



## A Study of Heating Effect on the Structural and Optical Absorbance of Olive Oil

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### Abstract

In this study, the number of times of heating of olive oil was studied. For the different refineries, the study was conducted using a temperature of 300K and for several times to determine the validity of the olive oil which is used for frying purposes after it was used for more than once times. It was found that there were significant changes in the behavior of the photophysical behavior like absorption and emission; there are changes in the nature and composition of the olive oil molecule, which makes it not useful for human use. The number of heating times was ten. The heating times also showed significant changes in the nature of the oil, such as color, taste, density, and smell.

**Keywords:** olive oil, frying, cooking, spectroscopic.

### دراسة تأثير الحرارة على التركيب الداخلي والخصائص البصرية لزيت الزيتون

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### الخلاصة:

تناولت الدراسة الحالية تأثير عدد مرات التسخين على زيت الزيتون لتحديد مدى صلاحية الزيت للاستخدام البشري بعد تسخينه اكثر من مرة. اظهرت النتائج ان لدرجات الحرارة المرتفعة و زمن التسخين تأثير واضح على اطياف الامتصاص والانبعث للزيت المدروس بالاضافة الى التغير في طبيعة وتركيب الجزيئات والخصائص الفيزيائية مثل اللون والطعم والكثافة والرائحة، كل هذه التغيرات تجعل من زيت الزيتون المسخن غير صالح للاستخدام البشري .

### Introduction

The most literature review for food industry indicates in several countries showed worried of Possible hazards about people health which were come from the consumption the oxidized the resulting from the oil processing by using the heating as frying this product containing lipid polymers. The fried foods have a huge amount of saturated fats, cholesterol, and calories, now the popularity idea growth to moderate the fat consumption to ensuring a healthy diet and balanced food. When food is fried in heated oil, the moisture forms steam, which evaporates with a bubbling action and gradually subsides as the foods are fried. Water, steam, and oxygen initiate the chemical reactions in the frying oil and food [1].

The Frying is the most and versatile way for cooking, which makes the food has unique sensory, it is the one of oldest and the most methods of cooking in the world. During frying methods there are

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many processes may take place, the water must be released in the samples by bubbling action and subsides then the oil enters the whole food which are fried. This processes make the structure of the oil must be changing because the oxygen water and steam initiate the chemical reaction in this stage of frying oil and whole food. Thermal hydrolysis in the oil phase takes place mainly than oil- water interface [2] as shown in Figure-1. When one frying the food, a hot of frying fat penetrated into it and replaced part of containing water this makes the food more palatable [3]. The scheme of a possible mechanism that production of 2, 4- decadienal from 2-decenal [4].

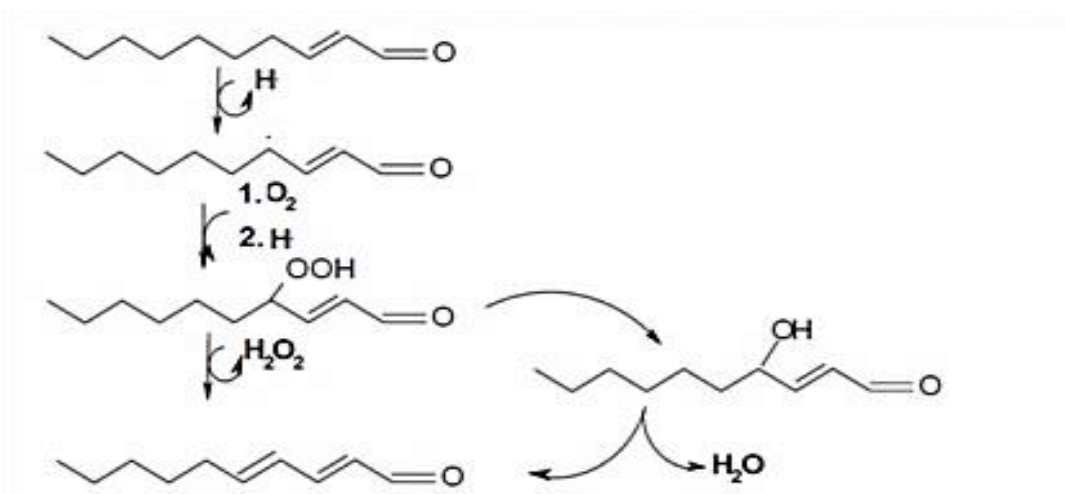


Figure 1-Thermal hydrolysis in the oil.

The rate of thermal oxidation is faster than processes of the autoxidation. The scientific information and specifications for the rate of the thermal oxidation with autoxidation not available, the termination of the reactions showed in the Figure-2. [2].

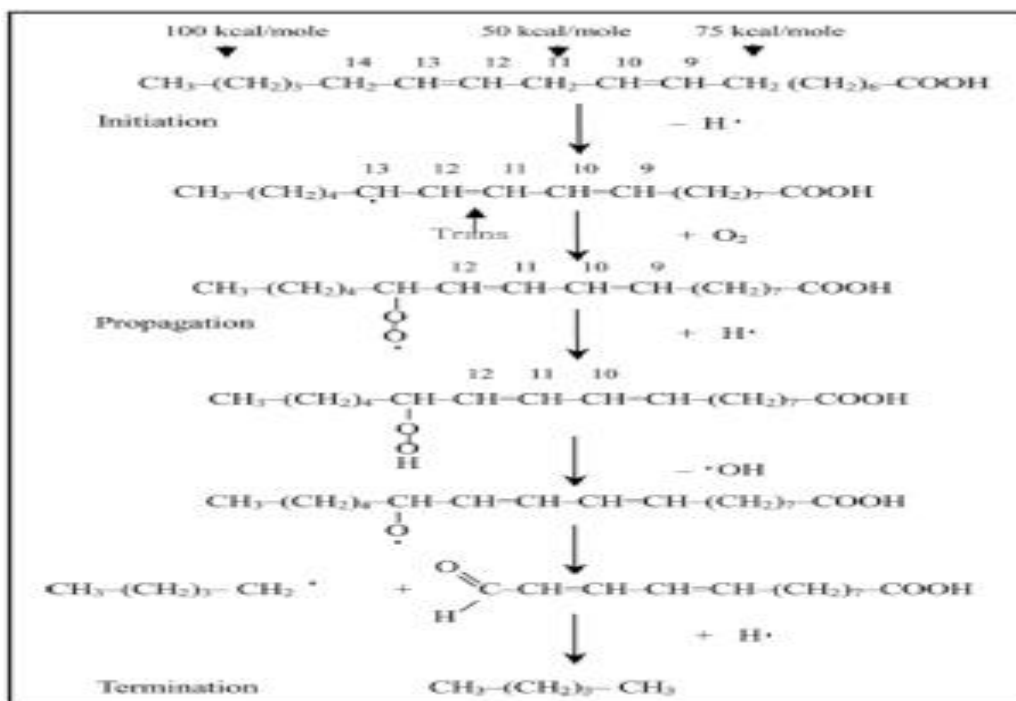


Figure 2-The processes i: initiation, ii: propagation, and iii: termination of the thermal oxidation [2].

**Table 1-**Chemical and physical properties of olive oils samples [5]

Free fatty acid (%oleic acid)	1.55-135
Peroxide value (meq O <sub>2</sub> / kg)	5.12-12.8
Saponification number (mg KOH/ g)	167.2-185
pH	5.11-4.91
Moisture (%)	2.81-0.92
Impurities (%)	7.95-1.25
Density (g/ml)	1.93-0.87

More than 400 different chemical compounds, including 220 volatile products, have been identified in deteriorated frying oil [6]. Repeated frying causes several oxidative and thermal reactions, which result in a change in the physicochemical, nutritional and sensory properties of the oil [7].

The olive oil is the most one of the oil it can be obtained by using olive fruit. The origin information about using this oil date back since 2400 years B.C, the using of olive oil began in the Mediterranean cultivation and then spreading to all word cultivations. In the first case of extra virgin olive oil which has the prized through the more possessing nutritional, cosmetic properties and also in cosmetic properties. The olive oil is the most oil expensive produced history in the food and also is one of most adulterated. The creation of olive oil and consumption Concentrated in the Mediterranean word. This oil export but extra virgin olive was growth continuously.

The adulterated olive oil can it causes to die some users like in 1980 more than 650 one died because the olive oil adulterated by aniline and rapeseed oil. Now, most of the olive oil marketing adulterated with more purity than one type of cheaper type of oil. Then now the user must look for requires testing to making sure it's about, authenticity and safety.

The NIR spectrum which is recorded characterized the vibration transition characterized by the combinations of the fundamental and overtones transitions of molecules, this containing the groups O-H, C-H and N-H, this transitions making NIR study best choice to analysis the oils under study like olive and vegetable oils because this test has no any preparation of the samples, no waste, no any skills required , can be analyses more than one component in one minute ,it may be used in soled or liquid samples and no typical errors of operation as in classical study .Safwan et. al. [8] used (FT IR) spectroscopy to put different category edible oils which are including the virgin olive oil. The FTIR studies Ersillia Alexa et al [9] to identify some olive which was adulteration by some oils .the result obtained from this study showed there are differences in behavior of the spectrum because there are various types of oils and using the calibration curve to know the other additive oils.

Measurement of oil degradation should be based on the changes after frying. Chemical analyses, including measurements of free fatty acid (FFA) content and total polar materials (TPMs), are reliable ways to measure degradation compounds in the frying oil. However, these chemical analyses are often time-consuming, costly, and destructive to the sample. In addition, they require potentially hazardous reagents and also require reasonable analytical expertise. Because of these shortcomings, spectroscopic methods have been investigated as alternatives to chemical methods [10]. UV-vis spectrophotometric study provides a very good assess method of appearing the presence of other derivative oil in a samples or olive oil contamination and the changing of the used oils when heated to high temperature. In this study there are different olive oils used and heated to high temperature to find out which temperature must use in the house kitchen to get healthy oil.

### Materials and Methods

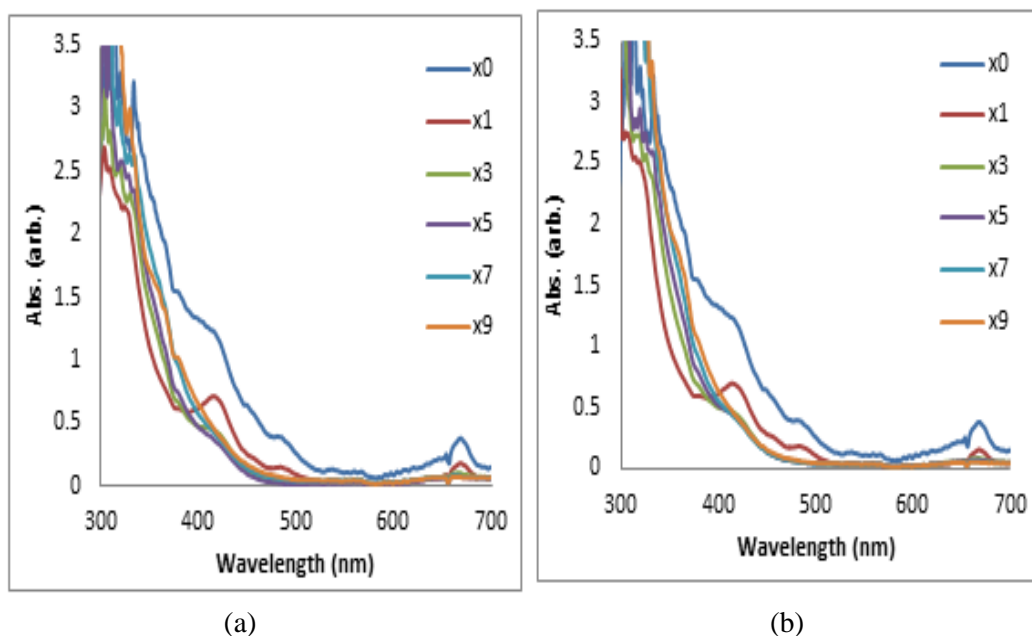
For the purpose of this analysis (21) samples of olive oil of different types of origin were considered as a samples used were purchased from local market. The absorption spectra in room temperature of oils were recorded. To be sure the water evaporated from the whole samples Onions were peeled and cut into pieces (approx. 2 cm<sup>3</sup>) and were fried in the oil at high temperature at ten frying times. To study the effect of the container the fried processes repeated in two containers for frying; aluminum and steel. Absorption spectra were obtained on a UV-Visible absorption spectrum of the prepared samples were carried out using UV-Visible double-beam (Halogen and deuterium lamps) spectrophotometer (Metertech SP-8001 UV/Visible) which operates in the wavelength range of 190 nm to 1100 nm. Absorption spectra carried out twenty times in order to show the thermal effect increasing use. Laser Induced Fluorescence (LIF) were using to get the fluorescence spectra of the

prepared samples have been recorded through the designed spectrofluorimeter using a laser diode of a 530 nm, spectral width 10 nm and beam diameter 2 mm.

FT-IR spectra of oil samples before and after frying were recorded with the help of a Fourier Transform Spectrophotometer Model IR prestige-21.

### Result and discussion

There are some Spectroscopic techniques were used to investigate the thermal effect on the chemical structure or composition of olive oil, like absorption behavior, FT-IR and fluorescence is used. The quantity about  $(50.0 \pm 0.5\text{ml})$  of olive oil samples were heated in oil Pan (12 cm inner diameter) by using a regular cooker or electric heater with continuously heated to about  $300 \pm 5^\circ\text{C}$  or controlling the temperature from  $(100 \text{ to } 300)^\circ\text{C}$  in the normal atmosphere to about 30 min. Firstly, tests were execution in order to getting information about spectrum oil behavior when heating to a high temperature for multiple times. After each samples heat treatment, the samples must be far from the heater or the source of the heating and covered and let it to reach the room temperature, and then stored for the next heating after 24 hours. The variation of absorption with temperature has been studied at the maximum temperature Figure-3, Physicist are used the same information to the separation of oils in the samples by the factor called fractional crystallization, and also this parameter used to separate the soluble compounds depending on the solubility of the compounds in a given suitable solvent.



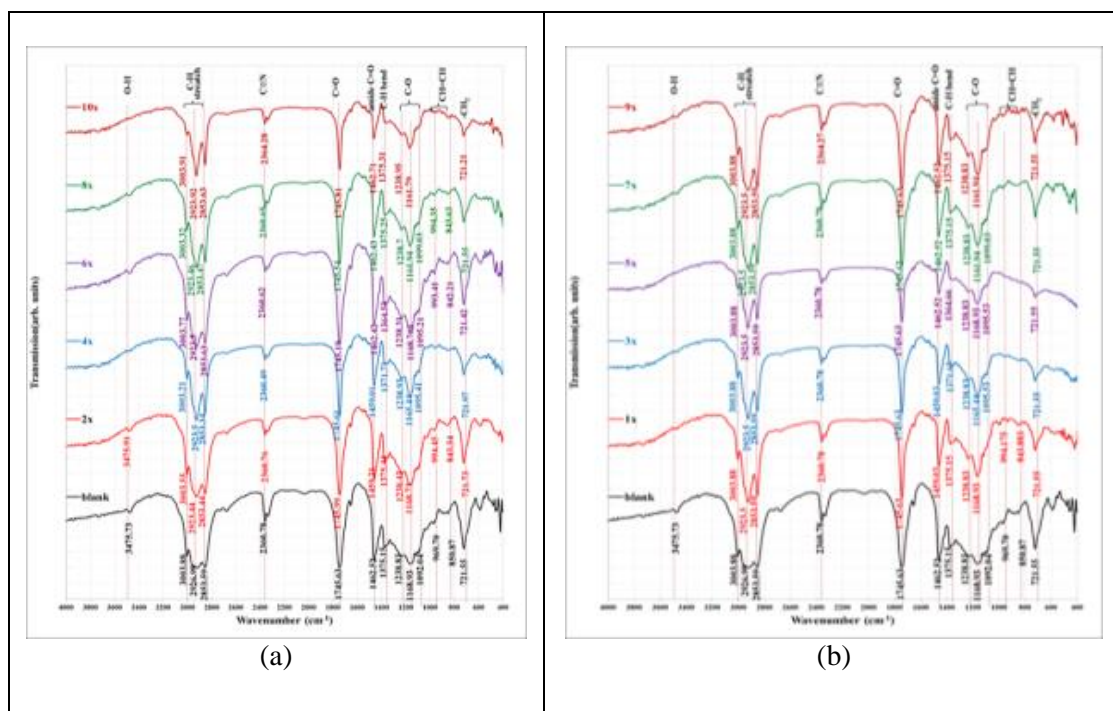
**Figure 3-** absorption spectrum of olive oil a: in steel pan b: in aluminum pan. Where X represent number of heating.

Figure-3, show the spectra of optical absorption for the olive oil taken temperature (T) range from  $RT=30\text{ C}^0$  to more than  $300\text{C}^0$  for a number of times of heating from one time to ten times and temperature used in all cases of fried food in all Iraqi kitchens and up to 300 degrees Celsius. We note that the behavior of the spectrum with increasing the number of times the heating begins to exaggerate its behavior at the absorption where we find that with each increase in the number of times the heat is the spectrum to a different behavior from the previous period, which leads to the formation of new molecular entities different from the original oil and can say that this oil It is different from the oil used initially at RT, however, we can observe a clear gap between the absorption spectrum it changes as the number of heating which indicates that the oil composition has changed. This change is confirmed by the measurements of other measurements after more than a day and for multiple times. If the change in spectrum behavior was caused by the effect of high temperature then we can find that the spectral behavior returns to its first position before heating the oils. This change in the behavior of the spectrum is accompanied by a change in the specifications of physical oil such as color, taste and smell, suggesting that this oil has become unfit for human use and perhaps this change in the

composition led to the formation of new compounds have a negative impact on the user reaches such an effect perhaps to poison to affect the user and may have delayed effects. Therefore, the oils should be excluded after heating and not used for multiple times.

This study adopted the mechanism of repeated heating of olive oil for 10 times about more than 300 degrees and with each heating leaves oil for 24 hours and then conduct the required spectral measurements, absorption, fluorescence, and FTIR.. In addition, the measurement is done again and again a few days later to confirm that the effect of heating has caused a constant change in the composition of olive oil, which causes the use of such oil for human use causes health problems, where the spectral studies have shown that fixed changes in the structure make this compound unusable because it lost his good qualities.

The absorption spectra of olive oil Figure-3 showed a change in the spectral structure with the number of times of heating, through the emergence of absorption packs in the short wavelengths. Increasing the number of times the heating cause's decreases in the intensity of the new spectrum, this is due to the increase in structural changes in the composition of olive oil with increasing the numbers of times the heating, making the oil lose the properties are constantly with heating. The study of Fourier transformations FTIR in the Figure-4 showed an increase in the absorbance spectra in this region. This was caused by the breaking of double bonds into a single bond. In addition, the appearance of new absorption peaks with high absorbance spectrum is evidence of the formation of new structures.



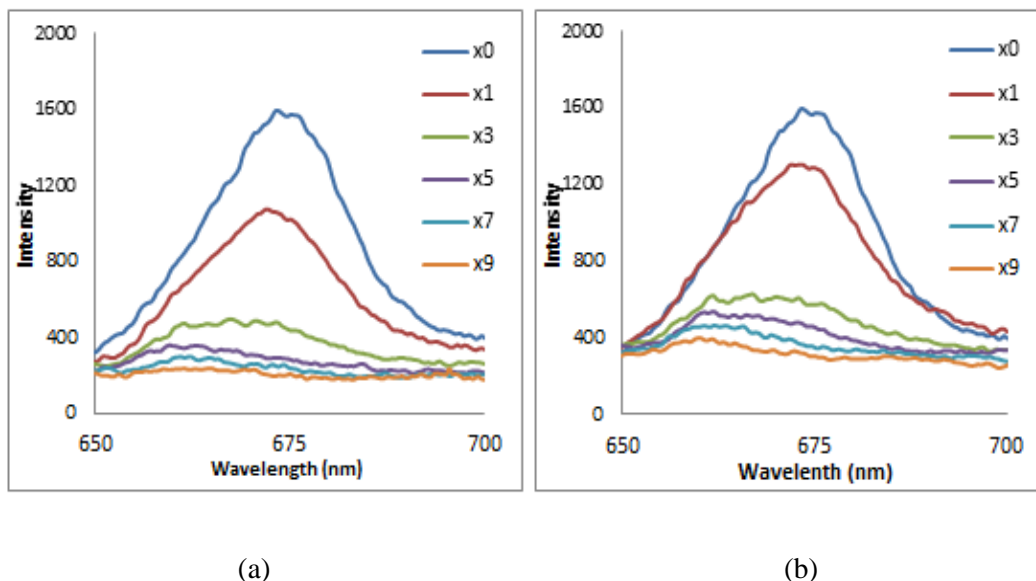
**Figure 4-** FTIR spectrum of olive oil **a:** in steel pan **b:** in aluminum pan.

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The fluorescence spectra Figure-5 showed high quenching with increasing the number of the heating time, demonstrating the existence of new components that lead to this quenching. It is needless to say that, the thermal conductivity of steel pan is less than that of aluminum one hence, the required heating temperature of oil in aluminum pan was taken less heating time than steel pan. When the heating time was upraised, an increase in the contents of fatty acids and polar compounds were observed too. so that, fluorescence spectrum of olive oil, which heated in, steel pan has recorded less intense than the sample which studied in aluminum pan.

The heating of olive oil is a structural change that results in the appearance of absorption peaks resulting from the fracture of the double bond structure to a single bond, which causes it to be shifted

towards the blue because that the single bond is sigma bond which is stronger than double bond then we see the blue shift. The breaking of the double bond and produced the new compounds act as an impurity which is quenching the fluorescence of the olive oil.



**Figure 5-** fluorescence spectrum of olive oil **a:** in steel pan **b:** in aluminum pan. Where X represent number of heating.

### Conclusions

Since the heating of olive oil changes its structural specifications, which makes it not good for human use after the first heating. Therefore, olive oil should not be used for more than one time in frying. The study showed that the type of frying pan is important.

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