Chapter 24
Sensory Evaluation of Stingless Bee Pot-Honey

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To Michel Gonnet, for the first imprinting with the sensory message of a lavanda honey served in a crystal gobblet in Monfavet, France

24.1 Introduction

The sensory characteristics of honey play an important role in producing quality standards, as they determine consumer acceptance. The sensory attributes in terms of appearance, aroma, flavor, and texture vary from product to product, revealing the need for investigating every honey in order to better understand their characteristics. When one evaluates honey sensory quality, several perspectives are taken into account, and among them is the consumer perception that leads to different honey evaluations. Consumers are more and more concerned about health and wellness and, consequently, they are more interested in the benefits from food and beverage (Sloan 2011). Honey is a health product (Amtmann 2010), and therefore, a thorough investigation of honey sensory properties is desirable.

Sensory analysis as a discipline uses the five human senses (sight, smell, taste, touch, and hearing) to analyze food, beverages, and other products. By using human panels to sample the products, with an adequate experimental design and statistical

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Table 24.1 Main characteristics of qualitative and quantitative sensory methods for investigating honey

Sensory issues in qualitative studies
How do you perceive this honey? What did you specifically like and dislike about it?
Please explain what do think about this honey color compared to the other one
Please describe the consistency of this honey
Please tell me more about why the color of this honey is unacceptable to you
Why in your opinion honey 371 is nicer than product 775?
Why your family preferred this honey instead of the others?
Characteristics of sensory quantitative studies
The honey consumer is invited to participate:
A relatively large group of consumers participates (depending on the statistical power required)
Careful honey preparation for a large number of participants
Written questionnaire with attributes and scales to score consumer response. Sensory questions may include overall liking, liking and perceived intensity of attributes, and preference
The selection of attributes in the questionnaire is critical
Data are statistically analyzed

Adapted from Deliza and Glória (2009)

analysis, it is possible to evaluate products in terms of appearance, aroma, flavor, texture, and aftertaste (Meilgaard et al. 1999). Assessment can derive from a panel selected according to specific criteria and trained to evaluate product sensory attributes, or from a consumer panel, i.e., any person who consumes the product under investigation or matches predefined recruitment criteria, normally based on demographics (e.g., gender, age, education, product consumption).

Several quantitative sensory methods are available and well defined in terms of application procedures (Stone and Sidel 2004). The choice regarding panel selection (trained people or consumers) will depend on the study objective. Three distinct methods are applied, as follows: the descriptive method (used when the aim is to have a sensory characterization of samples), discriminative tools (useful to investigate whether there are sensory differences between products), and affective tests, which investigate how much a product is liked/accepted by consumers. Consumer studies can be carried out through qualitative and quantitative studies. Qualitative research often has an exceptional value, since the consumer can be queried to obtain information not easily obtainable in quantitative studies. Qualitative information can provide the most important data and cannot be easily measured through a written questionnaire. The qualitative studies do not replace quantitative ones, but complement them (Muñoz 1998). Quantitative studies, on the other hand, are geared to collect data that can be summarized and analyzed statistically. The main characteristics quantitative and qualitative sensory studies are indicated in Table 24.1.

Consumers may have subjective impressions regarding product quality, and several aspects contribute to their product evaluation. Among them are psychological processes. Such processes are influenced by many factors, including the level of previous knowledge and cognitive competencies of each consumer (Deliza and MacFie 1996; McBride and MacFie 1990). Thus, from a consumer perspective, quality refers to the perceived quality and not to quality in an objective sense (Deliza and Glória 2009; Steenkamp 1990).

We illustrate a number of distinctive sensory characteristics of pot-honey. Comparisons between honey produced by *Apis* (in combs) or meliponines (in pots) are presented and discussed, as well as the sensory evaluation of fermented honey. The latter is, objectively, fairly common for honey in different stingless bee species. Sensory implications based on the extractive techniques are also included considering the new odor–aroma families needed to describe such a product. Preliminary data on acceptance of pot-honey produced by different species are given. A Free-choice profile described is a useful method to group honeys according to their entomological origin, by untrained panels.

24.2 Sensory Characteristics of Pot-Honey

Honey consumers in the cities can find honey from *A. mellifera* on supermarket shelves. In tropical villages where many of the stingless bees are appreciated, as well as the several species of tropical *Apis* produced in combs, there is also a great variety of honey produced in pots. Familiarity with local species of meliponines is also reflected in the cultural uses of honey by stingless bee honey hunters and stingless bee keepers. Their honeys were widely relished in tropical America before Columbus (Schwarz 1948). Honey is as varied as the different species that produce it and the different seasons and habitats in which it is harvested. Therefore, when we taste honey it is like a communication between man and the habits of bees through the human senses.

Honey produced in pots by Meliponini shares compositional properties with *A. mellifera* honey produced in combs, but differs in others such as higher water content and free acidity (Vit et al.; Souza et al. 2006). Therefore, their sensory attributes vary accordingly. For example, a higher acidity increases the sour taste perceived in pot-honey, as observed since Gonnet et al. (1964). The higher water content causes a lower visual viscosity, and has different implications in the perception of odors and aromas, caused by a flavor dilution factor. A wide range of applications derives from the perception of a paradoxical honey, so far the most ancient honey in the planet (Camargo, personal communication) but a new product in the honey market, with few recent sensory studies (Ferreira et al. 2009; Vit et al. 2011a, d).

Classical work on sensory characteristics and defects of honey from *A. mellifera* (Gonnet and Vache 1984) were expanded towards perception evaluation by human consumers. Persano Oddo et al. (1995) characterized honey by visual, olfactory, and flavor attributes, later organized in complete sheets of 20 European honey types (Persano Oddo and Piro 2004). Anupama et al. (2003) developed a specific lexicon for Indian honey by quantitative descriptive analysis (QDA). They applied Principal Component Analysis (PCA) to appearance, aroma, mouthfeel, and flavor descriptors and physicochemical variables. Galán-Soldevilla et al. (2005) developed a sensory lexicon for floral honey with 15 descriptors, in categories of odor, flavor, texture, and trigeminal sensations, i.e., more associated with the sense of touch, perceived through the action of specific compounds on the trigeminal receptors (e.g., the tingling effect of citric acid, cooling sensation from menthol, fizzy feeling of carbonated beverages, astringency caused by unripe persimmons and bananas, or the hotness perceived after eating chilli). Additionally, postharvest conservation methods (see Menezes et al. chapter in this book) cause variable sensations according to the stingless bee species, which leads to the human reaction and distinctive sensory perception, that needs to be considered.

A number of distinctive sensory characteristics of honey derive from extractive techniques. As we will discuss, some new odor–aroma families are needed to describe this product. The sensory interpretation of fermented honey, preliminary data on acceptance of pot-honey produced by different species, and the free-choice profile as a useful method to group honey according to their entomological origin are explored by untrained panels.

24.3 New Odor–Aroma Families for Pot-Honey

The system used to describe the honey of *A. mellifera* has identified and arranged seven families of sensory attributes in the odor–aroma wheel (Piana et al. 2004). This was adapted to eight odor–aroma families for pot-honey produced by stingless bees (Table 24.2), as follows: (1) Floral-fruity, (2) Vegetable, (3) Fermented, (4) Wood, (5) Bee hive, (6) Mellow, (7) Primitive, and (8) Industrial chemicals (Vit et al. 2007a, b). For the public the family bee hive makes sense, but for scholars bee nest would be a better expression.

24.4 Pot-Honey Extraction by Pressure or By Suction?

Compression of mature honey pots is the traditional method of extraction. Compared to modern honey extraction by suction after piercing sealed pots, more pollen is added to the honey by squeezing the storage pots, which may include adjacent pollen pots. The extractive technique has implications related to the fermented pollen (see Menezes et al., chapter this book) added to the honey.

Using descriptors of Table 24.2, eight assessors tasted pressed pot-honeys of *Melipona aff. fuscopilosa* [= *Melipona* (*Michmelia*) sp. 1, see Table in Pedro and Camargo chapter, this book, until the revision of *Melipona* is done] and *Tetragona clavipes* from the Venezuelan Amazon (Vit et al. 2007a, b). The intense fermented odor and aroma reduced the relative frequencies of descriptors from the other seven sensory families. Fermented odor was perceived more frequently than fermented aroma, somehow associated to volatile components of fermentation.

For honey of *A. mellifera*, fermentation is considered an off-odor, something that is not normal (Gonnet and Vache 1984). It represents not only a sensory defect,

Table 24.2 Organized odor–aroma descriptors for pot-honey

Family	Subfamily	Sensory descriptors
1. Floral-fruity	Floral	Orange blossom, jasmine, rose, violet
	Citrus fruit	Citrus zesty, lemon, mandarine, orange, grapefruit
	Fresh fruit	plum, coconut, apricot, berries, apple, melon, passion fruit, watermelon, pear, pineapple, rose apple, fig, peach, grape
	Processed fruit	Candied fruit, dehydrated fruit, syrup fruit, fruit jam
2. Vegetable	Fresh	Sugar cane, raw beans, fresh leaves, sweet corn, sweet parsnip, bitter plants, vegetation
	Dry	Dry hay, malted, chamomile, straw, tea
	Aromatic	Lemongrass, eucalyptus, bay leaves, peppermint, oregano, rue, lime, liquorice
3. Fermented	Acetic	Vinegar, meliponine pollen pots
	Alcoholic	Aguardiente, fermented fruit, yeast, liqueur, must, sake, vinasse, white wine, red wine
	Lactic	*Miso*, cheese, yogurt
4. Wood	Woody	Sawdust, cork, wood flakes
	Resinous	Cedar, incense, pine resin
	Spicy	Anise, cocoa, coffee, cinnamon, clove, nutmeg, tobacco, vanilla
	Seeds	Sesame, almond, marzipan, chestnut, hazelnut
5. Bee hive	Stingless bee	Bee, batumen, cerumen, pot-honey
	Apis mellifera	Beeswax, bee excrement, honey, bee pollen, propolis, moth
6. Mellow	Sugary	White sugar, brown sugar, syrup, tablets, chocolate
	Caramelized	*Arequipe*, burned sugar, candy, caramel, maple, molasses, jaggery, toffee, malt
	Pastry	Pudding, butter
7. Primitive	Animal	Formic acid, pet food, leather, stable, manure, fat, eggs, cat urine, sweat
	Smoke	Smoked food, burned straw
	Wet	Floor mop, after the rain, humus, moldy
	Sulfate	Artichoke, cabbage
	Mineral	Water, clay, ice, water
	Marine	Nori seaweed, fish
	Oily	Oil, rancid
8. Industrial Chemical	Petrochemical	Engine oil, book glue, rubber, paint, plastic, photographic film, solvent
	Medicinal	Ascorbic acid, soap, quinine, soap, vitamin B1

Vit et al. (2007)

but is considered to result from harvesting unripe honey which has a higher water content which causes fermentation. Meliponini process honey differently. Fermentation is accomplished by associated microorganisms inside the storage pots and also after harvest. Therefore, fermentation of pot-honey is not a defect but an aspect of honey maturation by meliponines and a human sensory attribute that needs further consideration. The consumer's preferences are related to cultural backgrounds, and tropical cultures value sour tastes, possibly because tropical fruits are sour-sweet. A group of 20 Venezuelan assessors tasted compressed pot-honey and honey extracted by suction. Despite the very small number of participants in this preliminary study, the results demonstrated that the acceptance was higher for the compressed honey than for the honey extracted by suction. Honey compressed with surrounding sour pollen pots contains fermented pollen, and was perceived with a more intense "lemon-like" flavor (unpublished data) i.e., the honey was perceived as having a citrusy note similar to lemon. This result suggests that such characteristic ("lemon-like" flavor) might have contributed to increase the compressed honey acceptance by consumers, compared to the honey extracted by suction.

The sensory evaluation and interpretation of fermented pot-honey is a challenge for those who work in the field. A transition from defect to value could be based on a direct preference for a more fruity-sour characteristics, a complex perception of fermentation patterns, and also an indicator of medicinal properties derived from the fermentive process.

Stingless bees have associations with microorganisms that transform and help to preserve honey and pollen (see Menezes et al. and Rosa et al. chapters in this book). Different microorganisms have a characteristic fermentation pathway. The presence of lactic acid was confirmed in honey of Meliponini (Vit et al. 2011c). Honey of *Tetragonisca angustula* was studied during a 30-day-postharvest experiment. The gradual increase of ethanol enhanced the antioxidant activity in fermented honey stored at 30ºC (Pérez-Pérez et al. 2007).

24.5 Acceptance of Pot-Honeys from Different Species of Meliponini

Considering that food acceptance depends on several consumers' and individual cultural background, the stingless bee honey's acceptance has been evaluated in different populations. In separate studies, participants from Spain, Venezuela, Mexico, and Australia rated how much they liked the honeys on 10-cm unstructured line scales anchored with the expressions "dislike it a lot" and "like it a lot", in the left (1 cm) and right ends (9 cm), respectively. The acceptance scores were measured and the data were analyzed, with ANOVA, followed by a Tukey test to check differences between means. The results are presented in Tables 24.3, 24.4, 24.5, 24.6 and 24.7.

Spanish consumers tasted pot-honey from Australia, Bolivia, Brazil, Mexico, and Venezuela (Vit et al 2010b). The results in Table 24.3 reveal that on average Spanish consumers did not like the pot-honeys, as the higher acceptance mean was 6.2, which is situated slightly above of the neutral score 5 (neither like nor dislike). Stratified sampling is suggested to see if any type of consumer emerges and we can identify people who most like the products.

Little is known about the perception of pot-honey from the forest by native communities of stingless bee-hunters and stingless bee-keepers. For this reason, the acceptance of honey was evaluated in a Huottuja group in Paria Grande, Amazonas

Table 24.3 Average honey acceptance evaluated by Spanish consumers

Common name of the bee	Country of origin	Bee species	Acceptance[1] (Mean ± SD)
"negrita"	Mexico	*Scaptotrigona mexicana*	4.3 ± 2.5^a
"suro negro"	Bolivia	*Scaptotrigona polysticta*	4.9 ± 2.1^a
"carby"	Australia	*Tetragonula carbonaria*	5.1 ± 2.3^a
"uruçú"	Brazil	*Melipona scutellaris*	5.6 ± 2.4^a
"erica"	Venezuela	*Melipona favosa*	6.2 ± 2.2^a

[1]Evaluated in 10-cm unstructured line scales varying from "dislike it a lot" (1) and "like it a lot" (9). Significant differences between honeys ($P < 0.05$, ANOVA) are indicated by different superscripts

Table 24.4 Average acceptance of honey by Huottuja consumers in Amazonas State, Venezuela

Common name of the bee	Bee species	Acceptance[1] (Mean ± SD)
honey bee	*Apis mellifera*	5.4 ± 3.3^a
"angelita" artificial	–	6.5 ± 3.1^a
"isabitto"	*Melipona aff. fuscopilosa*[2]	6.9 ± 3.6^a
"ajavitte"	*Tetragona clavipes*	7.9 ± 2.2^a
"angelita" artificial	–	8.4 ± 1.5^a

[1]Evaluated in 10-cm unstructured line scales varying from "dislike it a lot" (1) and "like it a lot" (9). Significant differences between honeys ($P<0.05$, ANOVA) are indicated by different superscripts

[2]*Melipona aff. fuscopilosa* [= *Melipona* (*Michmelia*) sp. 1, see Table in Pedro chapter, this book]

Table 24.5 Average acceptance of "tiúba" *M. fasciculata* honey from different locations

Location	Acceptance[1] (Mean ± SD)
Todos os Santos	3.5 ± 2.9^a
Limoeiro	$4.4 \pm 0.8^{a,b}$
Tabocas	$4.8 \pm 1.4^{a,b}$
Moura	5.1 ± 1.1^b
Preazinho	6.5 ± 2.6^c

[1]Evaluated in 10-cm unstructured line scales varying from "dislike it a lot" (1) and "like it a lot" (9). Significant differences between honeys ($P < 0.05$, ANOVA) are indicated by different superscripts

State, Venezuela (Vit et al. 2010a). Two artificial honeys sold as "angelita" *Tetragonisca angustula* in the indigenous market from Puerto Ayacucho, one honey bee and two genuine stingless bee honeys of "isabitto" *Melipona aff. fuscopilosa* and "ajavitte" from *Tetragona clavipes*, were evaluated. The acceptance results are given in Table 24.4.

Another study was carried out with commercial pot-honey produced by "tiúba" *Melipona fasciculata* in five different places: Limoeiro, Moura, Preazinho, Tabocas, and Todos os Santos, all located in Maranhão state, Brazil. In that honey, natural fermentation was completed, as the postharvest processing aiming at stabilizing the

Table 24.6 Average Mexican acceptance scores for pot-honey from different stingless bees

Common name of the bee	Bee species	Year of harvest	Acceptance[1] (Mean ± SD)
"ala blanca"	*Frieseomelitta nigra*	2011	4.7 ± 2.4[a]
"uruçú"	*Melipona scutellaris*	2011	4.8 ± 2.5[a]
"criolla"	*Melipona solani*	2011	5.2 ± 3.3[a,b]
"colmena real"	*Melipona fasciata*	2010	5.3 ± 2.2[a,b]
"abeja bermeja"	*Scaptotrigona hellwegeri*	2010	5.5 ± 1.9[a,b]
"mijui"	*Scaptotrigona polysticta*	2011	5.7 ± 2.3[a,b]
"pisilnekmej"	*Scaptotrigona mexicana*	2009	6.5 ± 2.1[a,b]
"abeja bermeja"	*Scaptotrigona hellwegeri*	2009	6.6 ± 2.0[a,b]
"abeja real"	*Melipona beecheii*	2011	6.8 ± 2.3[a,b]
"pisilnekmej"	*Scaptotrigona mexicana*	2010	6.8 ± 1.9[a,b]
"pisilnekmej"	*Scaptotrigona mexicana*	2011	7.3 ± 2.2[b]

[1]Evaluated in 10-cm unstructured line scales varying from "dislike it a lot" (1) and "like it a lot" (9). Significant differences between honeys ($P < 0.05$, ANOVA) are indicated by different superscripts

Table 24.7 Average Australian acceptance scores of pot-honey from different stingless bee species and unifloral *A. mellifera* honeys

	Acceptance[1] (Mean ± SD)
Stingless bee species	
Melipona fasciata	3.7 ± 2.6[a]
Scaptotrigona mexicana	4.0 ± 3.0[a]
Tetragonula carbonaria	4.1 ± 2.6[a]
Frieseomelitta nigra	4.1 ± 2.8[a]
Melipona beecheii	4.7 ± 3.2[a]
Unifloral honey	
Passion fruit	4.1 ± 2.7[a]
Lychee	5.1 ± 2.5[a]
Leatherwood	5.5 ± 2.6[a,b]
Manuka	6.0 ± 2.5[a,b]
Avocado	7.3 ± 0.2[b]

[1]Evaluated in 10-cm unstructured line scales varying from "dislike it a lot" (1) and "like it a lot" (9). Significant differences between honeys ($P < 0.05$, ANOVA) are indicated by different superscripts

honey prior to packaging. The word "natmel" was created for naming this type of honey. Honey was collected during the X IberoLatinamerican Congress of Apiculture held in Natal, Brazil 2010. The honey was taken to Venezuela to be tasted by Venezuelan honey consumers. Table 24.5 presents the acceptance results (Vit et al. 2011b).

During the VII Mesoamerican Seminar on Native Bees held in Cuetzalán, Puebla, Mexico, May 2011, the Municipality of Cuetzalán was declared Sanctuary of *S. mexicana* "pisilnekmej" (from the Nahuatl "pisil" small, "nektsin" bee).

Pot-honeys from eight species of stingless bees were tasted by a panel of Mexican creole, Mayan, and Nahuatls. Two species had honeys harvested in different years. Higher acceptance mean scores were observed for recently harvested *S. mexicana* (2011) (Table 24.6).

Another study investigated the acceptance of pot-honeys produced by five species of stingless bees (*M. beecheii*, *M. fasciata guerreroensis*, *S. mexicana*, *T. carbonaria*, and *T. nigra*) and five unifloral honeys: avocado *Persea americana* (Lauraceae), lychee *Litchi chinensis* (Sapindaceae), passion fruit *Passiflora edulis* (Passifloraceae), leatherwood *Eucriphia lucida* (Cunoniaceae), and manuka *Leptospermum scoparium* (Myrtaceae) of *A. mellifera* from Kuranda forest, Queensland, Australia. Table 24.7 shows the average acceptance results achieved in the study.

24.6 Descriptive Sensory Studies of Pot-Honey

Descriptive studies were also carried out with pot-honey, to investigate the relationship between sensory attributes and the bee origin of the honey produced in pots by Vit et al. (2011a and 2011d). Samples were analyzed by free-choice profiling (FCP) (Deliza et al. 2005), a quick and inexpensive method in which participants are asked to both identify attributes in the sample, and score their intensities on appropriate scales. They should be provided with adequate instruction on how to perform this test, and possibly given product categories to describe them in terms of appearance, aroma, flavor, texture, etc. Each participant will generate his/her own set of attributes, and consumers should be recruited as product users, age/gender/education level. It is important to note that consumers may use terms in different ways. Researchers may be able to separate consumers into groups, aiming at better identifying which characteristics are most important for that consumer segment. Generalized Procrustes Analysis (GPA) is a common statistical tool for analysis of FCP data. Figures 24.1 and 24.2 present the results of the studies conducted with the Huottuja (Piaroa) community and Spanish consumers, respectively.

24.7 Final Considerations

Perception is a multifactorial process that needs to be considered to explain any sensory response, in our case the pot-honey results. Orthonasal (breathing, nasal mucosal tissues, nasal metabolism) and retronasal (physicochemical release, salivation, oral metabolism, oral and pharyngeal) peripheral factors, besides chewing and swallowing patterns, and tongue movements affect the tasting process (Buettner and Beauchamp 2010). Odor, aroma, and taste are released from the honey matrix according to chemical and physical features. Although we are interested in comparing honeys—not assessors, we cannot forget the individual

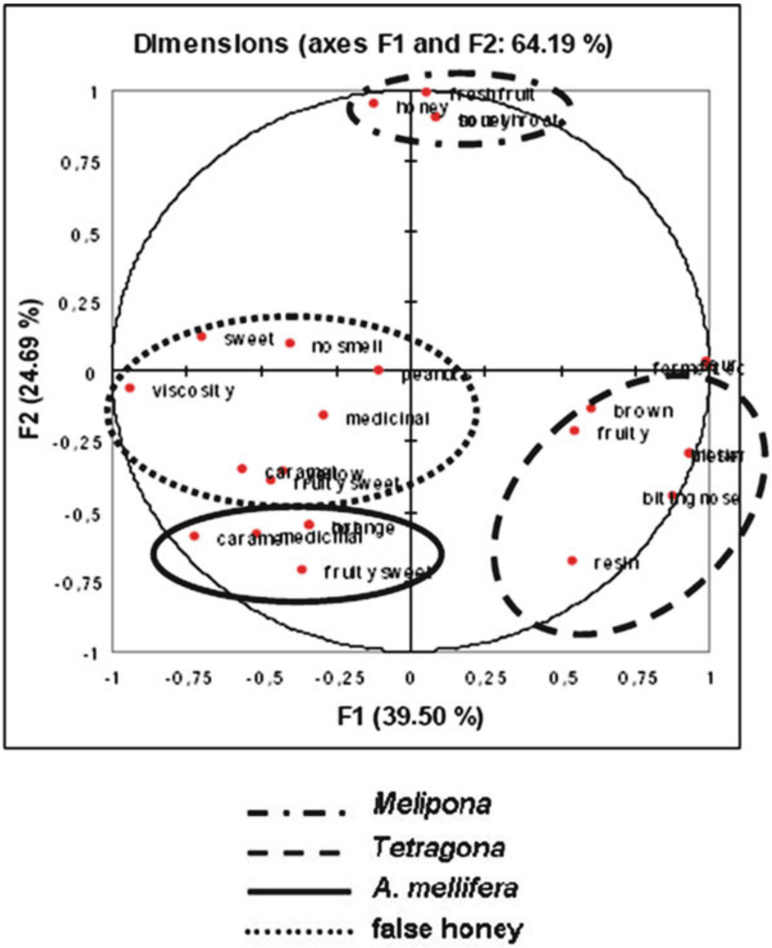

Fig. 24.1 Honey descriptive sensory evaluation by Huottuja community (from Vit et al. 2011a). Used by permission of Sociedade Brasilera de Farmacognosia

differences of participants regarding honey perception with a strong cultural imprinting since their childhood (Barthomeuf et al. 2009). In addition, due to today's market competitiveness, it is necessary to understand the factors influencing consumers at the emotional level. Identifying the emotional elements that consumers experience and expect in a product can help providing a complete perspective on consumer affective behaviors, and contributing to the identification of the products most liked by consumers. In this context, scales for measuring different emotions associated to food product have been developed to test food by consumers (King and Meiselman 2010), and may be a useful tool to help better understand consumer's honey perception.

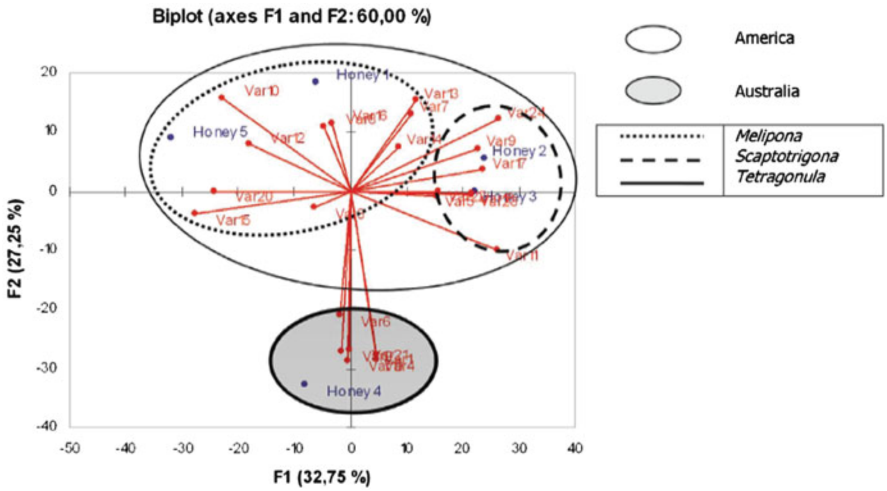

Fig. 24.2 Pot-honey descriptive sensory evaluation by Spanish consumer (from Vit et al. 2011d). Permission granted by the International Bee Research Association

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