International Food Research Journal 21(1): 407-411 (2014)
Journal homepage: *http://www.ifrj.upm.edu.my*

# Instrumental and visual evaluation of color change in Iranian honey samples under different illuminants

[1*]Safi, M., [2]Ansari, K. and [3]Zanganeh, M.

[1]*Department of Color Physics, Institute for Color Science and Technology, Tehran, IRAN*
[2]*Department of Color Imaging and Color Image Processing, Institute for Color Science and Technology, Tehran, IRAN*
[3]*Islamic Azad University-South Tehran Branch, Tehran, IRAN*

**Article history**

*Received: 12 December 2012*
*Received in revised form: 27 August 2013*
*Accepted: 30 August 2013*

**Keywords**

*Colorimetry*
*Iranian honey*
*Visual assessment*
*Color inconstancy index*
*Haze*

**Abstract**

Color appearance could be an important factor to choose the honey. There are some factors such as changes in light conditions that could affect color appearance and consequently, customer's decision to order. At the present study, the color appearance of 13 kinds of Iranian honey samples with different color was specified and raced under varying conditions of illumination and observer's judgment. The color parameters in the CIE1976 color system, haze values and color in constancy index according to CMCCON02 algorithm were determined in order that the color appearance of the samples could be instrumentally assessed. The results showed that most of the samples are in the range of yellow shades with the wavelength of maximum absorption equal to 400nm. From the average amount of measured haze, it was deduced that the samples are not high transparency. In addition, for the samples with a lower intensity or chroma of color, it was obtained the higher color constancy value compared to those with the higher color chroma. The visual judgments of the samples showed that most of Iranian honey samples are distinguishable in to five main color groups. In respect of color preference, the samples with a higher chroma of color which also possess a higher color in constancy index were more preferred by the observers.



## Introduction

The visual appearance of nutrients is one of the first-quality determinants made by the consumer. Often the appearance of the commodity is the most critical factor in the initial purchase (in addition to price) while subsequent purchases may be more related to texture and flavor. The customers usually are not allowed to test nutrients before purchasing; however, it can sometimes be seen from inside the packages. The previous researches showed that color would play a main role in the appearance of nutrient based on which the final decision is made (Mitcham *et al.*, 1996; Berns, 2000; MacDougall, 2002; McCaig, 2002; Ji *et al.*, 2005; Silva *et al.*, 2005).

Color and appearance measurement techniques provide solutions that measure reflected and transmitted color of nutrient (Berns, 2000; Amirshahi *et al.*, 2007). These give numerical values that correlate to what are seen and are ideal for measuring nutrient. The color measurement techniques (instrumental and visual) should be precise, simple and fast so that they can help both producer and customer to control the quality and have the better selection, respectively. The principles of colorimetry in different industries, especially in the assessment of color appearance are based on the calculation of color parameters in the two-color spaces of CIE$L^*a^*b^*$ and CIE$L^*C^*h^o$. Although, both color spaces are the same entitled the CIE 1976 color space, the CIE$L^*C^*h^o$ color space is paid more attention. It is because of presenting color components similar to color perception in the human brain-eye system (Ohta *et al.*, 2005). In addition to the CIE$L^*C^*h^o$ colorparameters, there are other important one-dimensional indexes such as haze and color constancy that describe the behavior of the color appearance of objects. Based on how they pass light, objects are generally divided into three categories, namely transparent, translucent and opaque. The presence of particles with specific size usually leads to a phenomenon called scattering and causes the light diffusion of system and subsequently, its haze. Transmission haze is defined as the forward scattering of light from a surface of a nearly clear specimen viewed in transmission (Hunter Associates Laboratory, 2008).Transmission haze is reported as the percentage of diffused light divided by the total transmitted light by using the equation:

$$\% \text{ Haze} = (T_{diffuse}/T_{total})_* 100$$

In this equation, $T_{diffuse}$ indicates the diffused

*Corresponding author.
Email: *mahdisafi@icrc.ac.ir*

transmission percentage, and $T_{total}$ shows the total transmission percentage (ASTM D1003 – 95, 2000).Generally, color constancy is defined as the overall tendency of object color to remain constant (visually) against the change of color and radiation of the illuminant (Luo, 2000). In most of the cases, there should be stable color appearance, but there are some factors such as light conditions that change color appearance (Safi *et al*., 2011). For numeric assessment of color constancy, color inconstancy index is calculated. In 2002, the color measurement committee suggested the CMCCON02 color inconstancy index to predict the direction and magnitude of the color changes under the test and the reference illuminants fora standard observer (Fairchild, 2005). More details on color inconstancy correlations can be found at the cited references (Amirshahi *et al.*, 2007).

One of the most nutritious foods produced in nature is honey. In additional to a high nutritive value, the medicinal properties of honey have been known over the years. When choosing the kind of honey, the color appearance seems to play an important role. The quality assessment of this valuable food is investigated mostly by its ingredients. However,using color measurement and visual assessment techniques is rarely seen. Studies show that honey color measurement is done by different methods.In work that has been published on the website "National Honey Board", it is stated that honey color can be measured by the techniques P found scale, Lovibond 2000, CIE1931 and CIELAB. Such factors as the source flower, the warmth and the storage duration influence the color of honey. The more the minerals of the nectar from which bees feed, the darker the honey is. The darkness of honey depends on temperature as well in such a way that the change in its color is more rapid in storage and higher temperature. It seems that the taste and smell of lighter honey samples are milder, and those of darker honey samples are stronger. Even so, there are also some exceptions. Dark honey samples are used as color additives in nutrients that turn their color into brown or golden (national honey board, 2011). In another study by Mr. Lourdes *et al.* an easy method is presented for reconstructing the reflection spectrum of honey using the characteristics` vector method (Lourdes *et al*., 2007). The findings suggested that determining the spectral reflection in four wavelengths of 443, 530, 554 and 628 nm for a white background and wavelengths of 439, 488, 555 and 628 nm for a black background are sufficient for reconstructing the honey reflection spectrum and result in color tristimulus values of honey. Honey is a valuable nutrient in the food basket of most Iranian families. It is chosen by its appearance in stores while it could not be tasted. At the present work, the color changes of Iranian honey samples were evaluated under different illuminants.

## Materials and Methods

### *Honey*

13 kinds of honey (by $H_1$-$H_{13}$ coding) with different color spectrums were collected from different parts of Iran. To that end, the national union of beekeepers and KhomeinSalarHoney Company cooperated with each other. The samples were kept in temperature 22$^o$ and away from sunlight to protect their nutritive values. All of the samples were put in a warm bath with a constant temperature of 40$^o$ to get rid of the produced crystals while testing - thepreparation step.

### *Color appearance measurement*

The chosen honey samples were approximately transparent. Therefore, their spectral transmission behavior was measured by Lambda25 spectrophotometer in the visible range of 400-700 nm with a 10 nm intervals. After preparation, the samples were poured into a quartz cell and then were put in the instrument. The color parameters were calculated in the two-color spaces of CIE$L^*a^*b^*$ and CIE$L^*C^*h^o$ under the illuminants D65, A and F11 as well as standard observers of 2 and 10 degree. Illuminant D65 is a simulator of daylight with correlated color temperature (CCT) equal 6500 K. Illuminant A is an incandescent light with CCT = 2940 K and Illuminant F11 is a fluorescent light that is widely used in the stores with CCT = 4000 K. The amount of haze of the samples was also calculated according to ASTM D1003-95 standard, using a Color Eye7000A spectrophotometer with the geometry of d/8. The color gamut of all the samples was depicted as well in CIE$L^*a^*b^*$ color system, under illuminants D65 and A with standard observer of 2 and 10 degrees. The color inconstancy index was calculated based on CMCCON02 algorithm and $\Delta E^*_{ab}$ color difference equation.

### *Visual assessment*

It was also tried to study the effect of color appearance of the honey samples in their selection and its relationship to instrumental measurement results. To that end, a population of one hundred observers, including 50 men and 50 women was randomly selected. The observers were asked to look at the five selected samples representing the color spectrum of

Iranian honey samples and then choose one of the samples based on their interest to honey color. The visual assessment tests were conducted under a light cabinet and daylight with 0/45 sight geometry.

## Results

*The spectral transmission behavior*

The obtained spectral transmission behavior showed that the most absorption occurs within the area of short wavelengths of the visible spectrum with the wavelength of maximum absorption equal to 400. Such a behavior indicates that the honey samples present a shade close to the yellow hue.

*Determining the color gamut*

The color gamut of the samples under illuminant D65 and standard observers of 2 and 10 degreeas well asthe color gamut of the samples under illuminants D65 and A and standard observer of 10 degree are illustrated in Figure 1. As it is observed, a change in the standard observer does not necessarily change the positions. In addition, the samples under illuminant D65 are more scattered compared to illuminant A. It indicates that using illuminant D65 is more appropriate for visual assessment of color taxonomy of honeys. This means that lighting conditions can affect the presentation of the color appearance of honey samples.

*Haze determination*

In specifying the amount of haze, the samples that transfer lighteras regular have less amounts of haze.The acquired haze value at each sample was as follows: $H_1$ = 21.86, $H_2$ = 39.05, $H_3$ = 37.91, $H_4$ = 35.85, $H_5$ = 28.25, $H_6$ = 28.61, $H_7$ = 23.58, $H_8$ = 46.91, $H_9$ = 23.32, $H_{10}$ = 26.74, $H_{11}$ = 38.73, $H_{12}$ = 21.69, $H_{13}$ = 29.38. According to the obtained data, it seems that the samples do not show high transparency. It is obvious, such samples as $H_2$, $H_4$ and $H_8$ that diffusemore light has more amounts of haze among other samples and the samples that transfer more light such as $H_7$, $H_9$ and $H_{10}$ have less amounts of haze. Thus, more transparency that is determined by haze index can be considered in choosing honey based on perceptible appearance.

*Color inconstancy index*

The color inconstancy index was calculated according to CMCCON02 algorithm. The index can predict the direction and magnitude to the color changes underan illuminantpair. The color inconstancy index under pair illuminant D65-A for each sample was calculated as follows: $H_1$ = 2.43, $H_2$ = 11.68, $H_3$ = 2.57, $H_4$ = 8.77, $H_5$ = 1.39, $H_6$ = 1.08, $H_7$ = 0.90, $H_8$ = 2.48, $H_9$ = 1.16, $H_{10}$ = 0.38, $H_{11}$ = 0.95, $H_{12}$ = 0.97, $H_{13}$ = 0.89. In addition, the values obtained of color inconstancy index for each sample under pair illuminant D65-F11 was as follows: $H_1$ = 11.23, $H_2$ = 8.48, $H_3$ = 8.94, $H_4$ = 17.50, $H_5$ = 6.29, $H_6$ = 5.39, $H_7$ = 4.63, $H_8$ = 5.45, $H_9$ = 5.84, $H_{10}$ = 2.00, $H_{11}$ = 4.22, $H_{12}$ = 6.35, $H_{13}$ = 5.32. Regarding to the average value obtained in the two situations, i.e. 2.58 for pair illuminant D65-A and 6.63 for pair illuminant D65-F11, it seems that the most color difference occurs when D65 is replaced with F11 illuminant. When the illuminant D65 is replaced with A, the sample $H_{10}$ has the least color inconstancy index. The mentioned sample has the least $C^*$ as well. The samples $H_1$-$H_5$ that show higher color inconstancy index have a high $C^*$ among other samples. Generally, it can be concluded that the honey samples with less $C^*$ have a higher color constancy compared to the honey samples with more $C^*$ value. The amount of color changes along with illuminant changes are also shown in Figure 2. As it can be seen, the maximum difference occurs when the illuminant is changed from D65 to F11. It seems that the difference in the spectral behavior of the used pair illuminants affectsthe honey color appearance specially the dark samples. In calculating the color inconstancy index, the effect of each of the components $\Delta H^*$, $\Delta C^*$ and $\Delta L^*$ on the total color difference was investigated. The largest contribution is related to the amount of chroma difference ($\Delta C^*$). The changes towards $C^*$ indicate that adding any color impurity to honey with

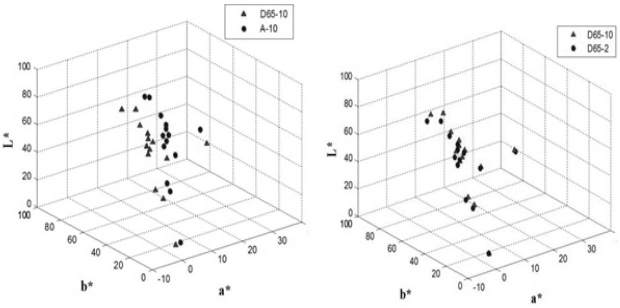

Figure 1. The color gamut of the honey samples under illuminants D65 and A and standard observers of 2 and 10 degree

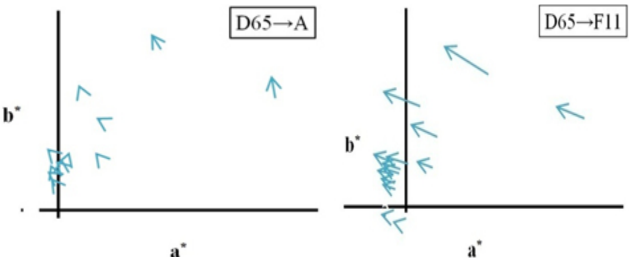

Figure 2. The amount of honey sample color change along with illuminant changes

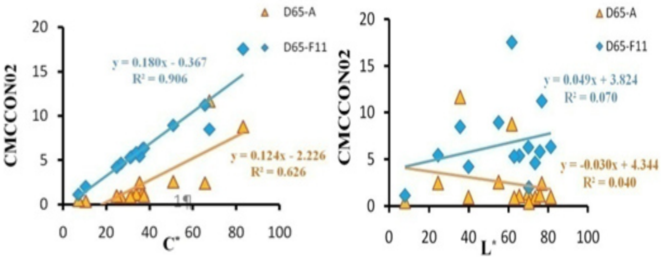


Figure 3. The correlation between color inconstancy index and $C^*$ and $L^*$

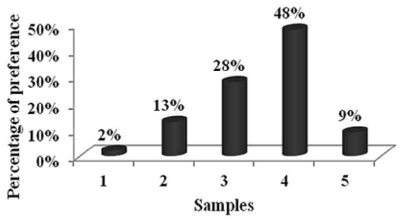


Figure 4. The visual preference results of the appearance of Iranian honey samples in terms of color

a different purpose by producer has a remarkable influence on its color changes. So, more attention should be paid in using honey additives. Figure 3 shows the correlation between color inconstancy index and $C^*$ amount. As it can be seen, the calculated color inconstancy index under pair illuminant D65-F11 is more than that under D65-A for almost all the samples. Moreover, Color inconstancy index shows an ascending linear trend with the increase in $C^*$. That is to say, the samples with higher chroma havea more color inconstancy index as well. Figure 3 shows also the correlation between $L^*$ and color inconstancy index. It is obvious that there is not a meaningful relationship between the two parameters.

*Visual assessment test*

This section refers to determine of color preference of Iranian honey samples by the observers. By dividing the samples in terms of color, it was concluded that most of Iranian honey samples lie in five color categories. The color variety indicates that there were various plantations all over Iran to feed bees. The samples 1 to 5 possess the cods $H_{10}$, $H_9$, $H_1$, $H_4$ and $H_2$, respectively. The samples were given to the observers, and they were asked to choose a sample based upon the color appearance that they prefer. According to the survey conducted on one hundred people, including 50 men and 50 women, the conclusion illustrated in Figure 4 was drawn. It suggests the sample 3 and 4 with percentage of preference equal to 28% and 48 % respectively received the most attention among the population.

Figures 5 shows the relationship between the percentage of preference with $C^*$ and inconstancy index CMCCON02. As it can be observed, the sample with more chroma and more color inconstancy such as sample 4 was more preferred by the observers.It seems that the more inconstant the honey is produced in terms of color, the more a customer accepts it. As a result, the producer can optimize the selling based on the preferred color specifications by the customers.

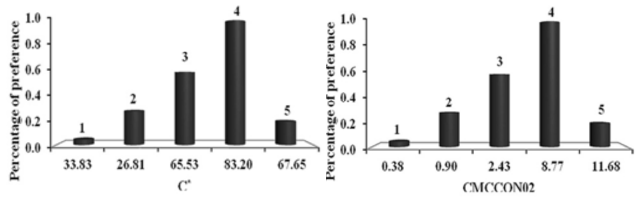


Figure 5. The relationship between the percentage of preference and purity $C^*$ and color inconstancy index CMCCON02 for the honey samples 1-5

## Conclusion

In the present work, changes in color appearance of Iranian honey samples under different illuminants were investigated. The conclusions were as follows: Almost all of the samples had the maximum absorption in 400 nm. Considering such a behavior, almost all the samples presented a shade close to the yellow hue. Changing the observer from 2 to 10 degree, does not make a remarkable change in the color parameters. The color gamut of the samples under illuminant D65 had more distribution compared to illuminant A. It meantthat illuminant D65 is more suitable for visual assessment of color taxonomy of honey. Regarding the color inconstancy index, most of the color difference occurred when the illuminant D65 was replaced with F11. Generally, it is concluded that honey samples with less $C^*$ have a higher color constancy compared to honey samples with more $C^*$ value. In visual assessment, the samples with higher chroma which have been also the more color inconstancy index were more preferred by the observers. The findings suggest that using color measurement techniques that are simple, precise and fast can be used on analysis and quality control and even better selection of nutrients, including honey.

## References

Amirshahi, S. and Agahian, F. 2007. Computational Color Physics, p. 374-379. Isfehan, Iran: Arkan Danesh.

Berns, R. S. 2000. Billmeyer and Saltzman's Principles of Color Technology, 3rd edn., p.128-130. New York:Wiley-Interscience.

Fairchild, M. D. 2005. Color AppearanceModels,p.181-182.Chichester: Addison Wesley Longman.

Internet: Hunter Associates Laboratory 2008. Haze. Downloaded from *http:www.hunterlab.com/appnotes/an05_97.pdf* on 10/05/2012.

Internet: National Honey Board. 2013. Honey varietals. Downloaded from http: *www.honey.com/honey-*

*at-home/learn-about-honey/honey-varietals/* on 14/07/2012.

Ji, W., Luo, M.R., Hutchings, J.B. and Dakin, J. 2005. Scaling transparency, opacity, apparent flavor strength and preference of orange juice. Proceeding of the 10th Congress of the International Colour Association, p. 729. Granada: Spain.

Luo, M.R. 2000. Areview of chromatic adaption transforms. Coloration Technology 30(1): 77–92.

MacDougall, D. B. 2002. Color in Food: Improving Quality, p.1-5. Cambridge: CRC Press.

McCaig, N. 2002. Extending the use of visible/near-infrared reflectance spectrophotometers to measure colour of food and agricultural products. Food Research International 35(8): 731–736.

Mitcham, B., Cantwell, M. and Kader, A. 1996. Methods for determining quality of fresh commodities. Perishables Handling Newsletter 85: 1-5.

Ohta, N. and Robertson, A. R. 2005. Colorimetry: Fundamentals and Applications, p. 115-150. Chichester: Wiley.

Safi, M. and Soleymanian, T. 2011.Astudy of correlation between color inconstancy level and CIE color parameters. Proceeding of the 4th International Color and Coatings Congress, p. 28. Tehran:Iran.

Silva, L., Pereira, A. and Punchihewa, A. 2005. Food classification using color imaging. Proceeding of Annual Conference on Image and Vision Computing, p. 1. Dunedin: New Zealand.