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Investigation of Natural Pigments and Optical Properties for Some Sudanese Edible Oils Using UV - VIS Spectroscopy Techniques

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Abstract: Edible oils are complex mixtures of organic substances of great commercial importance in the food, pharmaceutical, perfume and cosmetic industries due to their biological properties. This work was devoted to the detection of the total quantitative components of carotenoids and chlorophyll derivatives, as they are responsible for the color, which is an important qualitative characteristic of the oil because it contains antioxidants. Some optical properties of edible oils used in Sudan (corn, olive, peanut, factory sesame, presses sesame and sunflower) oil, purchased from local Sudanese stores were also measured and calculated using the method of UV-VIS spectroscopy (190-1100) nm. It was found that the absorption peak between (230-300) nm indicates the presence of di- and tri-unsaturated fatty acids. Polyphones share a band with different peaks between (300-400) nm. Carotenoids contribute a band with several peaks between (430 and 460) nm, and chlorophyll contribute another strong band at around (414, 670) nm. The results come to light similarity between the absorption spectrum, absorption coefficient and attenuation coefficient. From the transmission spectrum, it was found that corn oil and sunflower oil had the largest transmission spectrum and the lowest transmission spectrum of olive oil.

Keywords: Edible Oils, Natural Pigments, Optical Properties, UV-VIS Spectroscopy, Absorption, Transmission, Absorption Coefficient, Attenuation Coefficient

1. Introduction

Edible oils are widely used in the food industry and in the cooking at home, and are one of the important food stuffs in our daily life. Vegetable oils provide some important components for human nutrition and health benefits that including but not limited to essential fatty acids, vitamins, minerals, and so on [1, 2]. The color of edible oils is due to the presence of natural pigments belonging to the class of chlorophylls, carotenoids and their derivatives. These substances, other than being responsible for the color, an important qualitative feature of the oil, have antioxidant and, more generally, nutraceutical properties and their quantification can be related to the authenticity and product's quality [3, 4]. In Sudan, edible oils are the primary cooking oil, such as (corn, olive, sunflower, peanut, factory sesame and presses sesame) oils. Seed oils have recently become more popular than traditional animal fats [5, 6].

In recent years, spectroscopy techniques provide an alternative to the traditional methods and they have increased in importance in vegetable oils authenticating. In this respect, a lot of methods have been proposed based on Raman spectroscopy [7], fluorescence spectroscopy, mid-infrared spectroscopy, nuclear magnetic resonance spectrometry, Fourier transform near-infrared spectroscopy [8, 9]. These spectroscopic methods now have the potential to replace or at least complement the traditional methods. [10].

Ultraviolet-visible (UV-VIS) spectroscopy verifies the electronic excitation of molecules normally correlating with the absorption of photon energies congruous to ultraviolet (200-380) nm and Vis spectral regions (380-740 nm) [11, 12]. Molecules contain restrictive and unrestrictive electrons (n electrons) which can be succor to irradiation to a higher anti-bonding (MO) molecular orbital. In principle, four possible electronic transitions may occur; π - π *, σ - σ *, n - π * and n - σ *. The mostly specified orbital's for a given molecule are the highest occupied HOMO and lowest occupied LUMO, and the transition between these sites is usually the most prospective. The HOMO-LUMO energy gap nearly indicates the wavelength domain in which the compound absorbs, and this absorption is related to the species excitation from the base state to the excitation state [13, 14]. When this transition requires less energy, the absorption wavelength is higher, while when more energy is required, the wavelength is lower. While studying edible oils, UV / VIS Spectrophotometers can reveal information about the optical properties for edible oils. UV-Vis spectroscopy also has been widely used in evaluating edible oils since the components within such as chlorophyll and lutein are responsible for the color of oil [10, 15, 16].

2. Experimental

2.1. Samples

Six samples of oils were used for spectroscopic analysis:(corn, olive, sunflower, peanut, factory sesame and presses sesame) oil. All of these oils were purchased from Khartoum Sudan common supermarkets. The samples were analyzed in crude form, without any pretreatment or dilution with use of chemical solvents.

2.2. Experimental Parameters

The UV-VIS spectra were obtained in a shimadzo mini 1240 spectrophotometer that scans between (190-1100) nmwith the optimum resolution of 0.1 nm. Each experimental sample was put in a quadrate optical cuvette with 10 mm path-length for corresponding absorption spectra measurement.

2.3. Software

Origin Lab, is a user-friendly and easy-to-learn software application that provides powerful data analysis and publication-quality graphing capabilities tailored to the needs of scientists and engineers. Results of absorption spectroscopy (UV-VIS) were processed for all samples by Origin Pro 9 Software (Origin Lab, Northampton, USA). (www.originlab.com).

3. Result

3.1. Absorbance

Figure 1: The absorption of six Sudanese sample oil was obtained as a function of wavelength. It can be seen that the samples show similarities and differences in absorption, which makes it possible to distinguish between oil samples based on absorption spectra. At the beginning of the UV (200-350) nm spectrum, the absorption spectrum is identical for all samples up to 320 nm, because the characteristic transformations of the absorbed molecular bonds in this region are similar. After all, the acidity of the lipids is the same in composition.

The absorption begins to decrease from a converging region, peanut oil starts at (305 nm), olive at (310 nm), sunflower and sesame at (313 nm), and sesame at (314 nm). And finally, the atom is at 340 nanometers, which is a distinctive peak. The absorption begins to increase at (400 nm).

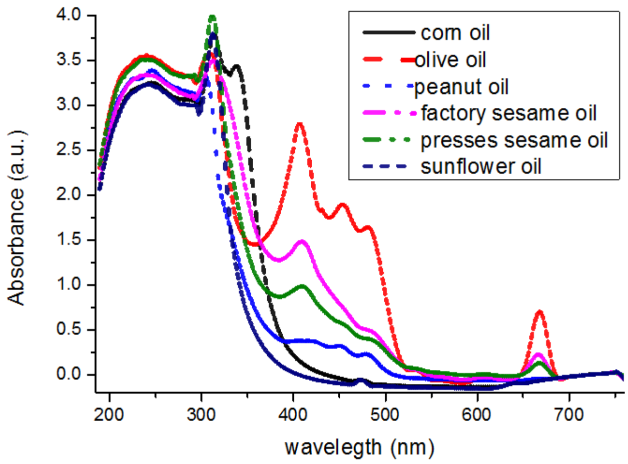

Figure 1. *UV−UIV absorption spectra of some Sudanese edible oils.*

Absorption peaks for corn oil appear at (249, 314, 340, 480) nm olive oil at (241, 310, 408, 454, 482, 612, 669) nm, sunflower oil at (239, 313, 474) nm, factory sesame oil at (239, 314, 410, 668) nm, presses sesame oil at (235, 313, 410, 669) nm and peanut oil at (246, 305, 480) nm. The absorption properties of vegetable oils depend on the content of dye components such as chlorophyll, fovitin, carotenoids and lutein. The absorption range between (230-300) nm indicating the presence of conjugated dienes and trienes of unsaturated fatty acids. The polyphones participate band with various peaks between (300-400) nm. The carotenoids contribute a band with several peaks between (430 and 460) nm, and the chlorophyll contributes another strong band at about (414, 670) nm.

3.2. Transmittance

The transmittance spectrum is characterized by its opposite behavior to the absorption spectrum, as Figure 2 shows the transmittance spectrum as a function of the wavelength of the oil samples. It is clear from the figure that the transmittance generally begins to appear at the wavelength that represents the boundary between the absorption and permeability of oils, or the so-called cut-off wavelength ($\lambda_{cut\text{-}off}$), and then the transmittance generally increases with the increase in the wavelength of the electromagnetic radiation falling on the samples. The sample oils reach their peak and hold in the visible region of the electromagnetic spectrum. It can be seen from Figure 2 that corn and sunflower oils have the greatest transmittance value about 99.2%. It was find that olive oil has the lowest transmittance points at (16 and 60.1) % at wavelengths (407 and 670) nm respectively.

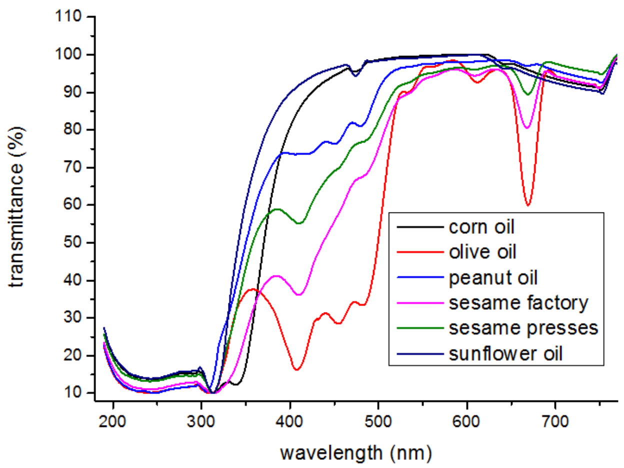

Figure 2. *UV−UIV Transmission spectra of some Sudanese edible oils.*

3.3. Reflection

The reflectivity spectrum was calculated from the absorption and transmittance spectrum according to the law of energy conservation.

$$R = 1 - \sqrt{Texp(A)} \quad (1)$$

Figure 3 shows the reflectivity spectrum of six Sudanese edible oils as a function of wavelength. From Figure 3 it is clear that the reflectivity decreases with increasing wavelength.

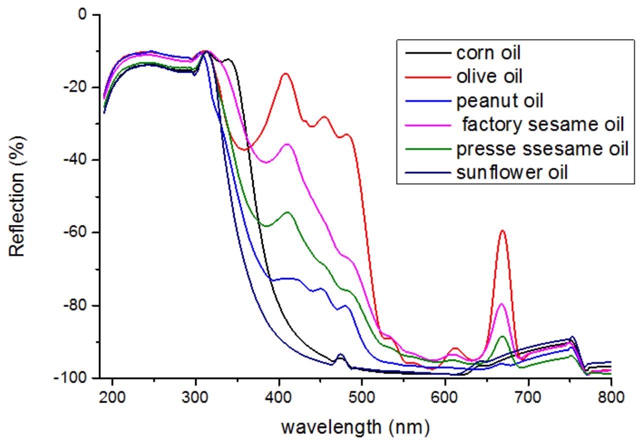

Figure 3. *UV−UIV Reflection spectra of some Sudanese edible oils.*

3.4. Absorption Coefficient (α)

Figure 4 shows the absorption coefficient as a function of the wavelength of the incident photon on six samples of edible oils used in Sudan. It is clear from the figure that the absorption coefficient behaves in a behavior similar to the behavior of the absorption spectrum, and this is due to the fact that the absorption coefficient is a function of absorption as in the equation (2).

$$\alpha = \frac{2.303A}{t} \quad (2)$$

A≡ Absorbance

t ≡path length (centimeters).

From the figure, it becomes clear that the absorption coefficient begins in general with a gradual increase with the increase in wavelength at the beginning of the spectrum and then begins to decrease. It is noted that the absorption coefficient of all samples is similar. It is noted that olive oil has the highest absorption coefficient, while corn oil and sunflower oil have the lowest absorption coefficient. High values of the absorption coefficient indicate the possibility of direct electronic transitions between the valence and conduction bands at these energies.

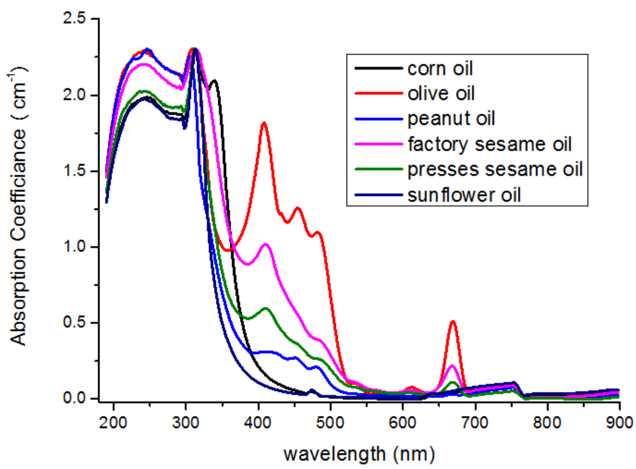

Figure 4. *UV−UIV Absorption Coefficient (α) spectra of some Sudanese edible oils.*

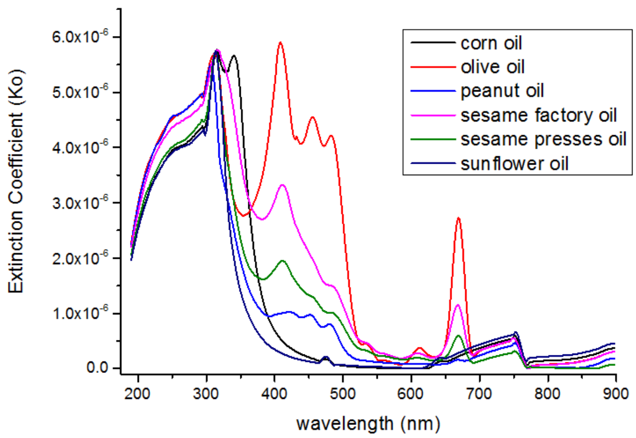

Figure 5. *UV−UIV Extinction Coefficient (K_o) spectra of some Sudanese edible oils.*

3.5. Extinction Coefficient (K_o)

The Extinction coefficient indicates the amount of attenuation obtained by the electromagnetic wave as it passes through the material medium, the Extinction coefficient can be calculated by adopting the following equation (3) in which it is related to the absorption coefficient and wavelength.

$$K_0 = \frac{\alpha\lambda}{4\pi} \quad (3)$$

α≡Absorption Coefficient

λ≡ wavelength

Figure 5 shows the change of the Extinction coefficient as a function of the wavelength of the incident photon on edible oil samples.

4. Conclusions

In this study, several Sudanese edible oils were studied to determine their pigment content and to find some optical properties, Used UV visible spectroscopy.

The absorption properties of edible oils have been studied in the region of visible wavelengths near ultraviolet rays. Each oil exhibits unique absorption properties over the wavelength range from (200 to 800) nm. Olive oil has unique absorbing properties that set it apart from other oils.

In the visible UV-visible wavelength region, the edible oils can be distinguished from each other.

The work points out the advantages of using UV Vis spectroscopy. The advantages are related to the non-destructive properties, speed, and low cost of each sample from spectroscopy plus no specific sample preparation or specially qualified laboratory personnel. In conclusion, it can be a reliable, fast and cheap classification tool.

5. Recommendations

(1) Using a spectrometer that covers all frequencies of electromagnetic wave.
(2) Expanding the study to include all edible oils used in Sudan.
(3) Find the electrical properties of oils.
(4) Calculate the all optical properties.
(5) Studying the effect of low and high temperatures on oils and comparing them with the current results.
(6) Verify the effect of storage method on optical properties.

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