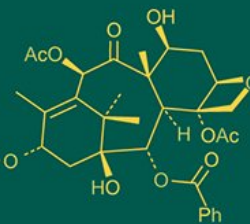
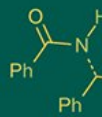


## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; SP-10(8): 484-493  
[www.biochemjournal.com](http://www.biochemjournal.com)  
Received: 08-06-2026  
Accepted: 10-07-2026

**Kathyayini HS**  
Ph.D. Scholar, Department of  
Processing and Food  
Engineering, College of  
Agricultural Engineering,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

**Dr. Udaykumar Nidoni**  
Professor and Head, Department  
of Processing and Food  
Engineering, College of  
Agricultural Engineering,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

**Dr. PF Mathad**  
Professor, Department of  
Processing and Food  
Engineering, College of  
Agricultural Engineering,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

**Dr. Ramappa KT**  
Associate Professor, Department  
of Processing and Food  
Engineering, College of  
Agricultural Engineering,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

**Dr. Lakmikanth M**  
Assistant Professor, Department  
of Soil Science (Biochemistry),  
College of Agricultural Sciences,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

**Dr. Vikas Kulkarni**  
Principal Scientist and Head,  
Department of Genetics and  
Plant Breeding, MARS, Raichur,  
Karnataka, India

**Corresponding Author:**  
**Kathyayini HS**  
Ph.D. Scholar, Department of  
Processing and Food  
Engineering, College of  
Agricultural Engineering,  
University of Agricultural  
Sciences, Raichur, Karnataka,  
India

## Investigating the physicochemical parameters of pure edible oils and adulterants

**Kathyayini HS, Udaykumar Nidoni, PF Mathad, Ramappa KT, Lakmikanth M and Vikas Kulkarni**

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8Sf.9474>

### Abstract

This study investigated the physicochemical properties of various pure edible oils (mustard oil and coconut oil) and adulterants (argemone, mineral, castor and palm oils) to establish distinct characteristic profiles. Physicochemical analysis revealed distinct differentiating characteristics for each oil type. Mustard oil was characterized by high iodine and erucic acid values, coconut oil by high saponification and lauric acid and castor oil by high ricinoleic acid and viscosity. Significantly, mineral oil's complete absence of fatty acids reliably marked its non-edible nature. These findings underscore the effectiveness and reliability of routine physicochemical analysis as a fundamental tool for distinguishing pure edible oils from potential adulterants, thereby supporting quality control, ensuring product authenticity and safeguarding consumer health.

**Keywords:** Edible oil, fatty acids, adulterants, quality, health

### Introduction

Vegetable oils are essential to our daily diets and also plays a fundamental role in feeding the world as well as shaping cooking practices everywhere. Primarily extracted from various plant seeds, these oils form a substantial part of what people eat globally, with an estimated 218.20 million tonnes produced in 2021-2022. Beyond their widespread culinary applications, edible oils are rich in essential fatty acids and fat-soluble vitamins (e.g., A, D, E, K), playing a crucial role in human nutrition, cellular membrane maintenance, cholesterol metabolism and overall physiological well-being (Kumar *et al.*, 2018) [1]. Despite their vital role and health benefits, growing global demand and high market value have unfortunately made edible oils prone to widespread adulteration. This illicit practice involves substituting pure, often expensive, oils with cheaper, inferior, or even toxic alternatives, posing a severe threat to public health and economic integrity.

Adulteration is a global concern, particularly pronounced in developing countries like India, where a significant portion of edible oils is sold in loose or unpackaged forms, increasing consumer vulnerability to fraudulent practices. The health consequences of consuming adulterated oils are diverse and alarming. They range from mild allergic reactions and high cholesterol levels to severe conditions such as liver damage, kidney dysfunction and an increased risk of cardiovascular diseases and cancer (Mukherjee and Mitra, 2009) [2]. Specific examples of adulteration highlight these dangers: mustard oil adulterated with argemone oil can cause epidemic dropsy, glaucoma and even vision loss, while mineral oil adulteration is linked to liver damage and cancer. Furthermore, the substitution of edible oils with karanja oil can lead to liver and heart problems and cottonseed oil adulteration has been associated with infertility due to gossypol (Pal and Jain, 2018) [3]. Addressing this critical issue, regulatory bodies, such as the Food Safety and Standards Authority of India (FSSAI), have implemented guidelines for edible oil quality, including permissible blending of certain vegetable oils under strict labelling requirements (Choudhary *et al.*, 2015) [4].

Quality in a product signifies its level of excellence, often defined by established grades, standards and specifications. For edible oils, this quality is paramount, as it directly dictates their suitability for various applications, particularly human consumption. The intrinsic characteristics of any oil are reflected through numerous physicochemical properties, which collectively provide insights into both its nutritive value and physical attributes.

In the context of quality control, key parameters are precisely assessed. These typically include moisture content, refractive index, viscosity, color, free fatty acid content, saponification value, peroxide value, acid value and iodine value. Such properties are crucial for determining the shelf-life, stability and ultimately, the economic value of the oil. Beyond these analytical measurements, the sensory profile of an oil also serves as a multifaceted indicator, providing a comprehensive assessment of its overall quality (Wazed *et al.*, 2023) [5].

However, a significant challenge in combating adulteration lies in the inherent similarities in physicochemical properties between pure edible oils and possible adulterants. Some current analytical methods are employed for detecting edible oil adulteration, including traditional chemical tests are Halphen's test, Baudouin test, Holde's test etc., in which some of tests we have conducted in our study. Consequently, it is imperative to determine the quality of commercially available edible oils to ensure their suitability for human consumption. Hence, this research aims to systematically investigate the distinct physicochemical parameters of various pure edible oils and possible adulterants.

## 2. Materials and Methods

### 2.1. Raw materials

The freshly extracted, cold-pressed edible oils and adulterants (mustard oil, coconut oil, castor oil, mineral oil, palm oil, and argemone oil) required for conducting experiments were extracted directly from the cold press in the Department of Processing and Food Engineering, College of Agricultura Engineering, UAS, Raichur, Karnataka. For this study, mustard oil and coconut oil were selected as edible oils while the other oils like argemone oil, mineral oil, castor oil and palm oil were taken as adulterants. All chemicals and reagents required for physicochemical analyses were procured from AR Scientific supplies, Raichur.

### 2.2. Sample preparation

After extraction, all oil samples were immediately transferred to amber, airtight glass bottles and stored in the dark at a controlled ambient temperature (25  $\pm$  0C). This prevented oxidation and degradation prior to physicochemical analysis. The freshly extracted pure edible oils and adulterants were filtered before direct use. Distilled water was used for all experimental procedures.

### 2.3. Methods

Pure edible oils and their adulterants were characterized for various physicochemical parameters, such as specific gravity, viscosity, color, moisture content, refractive index, flash and fire points, rancidity, free fatty acids, peroxide value, acid value, iodine value, saponification value, and fatty acid composition, by adhering to the subsequent protocols.

#### 2.3.1. Specific gravity and viscosity

Specific gravity was determined as the ratio of an oil's density to that of water at a specified temperature. The measurement was performed using a pycnometer (AOAC, 2021c ; Nduka *et al.*, 2021) [6, 7]. The pycnometer was first cleaned, dried and weighed empty. It was then filled with deionized water at 20  $\pm$  0C, equilibrated in a 30  $\pm$  0C water bath for 30 min. and reweighed. The same procedure was

repeated with the oil sample at 30  $\pm$  0C ensuring no air bubble entrapment during filling. Specific gravity was calculated using Equation 1.

$$\text{Specific gravity at } 30^{\circ}\text{C (g/mL)} = \frac{A - B}{C - B}$$

Where, A = Weight of specific gravity bottle with oil (g); B = Weight of specific gravity bottle (g); C = Weight of specific gravity bottle with water (g)

Viscosity of oil samples was determined at 25  $\pm$  0C using an Anton Paar MCR 102 Rheometer with a parallel plate system (PP 50-1, 50 mm diameter). The temperature was precisely controlled using the integrated thermostatic water bath (15  $\pm$  0C setpoint for the bath). Measurements were conducted at a shear rate range of 0-100s<sup>-1</sup>. After rheometer initialization, oil samples (2 drops) were placed on the plate and viscosity data was acquired (Paul *et al.*, 2021) [8].

#### 2.3.2. Color and moisture content

Oil color was determined using a Lovibond Tintometer by visual comparison with standard Lovibond glasses (Flores *et al.*, 2021; ISI, 1984a) [9, 10]. Oil samples were placed in a specified glass cell and their color matched using sliding red, yellow and blue glasses. The color was reported in Lovibond units, calculated using Equation 2.

$$\text{Color} = (aY + 5b)$$

Where, a = Sum of the yellow slides; b = Sum of the red slides; Y+5R=Mode of expressing the color of oils

Moisture content was determined gravimetrically by heating 10 g oil samples at 105  $\pm$  0C to constant weight and then samples were cooled in a desiccator until successive weight change was noted (Flores *et al.*, 2021) [9]. Moisture content was calculated using Equation 3.

$$\text{Moisture content (\%)} = \frac{W_1}{W} \times 100$$

Where, W<sub>1</sub>=Loss in weight of the material on drying (g); W = Weight of the material taken for test (g)

#### 2.3.3. Refractive Index, Flash and fire point

Refractive index was measured at 40  $\pm$  0C using an Abbe refractometer, temperature-controlled to 0.1  $\pm$  0C using equation 4 (AOAC, 2021d) [11]. The instrument was calibrated with distilled water (1.3306 at 40  $\pm$  0C). Samples were pre-filtered with anhydrous sodium sulfate (2g / 10g sample, 50  $\pm$  0C pre-heated) for dehydration and impurity removal. Readings were taken after 2 min. equilibration post-sample application.

$$R = R_1 + K(T_1 - T)$$

Where R= Refractometer reading (0C) ; R<sub>1</sub> = Reading at T<sub>1</sub> (0C) ; K = Constant (0.000385); T<sub>1</sub> = Temperature at which the reading R<sub>1</sub> is taken (0C); T = Specified temperature (40  $\pm$  0C)

Flash and fire points were determined using a Cleveland open cup tester following (IS 1448, 1970) [12]. Oil samples were heated at 5  $\pm$  0C/min with continuous stirring. The flash point was the lowest temperature causing momentary ignition from a 4.0 mm test flame. Heating continued and the

fire point was the temperature where vapours sustained combustion for at least 5 s.

### 2.3.4. Rancidity and Free fatty acids

Rancidity value an indicator of oxidation was determined by iodometric titration (Equation 5). A 5 g oil sample was dissolved in 30 mL of acetic acid-chloroform mixture. After adding 0.5 mL of saturated potassium iodide, the solution stood for 1 min. in the dark. Liberated iodine was then titrated with 0.1 N sodium thiosulfate using 0.5 mL starch indicator, until the blue color disappeared (AOAC, 2021g).

$$\text{Rancidity (meq / kg)} = \frac{\text{Titre} \times N \times 1000}{\text{weight of sample}}$$

Where, Titre = mL of sodium thiosulphate used; N = Normality of sodium thiosulphate solution Free fatty acid content, indicating hydrolytic rancidity, was determined by titrating a 7 g oil sample with 0.1 M sodium hydroxide (NaOH) solution. The sample was dissolved in 50 mL of neutralized ethanol (with phenolphthalein indicator) by boiling. Titration continued until a pink colour persisted for 30s (AOAC, 2021a). It was calculated using Equation 6.

$$\% \text{ FFA as oleic acid} = \frac{28.2 \times V \times N}{W}$$

Where, V= Volume of sodium hydroxide solution (mL); N= Normality used for titre(N); W= Weight of the sample(g)

### 2.3.5. Peroxide value and Acid value

Peroxide value indicating oil oxidation, was determined by iodometric titration (Equation 7). A 5 g oil sample was dissolved in 30 mL acetic acid-chloroform (3:2) mixture. After adding 1 mL potassium iodide, the solution kept for 1 min. in the dark. Liberated iodine was titrated with 0.01 N sodium thiosulfate (using 1 mL starch indicator) until the blue color vanished (AOAC, 2021g; AOCS, 2003).

$$\text{Peroxide value} = \frac{V \times N}{W} \times 100$$

Acid value indicating free fatty acid content, was determined by titrating an accurately weighed oil sample with a standard alkali solution (KOH or NaOH). The sample was dissolved in 50 mL of freshly neutralized hot ethyl alcohol with 1 mL phenolphthalein indicator. After heating at 75 °C for 15 min. hot mixture was titrated until a light pink colour persisted for 15 s (Equation 8) (AOAC, 2021e) [13].

$$\text{Acid value} = 56.1 \times V \times N / W$$

Where, V= Volume of standard potassium hydroxide or sodium hydroxide used (ml); N = Normality of the potassium hydroxide solution or sodium hydroxide solution; W = Weight of the sample (g)

$$\text{Acid value} = \% \text{ Fatty acid (as oleic)} \times 1.99$$

The acidity is frequently expressed as the percentage of FFA in the sample. The percentage of FFA in most oils and fats is calculated based on oleic acid. However, in coconut oil and palm kernel oil, it is often calculated as lauric acid, in castor oil in terms of ricinoleic acid and palm oil in terms of

palmitic acid. Free fatty acid as oleic acid % by weight =  $28.2 \times V \times N / W$ ; Free fatty acid as lauric acid % by weight =  $20 \times V \times N / W$ ; Free fatty acid as ricinoleic acid % by weight =  $29.8 \times V \times N / W$ ; Free fatty acid as palmitic acid % by weight =  $25.6 \times V \times N / W$

### 2.3.6. Iodine value and Saponification value

Iodine value a measure of oil unsaturation, was determined using the Wijs method (AOAC, 2021b) [14]. An accurately weighed oil sample was dissolved in 25 mL carbon tetrachloride in a 500 mL glassstoppered flask. Then, 25 mL of Wijs solution was added and the mixture stood in the dark for 30 min. (non-drying/semi-drying oils) or 1 h (drying oils). A blank was run concurrently. After reaction, 15 mL potassium iodide and 100 mL distilled water were added. The liberated iodine was titrated with standardized sodium thiosulfate using starch indicator until the blue colour disappeared (Equation 9).

$$\text{Iodine value (g I}_2 \text{ / 100 g oil)} = \frac{12.69 \times (B - S) \times N}{W}$$

Where, B = Volume in mL of standard sodium thiosulphate solution required for the blank; S= Volume in mL of standard sodium thiosulphate solution required for the sample; N =Normality of the standard sodium thiosulphate solution; W = Weight in g of the sample

Saponification value defined as milligrams of KOH needed to saponify 1 g of oil, was determined by refluxing 2 g of dry oil with 25 mL alcoholic KOH solution (ISI, 1984c; Nduka *et al.*, 2021) [10, 7]. A blank was run concurrently. Flasks were gently boiled on a water bath for approximately 1 h until saponification was complete (clear solution, no oily matter). After cooling, excess KOH was titrated with 0.5 N HCl using 1.0 mL phenolphthalein indicator (Equation 10).

$$\text{Saponification value (mg KOH / g oil)} = \frac{56.1 \times (B - S) \times N}{W}$$

Where, B = Volume in mL of standard hydrochloric acid required for the blank; S = Volume in mL of standard hydrochloric acid required for the sample; N = Normality of the standard hydrochloric acid solution; W = Weight of the oil taken for the test (g)

### 2.3.7. Fatty acid composition

Fatty acid composition was determined by Gas Chromatography (GC) after conversion to Fatty Acid Methyl Esters (FAMES) (AOAC, 2021h; AOCS, 2012) [17, 18].

- **FAME Preparation:** Approximately 350 mg of oil was reacted with 6 mL of 0.5 N methanolic sodium hydroxide and 7 mL of boron trifluoride solution. The mixture was refluxed (10 min.) until clear. After adding more boron trifluoride and heptane (boiling for 2 min. and 1 min. respectively) and then sodium chloride solution, 1 mL of the upper heptane layer was collected, treated with anhydrous sodium sulfate and used for GC.
- **GC Analysis and Quantification:** FAMES were analyzed by GC-FID, identified by retention times against standards. Individual FAME response factors ( $K_n$ ) were calculated using Equation 11 and the percentage of each FAME was determined by Equation 12.

$$K_a = A_E \times m_R / A_R \times m_E$$

$$\% \text{ of each FAME} = 100 \times A_{Rn} \times m_E \times K_a / A_E \times m$$

Where,  $A_R$  = Peak area - reference FAME standard - n;  $A_E$  = Peak area - internal FAME standard;  $m_R$  = N ass (mg) - reference FAME standard - n (known);  $m_E$  = M ass (mg) - internal FAME standard (known);  $A_{Rn}$  = Peak area FAME n in the mixture;  $m$  = Mass (mg) - methylated fat/oil

## 2.4. Adulteration tests

### 2.4.1. Detection of castor oil adulteration

The presence of castor oil, characterized by its predominant triglyceride, tricinolein was determined using Thin Layer Chromatography (TLC) based on a modified method from ISI (1984b) [19] and (Anand *et al.*, 2023) [20]. TLC plates were prepared by coating microscopic slides with a 1:2 (w/v) slurry of silica gel G in water. Plates were activated at 110 °C for 1 h and subsequently cooled in a desiccator. For sample preparation, 10 mL of the suspected oil was vigorously shaken with 10 mL of absolute alcohol for 1 min. in a separating funnel. After phase separation, the lower oil layer was discarded and the upper alcoholic extract was collected and concentrated to approximately 2 mL. A 10 µL aliquot of this alcoholic extract, along with a 10 µL aliquot of standard castor oil solution, was spotted onto the activated TLC plate. The plate was then developed in a chromatography tank containing a 1:1 (v/v) mixture of hexane and diethyl ether until the solvent front ascended to 15 cm. Tricinolein were visualized using iodine vapor.

### 2.4.2. Detection of mineral oil adulteration

The detection of mineral oil in edible oils involved two methods: Holde's method (Method A) for rapid screening and TLC/HPTLC (Method B) for confirmation. In this study, mineral oil adulteration was detected using Holde's method, a qualitative test sensitive to concentrations of 1% or more, which is less sensitive in oils with high unsaponifiable matter (AOAC, 2021f; Deepak *et al.*, 2013) [6, 21]. For this test, 1 mL of the oil sample was added to 25 mL of alcoholic KOH solution in a conical flask. The mixture was boiled on a water bath using an air- or water-cooled condenser until clear, with no oily drops visible on the flask sides. The contents were then transferred to a warm, wide-mouthed test tube, and 25 mL of boiling distilled water was added slowly along the sides while lightly shaking. The development of turbidity indicated the presence of mineral oil, with the depth of turbidity correlating to its percentage.

### 2.4.3. Detection of cotton seed oil adulteration

Cottonseed oil adulteration was assessed qualitatively using the Halphen's test, which identifies cyclopropanoid fatty acids characteristic of this oil (Atbhaiya *et al.*, 2022) [22]. This test can detect as low as 0.5% cottonseed oil but may show reduced intensity in oils subjected to high heat, hydrogenation or deodorization. Approximately 5 mL of the oil sample was mixed with an equal volume of sulfur solution (1% sulfur in carbon disulfide in amyl alcohol) in a test tube. The mixture was gently heated on a 70 °C water

bath with shaking until carbon disulfide evaporated and foaming stopped. The tube was then transferred to an oil or brine bath maintained at 115 °C for 2.5 h. The development of a characteristic red color at the end of this period indicated the presence of cottonseed oil.

### 2.4.4. Detection of argemone oil adulteration

Argemone oil was detected via High-Performance Thin-Layer Chromatography (HPTLC), sensitive to 50 ppm (Rogeboz *et al.*, 2024) [23]. Alkaloids were extracted from a 10 mL oil sample by vigorous shaking with 15 mL diethyl ether and 5 mL concentrated hydrochloric acid. The separated acid layer was evaporated to dryness and the residue redissolved in 1 mL of 9:1 (v/v) chloroform:acetic acid. This extract (10 µL) and a 0.1% standard were spotted on TLC/HPTLC plates. Plates were developed 10 cm using either butanol:acetic acid:water or hexane:acetone. Bright yellow/orange-yellow fluorescent spots under UV light with matching R<sub>f</sub> values confirmed argemone oil. A 1% aqueous sodium hydroxide spray yielded blue fluorescence under UV light for additional confirmation.

### 2.4.5. Detection of Karanja (Pongamia glabra) adulteration

Karanja oil was detected by High-Performance Thin-Layer Chromatography (HPTLC), which is sensitive to 0.01% of the oil (Rogeboz *et al.*, 2024) [23]. Furano flavonoids were extracted from a 20 mL oil sample by shaking with 10 mL concentrated hydrochloric acid for 15 min. The separated acid layer was evaporated to dryness and the residue redissolved in 0.5 mL chloroform. This extract and a standard karanja oil extract were spotted on a pre-activated TLC/HPTLC plate. The plate was developed for 20 min. in a solvent system of petroleum ether:diethyl ether:acetic acid (60:40:1, v/v). After drying, the presence of three bluish-green fluorescent spots at R<sub>f</sub> values of 0.34, 0.22 and 0.17 under ultraviolet light confirmed karanja oil.

### 2.4.6. Detection of sesame oil adulteration

The presence of sesame oil was determined using the Baudouin test, which detects sesamol, a characteristic lignan, through a color reaction with furfural in hydrochloric acid (Pardeshi, 2019) [24]. For the analysis, 5 mL of the oil sample was combined with 5 mL of concentrated hydrochloric acid and 0.4 mL of furfural solution in a glass-stoppered measuring cylinder. The mixture was vigorously shaken for 2 min. and then allowed to separate. The development of a pink or red color in the lower acid layer indicated the presence of sesame oil. Confirmation was made by adding 5 mL of water and re-shaking; persistence of the color indicated a positive result.

## 3. Results and Discussion

### 3.1. Physicochemical properties of edible oils and adulterants

#### 3.1.1. Physicochemical properties of mustard oil (1<sup>st</sup> main edible oil)

**Table 1:** Physicochemical properties of Mustard oil

| Particulars                                                      | Results                                                 | Standard specification | Remarks      |
|------------------------------------------------------------------|---------------------------------------------------------|------------------------|--------------|
| Specific gravity                                                 | 0.90                                                    | 0.907 - 0.910          | Within limit |
| Viscosity (mPa.s)                                                | 55.00                                                   | 35.5 - 64.0            | Within limit |
| Colour (on Lovibond scale in 1/2" cell expressed as Y+5R), units | 24.00                                                   | 50.00                  | Within limit |
| Moisture (%)                                                     | 0.13                                                    | 0.20                   | Within limit |
| Organoleptic test (taste and flavor)                             | Characteristic                                          | Pass                   | Passes       |
| Visual clear (clarity) at 20°C                                   | Free from sediments, suspended matter, separated matter | Shall be clear         | Passes       |
| Refractive index at 40°C                                         | 1.46                                                    | 1.4650 - 1.4660        | Within limit |
| Flash point (°C)                                                 | 310.00                                                  | Above 250.00           | Within limit |
| Fire point (°C)                                                  | 350.00                                                  | Above 248.89           | Within limit |
| Rancidity                                                        | Free from any rancidity                                 | Free from rancidity    | Passes       |
| FFA-free fatty acids (%)                                         | 1.52                                                    | 3.00                   | Within limit |
| Peroxide value (mg/kg)                                           | Nil                                                     | 4.29                   | Within limit |
| Acid value                                                       | 1.50                                                    | 6.90                   | Within limit |
| Iodine value                                                     | 107.37                                                  | 96 - 112               | Within limit |
| Saponification value                                             | 170.140                                                 | 166 - 177              | Within limit |
| Palmitic acid (%)                                                | 10.840                                                  | Pass                   | Passes       |
| Stearic acid (%)                                                 | 2.100                                                   |                        |              |
| Oleic acid (%)                                                   | 36.020                                                  |                        |              |
| Linoleic acid (%)                                                | 22.520                                                  |                        |              |
| Linolenic acid (%)                                               | 8.100                                                   |                        |              |
| Arachidic acid (%)                                               | 0.950                                                   |                        |              |
| Behenic acid (%)                                                 | 0.800                                                   |                        |              |
| Erucic acid (%)                                                  | 11.690                                                  |                        |              |
| Lignoceric acid (%)                                              | 0.790                                                   |                        |              |
| Adulterations tests                                              |                                                         |                        |              |
| Castor oil test                                                  | Negative                                                | Negative               | Negative     |
| Mineral oil test                                                 | Negative                                                | Negative               | Negative     |
| Cottonseed oil test                                              | Negative                                                | Negative               | Negative     |
| Argemone oil test                                                | Negative                                                | Negative               | Negative     |
| Karanja oil test                                                 | Negative                                                | Negative               | Negative     |
| Baudouin test                                                    | Negative                                                | Negative               | Negative     |

The quality of mustard oil was extensively evaluated focusing on its physicochemical properties, fatty acid composition and adulterants (Table 1). It was found that the mustard oil's specific gravity (0.90) was consistent with typical vegetable oils. However, its viscosity (55.00 mPa.s) was slightly higher, likely due to its unique triglyceride composition and fatty acid saturation (Kim *et al.*, 2010) <sup>[25]</sup>. High mustard oil quality was evident from the Lovibond color value (24.00 units), low moisture content (0.13%) and favourable organoleptic properties. The oil was visually clear (Sharma *et al.*, 2009) <sup>[26]</sup> and had a refractive index of 1.46. Safety parameters, including flash point of 310 °C and fire point of 350°C, were within safe ranges for handling and storage (Selvan *et al.*, 2017) <sup>[27]</sup>. Chemical analysis confirmed freshness and edibility. The free fatty acid content (1.52%) was low (Sharma *et al.*, 2009) <sup>[26]</sup> and a peroxide value indicated no significant oxidation, which is vital for health (Lobo *et al.*, 2010; Orhevba and Efomah, 2012) <sup>[28, 29]</sup>. Both acid value (1.50) and saponification value (170.14) met established standards for edible oils. The iodine value (107.37) also indicated its degree of unsaturation in the oil, based on the addition of iodine to the double bonds of unsaturated fatty acid chains (Sharma *et al.*, 2009) <sup>[26]</sup>. The fatty acid profile revealed substantial oleic (36.02%), linoleic (22.52%) and linolenic acid (8.10%) from the omega-3 family. Linoleic acid is an essential fatty acid crucial for maintaining skin integrity, cell membranes,

immune system function and eicosanoid synthesis. The erucic acid content (11.69%) was also quantified. While high levels of erucic acid have been associated with adverse health effects like impaired myocardial conductance, lipidosis in children and increased blood cholesterol (Piazza and Foglia, 2001; West *et al.*, 2002) <sup>[30, 31]</sup>, the overall composition needs to be considered in the context of dietary intake and regional regulations. Minor saturated long-chain fatty acids such as palmitic acid (10.84%), stearic acid (2.10%), arachidic acid (0.95%), behenic acid (0.80%) and lignoceric acid (0.79%) were also present. The bioavailability of behenic acid was relatively low, and its effect on cholesterol content was minimal. The fatty acid composition of oils was known to be significantly influenced by factors such as cultivar, ecological conditions, latitude and agricultural practices (Konuskan *et al.*, 2017) <sup>[32]</sup>. Importantly, all adulteration tests (castor oil, mineral oil, cottonseed oil, argemone oil, karanja oil and sesame oil) yielded negative results. This conclusively confirms the mustard oil's purity and authenticity, ensuring its compliance with FSSAI (2021), AOAC (2021) <sup>[6]</sup> and AOCS (2012) <sup>[18]</sup> guidelines for consumer safety and product integrity.

### 3.1.2. Physicochemical properties of coconut oil (2<sup>nd</sup> main edible oil)

**Table 1:** Physicochemical properties of Mustard oil

| Particulars                                                    | Results                                                 | Standard specification | Remarks      |
|----------------------------------------------------------------|---------------------------------------------------------|------------------------|--------------|
| Specific gravity                                               | 0.90                                                    | 0.907 - 0.910          | Within limit |
| Viscosity (mPa.s)                                              | 55.00                                                   | 35.5 - 64.0            | Within limit |
| Colour (on Lovibond scale in ½" cell expressed as Y+5R), units | 24.00                                                   | 50.00                  | Within limit |
| Moisture (%)                                                   | 0.13                                                    | 0.20                   | Within limit |
| Organoleptic test (taste and flavor)                           | Characteristic                                          | Pass                   | Passes       |
| Visual clear (clarity) at 20°C                                 | Free from sediments, suspended matter, separated matter | Shall be clear         | Passes       |
| Refractive index at 40°C                                       | 1.46                                                    | 1.4650 - 1.4660        | Within limit |
| Flash point (°C)                                               | 310.00                                                  | Above 250.00           | Within limit |
| Fire point (°C)                                                | 350.00                                                  | Above 248.89           | Within limit |
| Rancidity                                                      | Free from any rancidity                                 | Free from rancidity    | Passes       |
| FFA-free fatty acids (%)                                       | 1.52                                                    | 3.00                   | Within limit |
| Peroxide value (mg/kg)                                         | Nil                                                     | 4.29                   | Within limit |
| Acid value                                                     | 1.50                                                    | 6.90                   | Within limit |
| Iodine value                                                   | 107.37                                                  | 96 - 112               | Within limit |
| Saponification value                                           | 170.140                                                 | 166 - 177              | Within limit |
| Palmitic acid (%)                                              | 10.840                                                  | Pass                   | Passes       |
| Stearic acid (%)                                               | 2.100                                                   |                        |              |
| Oleic acid (%)                                                 | 36.020                                                  |                        |              |
| Linoleic acid (%)                                              | 22.520                                                  |                        |              |
| Linolenic acid (%)                                             | 8.100                                                   |                        |              |
| Arachidic acid (%)                                             | 0.950                                                   |                        |              |
| Behenic acid (%)                                               | 0.800                                                   |                        |              |
| Erucic acid (%)                                                | 11.690                                                  |                        |              |
| Lignoceric acid (%)                                            | 0.790                                                   |                        |              |
| Adulterations tests                                            |                                                         |                        |              |
| Castor oil test                                                | Negative                                                | Negative               | Negative     |
| Mineral oil test                                               | Negative                                                | Negative               | Negative     |
| Cottonseed oil test                                            | Negative                                                | Negative               | Negative     |
| Argemone oil test                                              | Negative                                                | Negative               | Negative     |
| Karanja oil test                                               | Negative                                                | Negative               | Negative     |
| Baudouin test                                                  | Negative                                                | Negative               | Negative     |

The cold-pressed coconut oil quality parameters were given in Table 2. Uniquely, this highly saturated coconut oil remains liquid due to its dominant medium-chain fatty acids, influencing its distinct metabolic behaviour (Nakpong and Wootthikanokkhan, 2010) [33]. Specifically, it was found that the oil's specific gravity (0.91) aligned with FSSAI standards, being slightly lower due to shorter fatty acid chains. The color value was 3.50 units, and a low moisture content (0.13%) was observed, which minimized rancidity (Gopalakrishna *et al.*, 2010; Santos, 2007) [34, 35]. The oil also presented its characteristic taste/flavor and was visually clear. Furthermore, the refractive index (1.44 at 40°C) met FSSAI (2021) specifications. Safety parameters, including a flash point (290°C) and fire point (327 °C), confirmed thermal stability (Vunguturi and Irfanuddin, 2017) [36], notably higher than engine oils (Abdurahiman, 2019) [37]. Regarding chemical analyses, it was found that the oil exhibited excellent freshness. A low free fatty acid (FFA) content (0.20%) indicated minimal hydrolysis/oxidation (P. K. P. Kumar and Krishna, 2015) [38]. A nil peroxide value meant no significant degradation (Santos *et al.*, 2005) [39], crucial for health. Both acid value (0.80) and saponification value (250.46) met established standards (Martins *et al.*, 2020) [40], while an iodine value (8.90) indicated low unsaturation. In terms of fatty acid composition, it was found that the oil had a high saturated fat content, dominated by lauric acid (48.01%), which contributed to oxidative stability (Nakpong and Wootthikanokkhan, 2010) [33]. Significant amounts of myristic (17.99%) and palmitic (8.90%) acids were also found, alongside other MCFAs like caprylic (6.98%) and capric acids (5.98%). Oleic (7.40%) and linoleic (1.39%) acids were also present.

Critically, it was found that all adulteration tests (castor, mineral, cottonseed, argemone, karanja and sesame oils) were negative, confirming the coconut oil's purity and authenticity and its full compliance with FSSAI (2021) guidelines.

### 3.1.3. Physicochemical properties of argemone oil (1<sup>st</sup> adulterant)

**Table 3:** Physicochemical properties of Argemone oil

| Particulars                                                      | Results                                                 |
|------------------------------------------------------------------|---------------------------------------------------------|
| Specific gravity                                                 | 0.92                                                    |
| Viscosity (mPa.s)                                                | 31.12                                                   |
| Colour (on Lovibond scale in 1/2" cell expressed as Y+5R), units | 3.25                                                    |
| Moisture (%)                                                     | 0.05                                                    |
| Organoleptic test (taste and flavor)                             | -                                                       |
| Visual clear (clarity) at 20°C                                   | Free from sediments, suspended matter, separated matter |
| Refractive index at 40°C                                         | 1.46                                                    |
| Flash point (°C)                                                 | 318                                                     |
| Fire point (°C)                                                  | 364                                                     |
| Rancidity                                                        | Free from any rancidity                                 |
| FFA-free fatty acids (%)                                         | 0.18                                                    |
| Peroxide value (mg/kg)                                           | Nil                                                     |
| Acid value                                                       | 2.10                                                    |
| Iodine value                                                     | 96.65                                                   |
| Saponification value                                             | 180.17                                                  |
| Palmitic acid (%)                                                | 13.11                                                   |
| Stearic acid (%)                                                 | 2.01                                                    |
| Oleic acid (%)                                                   | 26.01                                                   |
| Linoleic acid (%)                                                | 57.98                                                   |

The results of the argemone oil analysis, encompassing its physicochemical properties and fatty acid composition, are presented in Table 3. The oil's specific gravity (0.92) was consistent with typical vegetable oils (Khan and Yusup, 2009)<sup>[41]</sup>. Its viscosity (31.12 mPa.s) fell within ASTM standards, influenced by the fatty acid chain length (Khan and Yusup, 2009)<sup>[41]</sup>. Visual purity was also observed. The oil had a colour value of 3.25 units and a low moisture content (0.05%), which is crucial for extending shelf life and preventing rancidity (Khan and Yusup, 2009)<sup>[41]</sup>. It was further found that the oil displayed excellent visual clarity, being free from sediments or suspended matter (Khan and Yusup, 2009)<sup>[41]</sup>. The refractive index (1.46 at 40°C) was influenced by the degree of saturation and unsaturation in its triglycerides (Kapoor *et al.*, 2020; O'brien, 2008)<sup>[42, 43]</sup>. Safety parameters included a flash point (318°C) and fire point (364°C), findings consistent with previous research (Ashine *et al.*, 2022)<sup>[44]</sup>. Additionally, it was found that the oil was free from rancidity. Chemical analyses indicated good stability. The free fatty acid (FFA) content (0.18%) and peroxide value were found to be consistent with earlier reports (Onoji *et al.*, 2019)<sup>[45]</sup>, demonstrating strong oxidative stability during storage (Agarwal *et al.*, 2017)<sup>[46]</sup>. The acid value (2.10) was found to be a measure of its hydrolysis. A high iodine value (96.65) reflected a significant degree of unsaturation (Sharma *et al.*, 2009)<sup>[26]</sup>, suggesting its potential for bio-based chemicals. Finally, the saponification value (180.17) was found to be typical for vegetable oils (Danlami *et al.*, 2015)<sup>[47]</sup>, influenced by its constituent fatty acids (David *et al.*, 2002)<sup>[48]</sup>. Through GCMS, it was determined that linoleic acid (57.98%) was the primary fatty acid in the extracted argemone oil, alongside oleic acid (26.01%), palmitic acid (13.11%) and stearic acid (2.01%) (Table 3). These findings were consistent with other vegetable oil studies (Martinez *et al.*, 2022)<sup>[49]</sup>.

### 3.1.4. Physicochemical properties of mineral oil (2<sup>nd</sup> adulterant)

**Table 4:** Physicochemical properties of Mineral oil

| Particulars                                                      | Results                                                 |
|------------------------------------------------------------------|---------------------------------------------------------|
| Specific gravity                                                 | 0.87                                                    |
| Viscosity (mPa.s)                                                | 29.04                                                   |
| Colour (on Lovibond scale in 1/2" cell expressed as Y+5R), units | Colorless                                               |
| Moisture (%)                                                     | 0.05                                                    |
| Organoleptic test (taste and flavor)                             | Nil                                                     |
| Visual clear (clarity) at 20°C                                   | Free from sediments, suspended matter, separated matter |
| Refractive index at 40°C                                         | 1.45                                                    |
| Flash point (°C)                                                 | 170                                                     |
| Fire point (°C)                                                  | 210                                                     |
| Rancidity                                                        | Free from any rancidity                                 |
| FFA-free fatty acid (%)                                          | Nil                                                     |
| Peroxide value (mg/kg)                                           | Nil                                                     |
| Acid value                                                       | Nil                                                     |
| Iodine value                                                     | Nil                                                     |
| Saponification value                                             | Nil                                                     |
| Fatty acid composition (%)                                       | Nil                                                     |

A common mineral oil was utilized in this study without further treatment and its physicochemical properties are detailed in Table 4. Specifically, it was found to have a specific gravity of 0.87, values consistent with reported literature for mineral oils (Charoo and Wani, 2016)<sup>[50]</sup> and indicating its relatively light weight compared to water. The

oil's viscosity was found to be 29.04 mPa.s, a relatively low value that suggests a smooth flow behavior (Cheng *et al.*, 2021)<sup>[51]</sup>. Visually, it was observed that the mineral oil was colourless (expressed as Y+5R on the Lovibond scale) and presented with a very low moisture content of 0.05% (Li *et al.*, 2014)<sup>[52]</sup>. Organoleptic tests indicated the absence of any discernible taste or flavour and it was found to be visually clear at 20 °C, free from sediments or suspended matter. Its refractive index at 40°C was recorded at 1.45. For safety considerations, it was found that the oil had a flash point of 170°C and a fire point of 210°C, important for assessing flammability and handling safety (Huang *et al.*, 2020)<sup>[53]</sup>. The oil also showed no signs of rancidity. Crucially, it was found that the mineral oil exhibited nil values for free fatty acids, peroxide value, acid value, iodine value and saponification value. Furthermore, no fatty acid composition was detected (Table 4). These characteristics align with the expected profile of a highly refined mineral oil, confirming its stability.

### 3.1.5. Physicochemical properties of castor oil (3<sup>rd</sup> adulterant)

**Table 5:** Physicochemical properties of Castor oil

| Particulars                                                      | Results                                                 |
|------------------------------------------------------------------|---------------------------------------------------------|
| Specific gravity                                                 | 0.95                                                    |
| Viscosity (mPa.s)                                                | 252.08                                                  |
| Colour (on Lovibond scale in 1/2" cell expressed as Y+5R), units | 7.50                                                    |
| Moisture (%)                                                     | 0.04                                                    |
| Organoleptic test (taste and flavor)                             | Characteristic                                          |
| Visual clear (clarity) at 20°C                                   | Free from sediments, suspended matter, separated matter |
| Refractive index at 40°C                                         | 1.46                                                    |
| Flash point (°C)                                                 | 301                                                     |
| Fire point (°C)                                                  | 339                                                     |
| Rancidity                                                        | Free from any rancidity                                 |
| FFA-free fatty acid (%)                                          | 0.15                                                    |
| Peroxide value (mg/kg)                                           | Nil                                                     |
| Acid value                                                       | 5.12                                                    |
| Iodine value                                                     | 87.45                                                   |
| Saponification value                                             | 174.50                                                  |
| Caprylic acid (%)                                                | 0.23                                                    |
| Palmitic acid (%)                                                | 0.61                                                    |
| Oleic acid (%)                                                   | 5.19                                                    |
| Ricinoleic acid (%)                                              | 87.01                                                   |

The physicochemical properties of castor oil were analyzed and are presented in Table 5. The oil's specific gravity (0.95) aligned with its physical attributes. Its viscosity measured 252.08 mPa.s, which is high compared to other natural oils, a characteristic influenced by its unique fatty acid structure (Kyari, 2008)<sup>[54]</sup>. The oil exhibited a colour value of 7.50 units, appearing amber, similar to virgin sunflower oil (Arshad and Amjad, 2012)<sup>[55]</sup>. A low moisture content (0.04%) was observed, with variations depending on origin, variety, harvesting and storage (Omari *et al.*, 2015)<sup>[56]</sup>. The oil presented a characteristic taste and flavour and was visually clear at 20 °C indicating purity. Its refractive index (1.46 at 40 °C) was influenced by saturation and conjugated double bonds (Salimon *et al.*, 2010)<sup>[57]</sup>. Safety considerations included a flash point of 301 °C and fire point of 339 °C suggesting lower ignition risk under normal conditions and it was free from rancidity. Chemical quality indicators confirmed the oil's stability. The free fatty acid content was low (0.15%), signalling good quality (Mandal, 2023)<sup>[58]</sup> and a nil peroxide value demonstrated resistance to oxidation. The

acid value (5.12) reflected its hydrolysis or decomposition extent. An iodine value of 87.45 indicated a high degree of unsaturation, suggesting susceptibility to oxidation. The saponification value (174.50) was high, consistent with a significant proportion of lower molecular weight fatty acids (Panhwar *et al.*, 2019) <sup>[59]</sup>, suggesting its potential for soap and cosmetic manufacturing. The fatty acid composition, determined by GCMS (Table 5), showed ricinoleic acid as the dominant component at 87.01%. Other major fatty acids included oleic acid (5.19%) and palmitic acid (0.61%), with stearic acid at 3%. The high ricinoleic acid content is characteristic of castor oil, though geographical variations exist (Bale *et al.*, 2013) <sup>[60]</sup>.

### 3.1.6. Physicochemical properties of palm oil (4<sup>th</sup> adulterant)

**Table 6:** Physicochemical properties of Palm oil

| Particulars                                               | Results                                                 |
|-----------------------------------------------------------|---------------------------------------------------------|
| Specific gravity                                          | 0.90                                                    |
| Viscosity (mPa.s)                                         | 34.80                                                   |
| Colour (on Lovibond scale in 1/2" cell expressed as Y+5R) | 5.60 units                                              |
| Moisture (%)                                              | 0.05                                                    |
| Organoleptic test (taste and flavor)                      | Characteristic                                          |
| Visual clear (clarity) at 20°C                            | Free from sediments, suspended matter, separated matter |
| Refractive index at 40°C                                  | 1.45                                                    |
| Flash point (°C)                                          | 316                                                     |
| Fire point (°C)                                           | 355                                                     |
| Rancidity                                                 | Free from any rancidity                                 |
| FFA-free fatty acids (%)                                  | 0.14                                                    |
| Peroxide value (mg/kg)                                    | 2.00                                                    |
| Acid value                                                | 6.90                                                    |
| Iodine value                                              | 55.30                                                   |
| Saponification value                                      | 199.08                                                  |
| Lauric acid (%)                                           | 0.50                                                    |
| Myristic acid (%)                                         | 1.70                                                    |
| Palmitic acid (%)                                         | 48.70                                                   |
| Stearic acid (%)                                          | 3.90                                                    |
| Oleic acid (%)                                            | 37.10                                                   |
| Linoleic acid (%)                                         | 8.10                                                    |

The physicochemical properties of palm oil were comprehensively analyzed and are detailed in Table 6. The oil exhibited a specific gravity of 0.90, critical for commercial volume-to-weight conversions and purity assessment (Japir *et al.*, 2017) <sup>[61]</sup>. Its viscosity was 34.80 mPa.s, a property influenced by the hydrocarbon chain length and functional groups of its fatty acids (Khan and Yusup, 2009) <sup>[41]</sup>. Key quality indicators were favourable. The oil showed a color value of 5.60 units, characteristic of crude palm oil's deep orange hue due to carotenoids (Dunford, 2023) <sup>[62]</sup>. Its moisture content was low (0.05%), which is essential for quality and extended shelf life (Teye *et al.*, 2023) <sup>[63]</sup>. The oil also displayed a characteristic taste and flavour, was visually clear at 20 °C (free from sediments) and had a refractive index of 1.45 at 40 °C, attributed to its fatty acid composition (Falade *et al.*, 2008) <sup>[64]</sup>. Safety parameters included a flash point of 316 °C and a fire point of 355 °C, values that can be influenced by storage and processing (Lin and Chiu, 2010) <sup>[65]</sup>. The oil was found to be free from rancidity. Chemical stability was indicated by several parameters. The free fatty acid content was very low (0.14%), signifying high quality and minimal degeneration, influenced by seed storage conditions. A nil peroxide value suggested no early-stage rancidity or

oxidation (Onyeka *et al.*, 2005) <sup>[66]</sup>. The acid value (6.90) reflected minimal decomposition of oil glycerides, aligning with recommended standards (Onyeka *et al.*, 2005) <sup>[66]</sup>. The iodine value (55.30) indicated the oil's unsaturation and its susceptibility to oxidative rancidity. Finally, the saponification value (199.08) provided an estimation of oxidation during storage and decomposition levels (Neagu *et al.*, 2013) <sup>[67]</sup>, suggesting potential for soap and candle production. The fatty acid composition of the palm oil (Table 6) revealed its characteristic profile, comprising approximately 50% saturated fatty acids, 40% monounsaturated and 10% polyunsaturated. Notably, palmitic acid (48.70%) was the most abundant saturated fatty acid. Other significant components included oleic acid (37.10%), linoleic acid (8.10%), stearic acid (3.90%), myristic acid (1.70%) and lauric acid (0.50%). This composition, particularly the high palmitic acid content, distinguishes palm oil from many other vegetable oils (Tan and Nehdi, 2012) <sup>[68]</sup>.

### 4. Conclusion

This study clearly demonstrated the physicochemical analysis of various oil samples including mustard, coconut, argemone, mineral, castor and palm oil. Mustard oil showed high iodine and erucic acid values, indicative of its unsaturated fatty acid profile. Coconut oil exhibited a high saponification value and lauric acid content, typical of medium-chain triglycerides. Despite its elevated levels of the fatty acid linoleic acid, argemone oil is non-edible due to its inherent toxicity. In contrast, mineral oil contains no measurable fatty acids, clearly confirming it is not safe for consumption. Castor oil was dominated by ricinoleic acid and displayed significantly high viscosity. *Palm oil* was rich in palmitic and oleic acids, with moderate iodine and acid values. Since all samples were pure and free from adulteration or rancidity, our findings demonstrate that these physicochemical tests are reliable tools for ensuring the quality and authenticity of edible oils.

### References

- Kumar R, Chandra S, Samsher, Kumar V, Kumar K, Sunil. Processing, storability, physicochemical properties and human health benefits of edible oil: a review. *South Asian Journal of Food Technology and Environment*. 2018;4(2):668-679.
- Mukherjee S, Mitra A. Health effects of palm oil. *Journal of Human Ecology*. 2009;26(3):197-203.
- Pal AD, Jain A. Adulteration in commonly used cooking oils of Kolkata: evaluation of consumer perception and detection of adulterants. *International Journal of Health Sciences and Research*. 2018;8(12):30-37.
- Choudhary M, Grover K, Kaur G. Development of rice bran oil blends for quality improvement. *Food Chemistry*. 2015;173(1):770-777. doi:10.1016/j.foodchem.2014.10.051.
- Wazed M, Yasmin S, Basak P, Hossain A, Rahman M, Hasan M, *et al.* Evaluation of physicochemical parameters of edible oils at room temperature and after heating at high temperature. *Food Research*. 2023;7(4):91-100.
- AOAC. Official method 940.28: fatty acids in crude and refined oils. 17th ed.; 2021.
- Nduka JKC, Omozua PO, Imanah OE. Effect of heating time on the physicochemical properties of selected vegetable oils. *Arabian Journal of Chemistry*. 2021;14(4):103063. doi:10.1016/j.arabjc.2021.103063.
- Paul AK, Borugadda VB, Reshad AS, Bhalariao MS, Tiwari P, Goud VV. Comparative study of

- physicochemical and rheological properties of waste cooking oil, castor oil, rubber seed oil, their methyl esters and blends with mineral diesel fuel. *Materials Science for Energy Technologies*. 2021;4(1):148-155. doi:10.1016/j.mset.2021.03.004.
9. Flores M, Avendano V, Bravo J, Valdes C, Forero-Doria O, Quitral V, *et al.* Edible oil parameters during deterioration processes. *International Journal of Food Science*. 2021;2021(1):7105170. doi:10.1155/2021/7105170.
  10. ISI. Colour. In: *Handbook of food analysis*. Part XIII. 1984. p. 75.
  11. AOAC. Official method 921.08: index of refraction of oils and fats. 7th ed.; 2021.
  12. IS 1448. Methods of test for petroleum and its products: flash point, closed cup method by Cleveland. 1970.
  13. AOAC. Official method 940.28: acid value. 17th ed.; 2021.
  14. AOAC. Official method 920.160: saponification number of oils and fats, IUPAC 2.202. 17th ed.; 2021.
  15. AOAC. Official method 945.102: mineral oil in fats—qualitative test. 17th ed.; 2021.
  16. AOAC. Official method 965.33: peroxide value in oils and fats. 17th ed.; 2021.
  17. AOAC. Official methods 969.33 and 969.22: fatty acids in oils and fats—preparation of methyl esters and gas chromatographic method; fatty acid composition by capillary GLC. 17th ed.; 2021.
  18. AOCS. Official method Ce 1a-13: fatty acid composition. 6th ed.; 2012.
  19. ISI. Modified test for the presence of castor oil. In: *Handbook of food analysis*. Part XIII. 1984. p. 91.
  20. Anand J, Ramamoorthy K, Sagaya John Paul J, Sreekala KG, Sathuvan M, Bhavani L, *et al.* Oil cake extract as a low-cost alternative medium for increasing lipid and biomass productivity in *Scenedesmus quadricauda* for biofuel applications. *Biomass Conversion and Biorefinery*. 2023;13(16):14673-14682. doi:10.1007/s13399-022-03135-3.
  21. Deepak M, Kumar PU, Nitha B, Balachandran I, Shree ABR. Quality parameters, fatty acid profiling and estimation of umbelliferone in *Grahanimihira Tailam*: an Ayurvedic oil preparation. *Ancient Science of Life*. 2013;33(1):10-14. doi:10.4103/0257-7941.134557.
  22. Atbhaiya Y, Sharma R, Gandhi K, Mann B, Gautam PB. Methods to differentiate between cotton tract area ghee and cottonseed oil-adulterated ghee. *Journal of Food Science and Technology*. 2022;59(12):4782-4793. doi:10.1007/s13197-022-05563-5.
  23. Rogeboz P, Latado H, Sharma A, Chaubey N, Kadian S, Chavez E, *et al.* Oil adulteration evaluation using high-performance thin-layer chromatography. *Food Analytical Methods*. 2024;17(9):1336-1347.
  24. Pardeshi S. Assessing the genuineness of sesame oil available in markets of India using Bellier. 2019.
  25. Kim J, Kim DN, Lee SH, Yoo SH, Lee S. Correlation of fatty acid composition of vegetable oils with rheological behaviour and oil uptake. *Food Chemistry*. 2010;118(2):398-402. doi:10.1016/j.foodchem.2009.05.011.
  26. Sharma D, Pathak D, Atwal AK, Sangha MK. Genetic variation for some chemical and biochemical characteristics in cottonseed oil. *Journal of Cotton Research and Development*. 2009;23(1):1-7.
  27. Selvan RT, Sidhharth L, Wilson VH, Das A, Goel M. Studies on physical properties of biodiesel and blends from mustard oil. *International Journal of Mechanical Engineering and Technology*. 2017;8(7):1-4.
  28. Lobo V, Patil A, Phatak A, Chandra N. Free radicals, antioxidants and functional foods: impact on human health. *Pharmacognosy Reviews*. 2010;4(8):118.
  29. Orhevba BA, Efomah A. Extraction and characterization of cottonseed (*Gossypium*) oil. *International Journal of Basic and Applied Science*. 2012;1(2):398-402.
  30. Piazza GJ, Foglia TA. Rapeseed oil for oleochemical usage. *European Journal of Lipid Science and Technology*. 2001;103(7):450-454.
  31. West L, Tsui I, Balch B, Meyer K, Huth PJ. Determination and health implications of the erucic acid content of broccoli florets, sprouts and seeds. *Journal of Food Science*. 2002;67(7):2641-2643. doi:10.1111/j.1365-2621.2002.tb08791.x.
  32. Konuskan O, Konuskan DB, Levai CM. Effect of foliar boron fertilization on chemical properties and fatty acid compositions of corn (*Zea mays* L.). *Revista de Chimie*. 2017;68(9):2073-2075.
  33. Nakpong P, Wootthikanokkhan S. High free fatty acid coconut oil as a potential feedstock for biodiesel production in Thailand. *Renewable Energy*. 2010;35(8):1682-1687. doi:10.1016/j.renene.2009.12.004.
  34. Gopalakrishna AG, Gaurav R, Ajit Singh B, Prasanth Kumar PK. Coconut oil: chemistry, production and its applications—a review. *Indian Coconut Journal*. 2010;15-27.
  35. Santos JCO. Thermal characterization of favelone oil (*Cnidioscolus phyllacanthus*). *Journal of Food Technology*. 2007;5(1):77-78.
  36. Vunguturi S, Irfanuddin SA. Evaluation of flash point and fire point of selected edible oil blends: a biolubricant. *International Journal of Trend in Research and Development*. 2017;4(5):99-101.
  37. Abdurahiman A. Characteristical study of coconut oil-based nanolubricant. In: *Proceedings of the International Conference on Systems, Energy and Environment*; 2019. doi:10.2139/ssrn.3438121.
  38. Kumar PKP, Krishna AGG. Physicochemical characteristics of commercial coconut oils produced in India. *Grasas y Aceites*. 2015;66(1):e062.
  39. Santos JCO, Dantas JP, Medeiros CA, Atha'ide-Filho PF, Conceição MM, Santos JR Jr, *et al.* Thermal analysis in sustainable development: thermoanalytical study of faveleira seeds (*Cnidioscolus quercifolius*). *Journal of Thermal Analysis and Calorimetry*. 2005;79(1):271-275. doi:10.1007/s10973-005-0048-4.
  40. Martins J, Santos J, da Conceicao M. Comparative study of physicochemical properties of coconut oil (*Cocos nucifera* L.) obtained by industrial and artisanal processes. *Biotechnology: An Indian Journal*. 2020;16(3):210.
  41. Khan M, Yusup S. Solvent extraction and characterisation of rubber seed oil. *International Journal of Postharvest Technology and Innovation*. 2009;1(4):376-385. doi:10.1504/IJPTI.2009.030686.
  42. Kapoor S, Gandhi N, Tyagi SK, Kaur A, Mahajan BVC. Extraction and characterization of guava seed oil: a novel industrial by-product. *LWT*. 2020;132(1):109882. doi:10.1016/j.lwt.2020.109882.
  43. O'Brien RD. *Fats and oils: formulating and processing for applications*. CRC Press; 2008.

44. Ashine F, Balakrishnan S, Kiflie Z, Bachheti RK, Tizazu BZ. Parametric optimization of *Argemone mexicana* seed oil extraction using Box-Behnken experimental design and characterization of the oil. Results in Chemistry. 2022;4(1):100570. doi:10.1016/j.rechem.2022.100570.
45. Onoji SE, Iyuke SE, Igbafe AI, Daramola MO. *Hevea brasiliensis* rubber seed oil: modelling and optimization of extraction process parameters using response surface methodology and artificial neural network techniques. Biofuels. 2019;10(6):677-691. doi:10.1080/17597269.2017.1338122.
46. Agarwal S, Chhibber VK, Bhatnagar AK, Srivastav B, Kumar A, Singhal S, et al. Physicochemical and tribological studies of Argemone biodiesel synthesized using the microwave technique. Current Science. 2017;938-941.
47. Danlami JM, Arsad A, Zaini MAA. Characterization and process optimization of castor oil (*Ricinus communis* L.) extracted by the Soxhlet method using polar and non-polar solvents. Journal of the Taiwan Institute of Chemical Engineers. 2015;47(1):99-104. doi:10.1016/j.jtice.2014.10.012.
48. David F, Sandra P, Wylie PL. Improving the analysis of fatty acid methyl esters using retention time-locked methods and retention time databases. Agilent Technologies Application. 2002.
49. Martinez-Delgado AA, de Anda J, Leon-Morales JM, Mateos-Diaz JC, Castaneda-Nava JJ. *Argemone* species: potential sources of biofuel and high-value biologically active compounds. Environmental Engineering Research. 2022;27(2):1-34.
50. Charoo MS, Wani MF. Friction and wear properties of nano-Si<sub>3</sub>N<sub>4</sub>/nano-SiC composite under nanolubricated conditions. Journal of Advanced Ceramics. 2016;5(1):145-152. doi:10.1007/s40145-016-0183-3.
51. Cheng Y, Xue F, Yu S, Du S, Yang Y. Subcritical water extraction of natural products. Molecules. 2021;26(13):4004. doi:10.3390/molecules26134004.
52. Li Z, Li Y, Zhang Y, Ren T, Zhao Y. Tribological study of hydrolytically stable sulfur-containing alkyl phenylboric esters as lubricant additives. RSC Advances. 2014;4(48):25118-25126. doi:10.1039/C4RA01672F.
53. Huang Y, Wei J, Yi J. Combustion behavior of mineral insulating oil with the addition of flame retardants. IOP Conference Series: Earth and Environmental Science. 2020;508(1):012155. doi:10.1088/1755-1315/508/1/012155.
54. Kyari MZ. Extraction and characterization of seed oil. International Agrophysics. 2008;22(1):139-142.
55. Arshad M, Amjad M. Medicinal use of sunflower oil and the present status of sunflower in Pakistan: a review. Science, Technology and Development. 2012;31(2):99-106.
56. Omari A, Mgani QA, Mubofu EB. Fatty acid profile and physicochemical parameters of castor oils in Tanzania. Green and Sustainable Chemistry. 2015;5(4):154-163. doi:10.4236/gsc.2015.54019.
57. Salimon J, Noor DAM, Nazrizawati AT, Firdaus MYM, Noraishah A. Fatty acid composition and physicochemical properties of Malaysian castor bean (*Ricinus communis* L.) seed oil. Sains Malaysiana. 2010;39(5):761-764.
58. Mandal S. Physical and chemical properties of selected samples of castor oil, *Ricinus communis* L. Kemija u Industriji. 2023;72(3):187-.
59. Panhwar T, Mahesar SA, Kandhro AA, Sheerazi STH, Kori AH, Laghari ZH, et al. Physicochemical composition and FTIR characterization of castor seed oil. Ukrainian Food Journal. 2019;8(4):778-787.
60. Bale AT, Adebayo RT, Ogundele DT, Bodunde VT. Fatty acid composition and physicochemical properties of castor (*Ricinus communis* L.) seed obtained from Malete, Moro Local Government Area, Kwara State, Nigeria. Chemistry and Materials Research. 2013;3(12):11-13.
61. Japir AAW, Salimon J, Derawi D, Bahadi M, Al-Shuja'a S, Yusop MR. Physicochemical characteristics of high free fatty acid crude palm oil. OCL. 2017;24(5):D506. doi:10.1051/ocl/2017033.
62. Dunford NT. Properties of palm oil. Division of Agricultural Sciences and Natural Resources. 2023;2(1):248.
63. Teye E, Amuah CLY, Yeh TS, Nyorkeh R. Nondestructive detection of moisture content in palm oil using portable vibrational spectroscopy and optimal prediction algorithms. Journal of Analytical Methods in Chemistry. 2023;2023(1):3364720. doi:10.1155/2023/3364720.
64. Falade OS, Adekunle AS, Aderogba MA, Atanda SO, Harwood C, Adewusi SR. Physicochemical properties, total phenol and tocopherol contents of some *Acacia* seed oils. Journal of the Science of Food and Agriculture. 2008;88(2):263-268. doi:10.1002/jsfa.3082.
65. Lin CY, Chiu CC. Burning characteristics of palm oil biodiesel under long-term storage conditions. Energy Conversion and Management. 2010;51(7):1464-1467. doi:10.1016/j.enconman.2010.01.022.
66. Onyeka EU, Onuegbu N, Onuoha NU, Ochonogor F. Effect of extraction pretreatment on the composition and characteristics of seed and pulp oils of African black pear (*Dacryodes edulis*). Nigerian Food Journal. 2005;23(1):13-20. doi:10.4314/nifo.v23i1.33594.
67. Neagu AA, Nita I, Botez E, Geaca S. A physicochemical study of some edible oil properties. Ovidius University Annals of Chemistry. 2013;24(2):121-126.
68. Tan CP, Nehdi IA. The physicochemical properties of palm oil and its components. In: Palm oil. Elsevier; 2012. p. 377-391. doi:10.1016/B978-0-9818936-9-3.50016-2.
69. AOAC. Official method 920.212: specific gravity, apparent, of oils using the pycnometer method. 17th ed.; 2021.
70. AOCS. Official method Cd 8b-90: peroxide value. 2003.
71. Open cup apparatus.
72. ISI. Saponification value. In: Handbook of food analysis. Part XIII. 1984. p. 78.
73. Turbidity temperature test (BT TT). International Research Journal of Engineering and Technology. 6(8):1110-1113.