Vol.3, No.6, Page 1330- 1338, 2025 https://doi.org/10.59628/jast.v3i6.1949 ISSN 2958-9568 JAST

SUN PUBLISHER

مجلة جامعة صنعاء للعلوم التطبيقية والتكنولوجيا

Sana'a University Journal of Applied Sciences and Technology

https://journals.su.edu.ye/index.php/jast/

# Fatty Acid Profile and Physicochemical Properties of Yemeni Sesame Seed Oil: An Analytical Study

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## Abstract

This study investigated the fatty acid profile and physicochemical properties of sesame seed oil extracted from two regions in Yemen, Marib, and Hadhramaut. The sesame oil was extracted using the Soxhlet method with n-hexane as the solvent. The physicochemical parameters analyzed included the free fatty acid content (FFA%), acid value (A.V.), iodine value (I.V.), saponification value (S.V.), refractive index (R.I.), density, moisture content, specific gravity (S.g.), and viscosity at 26 °C. Oil yields were 47.5% and 48% for sesame seeds from Marib and Hadhramaut, respectively. The Marib oil exhibited FFA of 3.38 ± 0.01%, A.V of 7.41 ± 0.04 mg NaOH/g, I.V of 99.41 ± 0.10 g $I_2$/100 g, S.g of 197.75 ± 0.50 mg KOH/g, R.I of 1.461 ± 0.01, moisture content of 0.140 ± 0.05%, density of 0.871 ± 0.02 g/mL, S.g of 0.9442 ± 0.03, and viscosity of 31.75 cP. Corresponding values for Hadhramaut oil were FFA 1.21 ± 0.03%, A.V 2.65 ± 0.02 mg NaOH/g, I.V 99.92 ± 0.03 g I2/100 g, S.V 195.93 ± 0.40 mg KOH/g, R.I of 1.477 ± 0.01, moisture content 0.015 ± 0.01%, density 0.863 ± 0.02 g/mL, S.g of 0.951 ± 0.03, and viscosity 29.72 cP. Fourier-transform infrared spectroscopy (FTIR) and gas chromatography with flame ionization detection (GC-FID) were employed to characterize the chemical composition and fatty acid profiles of the oils. These findings provide valuable insights into the quality and composition of Yemeni sesame oils, highlighting the regional variations that may influence their nutritional and industrial applications.

## Article Info

**Keywords:**
Yemeni Sesame Seeds Oil, Soxhlet Extraction,Physicochemical Properties, Fatty Acid Composition, FTIR, GC-FID.

**Article History:**
**Received:** 20-June-2025,
**Revised:** 20-July-2025,
**Accepted:** 26-August-2025,
**Available online:** 28 December 2025.

## 1. INTRODUCTION

Sesame (*Sesamum indicum*) belongs to the Pedaliaceae family and genus Sesamum [1]. Sesame contains approximately 36 species, 19 of which are native to Africa [2]. Sesame oil is probably the most ancient oil seed crop known to humankind; it has been cultivated in Asia and Africa for 2000 years [3]. Sesame oil is used for its therapeutic properties and is commonly used in pharmaceutical applications [4].

Sesame oil is rich in vitamin E and contains important antioxidants such as sesaminol and sesamolinol, which help protect body tissues against oxidative damage [5]. The quality and quantity of sesame seed oil are influenced by various factors including climate, soil conditions, plant maturity, and seed variety. The physical and chemical properties of the oil are directly related to its lipid and glyceride composition, which varies depending on the type of sesame seed [6, 7].

The quality of vegetable oils, including sesame oil, is typically assessed using several physical and chemical parameters [6, 7]. Certain oils, such as olive oil and roasted sesame oil, are recognized for their health benefits, increasing consumer demand. However, fluctuations in production costs and availability of plant sources affect the prices of these oils, sometimes leading to the presence of blended oils in the market. Reliable methods to detect adulteration are essential to prevent economic loss, mislabeling, and unfair trade [8].

*Sesamum indicum* and *Sesamum radiatum* seeds exhibit notable tumorigenic, estrogenic, anti-estrogenic, and antioxidant properties compared with other plants. Phytochemically, sesame contains phenolic compounds (phenols, sterols, flavonoids, and lignans), non-protein amino acids, cyanogenic glucosides, alkaloids, unsaturated fats, lipids with multiple double bonds, glucosides, phospholipids, and vitamins E, B1, and B2. Sesame seeds, which are approximately 3-4 mm long, 2 mm wide, and 1 mm thick, are enclosed in pods or capsules and can vary in color from white, buff, tan, gold, brown, reddish, gray, to black [8].

Differences in the fatty acid composition of sesame seed oils can be attributed to genetic diversity, climate, oil-processing methods, and harvest conditions. Chemical analyses of seeds from two local cultivars (dark and white) of sesame (*Sesamum indicum* L.) include physicochemical characteristics, such as specific gravity, refractive index, acidity, peroxide value, iodine number, saponification number, and unsaponifiable matter [9].

Sesame is gaining importance as a source of healthy edible oils and high-quality protein for human nutrition. While sesame seeds are primarily used for oil extraction, they are also utilized for other consumption purposes [9]. The seed itself is the main source of oil (50-60%), protein (18-25%), carbohydrates (13.5%), and ash (5%) [10]. The fatty acid profile of sesame oil varies with the species of sesame seed [11, 12].

Nutritionally, sesame is an important source of fiber, which acts as an antioxidant, facilitates digestion, reduces cholesterol levels in food, and supports cholesterol secretion in the liver. It also contains metal salts, approximately 17.73% protein, 50% fat, and vitamins. Despite its nutritional importance, particularly in regions such as Yemen, limited scientific research has been conducted on locally produced sesame oil.

Although sesame oil is nutritionally important, especially in areas such as Yemen, little scientific research has focused on locally produced sesame varieties.

Although sesame oil exhibits nutritional and therapeutic properties, the fatty acid profile of locally produced sesame oil is unknown.Most local consumption relies on imported sesame seeds, and local sesame production faces challenges, such as high production costs, poor marketing, and limited technological advancement. Moreover, while some studies have evaluated antimicrobial properties and general sesame oil characteristics, comprehensive assessments of the oil quality, composition, and potential health benefits of local cultivars remain insufficiently explored. This gap hinders the ability to optimize local sesame cultivation and processing, improve product quality, and develop effective marketing strategies to enhance local industry competitiveness and meet domestic demands. The objectives of this study were to identify the physicochemical properties and fatty acid profiles of oils extracted from two local sesame cultivars (dark and white) (Sesamum indicum L).

## 2. MATERIALS AND METHODS

### 2.1. Instruments

Rotary Evaporator Tokyo Rikakikai (Japan), FT1R (Spectrum GX, Perkin Elmer), and Gas Chromatography-Flame Ionization Detector (GC-FID): A Shimadzu (Tokyo, Japan) GC 2010 (GC/FID) system equipped with a DB wax polyethylene glycol (PEG) capillary column 60m × 0.25 mm ID, film thickness 0.25µm (J & W Scientific, Folsom, CA, USA). Helium gas (purity >99.99%) was used as the carrier gas at a flow rate of 1.0 ml/min.

### 2.2. Sample Collection

#### *2.2.1. Sampling Area*

Sesame seed samples were collected from two distinct locations in Yemen: Al-Manin Farm, situated in Bilad Bais, Al Wadi District, Ma'rib Governorate, and Bin Dhabya Farm, located in Al-Sa'dah, Ghayl Bawazir District, Hadhramaut Governorate.

#### *2.2.2. Sample Treatments*

The sesame seeds were initially sun-dried for three days to reduce moisture content. Subsequently, the seeds were de-hulled and further dried at a high temperature of 100–105 ℃ for 30 minutes to ensure complete drying. After drying, the seeds were ground into a fine powder before oil extraction. Figure 1 illustrates the sesame tree, seeds, powdered form, and extracted oil.

### 2.3. Chemicals and Reagents

All chemicals and solvents were used as received without further purification. The reagents included carbon tetrachloride (99.5% v/v), hydrochloric acid (36.5% w/w), potassium iodide (99.5%), and sodium sulfate (99%). Wij's solution, a mixture of iodine and potassium iodide used for determining the iodine value, cyclohexane (99.7% v/v), sodium thiosulfate (99% w/w), n-hexane (99% v/v), and phenolphthalein, was all procured from Sigma-Aldrich.

### 2.4. Oil Extraction Procedure

Crude oil was extracted from powdered sesame seeds using a Soxhlet apparatus with n-hexane as the solvent [13]. Thirty grams of dried, powdered seeds were placed in the Soxhlet extractor and extracted with 200 mL of n-hexane for 3 hours. Following extraction, the solvent was removed using a rotary evaporator, and the extracted oil was further dried in an oven at 50 ℃ for 4 hours to eliminate residual solvent. The weight of the dried oil was then measured and used to calculate the oil content.

## 2.5. Chemical Characteristics Analysis

### 2.5.1. Determination of Free Fatty Acids (FFA%) and Acid Value (AV)

The acid value (AV) of the sesame seed oil was determined following the American Oil Chemists Society (AOCS) official method Ca 5a-40 [14]. Initially, 50 mL of isopropanol and 0.5 mL of phenolphthalein indicator were placed in a flask and neutralized by titration with 0.1 N sodium hydroxide (NaOH) until a persistent pink color appeared. This neutralized isopropanol solution was then added to 5 g of ground sesame seeds in an Erlenmeyer flask. The mixture was heated to 40 ℃ with continuous stirring until the sample was completely dissolved. Subsequently, the solution was titrated with 0.1 N NaOH until a faint pink endpoint was reached, using phenolphthalein as the indicator. The percentage of free fatty acids (FFA%) and the acid value (AV) were calculated using Eq. (1) and Eq. (2):

$$\%\ \textbf{FFA as oleic acid} = \frac{\mathbf{28.2 \times N \times V}}{\mathbf{W}} \tag{1}$$

Where $V$ is the volume of NaOH solution used in (ml); $N$ is the normality of NaOH solution in (Eq/L); $W$ is the weight of the sample in g.

$$\textbf{Acid value} = \%\ \textbf{FFA as Oleic Acid} \times \mathbf{2.81} \tag{2}$$

Where 2.81 is the conversion factor for oleic acid.

### 2.5.2. Determination of Iodine Value (I.V.)

Houketchang et. al 2023 [15] studied the iodine value (I.V.) of sesame seed oil using the following procedure. A 0.5 g sample of sesame seed oil was mixed with 15 mL of carbon tetrachloride in a tightly sealed flask. Subsequently, 25 mL of Wijs solution was added, and the mixture was gently shaken until it darkened, then left to stand for 60 minutes in the dark. After this, 20 mL of 10% (w/v) potassium iodide (KI) solution and 150 mL of distilled water were added. The mixture was then titrated continuously with 0.1 N sodium thiosulfate until the iodine color disappeared. A blank sample was treated under the same conditions without the oil. The iodine value was calculated using Eq. (3) as shown below:

$$\mathbf{I.V} = \frac{\mathbf{12.69 \times N(V_b - V_s)}}{\mathbf{W}} \tag{3}$$

Where $N$ is the exact normality of the $Na_2S_2O_3$ solution used equivalent per liter (Eq/L), $V_b$, $V_s$ is the volume in milliliters of $Na_2S_2O_3$ solution used for the blank test and sample, respectively, $W$ is the weight in (g) of the sample, and 12.69 is used to convert equivalent thiosulphate to g iodine.

### 2.5.3. Determination of Saponification Value

To estimate the saponification value (S.V.) of the sesame seed oil, a 2 g sample of the oil was placed in a flask containing 15 mL of 0.1 N alcoholic potassium hydroxide (KOH) solution. The flask was connected to a condenser, and the mixture was refluxed in a water bath for 60 minutes. After refluxing, 0.5 mL of 1% phenolphthalein solution was added as an indicator. The excess alkali was then titrated with 0.1 M hydrochloric acid (HCl). A blank titration was performed under the same conditions for reference [16, 17]. The saponification value was calculated using Eq. (4).

$$\mathbf{S.V} = \frac{\mathbf{56.1 \times N\,(V_b - V_s)}}{\mathbf{W}} \tag{4}$$

Where, $V_b$ = ml of titrant used for blank; $V_s$ = ml of titrant used for sample; $W$ = weight of the sample (g); N = normality of the KOH Eq/l.

## 2.6. Physical Characteristics Analysis

### 2.6.1. Refractive Index

The refractive index of sesame oil was determined according to the American Oil Chemists Society (AOCS) Official Method Cc 7-25 [9]. Measurements were performed using a TAGO Co. Ltd. refractometer at a controlled temperature of 26 ℃.

### 2.6.2. Moisture Content

The moisture content of Sesame seeds was measured according to the Das, M method using an MX-50 moisture analyzer [18]. Approximately 5g of the sample was weighed into a moisture dish and dried in the moisture analyzer for 30 min. at 101℃. the moisture content was calculated by differences.

### 2.6.3. Viscosity

The viscosity of sesame seed oil was measured using a Brookfield model RV DV-I+ viscometer (U.S.A.) equipped with spindle number 5. The measurement was conducted at 26 ℃, with the viscometer maintained at a rotational speed of 100 rpm for 1 minute. Viscosity values were recorded directly in centipoises (cP) from the instrument's display. This method follows established protocols for accurate and repeatable viscosity determination of oils [19, 20].

### 2.6.4. Density and Specific Gravity

The density of sesame oil was measured using a scientific digital balance. One milliliter of oil was carefully placed on the balance, and its weight was recorded at room temperature [21, 22]. The specific gravity was then calculated using the Lund relationship, defined as the ratio of the density of the oil to the density of water,

**Figure 1.** The Sesame Plant, Seeds, Powder, and Oil.

expressed by Eq. (5):

$$\text{Specific Gravity} = \frac{\text{Density of sesame oil}}{\text{Density of water}} \quad (5)$$

#### 2.6.5. Fourier Transform Infrared Spectroscopy Analysis Results

The FTIR spectrum of sesame oil was recorded following the method described by Osman et al. [23]. Measurements were performed using a Perkin Elmer Spectrum GX spectrophotometer over the wavenumber range of 4000 to 500 cm$^{-1}$.

#### 2.6.6. Analysis Results of Fatty Acid Composition

The fatty acids of the sesame oil samples were methylated, and the analysis of FAMEs was performed by dissolving 100 mg of the extracted oil with 5 mL n-hexane in a polypropylene tube, then adding 100 $\mu$L of 2N alcoholic sodium hydroxide and shaking by hand for 30 seconds. Then, the mixture was centrifuged at 3500 rpm for 5 min. 1 $\mu$L of clear supernatant was injected into the GC system at split mode in a ratio of 1:10. The GC system was set as follows: The temperature program was set up from 50 to 240 ℃ at a temperature ramp of 10 ℃/min (hold 25 min.), and the detector temperature was 280 ℃. The identification of FAMEs was performed by comparison with the retention time of standard compounds [24].

## 3. RESULTS AND DISCUSSION

### 3.1. Oil Extraction Yelid

The oil yield extracted from sesame seeds cultivated in Marib was 48.0%, while that from Hadramaut seeds was 47.5%. Statistical analysis indicated no significant difference between the two samples. However, the oil yields obtained in this study were lower than those reported for Malaysian sesame seeds extracted by solvent extraction, which reached up to 60% [25]. Whereas Yemeni *Moringa oleifera* seeds yielded only 28.34% by the same method. This significant difference underscores the efficiency and commercial viability of sesame oil, likely due to its oil-rich composition that is well-suited for extraction [26].

### 3.2. Physicochemical Characteristics

Table 1 summarizes the physico-chemical characteristics of sesame seed oil samples obtained from two Yemeni regions: Marib and Hadhramaut.

The refractive index measured at 26 ℃ was 1.461 ± 0.01 for the Marib sample and 1.477 ± 0.01 for the Hadhramaut sample. The higher refractive index in the Hadhramaut oil suggests a greater number of carbon atoms in its fatty acid chains, reflecting subtle compositional differences between the two oils. Moisture content, determined at 101 ℃, was 0.140 ± 0.01% for Marib and notably lower at 0.015 ± 0.01% for Hadhramaut oil. This variation may be attributed to differences in seed processing or environmental factors affecting seed drying. Density values at 28 ℃ were 0.871 ± 0.02 g/ml for Marib and 0.863 ± 0.02 g/ml for Hadhramaut samples. Corresponding specific gravities were 0.9442 ± 0.03 and 0.951 ± 0.03, respectively. These minor differences align with variations in fatty acid profiles and oil composition. Viscosity measurements at 28 ℃ revealed values of 31.75 cp for Marib and 29.72 cp for Hadhramaut oils. Both values exceed those reported in previous studies obtained by Sher, H et.al [27], indicating a relatively higher resistance to flow and potentially greater oil stability.

The statistical analysis a t-test, was used to compare the physicochemical characteristics between the two regions (Marib and Hadramaut). The results indicated no significant difference ($p < 0.05$) between the chemical properties of the two samples. The acid value (AV), an indicator of free fatty acid content and oil degradation, was higher in Marib oil (7.41 ± 0.04 mg NaOH/g) compared to Hadhramaut oil (2.65 ± 0.02 mg NaOH/g). The iodine value (IV), reflecting the degree of unsaturation, was comparable between samples: 99.41 ± 0.1 mg I2/100g for Marib and 99.92 ± 0.03 mg I2/100g for

**Table 1.** Physicochemical Properties of Tested Sesame Oil Samples

| Characteristic | Units | Sesame cultivated in Marib | Sesame cultivated in Hadhramaut |
|---|---|---|---|
| **FFA (as oleic acid)** | % | 3.38±0.01 | 1.21±0.03 |
| **Acid value (AV)** | mg NaOH/g | 7.41±0.04 | 2.65±0.02 |
| **Iodine value (IV)** | g/100 g | 99.41±0.1 | 99.92±0.03 |
| **Saponification value (SV)** | mg KOH/g | 197.75±0.5 | 195.93±0.4 |
| **Refractive index (R.I)** | - | 1.461 | 1.477 |
| **Moisture content** | % | 0.140±0.01 | 0.015±0.001 |
| **Density** | g/ml | 0.871±0.02 | 0.863±0.02 |
| **Specific gravity (S.g)** | g/ml | 0.951±0.03 | 0.944±0.01 |
| **Viscosity** | Cp | 31.75 | 29.72 |

Hadhramaut. These values indicate a balanced unsaturated fatty acid content consistent with high-quality edible oils. Saponification values (SV), which relate to the average molecular weight of fatty acids, were 197.75 ± 0.5 mg KOH/g for Marib and 195.93 ± 0.4 mg KOH/g for Hadhramaut. These results fall within typical ranges reported for sesame oils, confirming their suitability for nutritional and industrial applications [28]. Overall, these results are consistent with established oil specification ranges, confirming the quality and characteristic properties of Yemeni sesame seed oils from both regions.

## 3.3. FTIR Analysis Results

Fourier Transform Infrared (FTIR) spectroscopy is a powerful analytical technique for identifying the functional groups present in sesame seed oil. The FTIR spectra of vegetable oils, including sesame oil, are typically characterized by prominent absorption bands associated with triacylglycerols (TAGs) [23], which are the primary constituents of these oils. In this study, the FTIR spectra of sesame oil samples from two different sources were recorded in the range of 4000 to 500 $cm^{-1}$, as shown in Figure 2. The analysis revealed several characteristic peaks corresponding to key functional groups, which are summarized in Table 2. Notably, weak absorption peak at 3010$cm^{-1}$ **corresponding to aliphatic bending vibration $\nu$C = C**, strong absorption bands were observed around 2923 and 2853$cm^{-1}$, indicative of C–H stretching vibrations in aliphatic chains, and a distinct peak near 1745 $cm^{-1}$, attributed to the C=O stretching of ester groups. The peak at 1464 $cm^{-1}$ was ascribed to scissoring and bending for methylene C-H. The peaks at 1250-1162 $cm^{-1}$ was linked to C-O stretching vibrations. The peak band at 725 $cm^{-1}$ is characterized by C-H stretching. This indicates the presence of alkanes. Additional peaks in the fingerprint region further confirmed the presence of structural features typical of triacylglycerols. Overall, the FTIR results demonstrate that both sesame oil samples possess the essential functional groups associated with high-quality vegetable oils, supporting their purity and compositional integrity.

## 3.4. Fatty Acids Composition Results

The fatty acid composition of seed oils varies widely among different plant species. Unsaturated fatty acids (USFAs) have a more favorable effect and a greater health benefit than saturated fatty acids (SFAs) [29]. A key indicator of the nutritional quality of sesame seed oil, which primarily belongs to the oleic–linoleic acid group [30].

Methylation is a common method used to prepare fatty acid methyl esters (FAMEs) from glycerolipids, typically involving base-catalyzed trans-esterification [31, 32]. In this study, the fatty acid composition of sesame seed oil is detailed in Table 3. FAME peaks were identified and quantified by comparing their peak areas and retention times with those of standard methyl esters.

Sesame seed oil contains three main types of fatty acids: saturated fatty acids (Cn:0), monounsaturated fatty acids with one double bond (Cn:1), and polyunsaturated fatty acids with two double bonds (Cn:2). It is evident that sesame seed oil comprises both saturated and unsaturated fatty acids. The unsaturated fatty acids mainly include linoleic acid, oleic acid, eicosanoic acid, palmitoleic acid, and erucic acid, although the saturated fatty acids primarily consist of palmitic acid, stearic acid, arachidic acid, and behenic acid. Table 3 presents the percentages of these fatty acids in sesame oil extracted from seeds cultivated in different regions of Yemen.

The fatty acid composition of sesame seed oil from the Hadhramaut and Marib regions of Yemen closely matches the results reported in previous studies. In all cases, oleic and linoleic acids are the predominant fatty acids, together constituting over 82% of the total fatty acid content, which is characteristic of high-quality sesame oil. The Hadhramaut sample showed a slightly higher proportion of unsaturated fatty acids (84.39%) compared to Marib (84.16%) and the previous study (82%) [33], indicating a marginal regional variation that may be attributed to environmental or genetic factors. Conversely, the Marib sample had a total saturated fatty acid content (15.61%) close to Hadhramaut (15.84%), which is lower than the previous study (16.46%). Minor fatty acids such as palmitoleic, eicosenoic, and erucic

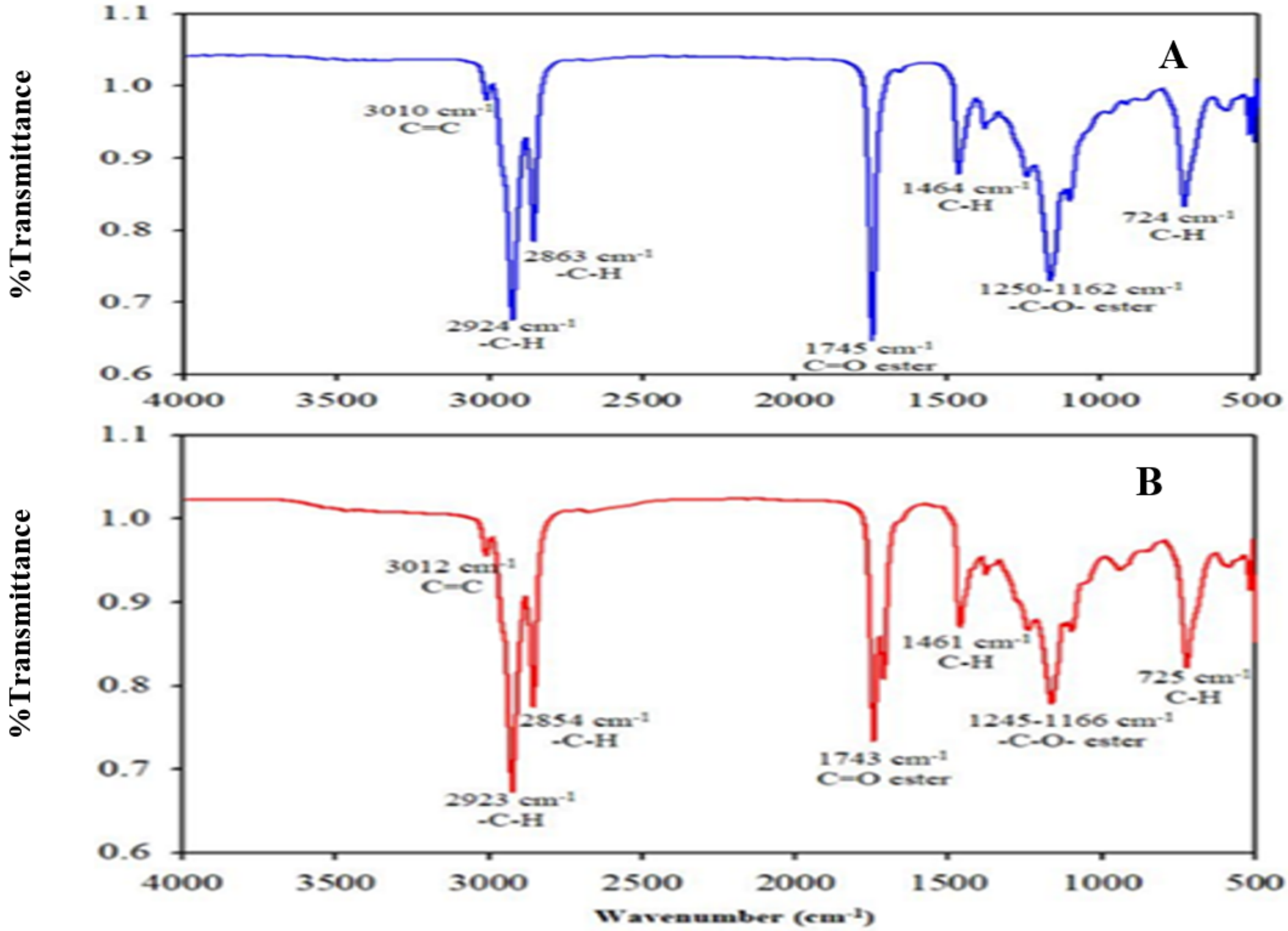


**Figure 2.** FTIR Spectrum of Sesame Seeds Oil (A) of Maribi and (B) of Hadrmi Coast.

**Table 2.** FTIR of The Functional Groups of Sesame Seed Oil

| Functional Group | Wavenumber ($cm^{-1}$) | |
|---|---|---|
| | Sesame Cultivated in Marib | Sesame Cultivated in Hadhramaut |
| aliphatic bending vibration $\nu C = C$ | 3010 | 3012 |
| aliphatic stretching vibration $\nu C - H$ | 2924,2863 | 2923,2854 |
| stretching vibration ester $\nu C = O$ | 1745 | 1743 |
| scissoring and bending for methylene $\nu C - H$ | 1464 | 1461 |
| Stretching vibration ester $\nu C - O$ | 1250-1162 | 1245-1166 |
| Vibration aliphatic $\nu C - H$ | 724 | 725 |

acids were present in low concentrations across all samples, consistent with earlier findings. These results confirm that Yemeni sesame seed oil maintains a favorable nutritional profile, with a high proportion of unsaturated fatty acids, supporting its recognized health benefits and nutritional value.

The levels of palmitic acid (C16:0) and stearic acid (C18:0) in Yemeni sesame oil are comparable to those found in oils from Turkey and Ethiopia. For example, the palmitic acid content in Yemeni oil (9.47–10.16%) falls within the range reported for Turkey (8.49–10.26% [34]; 9.13–10.88%) [35] and Ethiopia (8.33–10.15%) [36]. In contrast, samples from India (12.20–16.00%) [37] exhibit significantly higher concentrations. A similar trend is observed for stearic acid, with values from Yemen (4.78–5.25%) aligning with those from Turkey (4.79–6.21%) [**36**] and Ethiopia (5.34–7.00%) [36], but lower than those reported from India (7.05–9.42%) [37].

The most pronounced differences are observed in the unsaturated fatty acids, oleic acid (C18:1) and linoleic acid (C18:2). Yemeni samples contain relatively low levels of oleic acid (38.60–40.65%) and high levels of linoleic acid (42.06–44.65%). This linoleic acid-dominant profile is consistent with findings from Turkey [34, 35] and Ethiopia [36]. In contrast, Indian samples display the opposite trend, with higher oleic acid content (39.88–48.81%) and lower linoleic acid content (31.84–41.73%) [37].

**Table 3.** Profile of Fatty Acid (%) of Sesame Seed Oil

| No | Fatty acids | Molecular formula | Percentage (%) | | |
|---|---|---|---|---|---|
| | | | Sesame Cultivated in Hadhramaut | Sesame Cultivated in Marib | Previous study [33] |
| 1 | Palmitic Acid (16 : 0) | $C_{16}H_{32}O_2$ | 9.47±0.05 | 10.16±0.05 | 10.44 |
| 2 | Stearic Acid (18 : 0) | $C_{18}H_{36}O_2$ | 4.78±0.09 | 5.25±0.09 | 6.29 |
| 3 | Arachedic Acid (20 : 0) | $C_{20}H_{40}O_2$ | 0.48±0.009 | 0.18±0.005 | 1.20 |
| 4 | Behenic Acid (22 : 0) | $C_{22}H_{44}O_2$ | 0.88±0.02 | 0.25±0.01 | ND |
| Total saturated fatty acids | | | 15.61 | 15.84 | |
| 5 | Palmitoleic Acid (16: 1) | $C_{16}H_{30}O_2$ | 0.16±0.009 | 0.16±0.005 | ND |
| 6 | Oleic Acid (18 : 1) | $C_{18}H_{34}O_2$ | 38.60±0.12 | 40.65±0.12 | 36.31 |
| 7 | Eicosenoic Acid (20 : 1) | $C_{20}H_{38}O_2$ | 0.16±0.008 | ND | ND |
| 8 | Erucic Acid (22:1) | $C_{22}H_{42}O_2$ | 0.5 ± 0.025 | 0.4 ± 0.01 | ND |
| 9 | Linoleic Acid (18 : 2) | $C_{18}H_{32}O_2$ | 44.65±0.02 | 42.06±0.02 | 45.69 |
| 10 | Gamma-Linolenic Acid (C18:3n6) | $C_{18}H_{30}O_2$ | 0.26±0.002 | 0.31±0.003 | ND |
| 11 | Alpha-Linolenic Acid (C18:3n3) | $C_{18}H_{30}O_2$ | ND | 0.58±0.02 | ND |
| Total unsaturated fatty acids | | | 84.39 | 84.16 | |

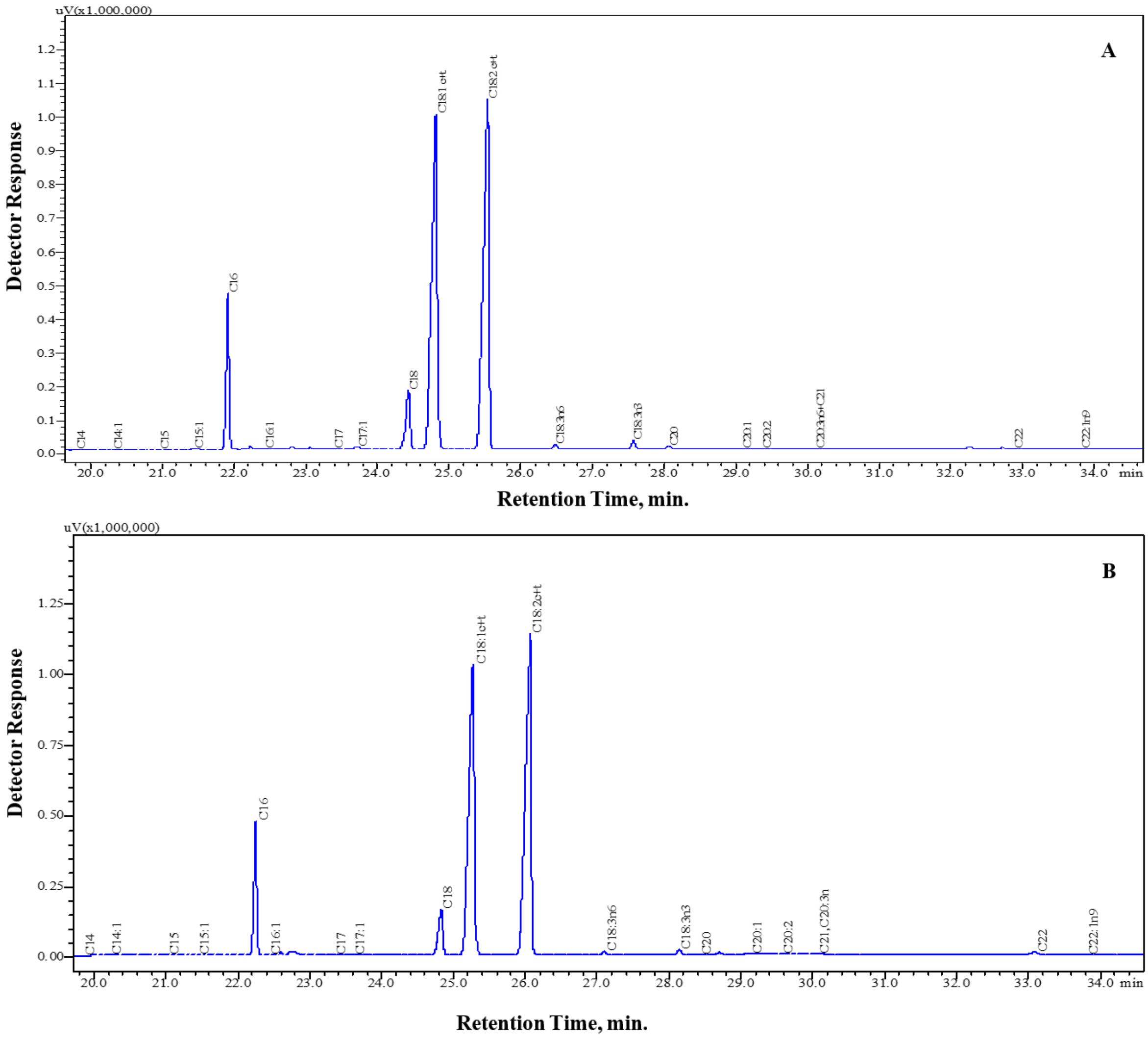


**Figure 3.** Fatty Acids Profile of Sesame Seeds Oil (A) Maribi and (B) Hadrmi,the GC parameters were (temperature programming 50 to 240°C at 10°C min$^{-1}$ (hold 25 min), injected volume 1$\mu$L in the split mode (1:10), Injector and detector temp. were 280°C). The chromatograms were obtained with a 60-m × 0.25-mm id × 0.25-$\mu$m DB-wax column.

Overall, the fatty acid profile of sesame oil from Yemen closely resembles that of oils from Turkey and Ethiopia, with linoleic acid as the predominant component, followed by oleic acid. The distinctive profile of Indian sesame oil—characterized by elevated oleic and reduced linoleic acid levels—suggests potential variation due to cultivar differences, environmental conditions, climate, or soil type.

Future research on sesame oil in Yemen could explore the impact of sesame oil quality on the local market. Investigating how variations in quality standards, processing methods, and adulteration practices affect consumer trust and market prices would be valuable. Another area for future study is the availability of active investment in Yemen's sesame industry. This research could analyze the potential for attracting both local and international investors by examining the economic policies and logistical infrastructure necessary to support large-scale production and export. A comprehensive study could also assess the feasibility of implementing new technologies to improve efficiency and quality, ultimately enhancing Yemen's position in the global sesame market.

## 4. CONCLUSION

This study revealed that the physicochemical properties of sesame oil from two samples cultivated in the Marib and Hadramaut regions of Yemen were consistent with those reported in previous studies conducted in the same areas. GC-FID analysis showed that the predominant fatty acids in the sesame oil extracted from these seeds are linoleic acid, oleic acid, palmitic acid, stearic acid, and arachidic acid. These findings contribute valuable information on the quality and composition of locally produced sesame oil. The high proportion of unsaturated fatty acids supports its nutritional value and potential for improving public health. Moreover, this study highlights the commercial and industrial potential of Yemeni sesame oil, especially if supported by improved local processing technologies. Future research is encouraged to explore the optimization of oil extraction methods, the effect of environmental conditions on oil stability, and implications for local market competitiveness.

## ACKNOWLEDGMENTS

The authors would like to thank Sana'a University and Hadhramaut University, especially the College of Environmental Sciences - Hadhramaut University.

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