BEE HONEY COLOR VARIATION THROUGHOUT THE YEAR IN HUEJOTITÁN, JALISCO, MÉXICO.

VARIACIÓN DEL COLOR DE LA MIEL A LO LARGO DE UN AÑO EN HUEJOTITÁN, JALISCO, MÉXICO

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ABSTRACT

Bee honey is a highly valued food. The international marketing of honey is controlled by quality standards that are based on its physicochemical properties. One of them is color, which does not reflect a high or low quality, but rather the preferences of certain consumer markets. Color in honey is mostly determined by the floral sources and it changes according to the seasonal transformations in the floristic composition of plant communities throughout the year. This study was intended to record color variations of the honey collected by *Apis mellifera*. For this purpose, honey was sampled from three selected hives, in an apiary in the town of Huejotitan, state of Jalisco, in western Mexico, on a monthly basis for a year. Color was measured according to the Pfund scale. Humidity was also measured since fermentation due to excessive moisture could spoil the samples. Two additional samples were collected, as well, from the bulk of honey at the time of the harvests, directly from the extractor: one from the spring harvest in May 2012, and the other from the fall harvest in December 2012. A total of 23 samples were obtained from December 2011 to December 2012. Color ranged from 0 mm Pfund (water white) to 85 mm Pfund (light amber) and humidity from 17% to 24%. It was discovered

that the samples collected during the peak of the nectar flow, October - November, were contrastingly whiter than the rest. Although requiring more work, since consumers prefer clearer honeys, it is concluded that honey harvested at intervals during the high flow in the hives, with careful consideration of the moisture and making sure to keep honeys from different hives, apiaries and producers separate, a wider variety of honeys would be obtained, with different shades of color and different properties, better targeting the more specialized and demanding markets of today.

Keywords: floral sources, physicochemical properties, blooming season, capped honeycomb.

RESUMEN

La miel de abeja es una comida muy apreciada. La comercialización internacional de la miel está controlada por estándares de calidad que se basan en sus propiedades fisicoquímicas. Uno de ellos es el color, que no refleja alta o baja calidad, sino las preferencias de ciertos mercados de consumo. El color en la miel está principalmente determinado por las fuentes florales y cambia según las transformaciones estacionales en la composición florística de las comunidades vegetales a lo largo del año. Este estudio fue diseñado para registrar las variaciones de color de la miel recolectada por Apis mellifera. Para este propósito, se tomaron muestras de miel de tres colmenas seleccionadas, en un apiario en el pueblo de Huejotitan, estado de Jalisco, en el oeste de México, mensualmente durante un año. El color se midió de acuerdo con la escala de Pfund. La humedad también se midió ya que la fermentación debida a la humedad excesiva podría echar a perder las muestras. También se recogieron dos muestras adicionales del grueso de la miel en el momento de las cosechas, directamente del extractor: una de la cosecha de primavera de mayo de 2012 y la otra de la cosecha de otoño de diciembre de 2012. Un total de Se obtuvieron 23 muestras desde diciembre de 2011 hasta diciembre de 2012. El color varió de 0 mm Pfund (blanco agua) a 85 mm Pfund (ámbar claro) y humedad del 17% al 24%. Se descubrió que las muestras recolectadas durante el pico del flujo de néctar, de octubre a noviembre, eran más blancas que el resto. Aunque se requiere más trabajo, ya que los consumidores prefieren miel más clara, se concluye que la miel se cosecha a intervalos durante el alto flujo en las colmenas, con una cuidadosa consideración de la humedad y asegurándose de mantener las mieles de diferentes colmenas, colmenares y productores separados, a una mayor se obtendría una variedad de mieles, con diferentes tonalidades de color y diferentes propiedades, dirigidas mejor a los mercados más especializados y exigentes de la actualidad.

Palabras clave: fuentes florales, propiedades fisicoquímicas, temporada de floración, panal tapado

INTRODUCTION

Bee honey, the sweet natural substance produced by *Apis mellifera* from the nectar of flowers and other plant secretions, has been hunted and harvested since the earliest times of human history (Bradbear, 2009); until the domestication and extensive cultivation of the sugar cane, it was the most widely used and appreciated sweetener in the world (Ulloa *et al*., 2010). For bees, honey is mainly the carbohydrate constituent of their diet. For humans, it is a highly-valued food whose characteristics have been classified and regulated in order to meet the requirements of quality and the standards of preference in the eclectic international markets.

Color is one of the most important properties of honey and the one that normally comes first, partly because color is the first parameter perceived by the consumers (Aubert and Gonnet 1983). Although color is in reality just a human perception, when it comes to honey it is of paramount importance not only because it is related to other physicochemical properties but also because it has different degrees of acceptance in different parts of the world and has become a key aspect in the determination of price (Delmoro *et al.*, 2010). For example, Americans prefer lighter honeys, between 0 and 34 mm Pfund, while Europeans prefer the darker ones, between 34 and 114 mm Pfund (Ulloa *et al.*, 2010). Thus, color is not directly related to quality in terms of low or high; instead, it is just a reflection of the cultural preferences of a region or nation.

However, color cannot be dealt with subjectively. In order to have a consensus and understanding, numerical values have been successfully assigned (Zandamela, 2008) through a variety of methodologies. Although honey colors were originally assigned by experts relying only on their sight, presently it is done by means of very modern but at the same time very simple technology. From several options, the European Union Directives, the Codex Alimentarius Commission and the International Honey Commission (IHC) have selected and established a series of standards to measure the quality of honey. In terms of color, honey is most commonly graded according to the Pfund and the Lovibond scales (Nickerson, 1946).

Although honey color is related to production processes, temperature and storage conditions (Salas *et al.*, 1993), the most important determining factor is the floral source (Persano-Oddo *et al.* 1995; Bogdanov, *et al*., 2004). Throughout the year, floral resources are temporary and sequential. This means that the floral composition changes gradually in a given landscape, except in cases of extensive single crops, and the physicochemical properties, especially color, change accordingly. The bulk of honey stored in the combs reflects those characteristics of the blooms that are dominant at any given time. If at harvest, beekeepers, and, later, middle men and exporters, mix together honeys form different hives, from different apiaries and from different producers into single lots, what once were many different and very particular batches will be

converted into a homogenous whole that loses the particularities of its original components. That is what normally happens and honey color studies are normally done at this stage. There are several practical reasons for it but the two most important ones are, first, that honey is harvested all at the same time, otherwise the extraction process would take too much time and the operative costs would rise. And, second, honey is harvested at the end of the blooming season when the bees have capped the honeycomb. This signals that the honey has lost excess humidity and it is said to be "ripe" and ready to be harvested. If harvested before, there is a high risk of fermentation. The international standards suggest a maximum of 21% moisture content although some European countries allow no more than 18.5% in their honey imports (Bogdanov, *et al.*, 2002). Despite the impracticality of harvesting at intervals and the risk of fermentation, at least theoretically, if honey were collected at intervals from single hives, avoiding at all costs mixing with other honeys, the result would be different honeys with different colors. Since colors are related to the other physicochemical properties, we would assume that those would vary as well. The purpose of this study was to determine honey color variation throughout the year.

MATERIAL AND METHODS

The current investigation involved sampling bee honey in three hives in the same location in the municipality of Jocotepec, state of Jalisco, in western México, to determine color variation. The site was selected within an area of importance for beekeeping.

Jocotepec is located on the west side of Chapala Lake and extends over an area of 384.36 km2, known as Región de las Cuencas Centrales (Gutiérrez-Vázquez, 1959). 61% of its surface is covered by mountains reaching heights of 2,960 m.a.s.l (Machuca-Núñez, 1989). The apiary was located in the town of Huejotitan, 20°21’13.45’’N, 103°29’6.97’’O, behind the old hacienda (a locally well-known landmark), 11 km northwest of the lake and 2 km south of Cerro Viejo, the highest peak of the mountain range, which runs from west to east. The elevation at the site is 1,597 m.a.s.l. The land cover is dominated by seasonal cultivated crops, pastures and secondary vegetation interspersed with tropical deciduous forest. The overall land cover in the valley includes meadows, different associations of secondary vegetation where cultivated land has been let to rest, and aquatic vegetation in the streams and lake. In the mountains there is an important extension of tropical deciduous forest in the low parts of slopes, cloud forest in the ravines and oak forest in the summits and high parts of the slopes, all of which account for a very diverse flora. The most abundant crops are *Zea mayz*, *Sorghum bicolor*, *Phaseolus vulgaris*, *Cucurbita* spp., *Sacharum officinarum*, *Sechium edule*, *Solanum lycopersicum*, *Allium cepa*, *Triticum aestivum* and *Cicer arietinum*. Increasingly,

greenhouses are built for strawberry (*Fragaria ananassa*) and raspberry (*Rubus idaeus*) culture. Urbanization has picked up in recent years.

Out of 23 bee hives in the apiary, three were chosen (for their strength) to be sampled once a month for a year, from December 2011 to November 2012. Each hive was provided with empty framed combs in a medium super for honey storage. On each visit, the combs containing honey were scraped with a spoon and the honey was poured into 110 ml glass jars, filled up as much as possible, one for each hive. Preference was given to extracting the honey from capped honeycombs.

The samples were processed at the premises of the Laboratory of Biology, Universidad Autonoma Agraria Antonio Narro, in the city of Torreon, state of Coahuila, Mexico. Color was measured with a C221 Hanna® Honey Colour Analyzer (Hanna® Instruments Inc. USA). Grading was done following the Pfund scale (Table 1) (USDA 1985). Humidity was measured with a M00596 Standard EA refractometer to anticipate risks of fermentation.

Table 1. Pfund scale and the equivalence in honey color classification names (Delmoro et al. 2010).

mm Pfund	International scale
0 - 8	Water white
9 - 17	Extra white
18 - 34	White
35 - 50	Extra light amber
51 - 85	Light amber
86 - 114	Amber
> 114	Dark amber

RESULTS AND DISCUSSION

A total of 23 honey samples were obtained from December 2011 to December 2012. In February 2012 hive one had no honey. On May 31st, 2012, hives one and three had no honey. No honey was found in the combs from July to September.

The color of the samples varied from month to month, with a tendency to change from the darker (Dec 2011) to the lighter (Nov 2012) shades (Figure 1). Nevertheless, regardless of our visual perception, most samples were comprised within the light amber range, even the darkest one (85 mm Pfund), according to the measurements. The lowest value, corresponding to the water white shade of color, was 0 mm Pfund (Table 2).

Table 2. Results of the color and humidity measurements for the honey samples taken in each hive.

Sample date	Hive	mm Pfund	Color	Humidity %
December 8th, 2011	1	70	Light amber	20
	2	85	Light amber	20.5
	3	68	Light amber	18.5
February 2nd, 2012	1	x	x	x
	2	56	Light amber	20
	3	59	Light amber	21.5
March 9, 2012	1	65	Light amber	18
	2	57	Light amber	17.5
	3	68	Light amber	19.5
April 11th, 2012	1	18	White	16
	2	54	Light amber	18
	3	40	Extra light amber	21
May 11th, 2012	1	21	White	17.5
	2	55	Light amber	19
	3	27	White	19
Harvest: May 11th, 2012	From extractor	51	Light amber	18
May 31st, 2012	1	x	x	x
	2	70	Light amber	18.5
	3	x	x	x
July 8th, 2012	1	x	x	x
	2	x	x	x
	3	x	x	x
August 7th, 2012	1	x	x	x
	2	x	x	x
	3	x	x	x
September 11th, 2012	1	x	x	x
	2	x	x	x
	3	x	x	x
October 7th, 2012	1	0	Water white	22
	2	0	Water white	21
	3	0	Water white	24
November 9th, 2012	1	0	Water white	17
	2	0	Water white	19
	3	0	Water white	16.5
Harvest: December 12th, 2012	From extractor	20	White	18

The "x" means no honey was found in that hive on that date.

Figure 1. Color variation of the samples, from water white to light amber.

It was discovered that the samples collected during the peak of the nectar flow, October - November, were contrastingly whiter than the rest, including the sample belonging to the fall harvest, which was "white" in shade. These samples correspond to the pre-harvest period, when the blooms and the honey flow in the apiary were at their peak.

This means that once the honeys stored at different moments during the season, in the different hives, are harvested together and extracted at the same time at the end of the blooming period, they all become homogenized in their color and properties, turning into one single whole.

Equally varied was the humidity content, which ranged from 17% to 24%; these two measurements correspond to the water white samples. Most samples were within the international humidity limits; only three of them slightly surpassed the range: 21.5, 22 and 24% (Table 2).

The variation in the shades of color from month to month was an indicator, and confirmation, of the change in floral resources as the year passed, especially during the blooming season. The lighter shades of honey are related to a lower mineral content, milder flavors and subtle aromas while the darker shades relate to the opposite, stronger flavors and aromas and a higher mineral content (Brice, *et* al., 1956). Since the American Continent markets tend to prefer lighter honeys, it could be assumed that they would be in higher demand. Although more work would be invested, since consumers prefer clearer honeys, it is concluded that honey harvested at intervals during the high flow in the hives, with careful consideration of the moisture and making sure to keep honeys from different hives, apiaries and producers separate, a wider variety of honeys would be obtained, with different shades of color and different properties, better targeting the more specialized and demanding markets of today.

Finally, as of the date of submission of this manuscript, after more than five years of storage in their jars, in the dark, the honey samples used for this study have not fermented despite some of them having humidity levels slightly above the international standards.

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