



STUDY OF THE PHYSICOCHEMICAL AND STORAGE PROPERTIES OF LOCALLY CULTIVATED *MORINGA OLEIFERA* LAM

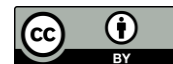
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ABSTRACT

The study aimed to characterize the properties of *Moringa oleifera* Lam. The seed oil of *Moringa* was grown in the fields of the College of Agricultural Engineering Sciences – University of Baghdad in summer season 2022-2023. The total composition of the seeds was estimated, and it was noted that the oil content in the seeds was high at 38.11%. The total fatty acid content of the oil extracted by the cold pressing method was estimated, the oleic acid was characterized as a high content of fatty acid, at 72.38%, followed by stearic acid, at 6.27%. Palmitic acid (6.17%). The antioxidants activity of *Moringa* were estimated as the total phenolic content (119 ppm), such as sterols, tocopherols and carotenoids at (1700, 88 and 17) ppm, respectively. Whereas the proportions of glycosides, tannins and saponins were (4.22, 5.88, 5.89) % respectively. Some physical properties of the oil were estimated at a temperature of 25°C. The refractive index value was 1.499, the specific gravity was 0.9238, and the melting point of the oil was 12.9°C. In addition the chemical properties of the extracted oil, the iodine value free fatty acids peroxide value and thiobarbituric acid were (120.8, 0.16, 0.24 and 0.051) meq/kg oil, respectively, of TBARS (milligrams of malonaldehyde per kilogram of sample). The results of the antioxidant test showed that *Moringa oleifera* seed oil was higher than ascorbic acid in scavenging free radicals (Diphenyl-2-picrylhydrazyl DPPH). Finally, the oil was high stability through the Rancimat test was more than 5 hours at a temperature of 200 degrees Celsius., respectively. Thus, *Moringa oleifera* seed oil was the most important strategic oils that can be used to provide a healthy source of oil is was included in sustainable development programs after the success of its cultivation in many parts of the world, including Iraq, to ensure food and health security.

Keywords: Physicochemical properties, *Moringa oleifera* Lam. Oil, Oleic acid, DPPH, Rancimat.

دراسة الصفات الفيزيوكيميائية والخزنية لزيت بذور المورينجا اوليفيرا (*Moringa oleifera Lam*) المزروعة محلياسؤدد عبدالمنعم علي¹، ايمان حميد الانباري²¹قسم علوم الاغذية، كلية علوم الهندسة الزراعية، جامعة بغداد، بغداد، العراق، soadod.abd2102m@coagri.uobaghdad.edu.iq
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الخلاصة

هدفت الدراسة الى توصيف خصائص زيت بذور المورينجا اوليفيرا (*Moringa oleifera Lam.*) المنزرعة في حقول كلية علوم الهندسة الزراعية- جامعة بغداد للموسم الصيفي 2022-2023 وقدرت نسب المكونات الكلية للبذور ولوحظ ارتفاع نسبة الزيت في البذور بلغت 38.11%، قدرت نسبة الأحماض الدهنية الكلية للزيت المستخلص بطريقة العصر البارد وتميز بارتفاع نسبة حامض الأوليك وبلغت 72.38% يليه حامض الستياريك الذي بلغت نسبته 6.27% وكانت نسبة حامض البالميتيك 6.17%، وتميز الزيت المستخلص باحتوائه على العديد من مضادات الأكسدة الطبيعية حيث بلغت اجمالي الفينولات الكلية (119 ppm) والستيرولات 1700 ppm وبلغ كل من اجمالي التوكوفيرولات والكاروتينويدات 88 و 17 ppm على التوالي، ونسبة كل من الكلايكوسيدات والتانينات والصابونين (5.89, 5.88, 4.22) على التوالي. قدرت بعض الخواص الفيزيائية للزيت عند درجة حرارة 25 °م وبلغت قيمة معامل الانكسار 1.499 والكثافة النوعية 0.9238 وكانت نقطة انصهار الزيت 12.9 °م. اما الخواص الكيميائية للزيت المستخلص فقد بلغ الرقم اليودي 120.8 ونسبة الاحماض الدهنية الحرة 0.16% وبلغت قيمة رقم البيروكسيد (0.24 meq/kg oil) وكانت قيمة حامض الثيوباربيتوريك (0.051 mg/kg of TBARS). وأشارت نتائج فحص مضادات الأكسدة تفوق زيت بذور المورينجا اوليفيرا على حامض الاسكوربيك في كبح الجذور الحرة (Diphenyl-2-picrylhydrazyl DPPH) كما امتاز الزيت بثباتية عالية من خلال فحص (Rancimat) لمدة تزيد على 5 ساعات على درجة حرارة 200 درجة مئوية وبذلك يعد زيت بذور المورنجا اوليفيرا احد اهم الزيوت الاستراتيجية التي يمكن استعمالها في توفير مصدر زيت صحي يدخل ضمن برامج التنمية المستدامة بعد نجاح زراعته في مناطق عديدة من العالم ومنها العراق لضمان تحقيق الأمن الغذائي والصحي.

الكلمات المفتاحية: الخصائص الفيزيائية والكيميائية، زيت المورينجا أوليفيرا لام، حامض الأوليك، DPPH، Rancimat.

INTRODUCTION

Moringa oleifera trees are perennial and fast-growing in most regions and climatic conditions. They have a unique ability to tolerate drought. Almost all parts of the tree are used to obtain essential nutrients. Moringa oleifera trees flourish globally in all tropical and subtropical regions (Ibrahim & Ameen, 2017). Studies have shown that the leaves and pods of *M. oleifera* trees are the cheapest and reliable alternatives for good nutrition (Ismet *et al.*, 2018). Moringa Oleifera trees was a good source of nutrients which important for human health. In addition to their nutritional uses, they are also used in plant production, fertilizer manufacturing, water purification, and etc (Sidney & Michael, 2015) (Abd, *et al.* (2023). They have been used to produce natural food supplements and have been studied by researchers in many fields, including medicine and nutrition. The different parts of the tree (such as stems, leaves, seeds, bark, and flowers) have been used. (Araújo *et al.*, 2013) It was used in the past to treat inflammation, infectious diseases, and disorders of the heart, liver, and kidneys. The use of plants for medicinal purposes has been linked to their possession of antioxidants, as they work to quench and suppress the formation of reactive oxygen species and



free radicals or inhibit oxidation processes inside the living body (Govardhan Singh *et al*, 2013). Moringa oleifera seeds have been used to treat eye diseases, headache, fever, snake and scorpion bites, warts, ulcers, gastritis, skin inflammations, bladder infections, scurvy, abdominal tumors, schistosomiasis, and to inhibit the growth of harmful bacteria. (Hussin, *et al.*, 2022). It is also used to treat ulcers, gastric inflammation, skin inflammations, bladder infections, arthritis, abdominal tumors, schistosomiasis, and to inhibit the growth of harmful bacteria (Anwar *et al.*, 2007).

The seeds of Moringa oleifera were of nutritional importance such as rich in proteins (30-35%) and oils (Stohs, & Hartman, 2015)., with oil content reaching (38-45)%. They are also rich in fiber and essential minerals for the human body, in addition to containing a reasonable amount of carbohydrates (Elsorady, 2023). The seeds of *Moringa oleifera* trees are considered a good source of edible oil, and this plant has been identified as one of the sources of vegetable oils (Al-Taweel & Al-Anbari, 2019). Furthermore, Moringa seed oil is rich in vitamins (Vit A, Vit D) and natural antioxidants such as flavonoids and glucosides (Lalas & Tsaknis, 2002) (Hussin, *et al.*, (2022)). It is used as a laxative and in the treatment of leprosy and ulcers. It also treats rheumatism, gout, causes of skin diseases, lupus, and bladder disorders (Ariani *et al.*, 2023).

The seed oil of *Moringa Oleifera* is characterized by containing more than 75% of unsaturated essential fatty acids, while oleic acid constituting over 70% of its content. (Asgari-Kafrani, *et al.* 2020). Its oil is distinguished by its ability to counteract oxidative stress and oxidative degradation, making it ideal for nutrition, medicinal, and commercial uses (Rong Liu *et al.*, 2022).

MATERIALS AND METHODS:

Seeds of *Moringa Oleifera* were obtained from the fields of the College of Agricultural Engineering Sciences, University of Baghdad, for the seasons 2022-2023 when they reached full maturity. The seeds were separated from the dry pods and manually dehulled.

Estimation of Total Components: The total components of *Moringa Oleifera* seeds were estimated as follows:

Moisture Content Estimation: The percentage of moisture was estimated using the method outlined in (A.O.A.C. 2016), employing oven drying until a constant weight was achieved.

Protein Content Estimation: The Micro Kjeldahl method was used to estimate the protein content in the seeds, following the procedure described in, (AOAC., 2017).

Fat Content Estimation: The fat content in *Moringa Oleifera* seeds was determined using the Soxhlet fat extraction method, as per (AOAC 2016)), utilizing a Soxhlet fat extraction apparatus provided by Electrotherma.(Al-Anbary, 2012).

Ash Content Estimation: The ash percentage in the samples was determined by ashing the seed powder using a Muffle furnace according to the method outlined in (AOAC 2016).

Estimation of Fiber Content: The percentage of fiber in the samples was determined according to the method outlined in (AOAC., 2017).



Estimation of Total Carbohydrate Percentage: Total carbohydrates were estimated mathematically by subtracting the sum of the total components from 100, as mentioned in **AOAC (2017)**. (Zouboulis, *et al.*, (2023).

Extraction of Moringa Seed Oil: The oil was extracted from dried Moringa seeds using the cold mechanical pressing method, as described by (Al-Anbari & Ali 2022), using a press machine provided by Oimaster, China.

Estimation of Total Fatty Acid Percentages: The total fatty acid percentages for *Moringa Oleifera* seed oil were determined using a Gas Chromatography-Mass Spectrometry (GC-MS) apparatus provided by Agilent Technology (Model: 7820-A).

Column Specifications:

- Length: 30 meters
- Inner diameter: 250 microns
- Column thickness: 0.25 microns
- Pressure: 11.933 psi
- Temperature: 250 degrees Celsius
- Helium gas was used as the carrier gas.

The spectra of the components were compared with the spectra of updated components stored in the library of standards and technology at the National Institute (Uduman, *et al.*, 2017; Al-Hayali, *et al.*, 2023).

Physical and Chemical Properties of Moringa Oleifera Seed Oil: Refractive index (RI), Free Fatty Acids (FFA), Peroxide Value (PV), Iodine Value, Thiobarbituric Acid (TBA) value, Saponification value, and melting point were estimated according to (AOAC 2016).

Quantitative Estimation of Some Active Compounds: Total Phenolic Determination: Total phenolic compounds were estimated as described by (Ali Khoddami *et al.* 2013).

Total Flavonoids Determination: Total flavonoids were estimated according to (Zangana & Al-Bahadly 2017) (Jahan, *et al.* 2018).

Total Tannins Content Estimation: Tannins were estimated using the method mentioned in (El-Geddawy *et al.*, 2019).

Total Saponin Content Determination: Saponins were estimated as per (Valentina *et al.* 2023). Percentage of saponins = $(W2 - W1 / \text{Wt. of sample}) \times 100$

Total Glycosides Estimation: Glycosides were estimated as described by (Akinlabu, 2019).

Estimation of Free Radical Scavenging Activity (Diphenyl-2-picrylhydrazyl DPPH): The free radical scavenging activity was estimated as described by (Shamrad & Shaki 2019).

The percentage inhibition of DPPH was calculated using the following equation:

DPPH scavenging effect (%) or Percent inhibition = $(A0 - A1) / A0 \times 100$

Where:

- A0 is the absorbance of the blank.
- A1 is the absorbance in the presence of the test sample.

Examination of Antioxidant Resistance (Rancimat Test): The stability of *Moringa Oleifera* seed oil was examined according to (Pedro *et al.*, 2013). This test was conducted using a Rancimat 743 apparatus provided by Metrohm, which measures the stability and resistance



of oil to oxidation. Five milliliters of the sample placed in the apparatus tubes were exposed to a stream of air at a constant temperature (200 degrees Celsius) and air pressure (20 liters/hour). Secondary oxidation products that vaporize are transferred from the reaction vessel to the measuring vessel with an air stream, where they are absorbed in distilled water (measurement liquid). The electrical conductivity is observed; an increase in conductivity indicates an increase in vaporized compounds. The time required from the start of the test until the appearance of these compounds is noted and referred to as the Induction time, which indicates the stability of the oil before model failure (**Lucía Félix & Irwin, 2021**).

Storage Stability Tests: Periodic tests were conducted every 10 days over a duration of 90 days for *Moringa Oleifera* seed oil (*Moringa Oleifera*) to assess the Free Fatty Acids (FFA), Peroxide Value (PV), and Thiobarbituric Acid (TBA) value, as outlined by (**Geisa Pazzoti et al., 2018**).

RESULTS AND DISCUSSION

The results showed that the percentages of moisture, total ash, protein, total fat, fiber, and carbohydrates were (4.08, 3.25, 32.11, 38.11, 7.55, 14.1) % respectively. The results were consistent with those found by (**Leone et al., 2016**) and **Pareek et al. (2023)**. The protein percentages were (31.4 and 31.7) %, fat (36.7 and 38.4) %, fiber (7.3 and 6.75) %, and carbohydrates (18.4) % for each of the researchers respectively. There was a relative difference in the percentage composition compared to what (**Barakat & Ghazal 2016**) found, as they reported moisture (7.5) %, ash (4.73) %, protein (35.54) %, fat (29.61) %, fiber (10.92) %, and carbohydrates (20) %. The results also contrasted with those reported by (Ijarotimi OS *et al.*, (2013). ((Ashutosh Pareek et al 2023) where moisture, protein, fat, and carbohydrates were (10.6, 18.86, 13.35, 53.36) % respectively. This could be due to the high moisture content in the samples or differences in environmental factors.

Table (1): chemical Composition of *Moringa Oleifera* Seed.

Component	Percentage (%)
Moisture	4.08
Total Ash	3.25
Protein	32.11
Total Fat	38.11
Fiber	7.55
Carbohydrates	14.1

Table (2) illustrates the percentages of fatty acids composing *Moringa Oleifera* seed oil. The results indicated that oleic, palmitic, and stearic acids could be consider the major components, which is consistent with findings of **Christos et al. (2023)**. The percentage of oleic acid was



72.38%, palmitic acid was 6.17%, and stearic acid was 6.27%. This aligns with previous studies by (Lalas & Tsaknis 2002) and (Obikili, 2010).

Some biological activities of different fatty acids in Moringa seed oil have been observed, such as antioxidant activity attributed to palmitic and oleic acids (Mohammed, *et al.*, 2003; Al-Anbari, 2013; Annamaria *et al.*, (2015) (Deusdelia, 2018) mentioned a liver protective effect due to palmitoleic acid. Oleic acid has been found to have anticancer activity. The biological results obtained by researchers confirm that Moringa seed oil protects the liver from fibrosis (Asgari-Kafrani *et al.*, 2020).

Table (2): Fatty Acid Composition in Moringa Seed Oil.

Fatty acid	Chemical Formula	Percentage%	Common Name	Commented
Palmitic acid	C ₁₆ H ₃₂ O ₂	6.17	hexadecanoic acid	Saturated
Stearic acid	C ₁₈ H ₃₆ O ₂	6.27	Octadecanoic acid	Saturated
Arachidic acid	C ₂₀ H ₄₀ O ₂	3.85	Eicosanoic acid	Saturated
Behenic acid	C ₂₂ H ₄₄ O ₂	5.91	docosanoic acid	Saturated
Lignoceric acid	C ₂₄ H ₄₈ O ₂	1.01	Tetracosanoic acid	Saturated
Palmitolic acid	C ₁₆ H ₂₈ O ₂	1.13	9-hexadecynoic acid	Mono-saturated
Oleic acid	C ₁₈ H ₃₄ O ₂	72.38	cis-9-Octadecenoic acid	Mono-saturated
Linoleic acid	C ₁₈ H ₃₂ O ₂	0.47	-9,12-Octadecadienoic acid	Poly-saturated
Linolenic acid	C ₁₈ H ₃₀ O ₂	0.17	9,12,15-Octadecatrienoic acid	Poly-saturated
Gadoleic acid	C ₂₀ H ₃₈ O ₂	2.23	cis-9-eicosenoic acid	Poly-saturated
Total Saturated Fatty Acids		23.21		
Total Monounsaturated Fatty Acids		73.51		
Total Polyunsaturated Fatty Acids		2.87		

Table (3) illustrates the physicochemical properties of *Moringa Oleifera* oil. The results indicate that the physical properties of the oil (density and melting point) fall within the normal range for liquid oils (Félix, & Donis 2021). As for the chemical properties, the decrease in both the peroxide value and free fatty acids, along with the value of thiobarbituric acid, is evidence of the oil's resistance to auto-oxidation (Al-Anbari, *et al.*, 2013). All values are within the acceptable range for edible vegetable oil (Laveena, & Chandra, 2018).

Table (3): illustrates the physicochemical properties of Moringa Oleifera seed oil.

physicochemical properties	Value
Saponification Number (Sapo) (g/mg KOH)	192.6
(Peroxide Value) P.V (Meq.100gm)	0.24
Acidity No.	0.9541
Free Fatty Acid (FFA)%	0.16
Thiobarbituric acid (TBA) (mg MDA/gm)	0.051



Refractive index (RI) (25°C)	1.499
Density (25°C)	0.9238
Iodine No.	120.8
Melting point	12.9

Table (4) highlights that Moringa seed oil contains numerous active compounds (**Ahmed, & Saeed, 2013**). Phenolic are a broad group of chemical compounds containing a phenol group (-OH) attached to the benzene ring (**Bouzenna, et al. (2019)**). These compounds encompass various classes of molecules such as flavonoids, simple phenols, tannins, stilbenes, and others (**Jahan et al., 2018**). Sterols play a crucial role in cellular structure and body functions, with cholesterol being the most important sterol, vital for cell membrane structure and hormone production. Plant sterols, such as phytosterols found in vegetable oils, play a significant role in reducing cholesterol levels in the blood (**Rong Liu, et al., (2022)**) (**Hafidh & Al-Anbari, 2023**).

Tocopherol (Vitamin E) is an antioxidant that plays a crucial role in protecting cells from damage caused by free radicals (**Hussin, et al (2022)**). Carotenoids are also considered antioxidants and have health benefits as they contribute to protecting cells from damage caused by free radicals. Some carotenoids are converted into vitamin A in the body, which is essential for vision, skin health, and the immune system (**Awad & Hind, 2016**).

Table (4): Active Compounds in Moringa Seed Oil.

No	content	Ppm
1	Total phenolic	105.8
2	Total flavonoid	72.58
3	Total alkaloid	14.89
4	Total glycoside	5.89
5	Total saponins	4.22
6	Total Tannin	5.88

Table (5) illustrates the assessment of antioxidant activity using DPPH to determine the oil's ability to donate hydrogen atoms to inhibit the resulting free radicals, commonly used in evaluating antioxidant activity (**Jahan, et al. 2022**). The comparison was made with vitamin C at various concentrations (30, 60, 120, 250, 500 ppm). The inhibition percentage for 30 minutes was recorded as follows: for Moringa seed oil, it was 22.56%, 48.97%, 71.25%, 84.56%, and 92.66%, respectively, compared to vitamin C, which exhibited percentages of 12.49%, 27.89%, 40.25%, 65.98%, and 80.55% in the same order. Moringa seed oil demonstrated higher inhibition capacity than vitamin C. These results suggest the potential use of Moringa seed oil as an effective natural antioxidant compound in dietary systems due to its richness in phenolic compounds, tocopherols, and carotenoids, which aligns with previous findings (**Ogbunugafor et al., 2011**) (**Khan, et al 2015**).



Table (5): Comparing the antioxidant activity of different concentrations of Moringa seed oil with the same concentrations of vitamin C using the DPPH assay.

Concentration (ppm)	Vitamin C	Moringa Seed Oil
30	12.49	22.56
60	27.89	48.97
120	40.25	71.25
250	65.98	84.56
500	80.55	92.66

Table (6) indicating the high storage stability of Moringa seed oil through monitoring of free fatty acids, peroxide value, and thiobarbituric acid value. After 90 days of storage at room temperature ($25\pm 2^{\circ}\text{C}$), the values were (1, 4.4, 0.8) ml/Kg respectively (**Ijarotimi et al., 2013**). This stability can be attributed to the presence of a high proportion of oleic fatty acid, which acts as a natural antioxidant, along with a good percentage of active compounds such as tocopherols and carotenoids. These findings are consistent with those reported by **Safa Bejaoui et al., (2021)** and **Akintola et al., (2022)**, The increase in peroxide value during the storage period may be due to the oxidation of unsaturated fatty acids, yet the increase is slight and considered acceptable within the limits specified by the Iraqi standard for oils (1582), which sets the permissible increase in peroxide value at 10 milliequivalents per kilogram of fat. (**Jahan, et al., 2022**). The researchers noted that the increase is natural throughout the storage period, although the results may vary depending on the type of oil and its storage stability, as mentioned by (**Leone, et al., 2016**). (**Pérez-Pérez, et al. 2020**).

Table (6): The changes in free fatty acids (FFA), peroxide value (PV), and thiobarbituric acid (TBA) over a 90-day storage period at room temperature ($25\pm 2^{\circ}\text{C}$).

Chemical analysis	Duration (day)									
	0	10	20	30	40	50	60	70	80	90
FFA%	0.16	0.2	0.32	0.38	0.4	0.48	0.53	0.62	0.7	0.8
PV meq/Kg oil	0.24	0.7	1	1.3	1.9	2.4	2.9	3.2	3.8	4.4
TBA ml/Kg	0.05	0.09	0.16	0.28	0.45	0.56	0.6	0.74	0.9	1

(Figure, 1) illustrates the resistance curve of *Moringa Oleifera* seed oil to oxidation through the Rancimat test. It can be observed that the oil resisted oxidation after five hours of exposure to air at a temperature of 200°C . This resistance is attributed to the high proportion of natural antioxidants in Moringa seed oil, which is consistent with what was mentioned by (**Lalas & Tsaknis 2002**) (**García-Moreno, et al 2013**),, stating that Moringa seed oil exhibits high stability due to its high content of oleic acid, tocopherols, and carotenoids. (**Zouboulis, et al. 2023**)

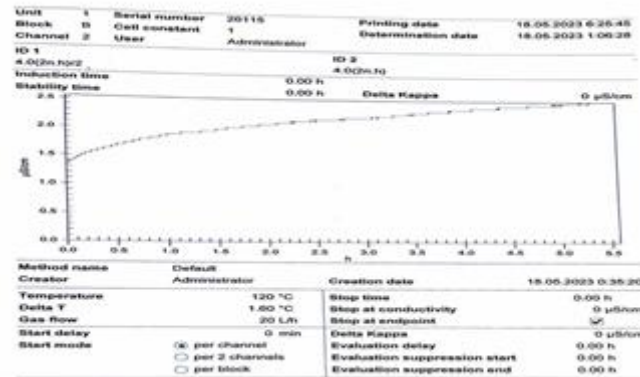


Figure (1): Shows the resistance of *Moringa oleifera* seed oil to oxidative rancidity.

CONCLUSIONS

The study results emphasize the nutritional importance of *Moringa Oleifera* seeds due to their high protein and oil content. Its oil is considered one of the most valuable nutritional and therapeutic oils due to its high content of oleic acid and natural antioxidants, which give it high storage stability compared to other vegetable oils. It can be used as a food product that meets all the standards of the standard specifications for vegetable oils and can be considered among oils with high economic value. Additionally, it can be used in the pharmaceutical industries due to its content of fat-soluble vitamins, natural antioxidants, and essential fatty acids.

REFERENCES

1. Abd, A. M., Obaid, N. A., & Odeh, M. M. (2023). Efficiency of antioxidants in some chemical traits of the fruits and leaves for two varieties of tissue culture date palm (*Phoenix dactylifera* L.). *Basrah Journal For Date Palm Research*, 22(2), 23–38.
2. Ahmed, M., Saeed, F., & et al. (2013). Evaluation of Insecticidal and Antioxidant activity of selected Medicinal plants. *Journal of Pharmacognosy & Phytochemistry*, 2(3), 153–158.
3. Akinlabu, D. K., Owoeye, T. F., Owolabi, F. E., Audu, O. Y., Ajanaku, C. O., Falope, F., & Ajani, O. O. (2019). Phytochemical and Proximate Analysis of African Oil Bean (*Pentaclethra macrophylla* Benth) Seed. *Journal of Physics: Conference Series*, 1378(3), 032057.
4. Al-Anbari, I. H. A., Hindi, M. J., & al-Qaisi, M. M. (2013). Manufacturing oils rich in omega-3 fatty acids using the cool ester method and studying some of their physico-chemical properties. *Kufa Journal for Agricultural Science*, (94-105).



5. Al-Anbari, I. H., & Ali, T. I. (2022). The use of ultraviolet rays to preserve fermented green olives and its effects on chemical properties of its extracted oil. *Iraqi Journal of Market Research and Consumer Protection*, 14(1).
6. Al-Anbary, E. H. (2012). The effect of adding natural antioxidants extracts from crude red palm oil to maintain shelf life of flax seed oil. *Journal of Food Industries & Nutrition Sciences*, 2(1), 209–218.
7. Al-Hayali, O. Z., AL Marjani, M. F., & Maleki, A. (2023). Evaluation of Rosmarinus officinalis Leaves Essential Oils Activity Against Vancomycin Intermediate Staphylococcus aureus (VISA) Isolated from Baghdad Hospital Patients. *Iraqi Journal of Science*, 64(5), 2153–2167.
8. Al-Taweel, S., & Al-Anbari, I. (2019). Moringa oleifera: A review on the phytochemical screening, proximate analysis, medicinal, nutritional, and plant biostimulants values of its leaves, pods, seeds and roots. *Plant Archives*, 19, 972-5210.
9. Anwar, F., Latif, S., Ashraf, M., & Gilani, A. H. (2007). Moringa oleifera: A food plant with multiple medicinal uses. *Phytotherapy Research*, 21, 17-25.
10. Araújo, L. C. C., Aguiar, J. S., Napoleão, T. H., Mota, F. V. B., Barros, A. L. S., Moura, M. C., ... & Paiv, P. M. G. (2013). Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from Moringa oleifera seeds. *PLoS One*, 8(Article e81973).
11. Ariani, L. N., Estiasih, T., Sunarharum, W. B., & Khatib, A. (2023). Potential of moringa (*Moringa oleifera*) leaf powder for functional food ingredients: A review. *Czech Journal of Food Science*.
12. Asgari-Kafrani, A., Fazilati, M., & Nazem, H. (2020). Hepatoprotective and antioxidant activity of aerial parts of Moringa oleifera in prevention of non-alcoholic fatty liver disease in Wistar rats. *South African Journal of Botany*, 129, 82–90.
13. Association of Official Agricultural Chemists [AOAC]. (2016). *Official methods of analysis of AOAC International* (20th ed.). Gaithersburg, Md. USA: AOAC International.
14. Association of Official Agricultural Chemists [AOAC]. (2017). *Official Methods of Analysis of AOAC International* (18th ed., revision). Gaithersburg, Maryland, AOAC International.
15. Awad, H. A., & Hindi, M. J. (2016). Study of the activity of carotenoids extracted from shrimp shells as antioxidant and antimicrobial agents in meat preservation. *University of Kerbala / College of Agriculture*, 3(2).
16. Barakat H, Ghazal GA (2016) Physicochemical properties of *Moringa oleifera* seeds and their edible oil cultivated at different regions in Egypt. *F. and Nutri. Sci.* 7 : 472-484.
17. Bejaoui, S., Ghribi, F., Chetoui, I., Aouini, F., Bouaziz, M., Houas-Gharsallah, I., Soudani, N., & El Cafsi, M. (2021). Effect of storage temperature and time on the fatty acids and nutritional quality of commercial mussel (*Mytilus galloprovincialis*). *Journal of Food Science and Technology*, 58(9), 3493–3503.
18. Bouzenna, H., Samout, N., S. Dhibi, S. Mbarki, S. Akermi, A. Khdhiri, A. Elfeki & Hfaiedh, N. (2019). Protective effect of essential oil from Citrus limon against aspirin-induced toxicity in rats.



19. Christos C. Zouboulis, ORCID, Amir M. Hossini, ORCID, Xiaoxiao Hou, Chaoxuan Wang 2,3ORCID, Karsten H. Weylandt 2ORCID and Anne Pietzner Effects of Moringa oleifera Seed Oil on Cultured Human Sebocytes In Vitro and Comparison with Other Oil Types nt. *Journal. Mol. Sci.* 2023, 24(12), 10332.
20. Deusdelia Almeida Effects of different storage conditions on the oxidative stability of crude and refined palm oil, olein and stearin (*Elaeis guineensis*) (April 2018). *Food Science and Technology* (Campinas), 39(2). DOI:10.1590/fst.43317
21. El-Geddawy, M. A. U., Sorour, M. A., Abou-El-Hawa, S. H., & Taha, E. M. M. (2019). Effect of domestic processing and microwave heating on phenolic compounds and tannins in some oil seeds. *SVU-International Journal of Agricultural Science*, 1(2), 23–32. ISSN 2636-381X | Online ISSN 2636-3801.
22. Elsorady, M. E. (2023). Evaluation of Moringa oleifera seed oil extracted with different extraction methods. *Croatian Journal of Food Science and Technology*, 15(1), 01.
23. Félix, L., & Donis-González, I. R. (2021). Optimization and validation of rancimat operational parameters to determine walnut oil oxidative stability, extraction and fractionation processes of functional components in food engineering. *Prossess* 9(4), 651.
24. García-Moreno, P. J., Pérez-Gálvez, R., Guadix, A., & Guadix, E. M. (2013). Influence of the parameters of the Rancimat test on the determination of the oxidative stability index of cod liver oil. *LWT - Food Science and Technology*, 51(1), 303–308.
25. Govardhan Singh, R. S., & Jayaveera, K. N. (2013). Antioxidant and anti-inflammatory potential of Moringa oleifera leaf extract in collagen-induced arthritis in rats. *Journal of Complementary and Integrative Medicine*, 10(4), 210-218.
26. Hafidh, B., & Al-Anbari, I. H. A. (2023). Extracting active compounds from sweet lupine seeds and studying their effective antioxidant activity. PS, *Indian Medicinal Plants- I*.
27. Hussin, W. S. A., Obeid, A. K., & Jawad, R. A. A. (2022). The protective effect of aqueous of Moringa Oleifera seeds extract against levofloxacin drug-induced liver damage in male white rats. *International Journal of Health Sciences*, 6(S2), 13044–13052.
28. Hussin, W. S. A., Obeid, A. K., & Jawad, R. A. A. (2022). The protective effect of aqueous of Moringa Oleifera seeds extract against levofloxacin drug-induced liver damage in male white rats. *International Journal of Health Sciences*, 6(S2), 13044–13052.
29. Ibrahim, I., & Ameen, I. (2017). In vitro propagation of Moringa oleifera. *Iraqi Journal of Agricultural Sciences*, 48(4).
30. Ijarotimi OS, Adeoti OA, Ariyo O (2013). Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated, and fermented Moringa oleifera seed flour. *Food sci. nut.* 1(6): 452–463.
31. Ionescu, M., Ungureanu, N., Biris, S.-S., & Voicu, G. (2019). Actual methods for obtaining vegetable oil from oilseeds.
32. Ismet Ara, M., Hemay et Hossain, K. S. A., Sultana, Z., Biswas, P. K., & Nada, K. (2018). Antioxidant Activity of Moringa Oleifera Seed Extracts. *Oriental Pharmacy and Experimental Medicine*, 18(4), 299–307.



33. Jahan, I. A., Hemay, M., Hossain, K. S. A., Sultana, Z., Biswas, P. K., & Nada, K. (2018). Antioxidant Activity of Moringa Oleifera Seed Extracts. *Oriental Pharmacy and Experimental Medicine*, 18(4), 299–307.
34. Jahan, I., Hossain, M., et al. (2022). Protective effect of aqueous of Moringa Oleifera seeds extract against levofloxacin drug-induced liver damage in male white rats. *International Journal of Health Sciences*, 6(S2).
35. Khan, M. K., Karnpanit, W., Abbas, S., & Huma, Z. (2015). Phytochemical composition and bioactivities of lupin. *International Journal of Food Science & Technology*, 50(9).
36. Khoddami, A., Wilkes, M. A., & Roberts, T. H. (2013). Techniques for Analysis of Plant Phenolic Compounds. *Molecules*, 18(2), 2328–2375.
37. Lalas, S., & Tsaknis, J. (2002). Characterization of Moringa oleifera seed oil variety “Periyakulam 1”. *Journal of Food Composition and Analysis*, 15(1), 65–77.
38. Laveena, K. B., & Chandra, M. (2018). Evaluation of bioactive compounds, antioxidant, and antibacterial properties of medicinal plants *Sauropus androgynus* L. and *Erythrina variegata* L., *Asian Journal of Pharmaceutical and Clinical Research*, vol. 11, no. 12, pp. 313-7,
39. Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., & Bertoli, S. (2016). Moringa oleifera Seeds and Oil: Characteristics and Uses for Human Health. *International Journal of Molecular Sciences*, 17(12), 2141.
40. Liu, R., Liu, J., Huang, Q., Liu, S., & Jiang, Y. (2022). Moringa oleifera: A systematic review of its botany, traditional uses, phytochemistry, pharmacology and toxicity. *Journal of Pharmacy and Pharmacology*, 74(3), 296–320
41. Mancini, A., Imperlini, E., Nigro, E., Montagnese, C., Daniele, A., Orrù, S., & Buono, P. (2015). Biological and Nutritional Properties of Palm Oil and Palmitic Acid: Effects on Health. *Molecules*, 20(9), 17339–17361.
42. Mohammed, A. S., Lai, O. M., Muhammad, S. K. S., Long, K., & Ghazali, H. M. (2003). Moringa oleifera, Potentially a New Source of oleic acid-type oil for Malaysia. In *Investing in Innovation 2003, Vol 3: Bioscience and Biotechnology*, 137–140. Universiti Putra Malaysia Press, *Serdang Press*, Selangor, Malaysia.
43. Obikili, C. M. (2010). Evaluation Of The Effect of Methods of Oil Extraction On Physico-Chemical Properties of Oil From African Breadfruit Seeds, (*Treculia africana*) And Cashew Nuts (*Anacardium Occidentale*). Unpublished Undergraduate Project, Federal University of Technology, Minna, Niger State. Published online 2015 Sep 18. doi: 10.3390/molecules200917339
44. Ogbunugafor, H. A., Eneh, F. U., Ozumba, A. N., Igwo-Ezikpe, M. N., Okpuzor, J., Igwilo, I. O., Adenekan, S. O., & Onyekwelu, O. A. (2011). Physico-chemical and Antioxidant Properties of Moringa oleifera Seed Oil. *Pakistan Journal of Nutrition*, 10(5), 409-414. ISSN 1680-5194.
45. Pareek, A., Pant, M., Gupta, M. M., Kashania, P., Ratan, Y., Jain, V., Pareek, A., & Chaturgoon, A. A. (2023). Moringa oleifera: An Updated Comprehensive Review of Its Pharmacological Activities, Ethnomedicinal, Phytopharmaceutical Formulation, Clinical,



- Phytochemical, and Toxicological Aspects. *International Journal of Molecular Sciences*, 24(3), 2098.
46. Pedro J. (2013), García-Moreno, Raúl Pérez-Gálvez, Antonio Guadix, Emilia M. Guadix Influence of the parameters of the Rancimat test on the determination of the oxidative stability index of cod liver oil LWT - Food Science and Technology Volume 51, Issue 1, April 2013, Pages 303-308
 47. Pérez-Pérez, V., Alamilla-Beltrán, L., Jiménez-Martínez, C., Pereyra-Castro, S. d. C., Ortiz-Moreno, A., Plazola-Jacinto, C. P., Camacho-Díaz, B. H., & Ortega, M. H. (2020). Evaluation of acute toxicity and chemical composition of refined oil *Moringa oleifera* cultivated in Mexico. *TIP Revista Especializada en Ciencias Químico-Biológicas*, 23, 1–9.
 48. Rong Liu, Jing Liu, Qi Huang, Shao Liu, Yueping Jiang (2022), *Moringa oleifera*: a systematic review of its botany, traditional uses, phytochemistry, pharmacology and toxicity *Journal of Pharmacy and Pharmacology*, Volume 74, Issue 3, March 2022, Pages 296–320.
 49. Sidney J. Stohs and Michael J. Hartman Review of the Safety and Efficacy of *Moringa oleifera* Phytotherapy Research ,*Phytother. Res.* 29: 796–804 (2015),Published online 24 March 2015 in Wiley Online Library,(wileyonlinelibrary.com)
 50. Shamrad, H. Y., & Shaki, K. A. (2019). Sesame oil extraction and antioxidant activity of lignans from locally cultivated sesame seeds (*Sesamum indicum* L). *Iraqi Journal of Agricultural Sciences*, 50(1), 382–398.
 51. Stohs, S. J., & Hartman, M. J. (2015). Review of the safety and efficacy of *Moringa oleifera*. *Phytotherapy Research*, 29, 796–804.
 52. Uduman, M. S., Rathinam, P., Karuru, Y., Obili, G., Chakka, G., & Janakiraman, A. K. (2017). GC-MS Analysis of Ethyl Acetate Extract of Whole Plant of *Rostellularia diffusa*. *Pharmacognosy Journal*, 9(1), 70–72.
 53. Valentina K., Balaussa T., Dzhakibaeva, G. T., Mukhanov, T. M., Total Content of Saponins, Phenols and Flavonoids and Antioxidant and Antimicrobial Activity of In Vitro Culture of *Allochrysa gypsophiloides* (Regel) Schischk Compared to Wild Plants. *Plants (Basel)*. 2023 Oct; 12(20): 3521.
 54. Zangana, B. S. R., & Al-Bahadly, K. O. J. (2017). Estimating of Fatty Acids, Tocopherols, Tocotrienols, Total Carotens, Study The Physiochemical Properties And Unsaponifiable Matters Extraction From Crude Red Palm Oil. *Baghdad Science Journal*.
 55. Zouboulis, C. C., Hossini, A. M., Hou, X., Wang, C., Weylandt, K. H., & Pietzner, A. (2023). Effects of *Moringa oleifera* Seed Oil on Cultured Human Sebocytes In Vitro and Comparison with Other Oil Types. *International Journal of Molecular Sciences*, 24(12), 10332.