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Simplified method for calculating colour of honey by application of the characteristic vector method

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Abstract

A quick and simple method to obtain the colour of honeys with minimum error is proposed. *Characteristic vector analysis* has been tested and proved to be applicable to the reconstruction of honey reflectance spectra. Expressions for tristimulus values are obtained as function of reflectance measurements at a few wavelengths. Different sets of reflectance were tested (from 3 to 6 wavelengths) showing better results as the number of characteristic vectors (wavelengths) increases. The measures were made both over white and over black backing. Results showed that, when spectrophotometric measurements are made with 10 mm pathlength cells, the determination of reflectance at four wavelengths (443, 530, 554, and 618 nm for white backing; 439, 488, 555 and 636 nm for black backing) is adequate to reconstruct the spectrum and to obtain the tristimulus chromatic characteristics. The black backing measurements showed better results, being 74% and 57% (black and white backing measurements, respectively) the percentage of samples giving colour differences less than 1 CIELAB unit between the calculated coordinates and those obtained from the whole visible spectra.

Keywords: Characteristic vector analysis; Honey colour; Tristimulus colorimetry; Simplified method

1. Introduction

1.1. Honey colour

The colour of honey is one of its most variable features. Honeys show very different colours, varying from white or pale yellow to dark red or even black. Many studies have dealt with the relation of honey colour to the floral origin, industrial processing methods, and the temperature and/or time of storage (Crane, 1984; Féller-Demalsy, Vincent, & Beaulieu, 1989; Free et al., 1983; Pereyra, Burin, & Buera, 1999; Salas, Echávarri, & Negueruela, 1993; Terrab, Díez, & Heredia, 2003a; Terrab, Díez, & Heredia, 2003b; Terrab, Díez, & Heredia, 2003c; Terrab, Recamales, Hernanz, & Heredia, 2004; Varju, 1970). In other study, the influence of the pollen grains, their morphology and colour, on the honey colour has been considered (Terrab, Escudero, González-Miret, & Heredia, 2004).

However, in spite of the great importance of the colour of honey as an indicator of its origin and quality, there is no official method for its determination. Thus, as for other foods, the method proposed by the Organisation Internationale de la Vigne et du Vin (OIV, 1979) for the colorimetric analysis of grape-derived products, which is a simplification of the CIEYxy (CIE, 2004) with the CIE 1931 Standard Observer (2° visual field) based on the consideration of the whole visible spectrum, is used.

Several subjective methods, as Lovibond visual comparators for measuring honey colour in Pfund units, have been

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employed (González & de Lorenzo, 2002; Swanson & Lewis, 1991/2); however, these methods do not differentiate between small colour differences. Besides, the visual assessment of foods not only depends on their colour but also on other appearance attributes (Hutchings, 1999). Thus, different physical systems have been developed in order to avoid subjectivity in the sensorial assessment of colour. Among the objective methods used for determining the colour of honey, techniques using transmittance or reflectance measures can be differentiated.

Aubert and Gonnet (1983) applied the transmittance technique, using the whole light spectrum between 350 and 700 nm. Mateo-Castro, Jiménez-Escamilla, and Bosch-Reig (1992) analysed the colour of seven types of Spanish unifloral honey using the transmittance method, and obtained better classification of the samples in the CIELAB colour space than in the CIE 1931 (CIEYxy). The colour of 112 unifloral honeys has been assessed by tristimulus colorimetry based on their diffuse reflectance spectra using white and black backgrounds (Terrab, Díez, & Heredia, 2002) and it was found better results for white background measurements. Colour measurement by reflectance is an alternative method, but gives some problems due to the translucent nature of the sample (Clydesdale, 1969; Lomas, Echávarri, Negueruela, & Ayala, 1997; Mackinney, Little, & Brinner, 1966). Negueruela, Pérez, de Juan, and Ayala (1994) characterized rosemary honey and observed that type of honey is better grouped with colour measurement by this method than by transmittance, where there is a higher dispersion due to the turbidity of the honey. Additionally, Negueruela and Pérez-Arquillué (2000) measured the reflectance spectrum with a white and black background, and then applied the Kulbelka–Munk theory in order to calculate the spectral distribution of reflectivity in rosemary honey in the solid state. Terrab, González-Miret, and Heredia (2004) found that the spectroradiometry method was better to differentiate between amber-to-dark honeys such as thyme and avocado.

1.2. Characteristic vector method

Vector analysis has been tested and proved to be applicable to the reconstruction of red wines (Ayala, Echávarri, Juárez, & Negueruela, 1993; Juárez, Echávarri, & Negueruela, 1990), vinegars (García-Parrilla et al., 1998) and virgin olive oils (Moyano et al., 2001) transmittance spectra obtaining suitable equations in these food products.

The aim of the characteristic vector method is to set up a method for measuring the colour of food with great accuracy (minimum error) and, especially, with great simplicity. The method consists in finding a short number of wavelengths (between 3 and 6, generally) from which it is possible to reconstruct the spectrum in such a way that it fits with the original spectrum, obtaining expressions for tristimulus values as function of reflectance values at these wavelengths. In this study the characteristic vector method has been applied to the honey colour measurement.

Current instruments allow us a rapid and precise measurement of the whole spectrum. Nevertheless, there are many laboratories scarcely equipped in which these methodology could be of great interest, since, based on these simplified methods, it would be possible to design a cheap device which measures in a short number of wavelengths, by using filters or LEDs, in order to obtain the colour of the honeys. This instrument would be rapid and reliable but with a lower cost and very manageable. So, it might be used as a field instrument but with a high reliability.

2. Experimental procedures

2.1. Samples

The colour of 139 honeys was assessed by tristimulus colorimetry based on their spectra, using diffuse reflectance spectrophotometry with the application of the equations for the uniform colour space CIELAB proposed by the Commission Internationale de l'Eclairage (CIE, 2004). The group of samples included honeys from different botanical origin and colorimetric characteristics in order to obtain representative results for all types of honeys. The botanical origin of the honeys was assessed by pollen content analysis being 101 unifloral (7 from Umbelliferae (*Ammi visnaga*, *Eryngium campestre*, *Ridolfia segetum*) 5 from *Arbutus unedo*, 2 from *Carlina* sp., 5 from *Ceratonia siliqua*, 3 from *Corrigiola* sp., 14 from *Citrus* sp., 4 from *Erica* sp., 31 from *Eucalyptus* sp., 5 from *Helianthus annuus*, 5 from Honeydew, 7 from *Lythrum* sp., 5 from *Mentha* sp., 5 from *Senecio* sp. and 3 from *Teucrium* sp.) and 38 multifloral honeys.

2.2. Pollen analysis

To assess the botanical origin of the samples, the techniques described by Maurizio (1979) and Erdtman (1960) for pollen analysis were used. Slides were prepared with acetolysis by centrifuging 10 g of honey dissolved in 20 ml of diluted sulphuric acid (5 g H_2SO_4/l) for 10 min at 2500 rpm. The supernatant was decanted, and the sediment washed twice with 10 ml distilled water and then centrifuged. The sediment was extended on a slide and dried at 70 °C, then mounted with stained glycerine gelatine. At least 500 pollen grains were counted among four different slides for each honey sample. A minimum percentage of each type of pollen was required to consider the honeys as unifloral from a melissopalynological point of view.

2.3. Apparatus

Colour was assessed by tristimulus colorimetry based on the reflectance spectra, with the application of the equations proposed by the Commission Internationale de l'Eclairage. The reflectance spectra were measured in 10 mm pathlength cells, using a Hewlett-Packard 8453 (Palo Alto, CA, USA) ultraviolet-visible diode array spectrophotometer equipped