Spectroscopic Study for Effect of Heating Temperatures on the Black Seed Oil.

Nawras k. Abd and Bahaa T. Chiad
nawrasalghurairu@gmail.com

Department of Physics, College of Sciences, University of Baghdad, Iraq

Abstract. The existing investigation explains the effect of temperature on black seed oil, what are the changes that occur to the oil when it is heated to a temperature higher than (100 C°), and what is the effect of that change on human health when using this oil. It was heated to several temperatures ranging from (30 C°) to (150 C°). The absorbance of the samples was measured before and after heating using the UFI device. The intensity was also measured by irradiating each sample using a red laser. It has been found that when the oil is heated to a temperature higher than 100 C°, a change occurs in the composition of the oil with a change in its physical properties such as color, smell, taste ... etc. and the formation of another compound, and the new compound may be toxic.

Key words: Black Seed Oil, Spectroscopic, Absorbance, Fluorescence, Temperature, Heating effect.

1. Introduction

The oil is subjected to long periods of heating at high temperatures in the presence of air and water. This leads to a wide range of complex chemical reactions, such as thermal oxidation, hydrolysis, and polymerization [1, 2]. Nigella sativa (N. sativa) is an annual flowering plant, which belongs to the Ranunculaceae family [3, 4]. It grows in three different regions: Eastern Europe, the Middle East, and Western Asia [5]. The plant produces small black seeds that are flat, trigonous, and angular in appearance, about 2 to 3.5 mm in length, and 1 to 2 mm in width [6]. In addition, these dark gray- or black-colored seeds are similar in appearance to sesame seeds [7] and are thought to be the most impressive part of the plant in terms of their valuable health impacts [5]. Chemical constituents: Nigella sativa seeds contain 36 to 28% fixed oil, proteins, alkaloid, saponin and 0.4 to 2.5% essential oil. It is composed of unsaturated fatty acid that includes arachidonic, eicosadienoic, linoleic and linoleic acid. The saturated fatty acid present in the oil are palmitic, stearic and myristic acid [8]. The oil of N. sativa seeds contains thymoquinone (TQ), dithymoquinone, thymohydroquinone, thymol, carvacrol, nigellimine-N-oxide, nigellicine, nigellidine, and alpha-hederin [9, 11, 13]. Therefore, the seed is utilized for many nutritional and pharmaceutical purposes. It can be added to tea, coffee, and bread and could also be mixed with honey or sprinkled on salads. Its oil is taken in the capsule form. The essential oil component of N. sativa has been shown to have anticancer [13], antioxidant [12], gastroprotective, hepatoprotective [14], analgesic, anti-inflammatory [9], antihypertensive [10], antidiabetic [12], antihistaminic, anthelmintic, and antimicrobial impacts [15].
2. Materials and Methods

2.1. Measurement of Absorbance
The UV-visible absorption spectrum of the prepared samples was measured using a UV-visible double-beam (Halogen and deuterium lamps) spectrophotometer with a wavelength range of (200-800 nm).

2.2. Fluorescence Spectra
A spectrophotometer with a (700 NM) laser diode and a spectral distance of 10 nm was used to test the prepared samples, and the output signal was registered using an X-Y scanner.
2.3. Examine samples
Samples were prepared from black seed oil and placed in glass spools after being heated from room temperature (30°C) until (150°C), then the absorption spectra of each sample is examined before and after heating and using a glass cell for examination, then the absorbance values of each sample are calculated. The fluorescence spectrum of each sample is measured using a red diode laser to calculate the intensity. The figure (3) shows the prepared samples of black seed oil after heating it at different temperatures.

Figure 3. Black seed oil at different temperatures.

3. Results and Discussion
3.1. Absorbance
When the oil temperature increases, as well as the heating time period, the absorbency increases, also, with each rise in the amount of heating elements, the peak wavelength shifts towards longer wavelengths. It has been shown that the more oil is heated to a higher temperature, the absorbance increases. Also, at each temperature, the composition of the oil differs from the original oil. This variation in the oil is accompanied by a difference in the physical properties of the oil, such as colour, scent, and taste... etc. And the new oil may be a toxic compound that harms the health of the user. At the highest height of the heights, there is a shift that can be seen. This effect is common when the temperature varies. As shown in the table(1), This result is consistent with the source [16].

Table 1. The maximum value of absorbance with wavelength for black seed oil at different temperature heating

| Time (sec) | Temperature °C | Absorbance | Wavelength (NM) |
|-----------|----------------|------------|-----------------|
| 0         | 30             | 0.815      | 661.41          |
| 15        | 50             | 0.868      | 661.41          |
| 30        | 60             | 0.961      | 661.41          |
| 45        | 70             | 0.999      | 661.021         |
| 60        | 80             | 1.008      | 661.021         |
| 75        | 90             | 1.046      | 662.186         |
| 90        | 100            | 1.104      | 662.186         |
| 105       | 110            | 1.132      | 662.186         |
| 120       | 120            | 1.19       | 662.186         |
| 135       | 130            | 1.247      | 662.574         |
| 150       | 140            | 1.338      | 662.574         |
| 165       | 150            | 1.463      | 664.899         |
Figure 4 shows the absorption spectra of black seed oil, where the absorbance increased with increasing temperature from (30 °C) to (150 °C) due to the breakage of the hydrogen bonds of oil and the formation of new compositions which is different from the constituents of the oil before heating.

Figure 4. Effect of heating temperature on absorbance.
Figure 5. Absorbance of black seed oil with wavelength At different heating temperatures.

3.2. Fluorescence spectra

The fluorescence spectra of black seed oil were studied at room temperature after being heated for several times from one to ten times. Red laser (700nm) was used, as shown in Fig. (6). It was noticed that the peak emission of black seed oil was in (671 NM) because of its high saturated and unsaturated fatty acid content. Then, with the increase in the temperature of oil, there has been a shift in wavelength to short wavelength, with an increase in intensity. During the heating process, oil is heated to an extremely high temperature in the case of air and humidity. A dynamic sequence of chemical reactions occurs under these conditions, resulting in the loss of both the oil's consistency and nutritional value. As the temperature of the oil increases, the solubility of oxygen decreases dramatically. Polymerization also occurs in hydrolysis products, which in turn leads to an increase in the molecular weight of cyclic fatty acid monomers and dimers, and this leads to an acceleration of the hydrolysis reaction. This result is consistent with the source [17].

Table 2. Fluorescence intensity values with wavelength for black seed oil at different heating temperatures.

| Temperature C° | Wavelength(NM) | Intensity |
|----------------|----------------|-----------|
| 30 C°          | 671.848        | 7585.465  |
| 50 C°          | 671.463        | 8839.849  |
| 60 C°          | 670.307        | 9145.571  |
| 70 C°          | 666.833        | 10774.983 |
| 80 C°          | 666.821        | 11965.938 |
| 90 C°          | 666.446        | 15133.322 |
| 100 C°         | 666.446        | 15783.708 |
| 110 C°         | 665.286        | 15847.699 |
| 120 C°         | 665.286        | 15879.680 |
| 130 C°         | 665.446        | 15883.798 |
| 140 C°         | 664.512        | 15960.682 |
| 150 C°         | 664.512        | 15969.094 |
Figure 6. The fluorescence intensity with heating temperature.

Figure 7. The fluorescence spectra of black seed oil at different heating temperatures.

4. Conclusion
The results showed there is a clear change in the spectrum of absorption and fluorescence when heating black seed oil several times. This effect has increased by increasing the number of times of heating, and the reason for this is the breakage of hydrogen bonds, especially the multiple bonds, and thus the generation of new compounds may affect the health of the user and these new compounds may have a toxic effect.
References

[1] P. J. White, “Methods for measuring changes in deep-fat frying oils,” Food Technology, vol. 45, pp. 75–80, 1991.

[2] W. L. Clark and G. W. Serbia, “Safety aspects of frying fats and oils,” Food Technology, vol. 45, pp. 84–89, 1991.

[3] S. Cheikh-Rouhou, S. Besbes, B. Bentati, C. Blecker, C. Deroanne, and H. Attia, “Nigella sativa L.: chemical composition and physicochemical characteristics of lipid fraction,” Food Chemistry, vol. 101, no. 2, pp. 673–681, 2007.

[4] R. Z. Hamza and M. S. Al-Harbi, “Amelioration of paracetamol hepatotoxicity and oxidative stress on mice liver with silymarin and Nigella sativa extract supplements,” Asian Pacif J. of Tropical Biomedicine, vol. 5, no. 7, pp. 521–531, 2015.

[5] K. M. Fararh, Y. Atoji, Y. Shimizu, T. Shina, H. Nikami, and T. Takewaki, “Mechanisms of the hypoglycaemic and immunopotentiating of Nigella sativa L. oil in streptozotocin-induced diabetic hamsters,” Research in Veterinary Science, vol. 77, no. 2, pp. 123–129, 2004.

[6] H. J. Harzallah, B. Koudhi, G. Flamini, A. Bakhrout, and T. Mahjoub, “Chemical composition, antimicrobial potential against cariogenic bacteria and cytotoxic activity of Tunisian Nigella sativa essential oil and thymoquinone,” Food Chemistry, vol. 129, no. 4, pp. 1469–1474, 2011.

[7] S. H. Mohamad Aljabre, M. A. Randhawa, N. Akhtar, O. M. Alakloby, A. M. Alqurashi, and A. Aldossary, “Antidermatophyte activity of ether extract of Nigella sativa and its active principle, thymoquinone,” Journal of Ethnopharmacology, vol. 101, no. 1–3, pp. 116–119, 2005.

[8] A. Ahmad, A. Husain, M. Mujeeb et al., “A review on therapeutic potential of Nigella sativa: a miracle herb,” Asian Pacific Journal of Tropical Biomedicine, vol. 3, no. 5, pp. 337–352, 2013.

[9] S. H. M. Aljabe, O. M. Alakloby, and M. A. Randhawa, “Dermatological effects of Nigella sativa,” Journal of Dermatology and Dermatologic Surgery, vol. 19, no. 2, pp. 92–98, 2015.

[10] L. Kokoska, J. Havlik, I. Valterova, H. Sovova, M. Sajfrtova, and I. Jankovska, “Comparison of chemical composition and antibacterial activity of Nigella sativa seed essential oils obtained by different extraction methods,” Journal of Food Protection, vol. 71, no. 12, pp. 2475–2480, 2008.

[11] M. Q. Hassan, M. Akhtar, S. Ahmed, A. Ahmad, and A. K. Najmi, “Nigella sativa protects against ischemic-induced myocardial infarction by alleviating oxidative stress, biochemical alterations and histological damage,” Asian Pacif J. of Tropical Biomedicine, vol. 7, no. 4, pp. 294–299, 2017.

[12] H. Younus, Molecular and :erapeutic: Actions of :ymoquinone, Springer, Berlin, Germany, 2018.

[13] M. Kanter, O. Coskun, and M. Budancamanak, “Hepatoprotective effects of Nigella sativa L. and Urtica dioica L. on lipid peroxidation, antioxidant enzyme systems and liver enzymes in carbon tetrachloride-treated rats,” World Journal of Gastroenterology, vol. 11, no. 42, pp. 6684–6688, 2005.

[14] K. M. Fararh, Y. Atoji, Y. Shimizu, and T. Takewaki, “Insulinotropic properties of Nigella sativa oil in streptozotocin plus nicotinamide diabetic hamster,” Research in Veterinary Science, vol. 73, no. 3, pp. 279–282, 2002.

[15] M. A. Khan, Y. H. Aldebasi, S. A. Alsuhaihabi et al., “therapeutic potential of thymoquinone liposomes against the systemic infection of Candida albicans in diabetic mice,” PloS One, vol. 13, no. 12, Article ID e0208951, 2018.

[16] Mays .K.A , Analysis and diagnostic by fluorescence spectroscopy for some natural oils, Baghdad University,2018.

[17] E. Choe and D. B. Min, “Chemistry of deep-fat frying oils,” J. Food Sci., vol. 72, no. 5, 2007.