Bulgarian Journal of Veterinary Medicine (2001), 4, No 4, 249 – 254

CHROMATICITY INDEX OF UNPROCESSED BEE HONEY

N. TAKUCHEV[1], D. DINKOV[2] AND H. DASKALOV[2]

[1]Faculty of Agriculture, [2]Faculty of Veterinary Medicine, Trakia University, Stara Zagora; Bulgaria

Summary

Takuchev, N., D. Dinkov and H. Daskalov, 2001. Chromaticity index of unprocessed bee honey, *Bulg. J. Vet. Med.*, **4**, No 4, 249 – 254.

The transition of object systematization from a qualitative description towards a suitable numerical quantitation of a given feature is observed in many scientific branches.

In this work we introduced an adequate quantitative characteristics of bee honey colour - the chromaticity index (CI). The possible application of this index as a quick quantitative parameter in the assessment of the quality of various bee honey types for the needs of veterinary inspection procedures is discussed.

Key words: bee honey, chromaticity index, colour measurement

INTRODUCTION

The colour of bee honeys is one of their primary organoleptic parameters. It depends on the botanical origin, the conditions of honey processing and storage (Ivanov, 1986).

The colour of honey is used as a parameter of quality in the complex organoleptic analysis (Chernigov, 1979; Ivanov, 1986; Bulgarian State Standards 2673; 1989; Dustmann, 1994) (Table 1). However, there are no literature data about objective, quantitative measurement of honey colours.

The aim of the present study was the investigation of colour characteristics of bee honey samples and the assessment of the possibility of colour quantitative evaluation for the needs of the veterinary inspection procedures.

MATERIALS AND METHODS

The study was performed on 77 samples of unprocessed bee honey originating from places covering almost the whole country. Samples were collected according to Bulgarian State Standards 3050 (1980) and 2673 (1989) from the companies "Palchutev-med" Ltd. and "Pchela-94" – Stara Zagora during the summer honey harvesting of 1999. The botanical origin of honeys (monofloral, polyfloral, nectar and honeydew) was determined according to Bulgarian State Standard 3050 (1980) in the laboratory of the Department "Food Hygiene and Technology, Veterinary Legislation and Management" of the Faculty of Veterinary Medicine at Trakia University – Stara Zagora.

A method for application of colorimetric theory in the quantitative determination of honey colour was developed. The chromaticity index (CI) was introduced as a quantitative parameter. For this purpose, the absorbance spectrum of a 10 mm layer of the sample was measured in 40 points of the visual area of the electromagnetic spectrum – within the wavelenghts range

380–770 nm by 10 nm steps. The spectra were measured with an automated system of colour measurement, consisting of a spectrophotometer and a computer, developed in the Department "Informatics, Mathematics and Physics" at Trakia University, Stara Zagora.

Using the obtained spectra, the system calculated the chromaticity coordinates of each sample on the basis of colorimetric theory (Judd and Wiszecki, 1975) taking into account the sensitivity of human vision to light, obtained on the basis of analysis of human eye response, the properties (spectrum) of the light source and the absorbance of illuminated objects (in this case, the absorbance spectrum of bee honey samples was used). The choice of the methodology was based on the assumption that the inclusion of the characteristics of human eye response to colours in the theory renders possible the introduction of a measurable value for colour, that is adequate to human colour vision. According to the rules of colorimetry, the physical value for colour, adequate to human perception, is a three-component vector, whose magnitude determines colour luminance and its direction – chromaticity (representing the hue and saturation). The vectors of all colours originate from a point, corresponding to the black colour and the sets of points (vector ends), corresponding to all observed colours form a three-dimensional colour space (each dimension corresponding to the one of the components characterizing the colour as a value). The set of points, equivalent to honey samples, form a three-dimensional line in the three-dimensional colour area. If all points from this line are projected on a plane, such, that it would correspond to colours with equal luminance, the projections of colour points are called points of chromaticity in the *x*O*y* plane colour coordinate system of the Commision Internationale d'Eclairage (CIE) from 1931 (Judd and Wiszecki, 1975). The use of chromaticity coordinates instead of colour coordinates reduces the number of dimensions from 3 to 2 preserving the adequacy of human perception.

Taking into account the forementioned facts, the colour points of studied samples were graphically shown in a plane coordinate system (Fig. 1).

RESULTS AND DISCUSSION

In the chromaticity diagram *x*O*y* of CIE, 1931 the chromaticities or the coulours with a single luminance are presented as points (Fig. 1). They form a narrow cluster of points (line) with paler samples being located in its left end and the darker - to the right. The coordinates are dimensionless but are presented in relative units. The application of regression analysis permitted to find the unknown relationship (dependence) between chromaticity coordinates x and y whose graphical presentation was further called chromaticity diagram (Fig. 1). The dependence could be expressed by the equation:

$$y(x) = -25.825x^3 + 27.415x^2 - 8.5148x + 1.1012 \qquad R^2 = 0.8942 \qquad (1)$$

R^2 (R-squared) characterizes statistically the adequacy of the model with the experimental set of data. The closer R^2 is to 1 (full correspondance of the model to the unknown relationship), the better is the adequacy between data and the model (as is the case).

Despite the better visualization in presenting colours with their colour points, in the cases with bee honey it was possible and easier to present the colours of a number of samples with only one value, based on the chromaticity coordinates,

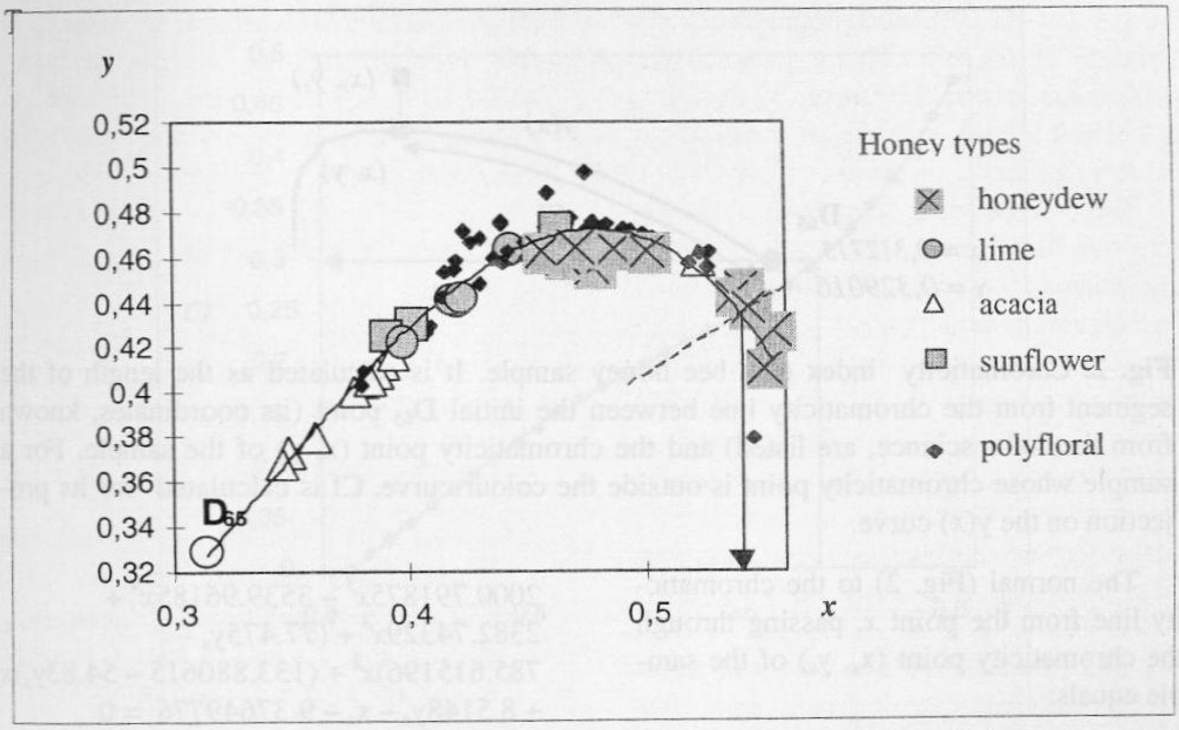

Fig. 1. Chromaticity points (CIE, 1931) for bee honey samples with a different botanical origin. D_{65} is the chromaticity point of a transparent colourless sample at disperse daylight illuminant. The curve is a regression model of the function y(*x*) for the set of samples. An example for the graphical determination of the *x* coordinate of the normal projection on the curve for a point outside the curve is presented. In this case, for a sample of honeydew honey, x=0.533 (reference CI values i.e. the numerical characteristics of the colour of various honey types are given in Table 2).

which retains the adequacy to the human colour vision. Our data evidenced that the distance along the curve between the left end (the point of colourless sample D_{65}) and the sample point (x, y) was suitable for such characterization of bee honey samples. If the point (x_s, y_s) lies outside the colour curve, the distance to its projection on the curve could be determined (Fig. 2).

The chromaticity index (CI) of honey sample (i.e. the distance along the chromaticity curve) is calculated according to the formula:

$$CI = \int_{x=0{,}3127}^{x} \sqrt{1+[y'(x)]^2}\,dx \qquad (2)$$

where

$$y'(x) = -77.475x^2 + 54.83x - 8.5148 \qquad (3)$$

is the first derivative of (1)

It was determined that the function (2) could be replaced with a high degree of precision by the following model:

$$CI = 141.33x^4 - 231.74x^3 + 139.28x^2 - 34.978x + 3.0537 \qquad R^2 = 0.9999 \qquad (4)$$

For obtaining CI of a given sample in cases where the chromaticity point of the sample lies on the regression (chromaticity) line, the respective *x* colour coordinate have to be replaced in (4).

Our analysis showed that for samples, whose chromaticity points (x_s, y_s) do not coincide fully with the chromaticity line, the coordinate *x* needs to be further calculated as follows:

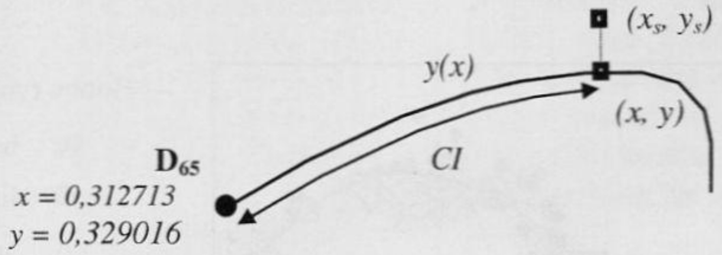

Fig. 2. Chromaticity index of a bee honey sample. It is calculated as the length of the segment from the chromaticity line between the initial D_{65} point (its coordinates, known from the color science, are listed) and the chromaticity point (x, y) of the sample. For a sample whose chromaticity point is outside the colour curve, CI is calculated for its projection on the y(x) curve.

The normal (Fig. 2) to the chromaticity line from the point x, passing through the chromaticity point (x_s, y_s) of the sample equals:

$$y(x) - y_s = -\frac{1}{y'(x)}(x - x_s) \quad (5)$$

where y(x) and y'(x) are replaced with the values calculated according to (1) and (3). Thus, the unknown value for a given point (x_s, y_s) in (5) is only x. After replacing in (5), follows:

$$2000.791875x^5 - 3539.96185x^4 + 2382.74329x^3 + (77.475y_s - 785.615196)x^2 + (133.880615 - 54.83y_s)x + 8.5148y_s - x_s - 9.37649776 = 0$$

Thus, the x value is obtained and from (4) – the CI value is obtained also in cases where a precise measurement is needed.

For practical purposes, a good precision is obtained by graphical estimation of x by making a perpendicular from the point (x_s, y_s) to the chromaticity line

Table 1. Qualitative description of the colour of some floral varieties of bee honey according to their organoleptic characterization in specialized literature

Honey types	Bulgarian State Standard 2673 (1989)	Chernigov (1979)	Ivanov (1986)
Acacia honey	pale yellow	colourless or white	pale yellow
Lime honey	light amber	light amber or pale yellow	
Sunflower honey	Gold	amber or yellow	
Polyfloral honey	pale yellow with a slight greenish cast, light amber, red, reddish-brown	light amber to dark amber	pale yellow to yellow, amber, brown with a greenish or reddish cast
Honeydew honey	greenish-brown to dark brown	dark with various casts	light (from coniferous plants to dark (from deciduous plants)

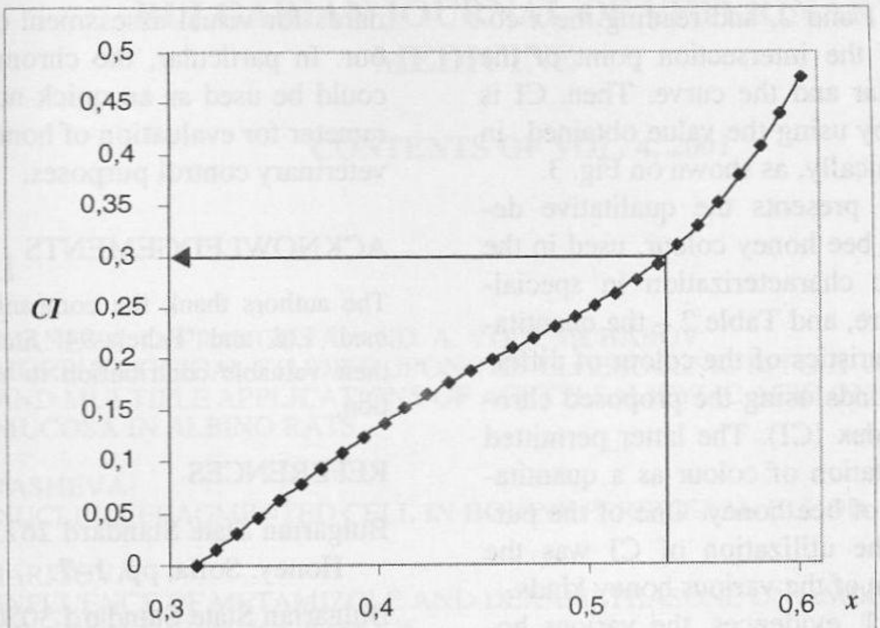

Fig. 3. Chromaticity index (CI) as a function of *x* coordinate of chromaticity diagram. If the x coordinate of a honey sample is known, CI could be calculated according to the formula or determined graphically as shown. For instance, for a sample whose $x = 0.533$ (see Fig. 1), the CI is 0.3.

Table 2. Quantiative characterization of the honey types from Table 1 using the proposed chromaticity index (CI)

	Floral varieties of bee honey				
Parameters	Acacia	Lime	Sunflower	Polyfloral	Honeydew
Sample size	8	5	3	59	2
CI – mean value	0.123	0.171	0.157	0.208	0.312
CI – standard deviation (SD)	0.064	0.018	0.046	0.046	0.024
Critical t-value (0.95 confidence level)	2.37	2.78	4.30	2.00	12.71
Confidence deviation	0.152	0.051	0.200	0.091	0.301
Confidence interval	0.275	0.103	0.400	0.181	0.601
Difference between CI_{max} and CI_{min}	0.217	0.033	0.085	0.253	0.253

from Figs. 1 and 2, and reading the x coordinate of the intersection point of the perpendicular and the curve. Then, CI is calculated by using the value obtained in (4) or graphically, as shown on Fig. 3.

Table 1 presents the qualitative description of bee honey colour, used in the organoleptic characterization in specialized literature, and Table 2 – the quantitative characteristics of the colour of different honey kinds using the proposed chromaticity index (CI). The latter permitted the interpretation of colour as a quantitative feature of bee honey. One of the purposes for the utilization of CI was the classification of the various honey kinds.

As Fig. 1. evidences, the various honey kinds were located in different areas of chromaticity diagram, i.e. they fell within specific CI ranges. In Table 2, the reference ranges of CI of various honey kinds are specified with the purpose of classification and in particular, of veterinary expertise. The number of polyfloral honey samples was sufficient for obtaining the confidence interval with an acceptable precision. For the other types of honey, the number of analyzed samples was too small for statistical purposes, so presented data could only be informative.

It must be emphasized that the chromaticity points of samples as a set, define adequately the chromaticity line, i.e. the overall number of the samples was sufficient for obtaining a representative model of the curve and therefore, for a reliable characterization of each sample colour by the proposed CI despite the lack of enough data for the quantitative classification of some of the studied honey types.

The chromaticity index CI could be used for a quantitative evaluation of the relationship between the colour of a set of honey samples with other features. It could be utilized in a scale of colour standards for visual assessment of honey colour. In particular, the chromaticity index could be used as an quick numerical parameter for evaluation of honey quality for veterinary control purposes.

ACKNOWLEDGEMENTS

The authors thank the companies "Palhutevmed" Ltd. and "Pchela-94" Stara Zagora for their valuable contribution to sample collection.

REFERENCES

Bulgarian State Standard 2673, 1989. Bee Honey. Sofia, pp. 1–7.

Bulgarian State Standard 3050, 1980. Bee Honey. Rules for sampling and methods of analysis. Sofia, pp. 1–12.

Chernigov, V. D., 1979. Honey. Uradjai, Minsk, pp. 14–54.

Dustmann, J. H., 1994. Honigsorten-Bezeichnungen. In: Deutscher Imkerbund e.V. Wachtberg, Germany, 3.4, 1–6.

Ivanov, Ts., 1986. Quality, standartization and evaluation of bee products. A Review, Agricultural Academy, Sofia, pp. 10–34.

Judd, D. and G. Wiszecki, 1975. Colour in Business, Science and Industry, eds.John Waley & Sons, New York.

Paper received 10.11.2000; accepted for publication 27.06.2001

Correspondence: Nikolay Takuchev
Dept. of Informatics, Mathematics and Physics,
Agricultural Faculty, Trakia University,
6000 Stara Zagora, Bulgaria
e-mail: npt@sz.inetg.bg; npt@uni-sz.bg