

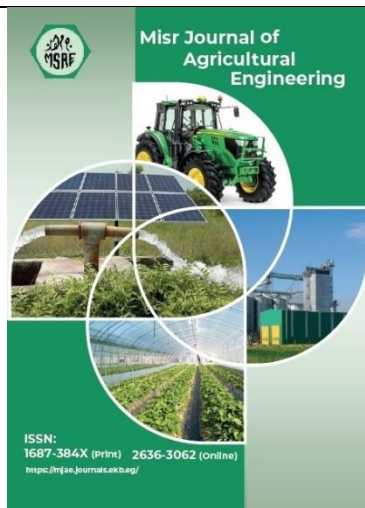
## PREDICTION OF CORN OIL QUALITY DURING STORAGE USING LASER TECHNIQUE

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### Keywords:

Laser; Corn oil; Quality;  
Chemical properties; Storage

### ABSTRACT

*This research was conducted to study the effect of laser exposure times on corn oil quality during storage periods. The Objectives of the present work are studying the effect of Laser radiations exposure time (5, 10, and 15 minutes) on physical and chemical properties of corn oil during storage period. Also, studying the effect of Laser Irradiation on shelf life of corn oil. Each period of storage is analyzed physical and chemical properties and comparison standard specification. Physical and chemical properties of samples were peroxide value, acid value, iodine value, saponification value and Refractive Index. The main results in this study can be summarized as follows:*

*(1) The exposure corn oil by laser, the quality of corn oil was improved, peroxide increased from (3.83 to 13.77 meq/kg oil) and acid values were decreased (0.17 to 0.12 mg KOH/g) oil at 0, 5, 10, 15 minutes for 0, 3, 6 months but still inside standard specific which was <15 meq/kg oil for peroxide value and was <4 mg KOH/g oil for acid value.*

*(2) By increasing laser exposure times, led to increasing saponification value from (186.82 to 193.99 mg KOH/ g oil), while Iodine value was decreased from (171.14 to 109.05 mg I<sub>2</sub>.g<sup>-1</sup>) at 0, 5, 10, 15 minutes for 0, 3, 6 months. the saponification and iodine values were inside standard specific was < 186-195 mg KOH/ g oil for saponification value and was < 104-120 I<sub>2</sub>.g<sup>-1</sup>) for iodine value. Also, it was found treated oil samples after six months were improved its quality.*

### INTRODUCTION

Corn oil has a great smoke point, It is appreciate for high-temperature cooking without compromising its neutral taste. Because decreasing the oxidation stability compared to other commercial oils. Enhance of the stability and reduce potential oxidative concerns due to oleic-rich varieties or antioxidants. (Fatma Boukid and Kurt A. Rosentrater 2024). Corn oil has a valuable physiochemical properties and high components some flavonoids (hesperidin and rutin), phenolics like (gallic, syringic, Rosmarinus, and trans-ferulic), sterols and tocopherols. linoleic (53%–54%) and oleic (30%–31%) are the two important fatty acids found in corn oil are. Moreover, Corn oil is used for cooking, reduce cholesterol, decrease inflammation, improve eye health, prevent chronic illnesses, lessen allergies. (Zarina et al.,2020)

The free fatty acid content in unrefined oils varies depending on their origin. These substances are chemically defined as tri-esters formed from glycerol and fatty acids. Although termed "oils" when liquid at ambient temperature, an exception is palm oil, which remains semi-solid **(Salaheldeen, 2019)**.

In Egypt, the edible oil sector is a crucial strategic industry. Annual consumption reaches approximately 2.5 million tons, yet domestic extraction from oilseeds supplies only about 48,500 tons. Consequently, local production satisfies merely 2% of demand, creating a 98% reliance on imports **(El-Hamidi et al., 2020; El-Hamidi and Zaher, 2018)**.

The three countries that produce the most corn worldwide The US, China and the EU have the highest producing of corn oil for. In 2018, 40% of the world's total production of corn oil .the largest producer of corn and corn oil is the, followed by China (26%) and the EU (9%). **(Market Intelligence Team 2020)**.

Globally, annual production of oils and fats is near 117 million tons, sourced from both plants and animals. Roughly 80% of this output is destined for food, 6% for animal feed, and 14% for oleochemical manufacturing **(Gunstone and Hamilton, 2001)**. Beyond nutrition, these lipids are utilized in perfumes, cosmetics, pharmaceuticals, insecticides, paints, and varnishes. Sesame production is led by China and India, followed by nations like Myanmar and Sudan **(Chemonics International Inc, 2002)**.

Vegetable oils derive from various sources, like cottonseed and corn oil, are byproducts of crops grown primarily for fiber or grain. Others, such as palm and olive oils, come from tree crops. Oilseeds typically yield both oil and protein-rich meal. Extraction efficiency varies; average oil yields range from 18.3% for soybeans to over 60% for coconut **(Gunstone, 2002)**.

Modern laboratory methods often employ Soxhlet extraction with solvents like n-hexane **(Mohammed and Hamza, 2008)**. Oil stability against oxidation is influenced by fatty acid unsaturation, antioxidant levels, and storage conditions. Higher unsaturation increases susceptibility. Common tests to monitor degradation include peroxide value (primary products) and measures of secondary products **(Frankel, 2005)**. The iodine value indicates the degree of unsaturation; for example, in blended oils, this value typically declines during storage **(Gulla and Waghay, 2011)**.

Nutritionally, oils provide dense calories and enhance food texture and flavor. They supply essential fatty acids and carry fat-soluble vitamins **(Bhawan and Road, 2015)**. Processing can alter their composition; gamma irradiation of seeds, for example, changed the unsaturated-to-saturated fatty acid ratios, particularly in sesame **(Afify et al., 2013)**, potentially through radical-induced oxidation **(Zoumpoulakis et al., 2012)**. Typical sesame seeds contain about 54% oil, with linoleic and oleic acids as the primary fatty acids **(Ali et al., 2014)**.

Physical and chemical properties can be affected by treatments like ultrasound, which may increase peroxide formation **(Sepideh et al., 2015)**, or by storage, which can raise specific gravity due to polymer formation **(Gulla and Waghay, 2011)**.

Studies on irradiated sesame oil show that acid and peroxide values generally rise with storage time but can be influenced by the irradiation dose applied **(Helmy et al., 2019)**.

This study aimed to investigate the effect of low-level laser irradiation (using a 650 nm diode laser) on the stability of corn oil during its long-term storage shelf life. Specifically, the study sought to evaluate different exposure times of laser on oil (and their corresponding energy densities) affected key physical and chemical quality parameters—including peroxide value, acidity value, iodine value, saponification value, and refractive index—over a 12-month period under typical storage conditions.

### **MATERIALS AND METHODS**

#### **Corn Oil Samples:**

Commercial corn oil was obtained from a retail market in Giza Governorate, Egypt. Samples of 100 ml each were stored at ambient temperature (approximately 25°C) under normal daylight exposure, simulating typical retail storage conditions. These samples were held in the Laser Applications in Agricultural Engineering Laboratory at the National Institute of Laser Enhanced Science (NILES), Cairo University, to investigate the influence of laser irradiation on product shelf life. Over a 12-month study period, (2024) physicochemical analyses were conducted at four-month intervals. For each testing point, four samples were assessed for peroxide value, acid value, iodine value, saponification value, and refractive index following the standard analytical procedures established by **the American Oil Chemists' Society (AOCS)**.

#### **Laser Irradiation Protocol**

Three corn oil samples were subjected to irradiation using a Diode laser (650 nm wavelength, 200 mW average optical output power), Model of 05- LHP manufactured in USA. Exposure durations were set at 5, 10, and 15 minutes then, storage time of 0, 3 and 6 months, corresponding to treatment labels RL5, RL10, and RL15, respectively. An unirradiated sample served as the control (Fig. 1). To ensure uniform exposure, the laser beam was expanded to cover a spot diameter of 5 cm (area  $\approx 19.63 \text{ cm}^2$ ). The total delivered energy was calculated as 60 J, 120 J, and 180 J for the three exposure times, resulting in energy fluences of  $3.06 \text{ J/cm}^2$ ,  $6.12 \text{ J/cm}^2$ , and  $9.18 \text{ J/cm}^2$ , respectively. Following irradiation, all four samples (including the control) were analyzed for key physicochemical parameters in the Faculty of Agriculture, Cairo University, Analytical Chemistry Laboratories and the main laboratory of the Agricultural Engineering Research Institute. These properties were monitored throughout storage and evaluated against standard specifications.



**Fig (1)** Photo of samples with laser irradiation (diode laser)

**Physical and Chemical Analysis:****Refractive Index:**

The Refractive Index (RI) was determined by an Abbe 60 Refractometer according to the method described in (AOAC. 2003) at 30°C.

**Peroxide Value:**

The peroxide value, which quantifies peroxide concentration in the oil, was determined via iodometric titration. A measured oil sample was dissolved in an acetic acid–chloroform mixture, followed by the addition of saturated potassium iodide (KI). Peroxides present liberate iodine from KI, and the resulting iodine is titrated with standardized sodium thiosulfate using starch indicator. A blank titration was performed concurrently. PV (in milliequivalents per kilogram) was calculated using the formula:

$$PV = \frac{(S - B) \times N \times 1000}{W}$$

Where *S* and *B* are the thiosulfate volumes (mL) for the sample and blank, respectively, *N* is the normality of thiosulfate, and *W* is the sample weight (g) (AOAC. 1984).

**Acid Value (AV)**

The AV of the oil samples was determined according to the (AOAC. 2005).

Acid value = ml of alkali x N of alkali x 56.1/W of oil sample (gm.)

**Iodine Value (IV):**

The iodine value indicates the degree of unsaturation. A known mass of oil was treated with excess iodine bromine (I Br) in glacial acetic acid. After reaction, unreacted I Br was converted to iodine by adding KI, and the liberated iodine was titrated with standard sodium thiosulfate. IV (grams of iodine absorbed per 100 g of oil) was computed as:

$$IV = \frac{(b - v)Nx126.9x100}{wx1000}$$

Where *b* and \* *v* \* are the thiosulfate volumes (mL) for blank and sample, *N* is thiosulfate normality, \**w* \* is the sample weight (g), and 126.9 is the atomic weight of iodine (Singh et al., 1981).

**Saponification Value (SV):**

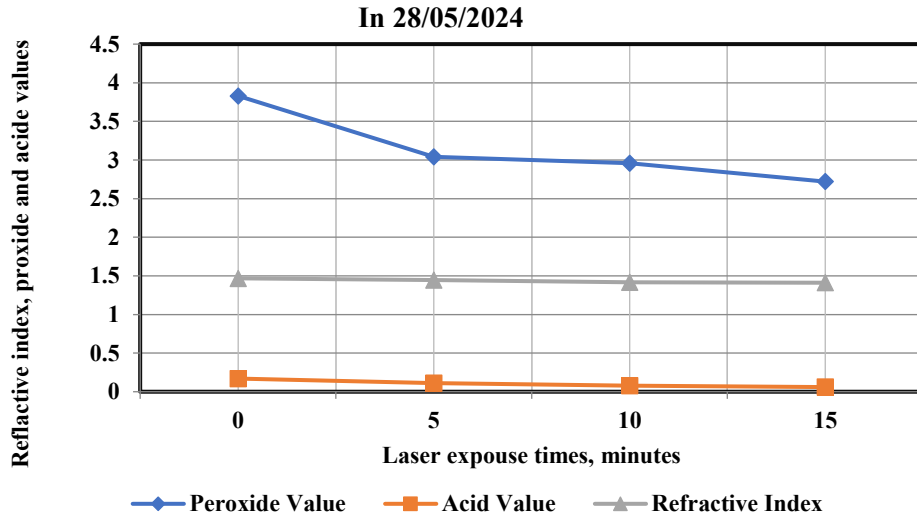
Potassium hydroxide (mg) needed to balance the fatty acids produced by the full hydrolysis of one gram of the material is the saponification value. While (0.5 mol/l) was the amount of hydrochloric acid, VS used in the blank titration is precisely 35.5 mL and 40 g/l, a 50-mL were the concentration of ethanol potassium hydroxide burette had to be used for titration by using methods of AOAC (2005).

## RESULTS AND DISCUSSIONS

**- Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil in beginning storage period (Zero Time):**

**Figure (2)** shows the effect of the exposure time of corn oil to laser beams at the beginning of the experiment (at the beginning of storage) on the refractive index, acid number, and peroxide number of the oil. It was found that by increasing the exposure time of the corn oil from 0 to 5

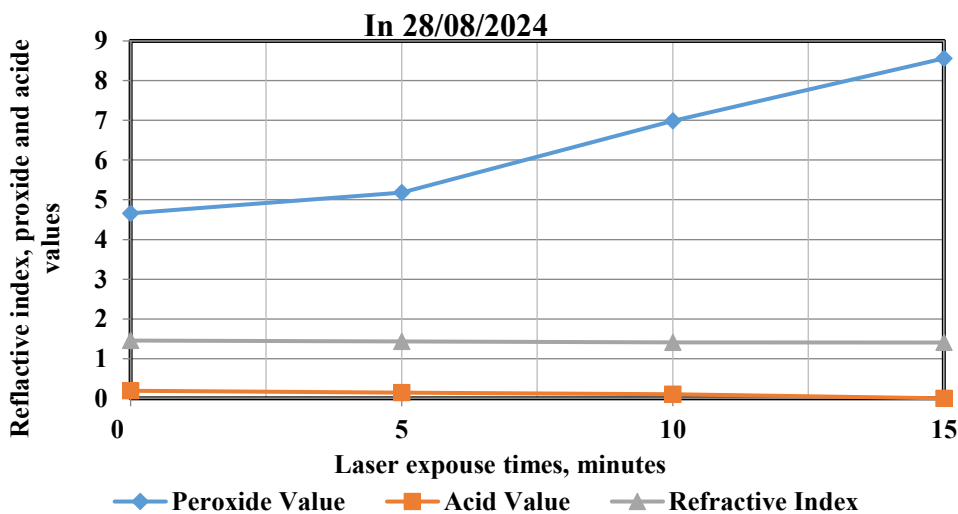
to 10 and 15 minutes, the refractive index decreased slightly to 1.468, 1.444, 1.415, and 1.411, respectively. The acid value also decreased to 0.17, 0.11, 0.08, and 0.06 mg KOH/g oil and the peroxide value decreased to 3.83, 3.04, 2.96, and 2.72 meq.kg<sup>-1</sup> oil) respectively, for 0, 5, 10, and 15 minutes of exposure times.



**Fig.(2):** Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil in beginning storage period

**- Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil after three months of storage period:**

**Figure (3)** shows the effect of the exposure time of corn oil to laser beams after three months of storage period on the refractive index, acid number, and peroxide number of the oil. It was found that by increasing the exposure time of the corn oil from 0 to 5 to 10 and 15 minutes, the refractive index decreased slightly to 1.455, 1.433, 1.411, and 1.405 respectively. The acid value also decreased slightly to 0.19, 0.14, 0.10, and 0.09 mg KOH/g oil and the peroxide value increased to 4.66, 5.18, 6.99, and 8.56 meq/kg oil respectively, for 0, 5, 10, and 15 minutes of laser exposure times.

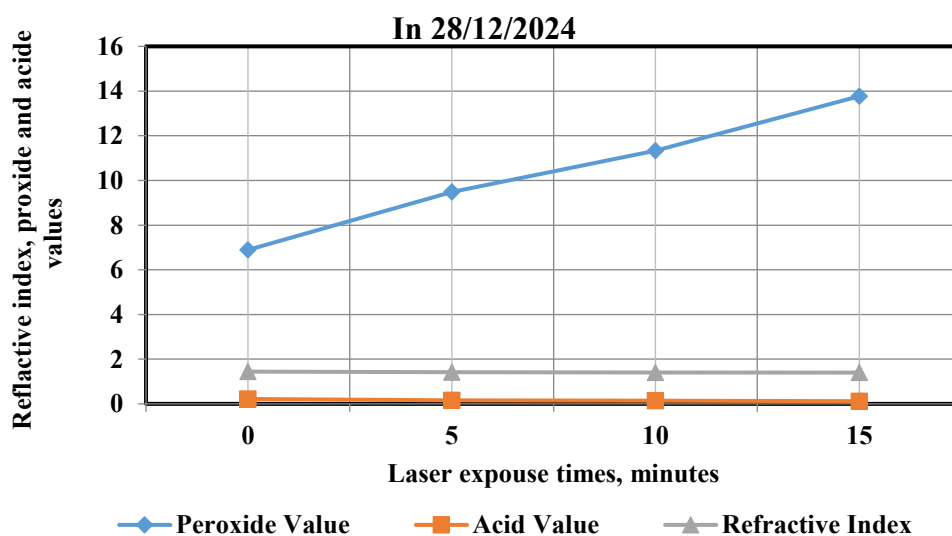


**Fig. (3):** Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil after three months of storage period.

Total acidity content of both irradiated and non-irradiated samples, increased during the storage, and the storage time had more pronounced effect on total acidity than irradiation. These results are in agreement with the literature that the total acidity of pistachio and almond kernels was increased with increasing storage periods. After 12 months of storage, the total acidity of irradiated sesame seeds was higher ( $p < 0.05$ ) than that of non-irradiated control ones. The pH value of un-irradiated control sample of sesame seed was 6.33. Immediately after irradiation the pH values of sesame seeds samples decreased significantly ( $p < 0.05$ ) upon irradiation from 6.33 for un-irradiated control samples to 6.28, 6.25 and 6.23 for samples irradiated with 3, 6 and 9 kGy, respectively. **AL-Bachir (2015 a,b)**.

**- Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil after six months of storage period:**

Figure (4) shows the effect of the exposure time of corn oil to laser beams after six months of storage period on the refractive index, acid number, and peroxide number of the oil. It was found that by increasing the exposure time of the corn oil from 0 to 5 to 10 and 15 minutes, the refractive index decreased slightly to 1.444, 1.422, 1.405, and 1.401 respectively. The acid value also decreased slightly to 0.22, 0.16, 0.14, and 0.12 mg KOH/g oil and the peroxide value increased to 6.89, 9.48, 11.33, and 13.77 meq/kg oil respectively, for 0, 5, 10, and 15 minutes of laser exposure times.



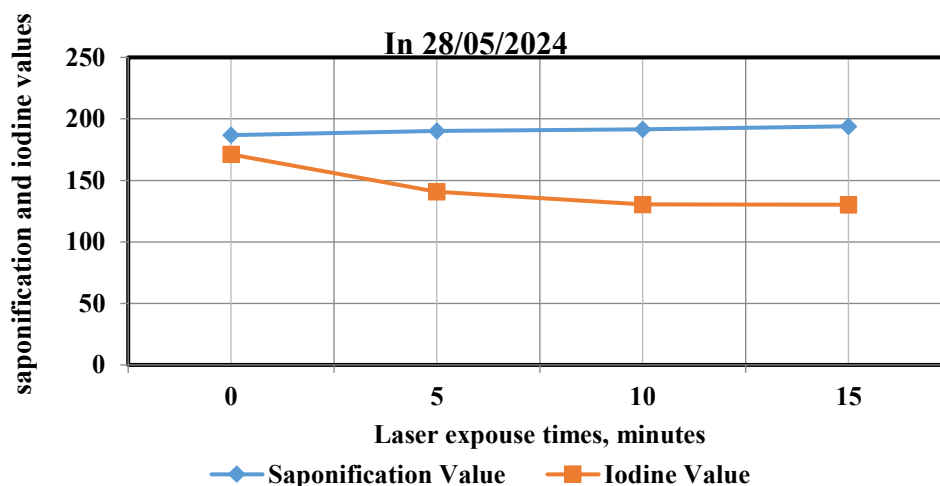
**Fig. (4):** Effect of laser exposure time on Reflective index, peroxide and acid values of corn oil after six months of storage period.

Storage changes in vegetable oil blends were measured by the peroxide formation, the final products of oxidation. The changes in the peroxide values of selected oil blends during storage. PV of oil blends and control stored for 12 months registered a progressive increase with the storage period. Steady increase in the blends according to the extent of oxidation caused by the formation of hydro peroxides during fat oxidation was observed. It was observed that the increase in PV of control was from (1.83 to 14.79) meq/kg during the 12 months of storage, the initial PV was seen to be higher in the blends in comparison to the control between 0 month to 12 months of storage, these results were declared by **Gulla and Waghay (2011)**.

From pervious results, it was noticed that the exposure corn oil by laser, the quality of corn oil was improved, where peroxide and acid values were decreased but still inside standard specific which was <15 meq/kg oil for peroxide value and was <4 mgKOH/g oil for acid value.

**- Effect of laser exposure time on Saponification and Iodine values of corn oil in beginning storage period ( Zero Time):**

Figure (5) shows the effect of the exposure time of corn oil to laser beams at the beginning of the experiment (at the beginning of storage) on the saponification and iodine values of the corn oil. It was found that by increasing the exposure time of the corn oil for laser radiation from 0 to 5 to 10 and 15 minutes, the saponification increased from 186.82, to 190.24, to 191.44, and to 193.99 mg KOH/ g oil respectively. While, the iodine value was decreased from 171.14 to 140.66, to 130.51, and to 130.25 mg I<sub>2</sub>/g oil respectively, for 0, 5, 10, and 15 minutes of laser exposure times.



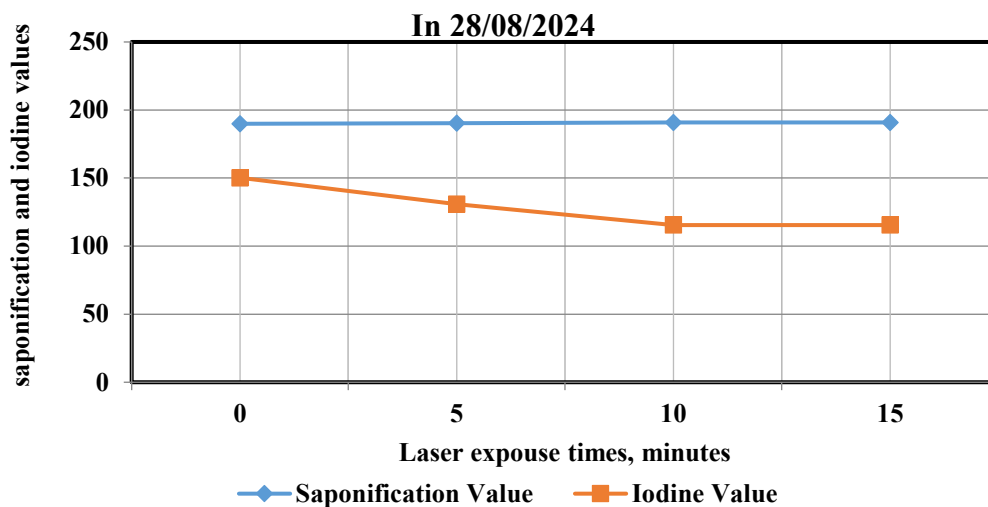
**Fig. (5):** Effect of laser exposure time on saponification and iodine values of oil corn in beginning storage period.

A gradual decrease in iodine values was noticed in irradiated seeds and reached its maximum decrease at the highest dose of 7.5 kGy 103.03 g.100g<sup>-1</sup> as compared with the control. Although the irradiation dose used in our investigation is permitted to control insects and shelf life of oil seed with doses ranging from 1 to 5 kGy in several countries including Egypt, according to **Yalcin et al. (2011)**. It is used to study both saturation and unsaturation degree of the selected oils samples before storage and after storage at average room temperature 25<sup>0</sup>C for monitoring the oxidation process in oils under the study. In addition, this method protects us from danger of chemicals that may take place in case of monitoring the oxidation of oils by traditional methods.

**- Effect of laser exposure time on Saponification and Iodine values of corn oil after three months of storage period:**

Figure (6) shows the effect of the exposure time of corn oil to laser beams after three months of storage period on the saponification and iodine values of the corn oil. It was found that by increasing the exposure time of the corn oil for laser radiation from 0 to 5 to 10 and 15 minutes,

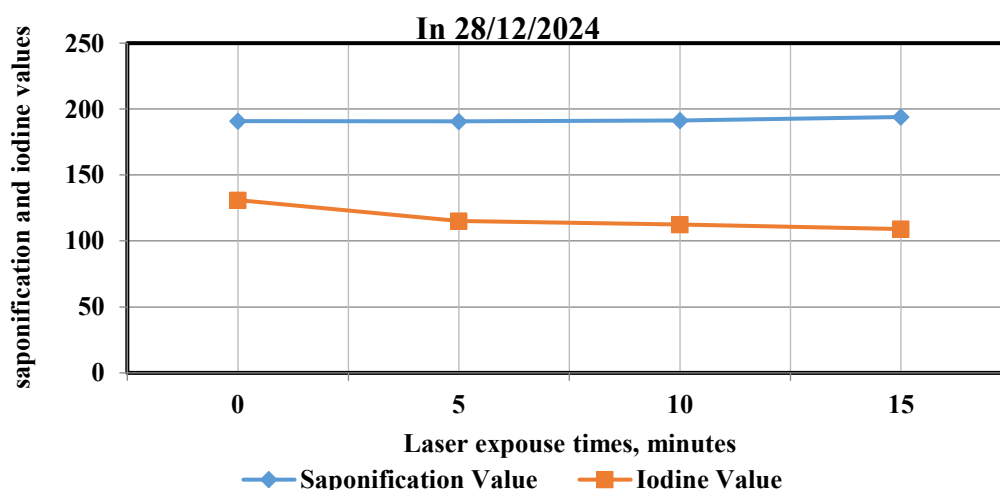
the saponification increased from 189.89, to 190.44, to 190.88, and to 190.88 mg KOH/ g oil respectively. While, the iodine value was decreased from 150.22 to 130.78, to 115.47, and to 115.47 mg I<sub>2</sub>.g<sup>-1</sup> oil respectively, for 0, 5, 10, and 15 minutes of laser exposure times.



**Fig. (6):** Effect of laser exposure time on saponification and iodine value of oil corn after three months of storage period.

**- Effect of laser exposure time on Saponification and Iodine values of corn oil after six months of storage period:**

Figure (7) shows the effect of the exposure time of corn oil to laser beams after six months of storage period on the saponification and iodine values of the corn oil. It was found that by increasing the exposure time of the corn oil for laser radiation from 0 to 5 to 10 and 15 minutes, the saponification increased from 190.88, to 190.75, to 191.44, and to 193.99 mg KOH/ g oil respectively. While, the iodine value was decreased from 131.03 to 115.08, to 112.56, and to 109.05 mg I<sub>2</sub>.g<sup>-1</sup> oil respectively, for 0, 5, 10, and 15 minutes of laser exposure times



**Fig. (7):** Effect of laser exposure time on saponification and iodine values of oil corn after six months of storage period.

From pervious results, it was noticed that by increasing laser exposure times, led to increasing saponification value, while iodine value was decreased. However, the saponification and iodine

values were inside standard specific. Also, it was found treated oil samples after six months were improved its quality, where chemical properties were inside standard specifications. This suggested that the hydro peroxides were found in the selected oils during storage at ambient temperature as a result of oxidation process.

### **CONCLUSIONS**

Summarized results were concluded as follows:

- The exposure corn oil by laser, the quality of corn oil was improved, where peroxide values were increased from (3.83 to 13.77 meq/kg oil) at 0,5,10,15minutes for 0,3,6 months and acid values were decreased (0.17 to 0.12 mgKOH/g) oil at 0,5,10,15minutes for 0,3,6 months but still inside standard specific which was <15 meq/kg oil for peroxide value and was <4 mgKOH/g oil for acid value.
- By increasing laser exposure times, led to increasing saponification value were increased (186.82 to 193.99 mg KOH/ g oil) at 0,5,10,15minutes for 0,3,6 months, while iodine value was decreased from (171.14 to 109.05 mg I<sub>2</sub>.g<sup>-1</sup>) at 0,5,10,15minutes for 0,3,6 months. However, the saponification and iodine values were inside standard specific was < 186-195 mg KOH/ g oil for saponification value and was < 104-120 I<sub>2</sub>.g<sup>-1</sup>) for iodine value. Also, it was found treated oil samples after six months were improved its quality, where chemical properties were inside standard specifications.

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## التنبؤ بجودة زيت الذرة أثناء التخزين باستخدام تقنية الليزر

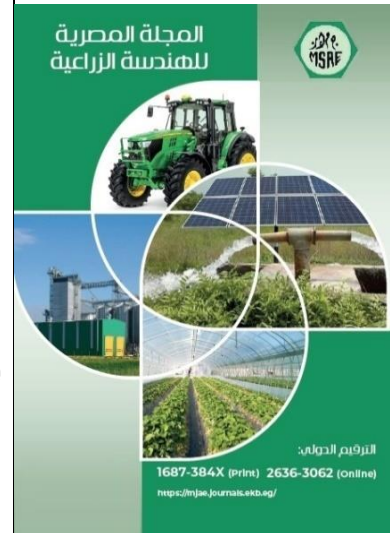
د. شيماء ربيع على<sup>١</sup> و د. عصام محمد عبد السلام<sup>٢</sup><sup>١</sup> مدرس بقسم تطبيقات الليزر فى القياسات والكيمياء الضوئية والزراعة - المعهد القومى لعلوم الليزر- جامعة القاهرة - مصر.<sup>٢</sup> استاذ مساعد بقسم تطبيقات الليزر فى القياسات والكيمياء الضوئية والزراعة - المعهد القومى لعلوم الليزر- جامعه القاهرة - مصر.

## الملخص العربى

أُجري هذا البحث لدراسة تأثير مدة التعرض لأشعة الليزر على جودة زيت الذرة خلال فترات التخزين. تهدف هذه الدراسة إلى بحث تأثير مدة التعرض لأشعة الليزر (٥، ١٠، ١٥ دقيقة) على الخصائص الفيزيائية والكيميائية لزيت الذرة خلال فترة التخزين، بالإضافة إلى دراسة تأثير تشعيع الليزر على مدة صلاحية زيت الذرة. تم تحليل الخصائص الفيزيائية والكيميائية لكل فترة تخزين ومقارنتها بالموصفات القياسية. شملت الخصائص الفيزيائية والكيميائية للعينات: قيمة البيروكسيد، وقيمة الحموضة، وقيمة اليود، وقيمة التصبن، ومعامل الانكسار. يمكن تلخيص النتائج الرئيسية لهذه الدراسة كما يلي:

(١) أدى تعريض زيت الذرة لأشعة الليزر إلى تحسين جودته، حيث ارتفعت نسبة البيروكسيد من ٣,٨٣ إلى ١٣,٧٧ ملي مكافئ/كجم زيت، وانخفضت قيمة الحموضة من ٠,١٧ إلى ٠,١٢ ملجم هيدروكسيد البوتاسيوم/جم زيت عند ٥، ١٠، ١٥ دقيقة، ولمدة ٥، ٣، ٦ أشهر، ولكنها ظلت ضمن الحدود القياسية المحددة، وهي أقل من ١٥ ملي مكافئ/كجم زيت لقيمة البيروكسيد، وأقل من ٤ ملجم هيدروكسيد البوتاسيوم/جم زيت لقيمة الحموضة.

(٢) مع زيادة مدة التعرض لأشعة الليزر، ارتفعت قيمة التصبن من ١٨٦,٨٢ إلى ١٩٣,٩٩ ملجم هيدروكسيد البوتاسيوم/جم زيت، بينما انخفضت قيمة اليود من ١٧١,١٤ إلى ١٠٩,٠٥ ملجم يود/جم عند ٥، ١٠، ١٥ دقيقة، ولمدة ٥، ٣، ٦ أشهر. كانت قيم التصبن واليود ضمن النطاق القياسي المحدد، حيث كانت قيمة التصبن أقل من ١٨٦-١٩٥ ملجم هيدروكسيد البوتاسيوم/جم زيت، وقيمة اليود أقل من ١٠٤-١٢٠ ميكروجرام/جم. كما لوحظ تحسن في جودة عينات الزيت المعالجة بعد ستة أشهر.



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## الكلمات المفتاحية:

الليزر؛ زيت الذرة؛ الجودة؛  
الخصائص الكيميائية؛ التخزين.