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Development of a Quantitative Descriptive Sensory Honey Analysis: Application to Eucalyptus and Clover Honeys

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Abstract: Sensory analysis of bee honey is an important tool for determining its floral origin, for subsequent quality control practices and which ultimately will determine consumer preferences towards this product. A procedure for the selection, training and monitoring of assessors was applied. Unifloraleucalyptus and clover honeys produced in Argentine were assessed using descriptive quantitative analysis. The sensory profiles differentiated clover honey (light, fruity and floral flavor with low intensity) from eucalyptus honey (more intense flavors, vegetable notes, aromatic, warm, small crystals with a high tendency to quick crystallization in mass). The analysis by principal components showed higher intensities of sweetness and smell for eucalyptus honeys and graininess for clover honeys. These appropriate indicators of quality provide a differentiating tool to increase the added value of these honeys.

Keywords: Descriptive quantitative analysis, flavor, graininess, principal component analysis, smell, sweetness, unifloral honeys

INTRODUCTION

Global trends are moving towards a clearer understanding of the honey market and their derived food products. It is of interest to seek its geographical origin, nutraceutical properties and benefits for health. The sensory analysis evaluates the correspondence with consumer expectations and complements the determination of botanical origin and physicochemical characteristics. In sensory terms, honey properties may be scored and described using the senses of human beings as an analytical tool. The application of sensory analysis for honey goes back to France, Italy and Spain **(**Gonnet and Vache, 1998; Estupinan *et al*., 1999; Piana *et al*., 2004; Galán-Sodevilla *et al*., 2005; Gonzalez *et al*., 2010). The International Honey Commission (IHC, 2001), in Europe and the U.S. National Honey Board (2002), published extensive work on the sensory attributes of honey. In Argentina and Chile, there are studies suggesting analytical methodology and descriptions (Ciappini, 2002; Garitta and Rodriguez, 2006; Montenegro *et al*., 2008; Sabag *et al*., 2009), as well as in India **(**Anupama *et al*., 2003; Aparna and Rajalakshmi, 1999).

This interest in the application of sensory analysis for honey can recognize two interrelated objectives: characterization and development of the product. For characterization, framing means to fit the product in a predefined type or standard. For honey, this refers primarily to identify as multior unifloral and in the latter case, consider that actually matches the declared origin, as expressed in Directive 110/01 (2001) of the European Union. It also allows the detection of defects in agricultural practices and conservation (fermentation, impurities, off flavors, smoke, burned) and it is essential in studies of consumer preferences.

The MERCOSUR supports a 10% of the world total production of honey. Within these indexes, Argentina ranks third as producer, after China and the United States, representing 70% of the South American honey and 6% of the world total production. Global exports are around 420,000 tons/year, with Argentina responsible for just over 20% of that total. Argentine exports 95% of its production, mostly sold in bulk and without differentiation. The production process takes place predominantly in the pampeana region with the province of Buenos Aires as the leader with 41% of the total production. Bee argentine products need to increase the added value, consolidating its image in the international market and incorporating the identification of origin as a quality certification (SAGPyA, 2008). This study has two main objectives, one related to summarize the methodology to select, train and monitor a descriptive sensory panel. The second aim is to recognize sensory differences between clover and eucalyptus honeys of pampeana region applying the established methodology.

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Table 1: Scoring reference substances and odor recognition

Sample	3 points	2 points	1 point
Geraniol$C_{11}H_{18}$	Rose	Floral	Fruit, citrus
Eugenol$C_{10}H_{12}O_2$	Clove	Dentist	Spicy
Anethole$C_{10}H_{12}O$	Anis	Camphorated	Aromatic, spicy
BenzaldehydeC_7H_8O	Almond	Marzipan, macaroons	Sweet
Limonene$C_{10}H_{16}$	Lemon	Citric	Fruit
AceticacidC_2H4O_2	Aceticacid, vinegar	Dressing	Chemical, pungent
MethylanthranilateC_8H9NO_2	Orange blossom	Floral	Fruit
Valerianic Acid 4 $C_5H_{10}O_2$	Sweat	Animal	Stable
Citral$C_{10}H_{18}O$	Lemon drop	Citrus, lemon	Fruit, candy, chewinggum
Thymol$C_{10}H_{14}O$	Thyme	Spices	Seasoning
Coumarin$C_9H_6O_2$	Clover, honey, vanilla	Sweet milk, coconut	Vegetable, sweet

MATERIALS AND METHODS

First experiment:

Selection of panel members: Candidates were preliminary selected based on interest and willingness to participate in sensory tests. Potential candidates completed a form with personal information as stated previously (Gonzalez *et al*., 2010). They were informed of the required time for sensory testing, the nature of work and food to eat and they were notified with an informed consent.

In different sessions the candidates performed a series of selection tests, as described below.

Test of basic taste recognition (ISO 22935-1, 2009). Test of odor recognition and description (ISO 5496, 2006a): The presentation was made into strips, soaked and used according to the substances listed in Table 1. For both tests, candidates whose scores are greater than or equal to 65% of maximum possible score were selected.

Color vision test: The Ishihara (1971) was used to detect if a person suffers from color blindness.

Order by strength (ISO 8587, 2006b)**:** For such screening assays, arrangement of sweet taste was designed, as indicated in Table 2. At least 60% correct answers were required.

Table 2: Solutions for sorting by intensity

Intensity	Sucrose [g/L]
1	0.55
2	0.94
3	1.56
4	2.59
5	4.32
6	7.20
7	12.00

Test description of textures (ISO 8586, 2008c)**:** A series of products, in Table 3, arranged at random was provided and candidates described the characteristics of texture. The solid samples were presented in uniform sized pieces and the fluid ones in opaque containers. Performance evaluation was quantified giving 3 points for a correct description, 2 points for a description in general terms, 1 point for a description or questionable association and 0 point if there was no response or if it was incorrect. An adequate success can be established only in relation to the products used. The candidate whose score was greater than or equal to 65% of the maximum possible was selected.

Table 3: Food for the description of Textures

Food	Texture
Breakfast cereals	Crunchy, crisp
Gummy	Rubbery, soft
Cake	Spongy
Raw carrots	Crunchy, hard
Fluid Honey	Smooth, sticky, unctuous
Crystallized honey	Tough, gritty, rough
Sugar	Crystalline, granular, coarse

After evaluating the results of individual candidates, those that have shown the best performance were selected.

Training of assessors: This step was designed to develop the ability to recognize and identify attributes, to improve the sensitivity and memory, to perform accurate and consistently and to develop language awareness. Instructions were also given on how to smell or taste the samples, rinse the mouth between samples and how to bite, chew or dissolve the sample in the mouth.

The training was conducted in fifteen successive sessions in which panel members become familiar with the honey and its various attributes. The tests were carried as previously according to general rules for sensory analysis (ISO 8589, 2007; ISO 6658, 2005; ISO 13300-1, 2006c).

First session: In the first session, samples presented were representative of the universe of honey and assessors came to look, smell, touch, taste it and to express their perceptions.

Second to fourth session: In each session, representative foods of two or three families of odor as indicated in Table 4 (Piana *et al*., 2004; IHC, 2001; Bruneu Barbier and Gallez Guyot, 2000) and a series of elementary taste intensity, according to Table 5, were given.

Fifth, sixth and seventh sessions: As the assessor has been trained to recognize odors, they were subsequently presented with a series of odor intensities, such as suggested in Table 6.

Table 4: Families and subfamilies of scents and aromas

Family	Sub family	References
Floral	Subtle	Orange blossom water, rosas
	Heavy	Azahar, jasmine, violet, Jacinto privet
Fruit	Citric	Lemon, orange, bergamot
	Fresh fruit	Strawberry, pear, apple, damascus
	Tropical fruit	Pineapple, banana, cantaloupe
	Processed fruit	Datiles, dried figs, raisins, grape juice, prunes, applesauce
Warm	Subtle	Beeswax, vanilla, marzipan, honeycomb
	Lactic	Butter, condensed milk, milk candy
	Caramelized	Black sugar, caramel, molasses
	Toasted	Toasted hazelnuts or almonds, instant coffee, coffee beans, toast, malta
	Burned	Toasted bread (some charred)
Aromatic	Spicy	Clove, nutmeg, thyme, oregano, anise, cinnamon, anethole
	Resinous	Pine resin, incense, propolis
	Fresh products	Mint, menthol, eucalyptus essential oil
	Citric	Lemon peel, orangepeel
Chemical	Phenolic	Phenol, cresol
	Petrochemical	Tar, plastic, solvent
	Smoked	Smoke cigarette ash
	Acetic	Acetic acid
	Ammonia	Ammonia
	Medicinal	White soap, vitamin B
	Alcoholic	Muscat wine, alcohol
Vegetable	Green	Grass clippings, fresh leaves crushed
	Wet	Wet grass, raw mushrooms, spinach thawed, wet wood, Algae
	Dry	Green tea, cereal straw, dry grass, cereal, bran
	Woody	Cedar wood
Animal	Sulfur	Hard boiled egg (yolk), boiled cauliflower
	Proteic	Dried mushrooms, bouillon cubes, food fish, soy sauce
	Valeric	Sweat, leather, blue cheese, cat urine, fecal

Table 5: Scale for the assessment of current tastes sweet, sour and bitter

Parameter	Values	Sweet g of sucrose/L	Acid citric acid g/L	Bitter caffeine g/L
Nothing/absent	0	Water	Water	Water
Some/weak	2	50	0.062	0.05
Sensitive	4	100	0.125	0.10
Intense	6	200	0.25	0.20
Very intense	7	350	0.50	0.40

Table 6: Scale for the assessment of tangerine and smoke odor intensity

		Dilutions in 20 g of commercial glucose syrup	
Parameter	Values	Essence tangerine[1]ul[*]	Smoke[2]ul[**]
Absence	0	0	0
Weak	2	50	3
Moderate	4	100	8
Intense	6	150	20
Very intense	7	200	50

[1]Essence of mandarinsE820486ES Flavor and Fragrance SA

[2]Essence of smoke Lir-2463 International Flavors and Fragrances

Table 7: Scale for the assessment of caramelized/burned odor intensity

Caramelized/Burned	Parameter	Values	Time
	Absence	0	7 min
	Caramelized weak	2	12 min
	Intense caramel	4	18 min
	Weak burning	6	21 min
	Intense burning	7	30 min

Caramelized and burned flavor: honey candies with increasing cooking time were made mixing 50 g of honey with 15 g of sugar and heating the mixture on high heat for the time indicated in Table 7, once after that time, shaping the candies by pouring about 10 sugar drops to ground in the depressions that have been practiced. The candies are dissolved in the mouth, perceiving the characteristic notes of caramelized and burned.

Fermentation: Some honeys that have developed this defect. The assessor only smells the samples. Assessors quantified both attributes according to the scale showed in Table 7.

It was also presented at texture scale per session:

Size of the crystals and graininess scale: The attribute is related to geometric texture, i.e. the perception of size, shape and number of particles in a product. In the case of honey, which crystallized spontaneously (according to the water content and sugars, particularly the ratio fructose/glucose) it was appropriate to measure the size of the crystals and the degree of crystallization, which refers to the presence of crystals and varies from nothing to complete crystallization. The degree of crystallization was explained with honey samples and with the aid of the fluidity scale (Table 8). To construct the scale of size of the crystals, glucose syrup (density = 1.722 g/L) was placed in Petri dishes and mixed with each of the different types of sugar shown in Table 8. The sugar should be added immediately before to test to avoid dissolution. The amount and size of the crystals can be seen visually, moving the honey or

Table 8: Scale for the assessment of graininess and fluidity

Graininess		Fluidity	
Product added to 35 g of corn syrup	Point on the scale	G powdered sugarin 20 g of corn syrup	Point onthescale
Nothing	0 -No	10	0 -Doesnotflow
Powdered sugar, 5 g	1 -Very fine	8	1-It flows very Little
Sweetener, 5 g	2 -Fine	6	2-It flows little
Common sugar, 3 g	3 -Medium	4	3-Fluid
Small crystal brown sugar 3 g	4 -Large	3	4-It flows quite
Glass medium brown sugar 3 g	5 -Coarse	2	5-It flows much
Large crystal brown sugar 3 g	7 -Verycoarse	0	7-Extremelyfluid

Table 9: Solutions for the identification of trigeminal sensations

Feeling	Standard substance	Concentration
Metallic	Ferrous sulfate	0.01 g/L H2O
Astringent	Al and K sulfate dodecahydrate	0.5 g/L H2O
Pungent	Acetaldehyde	1 g/100 mL etanol
	Propionaldehyde	1 g/100 mL ethanol

spreading it against the container wall. In mouth, the sample is dispersed against the palate with the tongue. Once this training step, honey samples with different degrees of crystallization were presented. Another discussion revealed how they perceive the crystals: soluble, insoluble, angular, round, soft, hard or other qualifying items, these will not be quantified when used to describe a sample of honey, but only referred to as observations.

Fluidity: Place in covered containers the mixtures depicted in Table 8. Each assessor took a portion of the mixture with the tip of spatula, placed it 5 cm above the free surface of the sample, observing the rate at which drops.

Eighth session: Persistence was tested, explaining that this parameter indicates the duration of sensation after the stimulus is removed. Honeys were used to illustrate each case and considered the following scale:

0 Intangible: no sensation appears when the stimulus withdraws
2 Low: less than 30 sec
4 Medium: about 1 min
7 Long: about two minutes or more

It was explained to the assessors that the aftertaste is the sensation of taste and or smell that appears after the removal of the product and that is different from the sensations perceived when the product is in the mouth. Often become distorted and unpleasant and it generally implies a negative note. It is classified as absent (NO) or perceptible (SI), in which case it was described.

Ninth session: Examples of trigeminal sensations were presented, using as reference the solutions indicated in Table 9. For the pungency, it was adopted the presentation with strips of paper.

The oral tactile sensation included features such as greasiness, stickiness and plasticity. They were not present in all honeys; therefore, they were only mentioned as observations, when describing the honey samples. To distinguish between them, examples of smoothness (Marroc snacks), adhesiveness (current style toffee) were presented, examples of easy dissolution (gelatin), coolness (menthol candy) or others that may arise with each definition were given (ISO 5492, 2008b).

Tenth to fifteenth session: Honey samples and controls were presented, so that the assessors describe them individually, using a standard evaluation form. Individual performance was analyzed with each assessor, in order to correct errors.

Assessment and monitoring of assessors: Once the training has been completed and the assessors were able to recognize at least 70% of the control samples, the panel analyzed six samples by triplicate, in balanced order. Scoring data for each assessor and the entire panel were analyzed using analysis of variance (Johnson, 2004). Significant variation between assessors were searched to prove the presence of bias, i.e., one or more of them give consistently higher scores or lower than the others, identifying assessors that deviate from the expected performance, which must to continue their training. Also significant variations between samples were searched. Furthermore, the presence of significant interaction between assessors and samples were analyzed to know if one or more of the assessors were using the scale differently from the others. Multivariate statistical tool as principal component analysis was also applied by XL Stat.

Second experiment:

Samples: Honey samples were collected from the pampeana phytogeographic region of Argentina (PersanoOddo and Bogdanov, 2004), supplied by beekeepers who had their number of National Register of Producers Beekeeping (RENAPA), from apiaries with health conditions that ensure the safety of the samples ensuring the provision of genuine honey. Samples were kept refrigerated (3±2°C),stored at dark, in glass jars with screw cap, in amounts not less than 1 kg. The floral origin was determined according to Louveaux *et al*., (1978) and established that honey is considered unifloral when the pollen content of the species exceeds 45% (PersanoOddo and Bogdanov, 2004). From these preliminary tests, samples were selected as unifloral clover *(Trifolium* sp., *Lotus*, *Melilotus* and *Medicago sativa*) and eucalyptus *(Eucalyptus* sp.) to be described by the trained panel referred according to the procedure proposed in the first experiment. To confirm if honey was safe for consumption, the moisture content and acidity (AOAC International, 1995), were determined.

Quantitative Descriptive Analysis (QDA): A QDA was applied to the honey evaluation by a trained panel. Comparing with standards previously memorized in the training step, visual, olfactory, gustatory and tactile cues were quantified in a series of structured visual scales (ISO 4121, 2008a; ISO 6564, 1985).

Test conditions: Tests were carried out according to the general directives for sensory tests (ISO 6658, 2005) and layout, with individual cabins free of odors and strange noises (ISO 8589, 2007).

Procedure: Coded samples in a single tray for each assessor were prepared, placing between 30 and 40 grams of honey in glass bowls of 160 mL keeping the ratio of sample/volume of the container close to 1/4 or 1/5 (Piana *et al*., 2004).These glasses must be perfectly clean, free of odors and flavors and were covered with aluminum foil and stored at room temperature (22 ± 2°C) at least 2 h prior to testing. In the case of smoking, there may be a preparation of 10 μL of the essence dispersed in 20 g of glucose.

Determination: On 16 cm horizontal lines, anchored in 1 cm (minimum) and 15 cm (maximum), which represent the continuous scale of 7 points for each attribute, the assessors indicated by a vertical line the perceived intensity for each attribute and sample. Upon completion of the trial, the leader of the panel measure the distance between the anchor and the mark left by the assessor, which represents the measurement result and will be analyzed statistically. The analysis is complemented by qualitative descriptors for odor and flavor and the mention of other sensations that may be present.

Odor evaluation: The first odor impression may be reinforced smelling the sample, spreading it on the container walls with a spatula or rotating the container. If necessary, it is expected between 5 and 20 seconds to repeat the process. The assessor must indicate odor intensity, the family or subfamily to which belongs the odor perception and the distinguished notes.

Appearance evaluation: Fluidity and Graininess: Both were evaluated as stated in the training step.

Basic tastes and aroma evaluation: A small amount of honey was placed on the tongue (1 or 2 g) with a disposable spatula. The sample was allowed to dissolve for a few seconds without inspiring air. The air was released through the nose, keeping closed the mouth, so that the aromas stimulate the olfactory receptors. Total intensity of aroma was evaluated, proceeding as for the smell.

Oral tactile sensation: the assessors differentiated physical sensations (i.e. viscosity, coarseness, roughness, spread ability, adhesiveness, ease of dissolution) as properties of the texture and chemical sensations (e.g., astringent, spicy, fresh, pungent) as properties of the flavor.

Intensity of color: was determined as described in ISO 11037 (1999).

Clean mouth: From sample to sample, the assessors neutralized with water, apple, bread, rice cakes or crackers without salt.

Analysis of data: For each characteristic, one can calculate the average and standard deviation obtained on repetition of the same sample by each assessor and the average panel were calculated. To compare samples together, the results were examined statistically by a proper technique of multiple variance (Johnson, 2004).

RESULTS AND DISCUSSION

Conformation and performance of a panel: By selection and training methodology previously described, it was formed a panel of four women and three men, aged between 20 and 50. After the training, which lasted about four months, the results of monitoring (ANOVA) indicated that the interaction was not significant and that the panel was consistent in their differences. Furthermore, there were no differences between score levels given by the assessors.

Verification of the use of descriptors: To check the use of descriptors and scales, the panel analyzed 72 samples of honeys from different floral origins, according to the methodology described in the first experiment. The honey samples analyzed met the quality standards. Origins were established according flower (Child and Simonetti, 2005) and proved to be honey from *Trifolium* sp.(37.5%), *Eucalyptus* sp.(8.5%), *Medicago sativa* (8.3%), *Salix* sp.(8.1%), *Prosopis* sp.(4.7%), *Geoffroeadecorticans* (4.7%) and the remainder from multifloral origin. The results showed significant differences between the samples for the attributes quantified. The principal component analysis showed that the first two components explained 59% of the total variance of the data. The first principal component, which accounted for 35.6% of the total variability of the data, is positively related

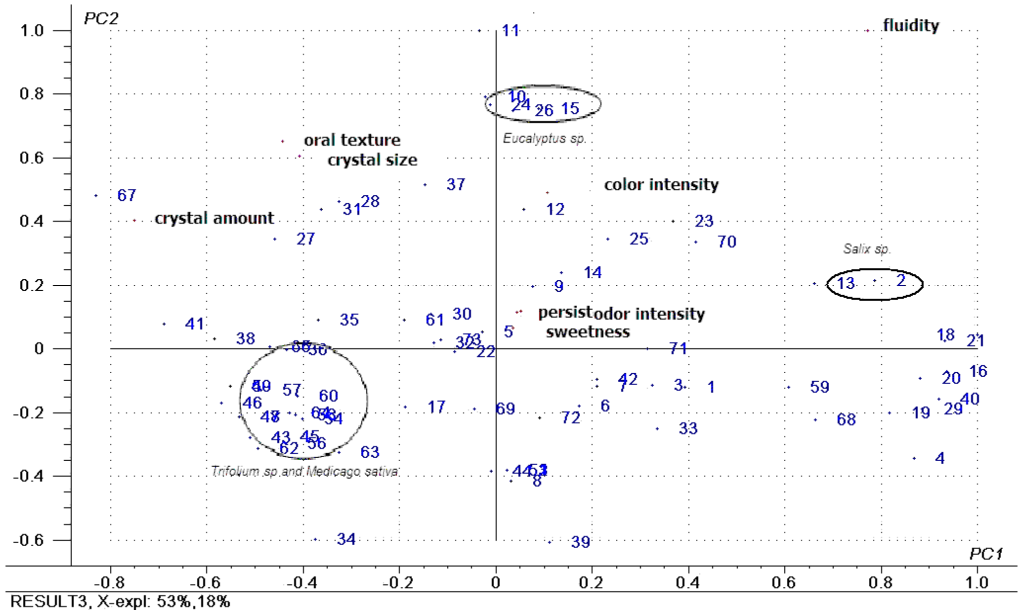

Fig. 1: Principal Component Analysis (PCA) of the main sensory descriptors for 72 honey samples

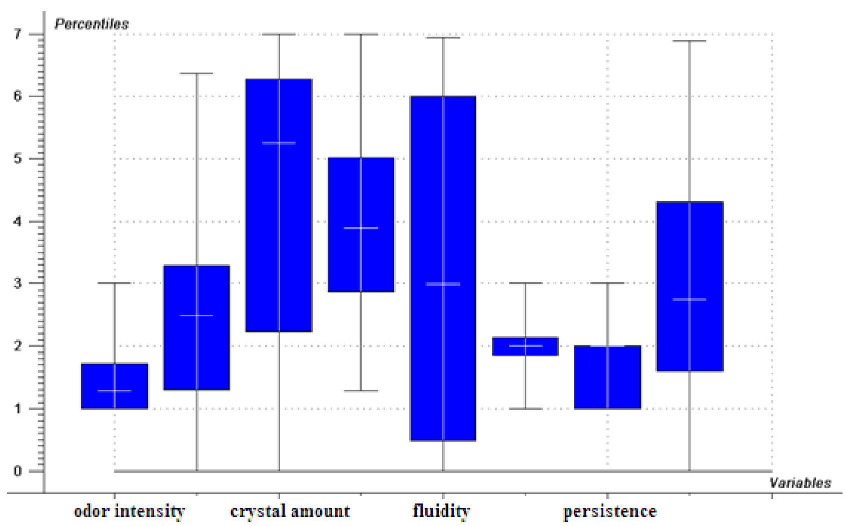

Fig. 2: Distribution of percentiles for the sensory attributes assessed by QDA of honeys

to fluidity and negatively with the attributes size and number of crystals and mouthfeel/touch. The fluidity is the attribute represented by the vector of greater length, indicating the high degree of variability among samples (Fig. 1). The second principal component showed no clear relationship with a particular attribute although there is a tendency to explain the variations in sweetness, aroma and persistence.

Trifolium samples sp. and *Medicago sativa* were located on the first axis, to the left, characterizing crystallized honey with weak sweetness, those of *Eucalyptus* sp. were located on the second axis in the upper plane, corresponding to intermediate fluidity, moderate smell and intense sweetness and *Salix* sp., in the first quadrant. The distribution of percentiles for the sensory attributes assessed by QDA of honeys is in Fig. 2.

The highest number of mentions referred to qualitative scent notes (floral, fruity, vegetable, grain, aromatic, alcoholic) followed by the flavor that includes the attributes fruity, floral, ripe fruit and aromatic. A large number of odor notes (68) and flavor (53) were mentioned sporadically by any member of the panel.

According to the results obtained it can be concluded that the methodology, the proposed scales and the training process for the evaluation panel

Table 10: Moisture content and acidity of honey samples from Argentine pampeana phytogeographic region

	Moisture [g/100g]		Acidity [meq/kg]	
Harvest year	Eucalyptus	Clover	Eucalyptus	Clover
Samples (n)	24	49	24	49
2005/06	18.24±0.60	18.64±1.10	20.25±11,74	21.98±4.92
2007/08	17.67±0.04	17.54±0.96	23.74±5.3	20.02±5.01
2009/10	16.28±1.28	16.30±1.65	23.00±6.31	15.58±2.34

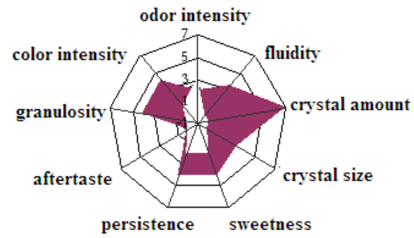

Fig. 3: Sensory Characteristics of clover honey from the Argentine pampeana phytogeographic region

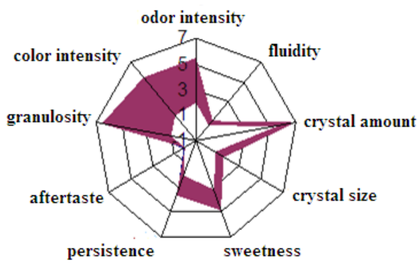

Fig. 4: Sensory characteristics of eucalyptus honeys from the Argentine pampeana phytogeographic region

descriptive groups, were appropriate for the intended purposes. The selected attributes and the range of variation of the scales developed were sufficient to describe all the samples tested.

Characterization of unifloral honeys:

Origin of samples: The moisture content and acidity (AOAC International, 1995), are shown in Table 10. All samples were within specifications for these parameters (Codex Alimentarius, 1998).

Characteristics of clover and eucalyptus honeys: The clover honey crystallizedspontaneously in a single homogeneous phase, forming small crystals, which dissolve easily in the mouth and gave a smooth oral sensation (Fig. 3). When *Lotus* was the predominant pollen, the crystals were larger and oral tactile sensation appeared as weakly sandy. The smell was perceived as weak to moderate with weak persistence. It was possible to see changes in taste/smell characteristics according to the predominant pollen type: if *Melilotus* spp. predominates, the smell was very weak and were perceived fruit and floral aromas; if instead the majority was *Medicago sativa* pollen, the odor intensity was too weak, but vegetable notes (cereal, dry grass, hay) and warm notes (wax, lactic) appeared, accompanying the fruity-floral scent. These results agree with those reported by other authors (Pajuelo Gomez, 2004) who characterized alfalfa honeys produced in Andalucía, Aragón and Lleida (Spain).When pollen is mostly *Trifolium*, odor intensity was moderate, with fruity floral, but predominantly vegetable (cereal, dry grass) and slightly warm notes (wax, vanilla).The *Lotus* is manifested as vegetable and farinaceous. The presence of pollen of *Eucalyptus* above 34% in clover honey, evoked an aromatic note and the presence of *Brassicaceae*pollen, even in small amounts (2.5% or less), evoked an animal note. The sweetness (unique elemental taste present) was moderate, the main aroma was vegetable (cereal, dry grass, farinaceous) of low persistence and there were not perception of residual tastes or trigeminal sensations. In the mouth, the crystals were perceived as very fine, easily soluble.

Eucalyptus honeys showed very fine crystals, which dissolved readily in the mouth. The odor intensity was characterized mainly as moderate with weak persistence, although there were some samples with weak and others with strong odor, giving to this parameter a very wide range of variation (between 2 and 5.5 units on a scale of 7 points). Odor notes were found in the vegetable family (pasture, dry grass, dry flowers, wood) and aromatic family (anise, anethole, menthol). In some cases, warm notes (lactic, malty, roasted) were perceived with weak persistence. The sweetness was moderate to intense, lacking salty or bitter notes. The flavor was predominantly vegetable (wood), warm (butter, wax) and aromatic. The color intensity also showed a wide variation range: between 1.5 and 5.5. In eucalyptus honeys from a different geographical area (Delta Paraná River), it was detected pollen from *Salix* (willow) and Mirtaceae, with a shift of color to redish note. The sweetness was intense and persistent, causing astringency and presence of metallic notes. In Eucalyptus honeys from Mediterranean coast and the Bay of Biscay, there were a wide range of variation for the color from light amber to dark amber when carrying broom or heather (40 to 80 mm P fund), a wet wood aroma, very intense and extremely persistent, slightly sweet and sour notes, light salty notes if accompanied by broom, tendency to crystallization as medium and fine crystals (Gómez Pajuelo, 2004). The Italian eucalyptus honeys have been described as strong-smelling, with medium sweetness and very weak acidity, warm scent, woody, which crystallizes spontaneously at moderate speed (PersanoOddo *et al*., 1995) (Fig. 4).

Table 11: Correlation matrix for sensory variables of clover and eucalyptus honeys

Variables	Odorintensity	Crystalsize	Sweetness	Persistence	Graininess	Color intensity
Odorintensity	1					
Crystalsize	0.25	1				
Sweetness	0.43	0.14	1			
Persistence	0.34	0.14	0.54	1		
Graininess	0.16	0.87	0.14	0.23	1	
Color intensity	0.56	0.18	0.06	0.11	0.20	1

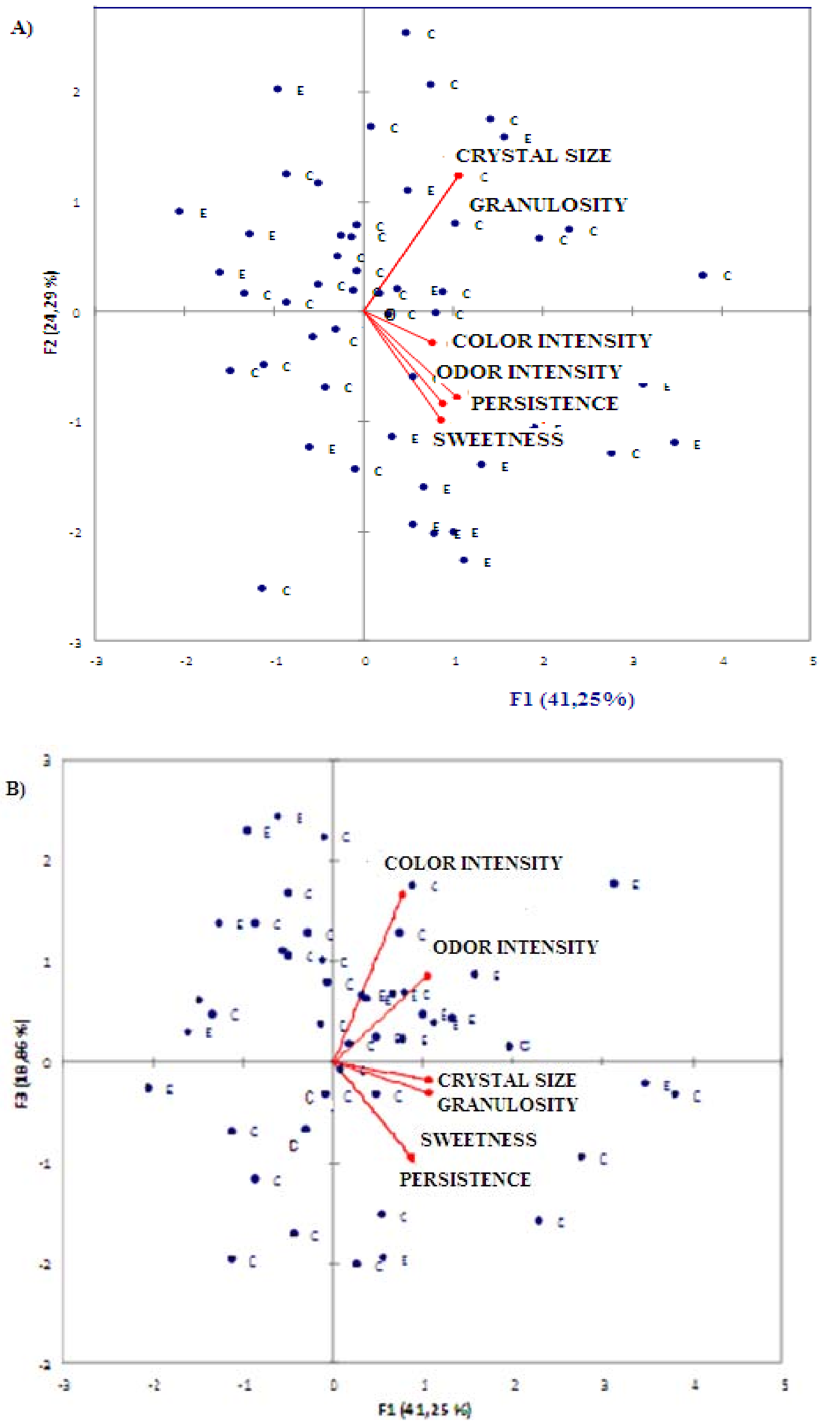

Fig. 5: Analysis by Principal Components of sensory variables for clover and eucalyptus honeys, A) representation on the plane of the first two components, B) representation on the plane of the first and third components

Correlations between variables and PCA: The graininess and size of crystals were highly correlated, indicating that the appreciation of the size of crystals was coincident by visual or oral assessment of this textural attribute. Sweetness intensity is correlated with persistence, indicating that the sweetness may be a component of the overall perception in the mouth. The intensity of the color and odor were also significantly correlated, perhaps suggesting that substances contributing to color constitute part of the set of substances which originate odor intensity (Table 11).

Other authors found correlations between odor intensity, persistence, bitterness and color, with correlation coefficients of 0.71, 0.45 and 0.50 and between color and graininess (r^2 = 0.63), when multifloral honeys were described using descriptors as odor intensity and persistence, sweetness, bitterness, acidity, color, graininess, adhesiveness and viscosity (Gonzalez *et al*., 2010).

A PCA on the variables describing sensory aspects of honeys explained together 84.4% of the total variation in the data (Fig. 5). The eigenvalues or the first three CP were: CP 1 = 2.475, CP 2 = 1.46 and CP 3 = 1.13.

The configuration of points (honey samples) represented on the plane of the first two components and the first and third components, demonstrated greater intensity for sweetness and smell of eucalyptus honeys. Clover honeys were directed instead towards higher values of graininess.

Other authors found that the variables that best discriminated honeys or honeydew were sweetness, bitterness, color and graininess, while acidity, viscosity and adhesiveness showed similar values for all tested honeys (Gonzalez *et al*., 2010).

CONCLUSION

This study shows that the protocol of selection and training of assessors was adequately established. Quantitative descriptive sensory profiles performed following this protocol differentiated clover honey (clear, fruity floral aroma and low intensity) of eucalyptus honey (intense aromas, vegetal notes, aromatic and warm, small crystals and high tendency to crystallize quickly). The principal component analysis showed higher intensities of sweetness and smell for eucalyptus honeys and granularity for clover honeys. In conclusion, sensory quality parameters allow differentiation, thereby achieving increased added value of these honeys. Future research may be designed to know whether the application of this sensory methodology in conjunction with physicochemical and melisopalinological analysis improves the assignation of floral origins to honeys.

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