Quality evaluation of sesame oil during pantry storage using laser technique

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Abstract: The objective of the present study was irradiation sesame oil for pantry storage using laser radiation then quality evaluation of sesame oil to prolong shelf life. Sesame seed sample was obtained from the Agricultural Research Center, Field Crops Research Institute (FCRI) - Department of Oil Crops Research. The sesame seed was extracted on cold press from Extraction Unit - National Research Institute to obtain sesame oil. Three samples of sesame oil were irradiated by laser rays with three exposure times 0.5, 1.0, 1.5 h and one sample without any treatment (control). The total samples of sesame oil after irradiated were analyzed the physical and chemical properties. The obtained results were showed as following: Acid, peroxide, and saponification values were increased by increasing storage time from three to nine months. While, for irradiation of exposure time from 0 to 1.5 h, that values were decreased at storage time. But, iodine and rancimate values were decreased by increasing storage time from three to six to nine months, for irradiation of exposure time from 0 to 1.5 h. While, it were found that iodine and rancimate values were decreased by increasing exposure time of laser from 0 to 1.5 h. Reflective index was lightly decreased by increasing storage time from three to six to nine months. Which, not effect of reflective index of oil sesame oil quality, at increasing irradiation doses of from control to 0.5 to 1.0 to 1.5 h. It was noticed that reflective index not changed by irradiated sesame oil during pantry of storage time.

Keywords: Quality, laser, exposure time, sesame oil, storage

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1 Introduction

Gould (1959) showed that lasers have many important applications. They are used in common consumer devices such as optical disk drives, laser printers, and barcode scanners. Lasers are used for both fiber-optic and free-space optical communication. They are used in medicine for laser surgery and various skin treatments, and in industry for cutting and welding materials. They are used in military and law enforcement devices for marking targets and measuring range and speed. Laser lighting displays use laser light as an entertainment medium.

Ndou and Warner (1991) observed that fluorescence spectroscopy is one example of an analytical technique suitable for multicomponent analysis due to it inherent sensitivity, selectivity, and versatility. In addition, the low limits of detection make molecular fluorescence the basis of many analytical methods. However, single-wavelength measurements can be limited for the analysis of complicated multi component sample, or even a simple mixture which contains severely overlapping emission and/or excitation spectra. This is because conventional fluorescence spectra reveal fluorescence of a sample within one spectral region, and do not provide nearly enough data to distinguish between two or more closely related molecules.

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Voisine et al. (1991) showed that the low radiation dose used could have produced its long-term effects in part by means of the stimulation of lipid degradation, possibly mediated through the action of free radicals that are known to be generated after irradiation.

Wilson and Goodfellow (1994) declared that infrared spectroscopy represents an attractive option for quality screening because it is rapid, Inexpensive and noninvasive. Mid-infrared (MIR) spectroscopy, in particular, rapidly provides information on a very largnumber of analytes, and the absorption bands are sensitive to the physical and chemical states of individual constituents. The high spectral signal-to-noise ratio obtained from modern instrumental analysis allows the detection of constituents present in very low concentrations, as well as subtle compositional differences between and among multi constituent specimens. Fourier transform infrared (FTIR) spectroscopy is one such technique.

White and Riethof (1999) used the fluorescence in food industry to investigate the quality of fish, oils, meat and other products . There are however, only a few works investigating honey quality .The sources traditionally are based on Xenon lamps and bulk monochromators which limits the methods to laboratory analysis. The proposed fluorescence method is perspective, time saving, faster and easier to implement, without using chemical treatments. It is low cost because, it uses LEDs in visible region and thus it is perspective for field analysis. The use of LEDs and first derivatives of fluorescence spectra is an improvement of the fluorescence methods used in food analysis to the moment.

Abou-Gharbia et al. (2000) showed that sesame seed (Sesamum indicum L.) is one of the world's most important and oldest oil seed crops known to man. It has been cultivated for centuries, particularly in Asia and Africa specially Sudan, Ethiopia and Nigeria (FAO, 2003). Nearly 70% of the world production is from Asia. Africa grows 26% of the world's sesame, with Sierra Leone, Sudan, Nigeria and Uganda being key producers. Latin America grows 4% of the total world production.

Andrikopoulos et al. (2001) reported that ultraviolet (UV) spectroscopy is widely used to detect the adulteration of extra virgin oil with refined olive oil. By this technique adulteration of virgin olive oil by refined oils can be detected down to 5%. Other analytical procedures including gas chromatography and liquid chromatography.

Miyahara et al. (2001) showed that sesame seed contains high amounts of (83%-90%) unsaturated fatty acids, mainly linoleic acid (37%-47%), oleic acid (35%-43%), palmitic (9%-11%) and stearic acid (5%-10%) with trace amount of linolenic acid. The high levels of unsaturated (UFA) and polyunsaturated fatty acids (PUFAs) of sesame oil enhance the quality of the oil for human consumption and plays an important role in preventing atherosclerosis, heart diseases and cancers .

Tunde-Akintunde and Akintunde (2004) mentioned that sesame seed (Sesamum indicum L.) is an oilseed with a chemical composition of about 50%-52% oil, 17%-19% protein and 16%-18% carbohydrate.

Mohammed and Hamza (2008) reported that modern laboratory methods normally employed in the analysis of oils usually includes Soxhlet extraction usually using n-hexane and the enzymatic extraction. Extraction of crude sesame oil by the use of a Soxhlet extractor with n –hexane solvent.

Akinoso et al. (2010) showed that Its seed contains about 42%-54% quality oil, 22%-25% protein, 20%-25% carbohydrates and 4%-6% ash. The hull contains large quantities of oxalic acid, crude fiber, calcium and other minerals. When the seed is properly dehulled, the oxalic acid content is reduced from about 3% to less than 0.25% of the seed weight.

Akinoso et al. (2010) mentioned that Black seed types have been reported to contain less oil than white and brown seeded strains. The chemical properties of oil are amongst the most important properties that determines the present condition of the oil. Free fatty acid and peroxide values are valuable measures of oil quality. The chemical properties of white and black sesame seed varieties from Hong, Adamawa State, Nigeria was determined. The un-saponifiable matter (% of oil), saponification value (mg $KOH.g^{-1}$), iodine value (g 100 g^{-1}) and free fatty acid (% oleic acid) was 0.76, 150.26, 98.20 and 0.78 while that of the black variety was 0.71, 158.04, 106.26 and 0.73 respectively.

Borchani et al. (2010) reviewed that the chemical composition of sesame shows that the seed is an important source of oil (44%-58%), protein (18%-25%), carbohydrate (~13.5%) and ash (~5%). Sesame seed is approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein).

Gulla and Waghray (2011) found that specific gravity, refractive index and colour units measured physical characteristics of the oils and their blends. A steady increase in specific gravity was observed in the control and the blends. It was observed that sesame-mustard blends were significantly different from control throughout the analytical period and sesame- rice bran (80:20) was only different in the first month of analysis though clearly an increasing trend in specific gravity on storage was seen. The rise in the specific gravity observed in the study may be attributed to the formation of polymeric fractions of high molecular weight. The refractive index of a substance varies with the wavelength of light used. No significant differences were observed during storage for refractive index of oil blends up to 12 months and it ranged from 1.465 to 1.63 units in the oil blends which were however seen to be significantly different from control, reported the changes in refractive index on storage which did not change significantly during the entire period of storage at lower temperatures, but increases were higher at high temperatures.

Objectives of the present work are the following:

- Analysis some of the physical and chemical properties of sesame oil during pantry storage periods.

- Determine the most appropriate exposure time of laser radiations to get the highest quality of the sesame oil during storage.

2 Material and methods

This work was carried out in the Laboratory of Laser Applications in Agricultural Engineering at the National Institute of Laser Enhanced Science (NILES), Cairo University, for quality evaluation of sesame oil during storage period by four treatments of laser technique.

2.1 Sesame Seed (SESAME INDICUM L.) Sample:

Sesame Seed sample was obtained from the Agricultural Research Center, Field Crops Research Institute (FCRI) - Department of Oil Crops Research. Sesame seed Shindwell 3 (The seedless crop is 720-840 kg. It has three capsules in the leaves and the seed color is white) was obtained from Field Crops Research Institute (FCRI) - Department of Oil Crops Research. Then sesame seed was extracted on cold press from Extraction Unit - National Research Institute to obtain sesame oil. Three samples of Sesame oil were exposure to laser (diode laser with wavelength 450 nm) with three times (0.5, 1.0 and 1.5 h) and one sample without any treatment (control). The total of four samples of sesame oil after irradiated by two treatments were analyzed the physical and chemical properties in (Agricultural Research Center – Food Technology Research Institute) during storage. Each period of storage is analyzed physical and chemical properties and comparison standard specification.

2.2 Physicochemical analysis

Samples were analyzed for acid value, peroxide value, iodine value, saponification value, color index, refractive index, fatty acid profile and oxidative stability (rancimat at 110^{o}C h^{-1}**)** according to the standardized methods proposed by The official methods of Analysis of Association of Official Analytical Chemists (AOAC, 2005). Samples were analyzed during the same time period to ensure uniform conditions and comparability.

2.3 Oxidative stability (Rancimat at 110^{o}C.h^{-1})

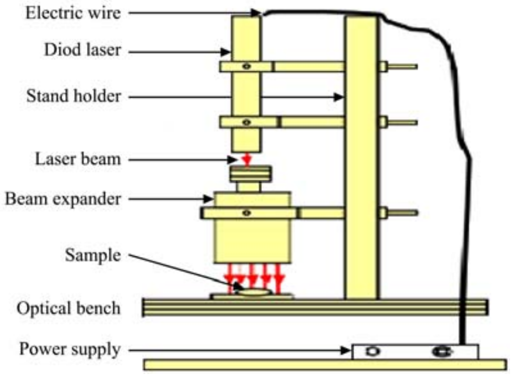
Oxidative stability of seed oils: Induction time was determined using the method ISO 6886 (2006). The oxidative stability was evaluated by the Rancimat method. Stability was expressed as the oxidative induction period (IP, hours) measured at 110^{o}C on a Rancimat 743 (Metrohm Co, Basel) apparatus using 3 g of oil sample with an air flow of 20 L h^{-1}. Volatile oxidation products were stripped from the oil and dissolved in cold water, whose conductivity increased progressively. The time taken to reach a level of conductivity was measured.

2.4 Exposure time treatment by laser

Theses samples of sesame oil were exposed to laser irradiation with wavelength 450 nm with power mW (dioed laser) at three times (0.5, 1.0, and 1.5 h).

Description of the apparatus, the opto- electronic apparatus was manufactured and developed to provide irradiation sesame oils samples with different doses. The opto – electronic apparatus were shown in Figure 1, consists of the following main parts:

Stand holder, it was designed and fabricated of iron as a shape square with length 45 mm and total length 900 mm, it contain seven holes to adjust the height and direction of laser and beam expender to insure a good aliment of laser beam on measurement area. The stand holder was fixed as a vertical on optical bench by two screw bolts.



(a) The designed apparatus.

(b) Photo of diode laser

Figure 1 Laser optical apparatus for irradiation sesame oil samples

Beam expander: the reverse Galilean telescope design provides a certain angular magnification, called the Expander Power. The beam diameter is first increased in size by its power. The expander was used in the optical unit in front of Helium-Neon laser. Each laser beam size 1 mm expanded in order to cover area 20×30 mm^2. The specifications of beam expander were as follow:

- Dimensions of the expander with length of 280 mm, maximum and minimum diameters of 110 and 50 mm.
- Source of manufacture: Egypt, made in hard Aluminum, electrostatic black paint.
- Beam expansion power: 50 x
- Lenses: 1^{st} Diverging lens: F = 20 mm; Dia.=15 mm; 2^{nd} Diverging lens: F = 2.2 mm; Dia.= 10 mm;

Collimating lens: F = 240 mm; Dia. = 100 mm (F is the focal lens)

Optical bench: The optical bench was fabricated from stainless steel. The dimensions of this bench were 880, 580 and 45 mm for length, width and height, respectively, with screw holes 6 mm diameter and the distance between them was 50 mm. Bench was manufactured in USA sitting on the second frame.

3 Results and discussions

3.1 Effect of exposure time of laser on physicochemical properties of sesame oil:

3.1.1 Acid values (AV)

Figures 2 and 3 show the effect of exposure time of laser and storage time on acid value of sesame oil at different exposure time of laser compared with control according to Egyptian specification. It was noticed that, acid values of sesame oil were (1.23, 1.16, 1.05, and 0.9 mg KOH g^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during three months. And acid values of sesame oil were (2.33, 1.49, 1.38, and 1.00 mg KOH g^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during six months. And acid values of sesame oil were decreased (3.56, 2.55, 2.55, and 2.29 mg KOH g^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during nine months. While, acid values were increased (1.23, 2.33, and 3.56 mg KOH g^{-1} oil); (1.16, 1.49, and 2.55 mg KOH g^{-1} oil); (1.05, 1.38, 2.55 mg KOH g^{-1} oil); and (0.9, 1.0, 2.29 mg KOH g^{-1} oil) at (0, 0.5, 1.0 and 1.5 h) exposure times of laser respectively, for three, six, and nine months of storage period. That result indicated that acid values gradually increased with storage periods and decreased with exposure time of laser. From above results, it showed that the acid values were in available standard limitation.

3.1.2 Peroxide values (PV)

The peroxide values are important for assessment of fats and oils, peroxide values reflect the oxidative rancidity in oils and fats. The data presented in Figures 4 and 5 showed that the effect of exposure time of laser on peroxide value and effect of storage time on peroxide value of sesame oil at different exposure time of laser compared with control according to Egyptian standard. It was noticed that, peroxide values of sesame oil were (8.81, 6.36, 5.82, and 1.63 meq.kg^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during three months. And peroxide values of sesame oil were (12.31, 9.43, 9.03, and 4.22 meq kg^{-1} oil) respectively during six months. And peroxide values of sesame oil were decreased (18.2, 15.94, 9.23, and 5.69 meq kg^{-1} oil), respectively during 9 months. While, peroxide values were increased (8.81, 12.31, and 18.20 meq kg^{-1} oil); (6.36, 9.43, and 15.94 meq kg^{-1} oil); (5.82, 9.03, 9.23 meq kg^{-1} oil); and (1.63, 4.22, 5.69 meq kg^{-1} oil) at (0.0, 0.5, 1.0 and 1.5 h) exposure times of laser respectively, for three, six, and nine months of storage period. The results data indicated that peroxide values of sesame oil increasing with storage period and decreased with exposure time of laser.

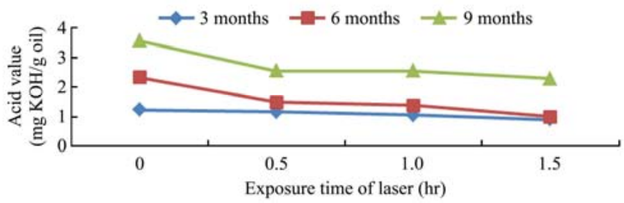


Figure 2 Effect of exposure time of laser on acid value of sesame oil during storage

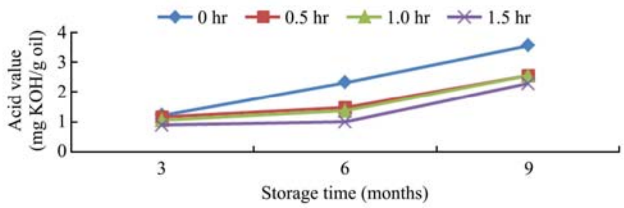


Figure 3 Effects of storage time on acid value of sesame oil at exposure time of laser

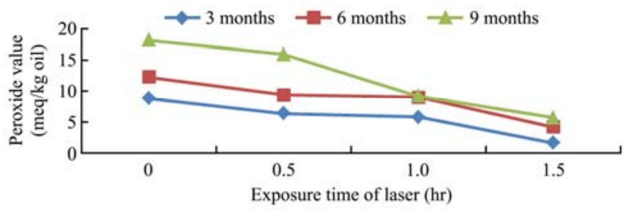


Figure 4 Effects of exposure time of laser on peroxide value of sesame oil during storage

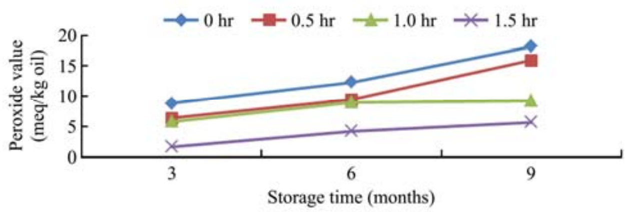


Figure 5 Effects of storage time on peroxide value of sesame oil at exposure time of laser

3.1.3 Iodine values (IV)

Iodine values are an important which could be used as an indicator for the stability and the shelf life of oils. Data presented in Figures 6 and 7 showed that the iodine values decreased by (122.2, 118.35, 117.44, and 117.04 mg $I_2.g^{-1}$ oil) for three months of storage period at different exposure time of laser (0, 0.5, 1.0, and 1.5 h). So, the data showed that changes in the iodine value of the sesame oil during storage is presented in Figures 6 and 7. Also, iodine values were decreased by (119.3, 117.34, 116.99, and 116.4 mg $I_2.g^{-1}$ oil) for six months of storage period at different exposure time of laser (0, 0.5, 1.0, and 1.5 h). Also, the iodine values were decreased by (116, 115.5, 115.25, and 115 mg $I_2.g^{-1}$ oil) for nine months at different exposure time of laser (0, 0.5, 1.0, and 1.5 h). The results of data indicated that iodine values decreased with storage period. Also, iodine values were decreased (122.2, 119.3, and 116.0 mg $I_2.g^{-1}$ oil); (118.33, 117.34, and 115.5 mg $I_2.g^{-1}$ oil); (117.44, 116.99, 115.55 mg $I_2.g^{-1}$ oil); and (117.04, 116.4, 115.0 mg $I_2.g^{-1}$ oil) at (0.0, 0.5, 1.0 and 1.5 h) exposure times of laser respectively, for three, six, and nine months of storage period.

3.1.4 Saponification values (SV)

Figures 8 and 9 showed that the effect of exposure time of laser on saponification value of sesame oil at different pantry storage. From obtained results, it was noticed that saponification values were increased from (119.3, 193.4, 193.8, and 194 mg KOH.g^{-1} oil) for three months at different exposure time of laser (0, 0.5, 1.0, and 1.5 hours) and in available with Standard limitation. Also, saponification values were increased from (193, 194.7, 195 and 195.8 mg KOH.g^{-1} oil), respectively at (0, 0.5, 1.0, and 1.5 h) during six months and in available with standard limitation. Meanwhile, saponification values were decreased from (200.42, 195.8, 196.5, and 197.5 mg KOH.g^{-1} oil), respectively at (0, 0.5, 1.0, and 1.5 h) during nine months and in unavailable with standard limitation. So, the results indicate to the saponification values were decreased with increasing exposure time from 0 to 1.5 h. While, it was increased by increasing storage period from three to nine months, because of its value were increased (119.3, 193 and 200.42 mg KOH.g^{-1} oil); (193.4, 194.7, and 195.8 mg KOH.g^{-1} oil); (193.8, 195 and 196.5 mg KOH.g^{-1} oil); (194, 195.8 and 197.5

mg KOH.g^{-1} oil) at 0, 0.5, 1.0 and 1.5 h at exposure time from 0 to 1.5 h respectively, for three, six and nine months of storage period.

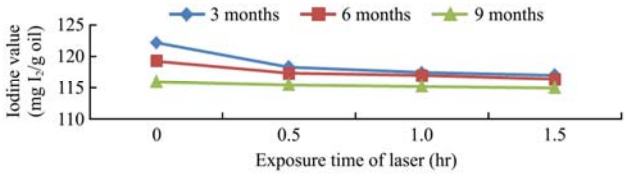


Figure 6 Effects of laser exposure time on iodine value of sesame oil during storage

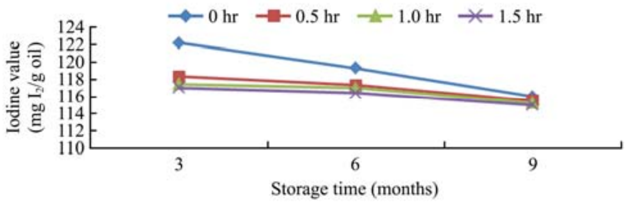


Figure 7 Effect of storage time on iodine value of sesame oil at exposure time of laser

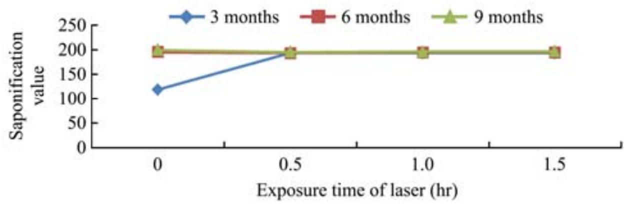


Figure 8 Effects of laser exposure time on saponification value of sesame oil during storage

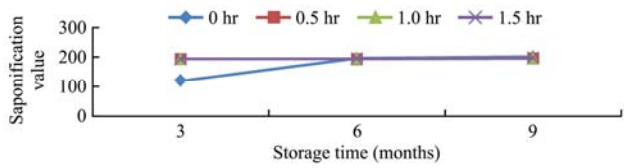


Figure 9 Effects of storage time on saponification value of sesame oil at laser exposure time

3.1.5 Effects laser radiation on Rancimate value

Table 1 and Figures 10 and 11 show that effect of exposure time of laser radiation on Rancimate value during pantry storage period. It was found that Rancimate value was decreased by increasing storage time from three to six to nine months. Which, was decreasing as follows (7.96-6.62 h), (7.33-6.82 h), (7.4-4.57 h), (6.21-3.5 h), for irradiation doses of 0, 0.5, 1.0, and 1.5 h, respectively. It was noticed that Rancimate value was decreased of 21.86%, 12.41%, 41.08% and 51.94% for sesame oil samples of 0, 0.5, 1.0, and 1.5 h, exposure times of laser, respectively. So, the laser irradiation might affect the quality of oils by increasing the oxidation rate.

3.1.6 Effects laser radiation on reflective index of sesame oil during pantry storage

Table 2 shows that effect of gamma radiation on reflective index (RI) during pantry storage period at different storage time. It was found that reflective index was light decreased by increasing storage time from three to six to nine months. Which, not affect of reflective index of oil sesame oil quality, at increasing irradiation doses for 0, 0.5, 1.0, and 1.5 h. It was noticed that reflective index not changed by irradiated sesame oil during pantry of storage time.

Table 1 Effects of laser exposure time on oxidative stability of sesame oil at pantry storage

Storage period, months	Exposure time of laser (h)			
	0.0	0.5	1.0	1.5
	Oxidative stability by Rancimate test at 100 (h)			
3	7.96	7.53	7.4	6.21
6	7.88	7.45	6.22	5.97
9	6.62	6.82	4.57	3.5

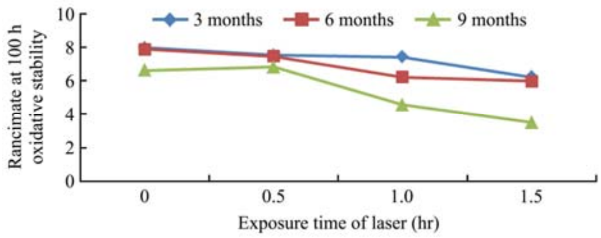


Figure 10 Effects of exposure time of laser on Rancimate at 100 h oxidative stability of sesame oil at different pantry storage

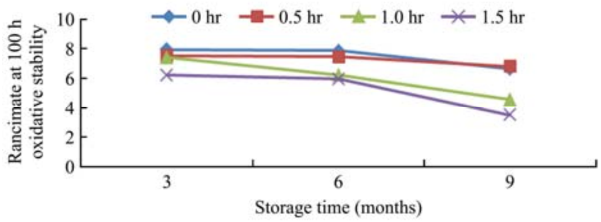


Figure 11 Effects of storage time on Rancimate at 100 h oxidative stability of sesame oil at different exposure time of laser

Table 2 Effects laser radiation on reflective index of sesame oil during pantry storage

Storage time , months	Exposure time of laser (h)			
	0.0	0.5	1.0	1.5
	Reflective index (RI)			
3	1.4717	1.4717	1.4717	1.4718
6	1.4704	1.4704	1.4704	1.4704
9	1.4702	1.4702	1.4702	1.4702

4 Conclusions

The previous results were summarized as following:

Acid values of sesame oil (1.23, 1.16, 1.05, and 0.9 mg KOH g^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during three months. And acid values of sesame oil (2.33, 1.49, 1.38, and 1.0 mg KOH g^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during six months. And acid values of sesame oil (3.56, 2.55, 2.55, and 2.29 mg KOH g^{-1} oil) were decreased at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during nine months

Peroxide values of sesame oil were (8.81, 6.36, 5.82, and 1.63 meq Kg^{-1} oil) at exposure time of laser (0, 0.5, 1.0, and 1.5 h) respectively during six months. And peroxide values of sesame oil were (12.31, 9.43, 9.03, and 4.22 meq Kg^{-1} oil) respectively during six months. And Peroxide values of sesame oil were decreased (18.2, 15.94, 9.23, and 5.69 meq Kg^{-1} oil), respectively during nine months.

Iodine values were decreased by (116, 115.5, 115.25, and 115 mg $I_2.g^{-1}$ oil) for nine months at different exposure time of laser (0, 0.5, 1.0, and 1.5 h). The results of data indicated that iodine values decreased with storage period. Also, iodine values were decreased (122.2, 119.3, and 116.0 mg $I_2.g^{-1}$ oil); (118.33, 117.34, and 115.5 mg $I_2.g^{-1}$ oil); (117.44, 116.99, 115.55 mg $I_2.g^{-1}$ oil); and (117.04, 116.4, 115.0 mg $I_2.g^{-1}$ oil) at (0, 0.5, 1.0 and 1.5 h) exposure times of laser respectively, for three, six, and nine months of storage period

Saponification values were increased from (119.3, 193.4, 193.8, and 194 mg $KOH.g^{-1}$ oil) for three months at different exposure time of laser (0, 0.5, 1.0, and 1.5 h) and in available with standard limitation. Also, saponification values were increased from (193, 194.7, 195 and 195.8 mg $KOH.g^{-1}$ oil), respectively at (0, 0.5, 1.0, and 1.5 h) during six months and in available with standard limitation.

Rancimate value was decreased by increasing storage time from 3 to 6 to 9 months. Which, was decreasing as follows (7.96-6.62 h), (7.33-6.82 h), (7.4-4.57 h), (6.21-3.5 h), for irradiation doses of 0, 0.5, 1.0, and 1.5 h, respectively. It was noticed that Rancimate value was decreased of 21.86%, 12.41%, 41.08% and 51.94% for sesame oil samples of 0, 0.5, 1.0, and 1.5 h, exposure times of laser, respectively.

Reflective index was light decreased by increasing storage time from three to six to nine months. Which, not effect of reflective index of oil sesame oil quality, at increasing irradiation doses for 0, 0.5, 1.0, and 1.5 h. It was noticed that reflective index not changed by irradiated sesame oil during pantry of storage time.

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