A Spectrophotometric Study of Various Commercial Honey Samples

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Abstract

UV – Visible spectrophotometry was used to investigate the optical properties of five different samples of commercial honey. These properties include absorbanc , reflectance , transmittance, absorption coefficient , extinction coefficient , and refractive index . The absorption spectra showed maximum absorption in the uv – region (~ 300 nm). This is due to the presence of flavonoids and phenolic acids in the honey samples

(1) Introduction

Honey has been used as a food and medical product since ancient times. Apart from carbohydrates (fructose, glucose, and sucrose) that are its main constituents, honey also has small quantities of vitamins, minerals, proteins, and amino acids . The high sugar concentration, low pH and the presence of flavonoids, hydrogen peroxide, phenolics and terpenes make it a powerful antiseptic and antimicrobial agent [1]. Honey is a viscous liquid. Its viscosity depends on the water content and on the temperature [2]. The moisture content of pure honey should be between 14% and 18%, for good quality [3].

UV-Visible spectrophotometry is a fast, simple, non-destructive analytical technique for identifying and measuring certain properties of honey samples . Accuracy, precision , short time of analysis and limited sample preparation make this an ideal method for routine analysis . Experimental results demonstrate the superior capabilities of the technique for reliable and fast quality control [4].

(2) Theory

UV-Visible spectroscopy refers to the absorption spectroscopy in the ultraviolet-visible spectral region. Many molecules absorb ultraviolet or visible light. Different molecules absorb radiation of different wavelength. An absorption spectrum will show a number of absorption bands corresponding to structural groups within the molecule. The absorption of UV or visible radiation corresponds to the excitation of outer electrons [5].

The fundamental relation of photon absorption is

$I_d = I_0 e^{-\alpha d}$ ---------- (1)

Where I_d is the incident photon energy at thickness d inside the material , I_0 is the incident photon energy at the material surface , and α is the optical absorption coefficient. It is a function of wavelength and can be calculated from the optical absorbance spectra , using the relation [6]

$ln\ (I_0/I_d) = \alpha d = 2.303\ A$ ---------- (2)

where the absorbance is defined by $A = \log (I_0/I_d)$.

The extinction coefficient k is related to α by the relation [7]

$k = \frac{\alpha\lambda}{4\pi}$ ---------- (3)

The refractive index (n) can be determined (for normal reflectance) from the relationship

$n = \frac{(1+\sqrt{R})}{(1-\sqrt{R})}$ ---------- (4)

where R is the reflectance which is found using the relationship

$R + T + A = 1$ ---------- (5)

T being the transmittance.

The optical absorption method is used to determine the optical band gap of the sample. The fundamental absorption refers to band to band transitions and it manifests itself by a rapid rising in the absorption used to determine the optical band gap [8]. The photon absorption in many amorphous materials is found to obey the Tauce relation , which is of the form [9]

$\alpha h\nu = B(h\nu - E_g)^m$ ---------- (6)

where α is the absorption coefficient , as we mentioned earlier , $h\nu$ is the photon energy , the factor B depends on the transition probability and can be assumed to be constant within the optical frequency range , and m is a constant which determines the type of optical transition (m=1/2 and 3/2 for direct allowed and forbidden transitions, respectively , m=2 and 3 for indirect allowed and forbidden transitions , respectively). The usual way to find E_g is by plotting $(\alpha h\nu)^m$ against $h\nu$, and estimating the value of E_g from the extrapolation of the linear portion of the graph to the photon energy axis.

At the band-edge region, the absorption coefficient reveals an exponential dependence on photon energy ($h\nu$) and is expressed by the so-called Urbach relationship[8]

$\alpha(\nu) = \alpha_0 \exp(h\nu / E_t)$ ---------- (7)

where α_0 is a constant and E_t is the Urbach energy , which characterizes the slope of the exponential – edge region. The inverse of this slope gives the width of the band tails of localized states in the normally forbidden band gap associated with the amorphous nature of the material.

(3) Materials and Method

Five samples of commercial honey belonging to different suppliers, purchased in local markets, were included in the study. Sample (1) is from Saudi Arabia (Sunbulah), sample (2) is from Spain (Miel), sample (3) is from Germany (Longnese), sample (4) is from Turkey (Buram), and sample (5) is from Pakistan (Florea). All honey samples used were in liquid form, and they are used without any further processing. A Perkin Elmer lambda 25 UV - Visible spectrophotometer was used to measure the absorption spectra of the samples, which are put in glass cells of path length 1 mm.

Figure (1) shows absorption spectra of the honey samples in the wavelength range 290-500 nm . The spectra were very noisy below 290 nm . Thus we started our analyses from this wavelength.

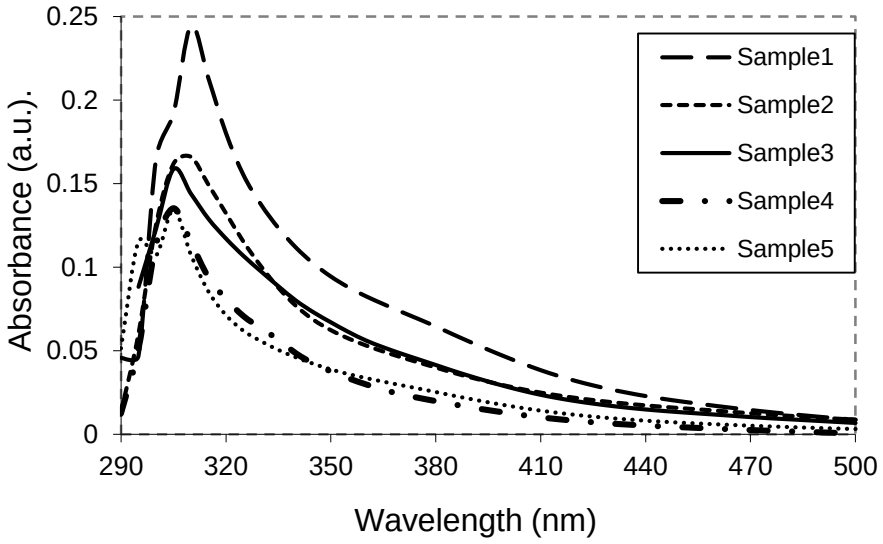

Fig.(1) Absorbance versus wavelength for the different honey samples

Honey contains different UV-absorption compounds (such as flavonoids and phenolic acids) . Majority of honey flavonoids have their UV absorption around 290 nm and 340 nm [10]. Fig.(1) reveals this fact clearly, where we see the absorption maxima at 305 nm for most of the samples. The differences in the absorbance peak values of the samples indicate that these samples contain different proportions of flavonoids and phenolic acids.

Figures (2) & (3) show the reflectance and transmittance of the samples in the wavelength region (290-500 nm) .

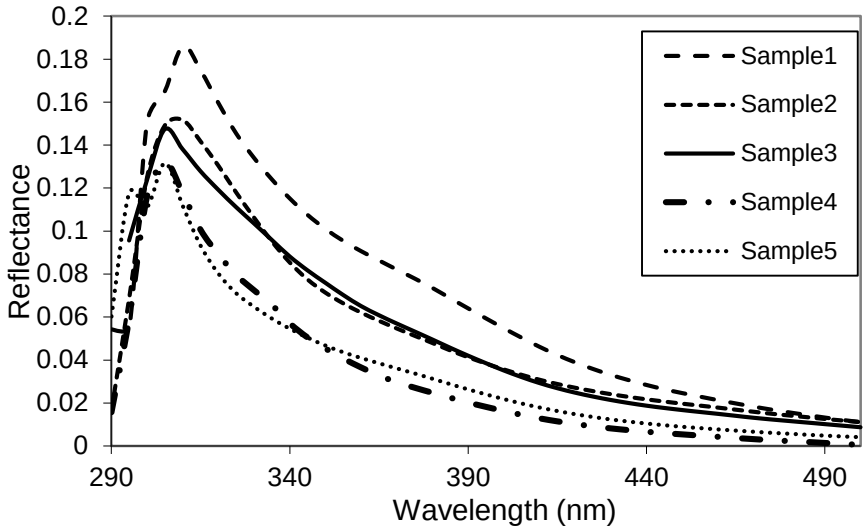

Fig.(2) Reflectance versus wavelength for honey samples

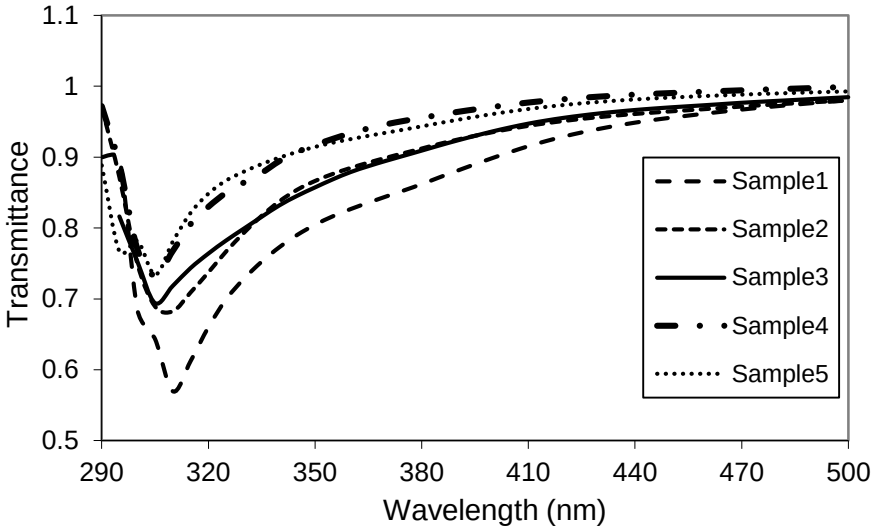

Fig.(3) Transmittance versus wavelength for honey samples

From absorbance measurements we can calculate the absorption coefficients (α) of the samples in the wavelength range (290-500 nm), using Equation(2). This is illustrated in Fig.(4).

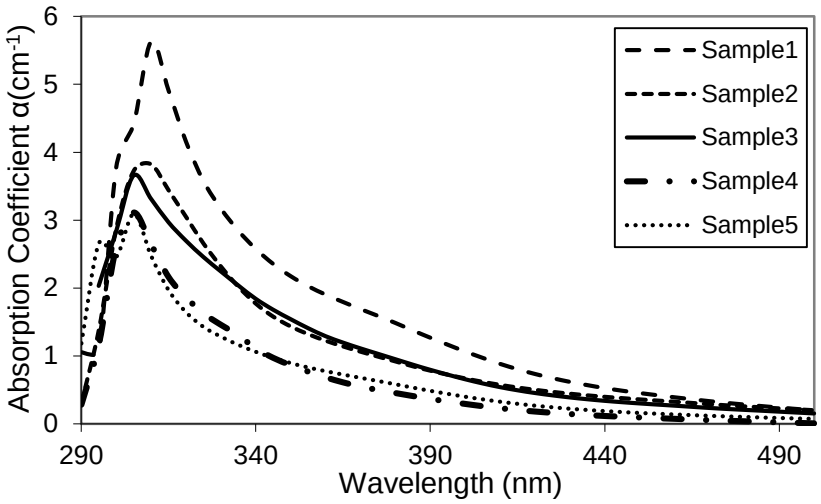

Fig.(4) Absorption coefficient versus wavelength for honey samples

The extinctio coefficient and refractive index are two of the most important optical properties, which are generally called the optical constants. These are calculated, using the data given by the spectrophotometer. The results are shown in Figs.(5) & (6).

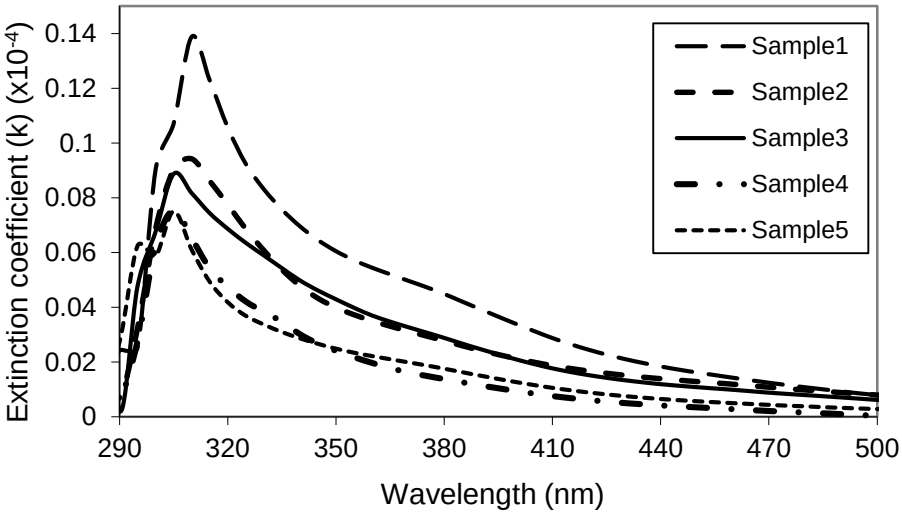

Fig.(5) Extinction coefficient versus wavelength for honey samples

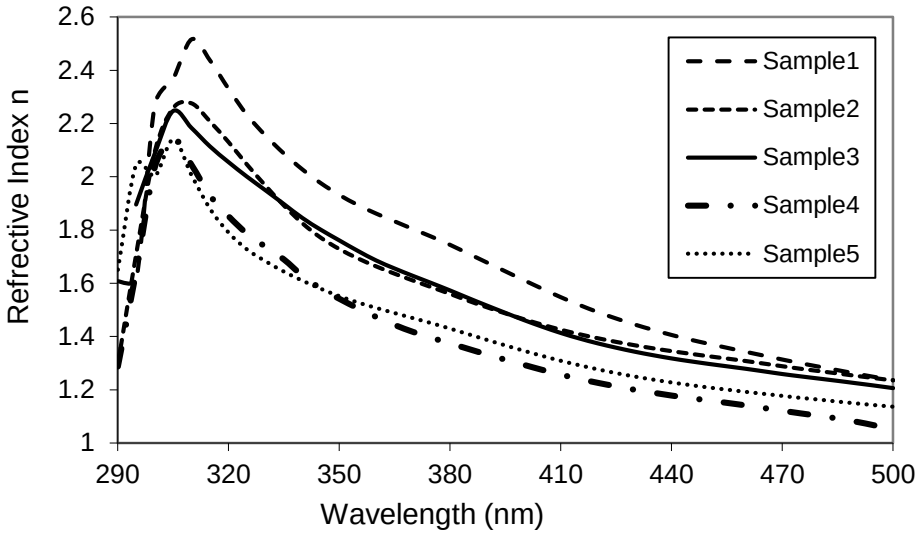

Fig.(6) Refractive index versus wavelength for honey samples

The exponential dependence of the absorption coefficient on wavelength (or frequency) is obvious in the region 310-400 nm (corresponding to photon energies ~ 4.0-3.0 eV) for all honey samples . This is in agreement with Equation (6) . By plotting values of $ln(\alpha)$ against photon energies hv , for all honey samples , the result will be as shown in Fig.(7).

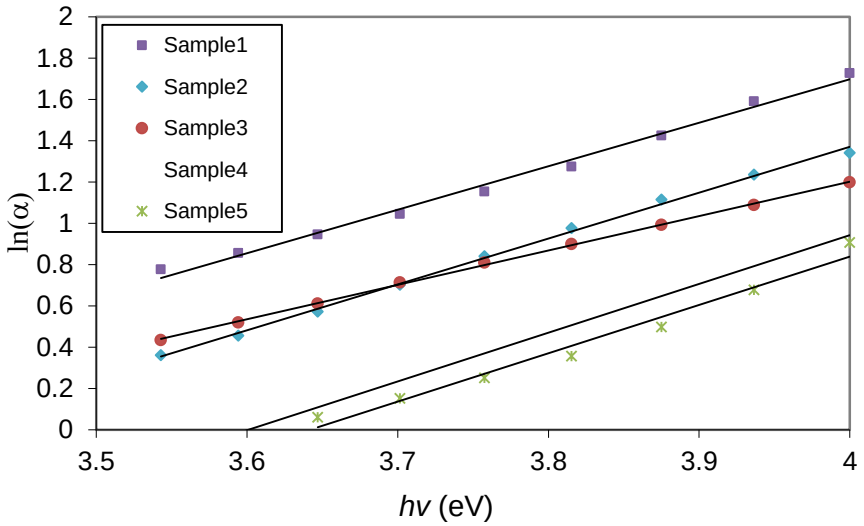

Fig.(7) Values of ln(α) versus photon energy *hv*

From regression analyses of the data shown in Fig.(7), the width of the band tails of localized states of each sample can be calculated. The results are shown in Table (1).

Table (1) Band tails of localized states of honey samples

Samples	1	2	3	4	5
Band tails of localized states E_t (eV)	0.4748	0.4500	0.6002	0.4237	0.4221

(4) Conclusions

UV-Visible spectrophotometry was used to study the optical properties of five different samples of commercial honey. These optical properties include absorbance , reflectance, transmittance, absorption coefficient, extinction coefficient , and refractive index . From the absorption spectra of the samples, we see that the absorption peak of each sample occurs in the uv-region (~ 300 nm). The reason is that honey contains uv-absorbing compounds such as flavonoids and phenolic acids . The value of the absorption peak of each sample differ from those of the others . This means that the flavonoid and phenolic acid contents of each honey sample differ from the others .

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دراسة طيفية ضوئية لنماذج مختلفة من العسل التجاري

الخلاصة :

تم استخدام التحليل الطيفي الضوئي في المنطقتين فوق البنفسجية والمرئية لدراسة الخصائص البصرية لخمسة نماذج مختلفة من العسل التجاري . وتشمل هذه الخصائص الامتصاصية , الانعكاسية , النفوذية , معامل الامتصاص , معامل التوهين , و معامل الانكسار. وقد أبدت أطياف الامتصاص امتصاصا أعظم في المنطقة فوق البنفسجية (حوالي 300 نانومتر) . ويعود السبب في ذلك الى وجود مادة الفلافونويد flavonoid وحامض الكربوليك (الفينول) phenolic acid في نماذج العسل المختلفة .