yucatan peninsula, Mexico, because stingless bees are threatened both by environmental changes and by inappropriate management (overharvest and unsuccessful transfer of feral colonies to hives, and division to duplicate colonies; Villanueva *et al.*, 2005). In Australia, the development of a propagation method (Heard, 1988) has stimulated interest. Stingless bee colony multiplication is slow compared to honey bees, but the numbers of hives and of stingless beekeepers are growing exponentially and these bees require low maintenance for pollination (Heard, 1999). The total current annual production in Australia is small, but is growing rapidly. The market price of the honey is currently very high, reflecting its rarity, and will remain high as production per hive is low and production costs are high (Heard and Dollin, 2000).

## How to name the stingless bee honey?

Honeys produced by stingless bees have been widely relished in the past (Schwarz, 1948) and besides their putative medicinal properties (Vit *et al.*, 2004) there are overbearing traditional reasons to harvest honey from pots, either from the forest or with the comfort of a well established meliponary. In Venezuela, peasants and natives are more familiar to differences due to the entomological origin of honey than those caused by the floral sources. However, people in the cities scarcely know what stingless bee honey is, until they go to the field. At first glance most meliponine honeys are oil-looking; others are a whitish paste after crystallization.

In food science, there is no official name for meliponine honeys. They could be named after their genus such as *Melipona* honey or *Trigona* honey, or by their local names such as *angelita*, *blanca*, *criolla, erica*, *guanota*, *real* or *tinzuca*, etc. A strategy for commercial promotion could use the names such as "grape honey" based on the shape, "sugarbag" from the Australian aborigines, "iramel" from a native Brazilian word for bees, "mayá" which means honey in the Neotropics, "saná" for a simple connotation of sweet for the piaroa/wóttöja people, or "divine elixir", because the presence of ethanol is creating a natural pharmaceutical elixir. However, honey is the simplest word for nectar derived product made by bees, no matter if they sting or not.

Scientists would agree to call it stingless bee honey, adding the genus, region of origin and habitat (forest, agricultural, riparian or littoral). The date of collection should be also stated, as well as the species and common name of the bee, if known. However, unless people with extensive knowledge do the harvest and collect specimens to be sent to an expert, it is doubtful whether species names or local common names would often be applied correctly.

## Studies of meliponine honey composition

### *Methods*

Generally, the studies are made through routine methods in food science laboratories to determine reduced sugars and apparent sucrose according to the Lane and Eynon method (AOAC, 1984), free acidity, ash content, diastase and invertase activities, electrical conductivity, hydroxymethylfurfural (HMF) and moisture content, according to the IHC methods (Bogdanov *et al.*, 1997). Nitrogen content is measured by the microKjeldhal method (AOAC, 1984).

The sugars in honey are measured by different methods and apparatus such as refractometers (in ºBrix) or liquid (HPLC) and gas (GC) chromatographers, but they are mostly determined following the volumetric Lane and Eynon method (AOAC, 1984). Accordingly, results are reported as glucose, fructose and sucrose content, or as reducing sugars and apparent sucrose. The moisture is measured by refractive index, converted by the Chataway table into moisture content, although some authors use ovens or infrared equipment.

*Quality criteria*

Different quality criteria based on physicochemical parameters have been used to test stingless bee honey. Data on sugars obtained by modern HPLC or GC techniques are rare. The lack of official standards for stingless bee honey, the problem of adulterated meliponine honey, the variety of stingless bee species producing honey and the unknown bee flora for precise pollen analysis, are constraints to be tackled with collaborative interdisciplinary work for correct interpretations on compositional and ecological significance, with implications in the bioactive properties of this honey with entomological origin different from *A. mellifera*. Current proposed standards are limited to a suggested grouping of honey produced by *Melipona*, *Scaptotrigona* and *Trigona* species (Vit *et al.*, 2004) and have also been suggested for Brazilian honey, with the additional parameter of total solids (Villas-Bôas and Malaspina, 2005). However, this is a simplistic interphase between the elaborated *A. mellifera* honey standards and the required set for more complex quality requirements of honey produced by so many species of Meliponini. In this paper, the state of the art on physicochemical data of stingless bee honey available from journals and abstracts is shown in Table II. Values of acidity, diastase, HMF, invertase, sugars and moisture are given with only one decimal, as suggested by Bogdanov *et al.* (1997).

TABLE II
PHYSICOCHEMICAL COMPOSITION OF STINGLESS BEE HONEY

| Bee species* | Nr. honey samples | Physicochemical parameters[a] pH | Free acidity (meq/Kg honey) | Ash (g/100g honey) | Diastase activity (DN)[b] | Electrical conductivity (mS/cm) | HMF (mg/Kg honey) | Invertase activity (IU)[c] | Nitrogen (mg/100g honey)[d] | Reducing sugars (g/100g honey) | Sucrose (g/100g honey) | Moisture (g/100g honey) | Country[e] | Year/ reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Articles in indexed Journals (1964-2005) | | | | | | | | | | | | | | |
| *F. aff. varia* | 7 | - | 73.0 | 0.76 | 7.8 | - | 1.1 | - | 134.12 | 61.0 | 4.8 | 19.9 | VEN | 1994[1] |
| *M. asilvai* | 11 | 3.27 | 41.6 | - | - | - | 2.4 | - | - | 68.9 | 4.7 | 29.5 | BRA | 2004a[2] |
| *M. compressipes* | 1 | 3.65 | 25.1 | - | - | - | 35.8 | - | - | - | - | 22.3 | BRA | 1964[3] |
| *M. compressipes* | 5 | - | 48.4 | 0.30 | 1.1 | - | 1.0 | - | 48.94 | 75.7 | 1.6 | 23.4 | VEN | 1994[1] |
| *M. favosa* | 14 | - | 62.9 | 0.29 | 0.9 | - | 1.2 | - | 40.66 | 72.1 | 1.5 | 25.5 | VEN | 1994[1] |
| *M. favosa* | 6 | - | 36.8 | 0.15 | 2.9 | 2.06 | 17.1 | 90.1 | 70.87 | 70.3 | 2.0 | 24.2 | VEN | 1998b[4] |
| *M. lateralis kangarumensis* | 3 | - | 40.7 | 0.11 | 2.8 | 1.65 | 3.9 | 58.9 | 23.42 | 64.8 | 1.1 | 28.8 | VEN | 1998b[4] |
| *M. mandacaia* | 20 | 3.27 | 43.5 | - | - | 3.52 | 5.8 | - | - | 74.8 | 2.9 | 28.8 | BRA | 2005c[5] |
| *M. paraensis* | 4 | - | 30.4 | 0.14 | 2.9 | 1.37 | 3.4 | 19.8 | 14.34 | 60.8 | 1.2 | 26.4 | VEN | 1998b[4] |
| *M. quadrifasciata anthidioides* | 1 | 3.35 | 103.3 | - | - | - | 31.5 | - | - | - | - | 41.9 | BRA | 1964[3] |
| *M. scutellaris* | 1 | 4.66 | 28.3 | 0.17 | - | - | 18.9 | - | - | - | - | 25.3 | BRA | 2005[6] |
| *M. trinitatis* | 4 | - | 24.2 | 0.12 | 1.0 | - | 1.3 | - | 47.82 | 73.7 | 1.5 | 25.7 | VEN | 1994[1] |
| *S. postica* | 1 | 3.40 | 83.7 | - | - | - | 18.9 | 24.6 | - | - | - | 26.5 | BRA | 1964[3] |
| *T. angustula* | 3 | - | 48.3 | 0.38 | 23.0 | 7.32 | 9.8 | 50.1 | 142.27 | 65.9 | 2.1 | 23.2 | VEN | 1998b[4] |
| *T. angustula* | 5 | - | - | - | 17.9 | - | 5.0 | - | - | 58.7 | - | >26.0 | BRA | 1998[7] |
| Abstracts in meetings (1998-2004) | | | | | | | | | | | | | | |
| *C. capitata* | 1 | 3.62 | 31.5 | 0.52 | - | - | 3.4 | - | - | - | - | 27.0 | BRA | 2004[8] |
| *M. beecheii* | 1 | 4.50 | 28.0 | - | - | 0.55 | 64.8 | - | - | - | - | 24.0 | MEX | 2001[9] |
| *M. beecheii* | 1 | 4.18 | 5.9 | - | - | 0.66 | 5.4 | - | - | 68.0 | 1.6 | 27.0 | MEX | 2003[10] |
| *M. compressipes* | 8* | 3.46 | 39.0* | 0.22 | 7.9* | - | 1.2 | - | 44.80 | 65.3 | 3.5 | 24.6 | BRA | 2004[11] |
| *M. compressipes* | 1 | 4.06 | 45.8 | - | - | 8.77 | 30.5 | - | - | - | - | 25.0 | BRA | 1998[12] |
| *M. quadrifasciata* | 1 | 4.52 | 16.5 | 0.54 | - | - | 1.0 | - | - | - | - | 34.0 | BRA | 2004[8] |
| *M. scutellaris* | 6* | 3.15 | 8.9 | 0.01 | - | 3.39 | 0.4 | - | 81.60 | - | - | 28.4 | BRA | 1998[13] |
| *M. seminigra* | 8* | 3.53 | 79.0* | 0.15 | 5.0* | - | 0.8 | - | 56.00 | 65.4 | 3.0 | 26.0 | BRA | 2004[11] |
| *M. solani* | 1 | 4.00 | 85.0 | - | - | 0.62 | 78.5 | - | - | - | - | 25.0 | MEX | 2001[9] |
| *Pl. droryana* | 1 | 3.83 | 52.0 | 1.18 | - | - | 7.6 | - | - | - | - | 31.0 | BRA | 2004[8] |
| *P.* sp. | 1 | 3.42 | 23.7 | - | - | 0.81 | 2.4 | - | - | 62.5 | 1.1 | 34.1 | MEX | 2003[10] |
| *S. mexicana* | 4 | 4.05 | 76.7 | - | - | 0.76 | 42.0 | - | - | - | - | 24.7 | MEX | 2001[9] |
| *S. pachysoma* | 1 | 3.94 | 6.6 | - | - | 0.49 | 1.1 | - | - | 70.1 | 2.0 | 26.9 | MEX | 2003[10] |
| *T. angustula* | 1 | 3.69 | 26.0 | 0.32 | - | - | 8.1 | - | - | - | - | 25.5 | BRA | 2004[8] |
| *T. angustula* | 1 | 3.88 | 7.7 | - | - | 0.78 | 4.3 | - | - | 70.0 | 2.4 | 26.7 | MEX | 2003[10] |
| *T. angustula* | 25 | 3.80 | 109.0 | 0.45 | - | - | - | - | 144.00 | 58.0 | 2.4 | 23.7 | BRA | 2002[14] |
| *T. angustula* | 4 | 4.35 | 57.5 | - | - | 1.10 | 39.1 | - | - | - | - | 23.2 | MEX | 2001[9] |

* *C*: *Cephalotrigona*, *F*: *Frieseomelitta*, *M*: *Melipona*, *P*: *Partamona*, *Pl*: *Plebeia*, *S*: *Scaptotrigona* and *T*: *Tetragonisca*. The number of honey samples and values of physicochemical analysis were provided by the authors after publication. Underlined values indicate minimal and maximal values of each parameter in the analyzed honey samples.

[a] Mean values for each quality factor.

[b] The Diastase Number (DN) indicates g starch hydrolyzed/100g honey/h, at pH 5.2 and 40°C.

[c] An Invertase Unit (IU) indicatess µmoles p-nitrophenyl glucopyranoside hydrolyzed/kg honey/min, at pH 6.0 and 40°C.

[d] Values of protein content (%) were transformed into mg Nitrogen/100 g honey, multiplying by a factor of 160 (1000/6.25).

[e] Abbreviations for countries are BRA (Brazil), MEX (Mexico), VEN (Venezuela).

Sources : [1]Vit *et al.*, 1994; [2]Souza *et al.*, 2004a; [3]Gonnet *et al.*, 1964; [4]Vit *et al.*, 1998b; [5]Alves *et al.*, 2005c, [6]Evangelista-Rodrigues *et al.*, 2005; [7]Rodrigues *et al.*, 1998; [8]Almeida and Marchini, 2004; [9]Grajales-C *et al.*, 2001; [10]Santiesteban-Hernández *et al.*, 2003; [11]Villas-Bôas and Malaspina, 2004; [12]Souza and Bazlen, 1998;[13]Marchini *et al.*, 1998; [14]Denadai *et al.*, 2002.

TABLE III
STINGLESS BEE HONEY TOTAL SUGAR CONTENT

| Bee species* | Total sugars (°Brix) |
|---|---|
| *Melipona panamica* | 57.2 - 75.0 |
| *M. compressipes triplaridis* | 67.0 - 75.5 |
| *M. fuliginosa* | 68.0 - 75.0 |
| *M. micheneri* | 55.0 - 66.8 |
| *M. favosa phenax* | 68.4 - 73.0 |
| *M. aff. crinita* | 64.0 - 66.8 |
| *P. jatiformes* | 66.8 - 70.0 |
| *P. franki* | 76.8 - 86.0 |
| *P. aff. Minima* | 63.8 - 72.0 |
| *Nannotrigona mellaria* | 62.2 |
| *C. capitata zexmeniae* | 62.0 - 72.5 |
| *Oxytrigona daemoniaca* | 72.6 |
| *F. nigra paupera* | 63.2 - 73.0 |
| *T. dorsalis ziegleri* | 60.0 - 73.0 |
| *Tetragonisca angustula* | 71.2 - 75.7 |
| *Geotrigona kraussi* | 65.6 - 76.6 |
| *T. pectoralis panamensis* | 71.4 - 71.6 |
| *Scaptotrigona luteipennis* | 67.2 - 72.2 |
| *T. fulviventris* | 59.0 |
| *T. corvina* | 73.0 - 78.2 |
| *Trigona necrophaga* | 71.0 - 74.8 |
| *T. nigerrima* | 67.8 - 75.2 |
| *Trigona mazucatoi* | 62.4 - 72.0 |
| *Scaura latitarsis* | 75.0 |
| *Trigonisca roubiki* | 72.5 |
| *Aparatrigona isopterophila* | 67.6 - 69.6 |
| *Partamona peckolti* | 56.0 - 63.0 |

* *C*: *Cephalotrigona*, *F*: *Frieseomelitta*, *M*: *Melipona*, *P*: *Plebeia* and *T*: *Trigona*.
From Roubik (1983)

TABLE IV
STINGLESS BEE HONEY MOISTURE AND ASH CONTENT

| Bee species | Moisture(g/100g) | Ash [4] (g/100g) |
|---|---|---|
| *Melipona quadrifasciata* | 45.0 [1] | - |
| *Plebeia droryana* | 27.0 [1] | - |
| *Scaptotrigona postica* | 27.0 - 40.2 [1] | - |
| *Melipona scutellaris* | 27.0 - 27.5 | - |
| *Melipona seminigra* | 26.0[2] | - |
| *Plebeia droryana* | 27.0 [2] | - |
| *Plebeia poecilochroa* | 32.0 [2] | - |
| *Plebeia* sp. | 38.9 [2] | - |
| *Scaptotrigona* sp. | 27.0 [2] | - |
| *Scaptotrigona nigrohirta* | 26.8 [2] | - |
| *Scaptotrigona postica* | 26.0 [2] | - |
| *Tetragona quadrangula* | 28.0 [2] | - |
| *Trigona ref. guianae* | 30.4 [2] | - |
| *Plebeia tobagoensis* | 42.0 ±4.0 [3] | - |
| *Trigona nigra* | 36.2 ±1.9 [3] | - |
| *Melipona trinitatis* | 32.2 ±2.3 [3] | - |
| *Melipona favosa* (from Trinidad) | 35.1 ±1.0 [3] | - |
| *Melipona favosa* (from Tobago) | 30.2 ±2.2 [3] | - |
| *Melipona compressipes* | 25.3 - 34.6 [4] | 0.03 - 0.40 |
| *Melipona rufiventris paraensis* | 27.0 [4] | 0.30 |
| *Melipona seminigra merrillae* | 23.9 [4] | 0.20 |

From [1] Pamplona (1989), [2] Carvalho *et al.* (2005), [3] Bijlsma *et al.* (2006) [4] Souza *et al.* (2004b).

In addition to the data presented in Table II, in some studies, sugars expressed as sucrose (°Brix) and moisture content were the only physicochemical parameters measured in stingless bee honey, possibly because moisture content is generally high in these honeys, but also because the measurement is easy and the equipment accessible. Brix degrees and refractometric indexes can be measured in the field with hand refractometers. An example of this can be seen in Table III, where total sugar concentration (°Brix= weight sucrose/total weight) was the only parameter measured in the honey of 79 nests, distributed among 27 species (Roubik, 1983).

Moisture content was reported by Pamplona (1989), Carvalho *et al.* (2005) and Bijlsma *et al.* (2006). Ash and moisture content of honey from three species in Brazil, were reported by Souza *et al* (2004b). The values are presented on Table IV.

In another group of publications (Table V) only average values and ranges of physicochemical parameters are given for stingless bee honey samples from *Tetragona clavipes*, *Tetragonisca angustula*, *Melipona subnitida*, *M. quadrifasciata*, *Plebeia* sp. and *M. scutellaris* in Brazil (Cortopassi-Laurino and Gelli, 1991), and for other stingless bee species different from *Melipona*, such as *Frieseomelitta nigra paupera*, *Plebeia* sp., *Scaptotrigona* sp. *aff. depilis*, *Scaura latitarsis* and *T. angustula* collected in Venezuela (Vit *et al.*, 1994), and *Melipona* honey from Trinidad (*M. trinitatis*) & Tobago (*M. favosa*), Costa Rica (*M. beecheii*) and Surinam (*M. lateralis*) (Bruijn and Sommeijer, 1998).

In the papers reviewed herein, free acidity is reported sometimes as acidity or free acidity, lactones

TABLE V
AVERAGES AND RANGES OF PHYSICOCHEMICAL HONEY COMPOSITION REPORTED FOR GROUPS OF STINGLESS BEE SPECIES

| Physicochemical parameters | Countries of origin | | | |
|---|---|---|---|---|
| | Brazil | | Venezuela [3] | Costa Rica, Trinidad & Tobago and Suriname [4] |
| Number of honey samples | 14 [1] | Unknown [2] | 10 | Unknown |
| Water content (g/100g) | (18.0-36.0) | (23.1-32.7) | 22.3 (19.3-27.3) | 23.7 (20.3-28.1) n=25 |
| Free acidity (meq/Kg) | (30.0->160.0) | (69.7-77.5) | 79.7 (16.9-248.5) | 45.8 (20.5-50.9) n=10 |
| Lactonic acidity (meq/Kg) | - | - | - | 6.2 (3.5-11.5) n=10 |
| Total acidity (meq/Kg) | - | - | - | 45.8 (23.9-56.9) n=10 |
| pH | 3.90 | (3.30-3.80) | - | 3.53 (3.1-4.1) n=21 |
| Hydrogen peroxide (µg/g/h 20°C) | - | - | - | 23.91 (10-31.25) n=9 |
| Reducing sugars (g/100g) | - | - | 63.4 (48.18-72.69) | - |
| Fructose (g/100g) | - | - | - | 31.2 (22.2-41.8) n=8 |
| Glucose (g/100g) | - | - | - | 27.5 (21.9-35.7) n=7 |
| Ratio fructose/glucose | - | - | - | 1.2 (1.0-1.5) n=7 |
| Sucrose (g/100g) | - | - | 4.6 (1.1-12.3) | 4.8 (0.0-13.0) n=8 |
| Gluconic acid | - | - | - | 0.4 (0.2-0.6) n=7 |
| Ash (g/100g) | - | (0.10-0.20) | 0.67 (0.12-1.49) | - |
| HMF (mg/Kg) | - | - | 1.1 (1.0-2.0) | - |
| Nitrogen (mg/100g) | - | - | 175.8 (41.91-335.31) | - |
| Diastase index | - | - | - | 0.0 n=5 |

n: number of analysis. Adapted from [1] Cortopassi-Laurino and Gelli (1991), [2] Cortopassi-Laurino (1997), [3] Vit *et al.* (1994), and [4] Bruijn and Sommeijer (1998).

and total acidity. Ash content is also reported as minerals after incineration. Nitrogen content sometimes is reported as protein, in which cases, protein content (%) was converted into mg N/100g honey, multiplying by 1000/6.25, as indicated in Table II.

Sugar profiles of stingless bee honey might be powerful tools to discriminate its entomological origin. Indeed, in two studies, differences between the spectra of different stingless bee honeys were found (Bogdanov *et al.*, 1996; Vit *et al.*, 1998a). However, HPLC or GC analysis of sugars is not available in most laboratories performing honey quality control in the tropics and subtropics, where stingless bees live. In a pioneer study (Bogdanov *et al.*, 1996), it was concluded that *A. mellifera* and *Melipona* honey are poor in oligosaccharides, but honeys produced by other stingless bee species are rich in maltose and show slightly higher values of turanose, erlose and trehalose.

The physicochemical data of meliponine honey, as reported in 7 papers and 7 abstracts (Table II) and on 9 other references, show differences in the analyzed parameters, probably due in part to the intrinsic variability of the product, or to possible differences in analytical methods used by various authors. Altogether, the physicochemical parameters for stingless bee honey collected in Table II varied in the following ranges for pH (3.15-4.66), acidity (5.9-109.0meq/kg), ash (0.01-1.18g/100g), diastase activity (0.9-23.0DN), electrical conductivity (0.49-8.77mS/cm), HMF (0.4-78.4mg/kg), invertase activity (19.8-90.1IU), nitrogen (14.34-144.00mg/100g), reducing sugars (58.0-75.7g/100g), sucrose (1.1-4.8g/100g) and moisture content (19.9-41.9g/100g). Values presented in Tables III, IV and V were not considered for the min./max. values presented in this work, wich are limited to Table II as previously indicated. Other reported parameters not considered here, are water activity ($a_w$; Matsuda *et al.*, 2005), formol index (Almeida and Marchini, 2004; Alves *et al.*, 2005c), insoluble solids (Villas-Bôas and Malaspina, 2005), minerals (Marchini *et al.*, 1998), total solids (Silva *et al.*, 2004; Villas-Bôas and Malaspina, 2004) and viscosity (Alves *et al.*, 2005c).

The data of Table II are summarized in Table VI. Averages of all parameters considered in this review are given for the honey produced by all meliponine species, and also divided into two groups of honey produced by *Melipona* spp. and by other Meliponini, as well as for the five major species with more than 10 honey samples analyzed.

On Table VI it is noticeable that moisture content is always measured in honey (152 samples), followed by free acidity (147), reducing sugars and HMF (127), sucrose, pH, ash, and nitrogen. However electrical conductivity, diastase and invertase are measured less frequently. Free acidity is lower in *Melipona* honey, than in other Meliponini, as are ash, diastase activity, electrical conductivity, nitrogen and sucrose. On the other hand, HMF, reducing sugars and invertase activity tend to be higher in *Melipona* than in other Meliponini honey.

Compared to *A. mellifera* honey, the most relevant differences with meliponine honey, previously reported, are higher values of water, free acidity, electrical conductivity, maltose and nitrogen, and lower values of diastase in honey from *Melipona* species but not in other studied Meliponini genera (Vit *et al.*, 1994, 1998b; Bogdanov *et al.*, 1996). Criteria for stingless bee honey quality control should take into account these differences derived from meliponine physiology. In Venezuela, stingless bee honey is often sold mixed with *A. mellifera* honey and fruit juice, and declared on the label. Although new parameters have not been suggested yet, they will be necessary for control of stingless bee honey adulterations and their mixtures with *A. mellifera* honey to increase commercial benefits.

Due to the great heterogeneity of vegetation, stingless bee products, and also honey, change frequently their properties and characteristics. *Spondias, Anacardium, Machae-*

TABLE VI
SUMMARY OF STINGLESS BEE HONEY COMPOSITION

| Bee species | Number of samples | Physico-chemical parameters [1] pH | Free acidity (meq/Kg honey) | Ash (g/100 g honey) | Diastase activity (DN)[2] | Electrical conductivity (mS/cm) | HMF (mg/Kg honey) | Invertase activity (IU)[3] | Nitrogen (mg/100 g honey) | Reducing sugars (g/100 g honey) | Sucrose (g/100 g honey) | Moisture (g/100 g honey) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meliponini | 152 | 3.81 (101) | 44.8 (147) | 0.34 (98) | 6.7 (67) | 2.34 (68) | 14.4 (127) | 48.7 (17) | 58.31 (93) | 66.0 (127) | 2.3 (122) | 26.7 (152) |
| *Melipona* spp. | 97 | 3.82 (61) | 41.8 (97) | 0.20 (60) | 3.1 (52) | 2.62 (54) | 16.0 (97) | 56.3 (13) | 40.78 (58) | 69.1 (84) | 2.2 (84) | 27.2 (97) |
| other Meliponini | 55 | 3.80 (40) | 49.6 (50) | 0.60 (38) | 16.2 (15) | 1.88 (14) | 11.9 (30) | 37.4 (4) | 110.88 (35) | 63.8 (43) | 2.5 (38) | 26.0 (55) |
| *M. asilvai* | 11 | 3.27 (11) | 41.6 (11) | - | - | 3.63 (11) | 2.4 (10) | - | - | 68.9 (11) | 4.7 (11) | 29.5 (11) |
| *M. compressipes* | 15 | 3.72 (10) | 36.6 (15) | 0.26 (13) | 4.5 (13) | 8.77 (1) | 17.1 (15) | - | 33.22 (13) | 70.5 (13) | 2.5 (13) | 23.8 (15) |
| *M. favosa* | 20 | - | 49.9 (20) | 0.22 (20) | 1.9 (20) | 2.06 (6) | 9.1 (21) | 90.1 (6) | 55.77 (20) | 71.2 (20) | 1.7 (20) | 24.8 (20) |
| *M. mandacaia* | 20 | 3.27 (20) | 43.5 (20) | - | - | 3.52 (20) | 5.8 (20) | - | - | 74.8 (20) | 2.9 (20) | 28.8 (20) |
| *T. angustula* | 39 | 3.93 (31) | 49.7 (34) | 0.38 (29) | 20.5 (8) | 3.07 (8) | 13.3 (14) | 50.1 (3) | 99.26 (3) | 63.1 (34) | 2.3 (29) | 24.7 (39) |

[1] Mean values and (number of honey samples) are presented.
[2] The diastase number (DN) indicates g starch hydrolysed/100g honey/h, at pH 5.2 and 40°C.
[3] An invertase unit (IU) indicates µmoles p-nitrophenyl glucopyranoside hydrolysed/kg honey/min, at pH 6.0 and 40°C.

*rium* and *Celtis* were common genera in a study of *Tetragonisca angustula* honey from Peru and Bolivia, with 15-52 pollen species/colony; here trees were represented three times by pollen of lianas and herbs, and six times by pollen of shrubs (Roubik, 2003).

In Brazil, the main unifloral meliponine honeys have been reported to be from *Acacia polyphyla*, *Anadenanthera macrocarpa*, *Citrus, Eucalyptus*, Brassicaceae, *Mimosa caesalpinifolia*, *Myrcia*, *Piptadenia rigida*, *Schinus*, *Solanum* and *Vernonia polyanthes* (Bazlen, 2000; Almeida, 2002; Barth, 2004, Alves *et al*., 2006).

There is the need to create regional pollen reference collections or palynothecae that incorporate the plant species visited by the Meliponini. Commonly, meliponine honey and pollen bread are of heterofloral origin. It is required to make known the source of unifloral meliponine products, and to obtain a product with more constant smell, taste, color and texture. Pollen analysis will be a good instrument in this purpose but, unfortunately, there are few laboratories with this expertise. In food science, routine natural pollen analysis is more frequent, whereas acetolyzed pollen is preferred for ecological research. More specialists on melissopalynology must be trained.

## Conclusions

It is hoped that this review could constitute a starting point for creating a solid database of stingless bee honey, including all parameters useful for honey quality control. Also, it is advised of the need of an entomological entry in any stingless bee collection, for each honey sample of databases in the countries carrying out this type of research, and both local common names and scientific names of stingless bees are suggested for better communication.

Following quality criteria, using the methods of the IHC, future studies on stingless bee honey composition should determine moisture content and HMF, and additional parameters such as sugars (at least fructose, glucose, maltose and sucrose), electrical conductivity, free acidity, and pollen analysis should also be included for a more complete analysis.

Concerning the publications of results, special attention should be given to provide tables with data of individual parameters and numbers of honey samples if possible, so that more reliable statistical analysis could be done in the future. It is not helpful to provide only analytical averages for a given parameter of honey produced by a group of stingless bee species. The relevance of the number of honey samples analyzed was not obvious in some of the works, but it should not be absent in future works. It was observed that information on measurement units, name of stingless bee species, number of honey samples, etc. was not accurate in some abstracts.

It is imperative to adjust the measurements of moisture content in stingless bee honeys, which generally have a higher value than that provided in the Chataway table. Generally, extrapolations of the table have been used. The elaboration of an expanded Chataway table for the refractometric measurement of honeys with values higher than 25g water/100g honey, to be validated, is suggested.

The next step should be to establish one or several standards for meliponine honeys. For that purpose, the working group on stingless bee honey must gather more data of the important stingless bee honeys. This will allow the control of this valuable product, leading to an improved quality.


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## COMPOSICIÓN DE LA MIEL DE ABEJAS SIN AGUIJÓN: ESTABLECIENDO REQUISITOS DE CALIDAD

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*RESUMEN*

*Se compilaron datos de composición de 152 mieles de abejas sin aguijón (Meliponini) en estudios realizados desde 1964, y se evaluaron para proponer requisitos de calidad para este producto. Dado que la miel de abejas sin aguijón tienen una composición distinta a la de Apis mellifera, algunos parámetros físico-químicos fueron presentados según la especie abejas sin aguijón. El origen entomológico de la miel se asignó a 17 especies de Meliponini de Brasil, una de Costa Rica, seis de México, 27 de Panamá, una de Surinam, dos de Trinidad & Tobago, y siete de Venezuela, mayormente del género Melipona. Los resultados variaron así: humedad (19,9-41,9g/100g), pH (3,15-4,66), acidez libre (5,9-109,0meq/Kg), cenizas (0,01-1,18g/100g), actividad de la diastasa (0,9-23,0DN), conductividad eléctrica (0,49-8,77mS/cm), HMF (0,9-78,4mg/Kg), actividad de la invertasa (19,8-90,1IU), nitrógeno (14,34-144,00mg/100g), azúcares reductores (58,0-75,7g/100g) y sacarosa (1,1-4,8g/100g), El contenido de humedad de las mieles de abejas sin aguijón es generalmente superior al máximo de 20% establecido para la miel de A. mellifera. Las directrices ofrecidas pueden ayudar a la expansión consistente de la base de datos físico-químicos de miel de abejas sin aguijón, para establecer sus requisitos de calidad en un futuro. El análisis de polen debería dirigirse hacia el reconocimiento de las mieles uniflorales producidas por las abejas sin aguijón, a fin de obtener productos estandarizados según las especies botánicas. Se necesita una campaña de control de calidad de miel tanto para los recolectores de miel de abejas sin aguijón como para los meliponicultores, junto con la armonización de los métodos analíticos.*

## COMPOSIÇÃO DO MEL DE ABELHAS SEM FERRÃO: ESTABELECENDO REQUISITOS DE QUALIDADE

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*RESUMO*

*Dados de composição de 152 amostras de mel de abelhas sem ferrão foram compilados de estudos realizados desde 1964, e sendo avaliados para propor requisitos de qualidade para este produto. Considerando que o mel de abelhas sem ferrão apresenta uma composição distinta ao de Apis mellifera, alguns parâmetros físico-químicos foram apresentados de acordo com a espécie de abelha sem ferrão. A origem entomológica do mel correspondeu a 17 espécies de Meliponini do Brasil, uma da Costa Rica, seis do México, 27 do Panamá, uma do Suriname, duas de Trinidad & Tobago, e sete da Venezuela, a maioria do gênero Melipona. Os resultados variaram como segue: umidade (19,9-41,9 g/100g), pH (3,15-4,66), acidez livre (5,9-109,0 meq/Kg), cinzas (0,01-1,18 g/100g), atividade diastásica (0,9-23,0 DN), condutividade elétrica (0,49-8,77 mS/cm), HMF (0.4-78.4 mg/Kg), atividade da invertase (19,8-90,1 IU), nitrogênio (14,34-144,00 mg/100g), açúcares redutores (58,0-75,7 g/100g) e sacarose (1,1-4,8 g/100g). O conteúdo de umidade dos méis de abelhas sem ferrão é geralmente superior ao máximo de 20% estabelecido para o mel de A. mellifera. As diretrizes oferecidas podem ajudar a expansão consistente da base de dados físico-químicos de mel de abelhas sem ferrão, para estabelecer seus requisitos de qualidade. A análise polínica deve ser direcionada para o reconhecimento dos méis uniflorais produzidos pelas abelhas sem ferrão, a fim de obter produtos padronizados de acordo com sua origem botânica. É necessária uma campanha de controle de qualidade do mel tanto para os coletores de mel de abelhas sem ferrão, como para os meliponicultores, juntamentente com a harmonização dos métodos analíticos.*