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# Chemical Compositions and Essential Fatty Acid Analysis of Selected Vegetable Oils and Fats

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**Abstract:** The fatty acid (FA) compositions of thirty-nine vegetable oils and fats, including nangai nut, pili nut, shea butter, tamanu oil, baobab, sea buckthorn berry, Brazil nut, grape seed, black seed, evening primrose, passion fruit, milk thistle, sunflower, pumpkin seed, sesame, soybean, flax seed, kukui, red raspberry seed, walnut, chia seed, hemp seed, rosehip, almond, avocado, carrot seed, moringa, apricot kernel, camellia seed, macadamia, olive, marula, argan, castor, jojoba, pomegranate seed, medium-chain triglyceride (MCT) coconut, roasted coconut, canola, and mustard oil, were analyzed using gas chromatography–mass spectrometry (GC-MS). Vegetable oils and fats have different profiles in terms of their fatty acid composition, and their major constituents vary significantly. However, we categorized them into different classes based on the percentages of different fatty acids they contain. The saturated fatty acids, such as palmitic acid and stearic acid, and the unsaturated fatty acids, including oleic acid, linoleic acid, and linolenic acid, are the main categories. Among them, roasted coconut oil contained the greatest amount of saturated fatty acids followed by nangai nut (45.61%). Passion fruit oil contained the largest amount of linoleic acid (66.23%), while chia seed oil had the highest content of linolenic acid (58.25%). Oleic acid was exclusively present in camellia seed oil, constituting 78.57% of its composition. Notably, mustard oil had a significant presence of erucic acid (54.32%), while pomegranate seed oil exclusively contained punicic acid (74.77%). Jojoba oil primarily consisted of (*Z*)-11-eicosenoic acid (29.55%) and (*Z*)-docos-13-en-1-ol (27.96%). The major constituent in castor oil was ricinoleic acid (89.89%). Compared with other vegetable oils and fats, pili nut oil contained a significant amount of (*E*)-FA (20.62%), followed by sea buckthorn berry oil with a content of 9.60%. FA compositions from sources may be problematic in the human diet due to no labeling or the absence of essential components. Therefore, consumers must cast an eye over some essential components consumed in their dietary intake.

**Keywords:** essential fatty acids; (*E*)-fatty acids; oleic acid; linoleic acid; erucic acid; linolenic acid; punicic acid; ricinoleic acid; (*Z*)-11-eicosenoic acid; vegetable oils

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## 1. Introduction

In both human and animal diets, fats and oils are acknowledged as indispensable nutrients [1]. Their function includes being the most condensed source of energy among all food types, providing necessary fatty acids (FAs), acting as a transporter for fat-soluble vitamins, and enhancing the taste of foods. Dietary fats play a crucial role in the absorption and transportation of fat-soluble vitamins, as well as fat-soluble antioxidants [2,3].

Fats and oils can be found in different quantities in a variety of foods. FAs are the primary constituents of lipids, which make up about 90% of the fats found in food. FAs are classified based on the presence or absence of double bonds. FAs with single bonds between each carbon atom are considered saturated FAs. They are mainly present in animal fats and dairy products. FAs with one double bond between carbon atoms are considered as monounsaturated and two or more double bonds between carbon atoms are called polyunsaturated [4]. Furthermore, the terms *cis* or (*Z*) and *trans* or (*E*) describe the positioning of carbon atom chains in relation to a double bond. When the chains are on the same side of the double bond, a bent shape called the (*Z*) arrangement is created. In contrast, the chains are on opposite sides of the double bond in the (*E*) arrangement, resulting in a straight shape. The first arrangement occurs without any human intervention, whereas the second arrangement is produced through the implementation of technology during the process of extraction and purification [5]. Since most of the (*E*)-fats that we consume in our diet come from industrial sources, particularly in the form of vanaspati, shortening, and margarine, which are used in baked and fried food like cakes, cookies, bread, potato chips, and other fried products. The intake of (*E*)-FAs has been linked to elevated levels of low-density lipoprotein cholesterol, which is associated with a higher risk of cardiovascular and cerebrovascular diseases [6,7]. The major FAs discussed in this work are shown in Figure 1.

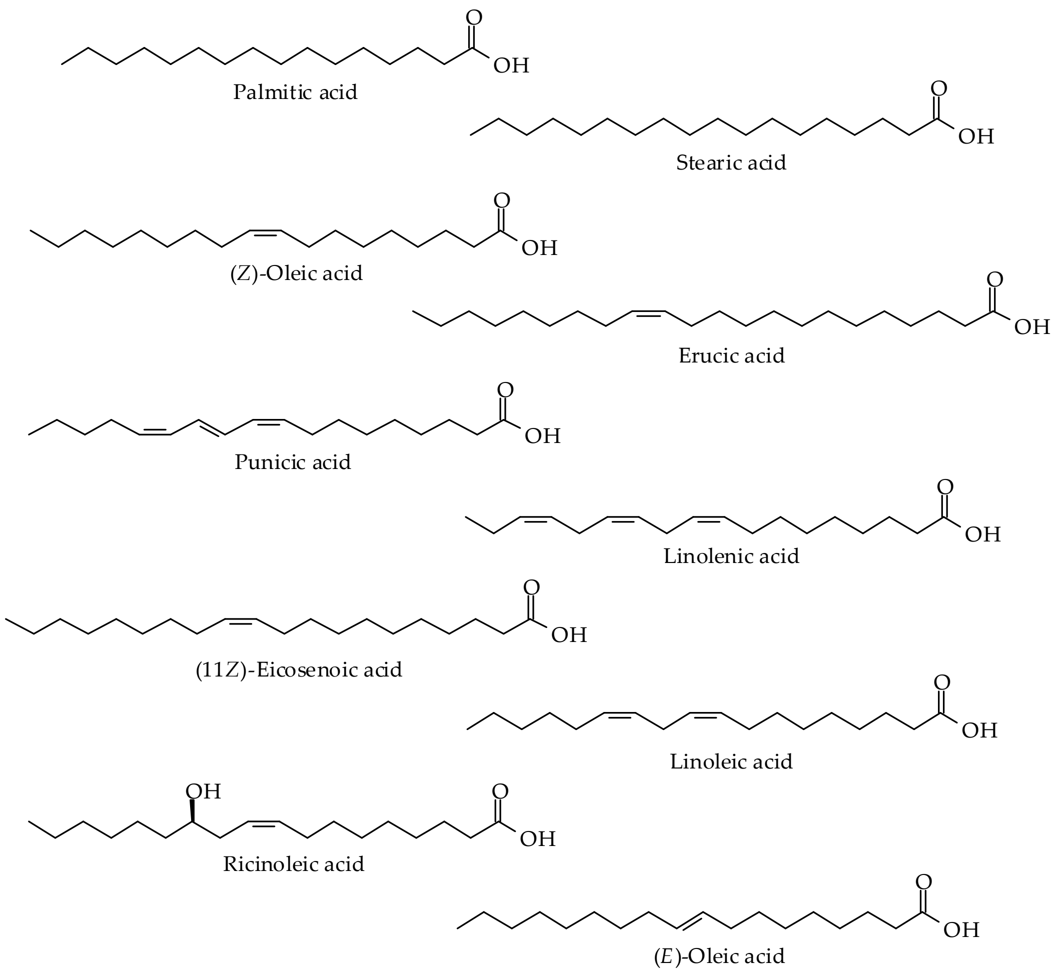


**Figure 1.** Major fatty acids present in different vegetable oils and fats.

Polyunsaturated FAs are categorized as either n-3 (omega-3) or n-6 (omega-6) depending on the location of the initial double bond relative to the methyl end of the FA molecule [8]. Since the human body lacks the necessary enzyme to produce polyunsaturated FAs with the first double bond on C3 and C6 from the methyl end, these two types of polyunsaturated FAs are considered essential FAs and must be obtained through dietary means [9]. Additionally, essential FAs can contribute to an increase in high-density lipoproteins, which are commonly referred to as "good cholesterol" [10]. Vegetable oils are the primary sources of essential FAs for human beings. Monounsaturated FA (omega-9) is considered to be important but is not classified as an "essential" nutrient since the body is capable of producing a limited quantity on its own, as long as there is an adequate supply of essential FAs [11].

Essential FAs play a vital role in maintaining the health of the cardiovascular [7], reproductive [12], immune [13], and nervous systems [14,15]. They are necessary for the production and repair of cell membranes, which enables cells to receive proper nourishment and eliminate harmful waste [16]. The key function of essential FAs is to produce prostaglandins, which help regulate various bodily processes, such as heart rate, blood pressure, blood clotting, fertility, conception, and immune function. Prostaglandins also have anti-inflammatory properties and can stimulate the body to fight off infections [17,18]. For optimal health, it is recommended to maintain a ratio of omega-6 to omega-3 fatty acids within the range of 5–10:1 [19]. Inadequate consumption of essential FAs and an imbalance between omega-6 and omega-3 FAs have been associated with various severe health conditions. These include heart attacks, cancer, insulin resistance, asthma, lupus, schizophrenia, depression, postpartum depression, premature aging, stroke, obesity, diabetes, arthritis, and Alzheimer's disease [20]. The levels of *trans* and *cis*-FAs in the blood serum of women revealed a correlation between higher *trans*-FA levels and an elevated risk of breast cancer. Also, there is a hypothesis suggesting that the heightened risk of cancer associated with *trans*-FAs may be linked to changes in immune response, cell wall integrity, and prostaglandin synthesis [21].

There is an increasing concern regarding the consumption of foods that contain (*E*)-FAs due to their harmful impact on human health. The purpose of this study was to examine the composition of specific vegetable oils and fats and to determine their potential uses in biofuel production, cosmetics formulation, and pharmaceutical and nutraceutical industries based on their compositions as well as to establish a chemical fingerprint of various vegetable oils and fats for authentication. Also, this study investigates the chemical makeup of oils and fats and suggests that individuals should pay close attention to certain important elements included in their diet.

## 2. Materials and Methods

### 2.1. Sample Collection

A total of 263 cold-pressed commercial samples of vegetable oils and fats were received from bona fide suppliers around the world at the Aromatic Plant Research Center, Lehi, UT, USA (Table 1).

### 2.2. Preparation of Fatty Acid Methyl Esters (FAMEs)

Each sample (0.15 g) of oil and fat was mixed with 5 mL of 0.5 N sodium methoxide solution. The resulting mixture in a test tube was capped and swirled. Then, the mixture was placed in a hot water bath at 87 °C. After 10 min, 6 mL of boron trifluoride methanol solution was added to the mixture and swirled, and then it was kept in the hot water bath for another 10 min. Subsequently, enough brine (saturated sodium chloride) solution was added to fill the test tube. Four drops of the top oil layer were pipetted out using a glass Pasteur pipette and transferred to a 2 mL glass vial. Dichloromethane was added until the vial was full, and then it was mixed using the inversion method. Finally, the sample was analyzed using the 100 min gas chromatography–mass spectrometry (GC-MS) method and the peaks were recorded for their respective retention times and areas. Each specific fatty acid methyl ester was identified by comparing it with verified reference standards [22].

### 2.3. GC-MS Analysis

The Shimadzu GC-MS-QP2010 Ultra with an electron impact (EI) mode with 70 eV and a ZB-5MS capillary GC column (Shimadzu Scientific Instruments, Columbia, MD, USA) were used to analyze the FAME samples. The scans were carried out in the 40–400 m/z range with a scan rate of 3.0 scan/s, as described previously [23,24]. The identification of compounds was conducted by comparing the retention indices based on a homologous series of *n*-alkanes and comparing their mass spectra with those reported in the literature [25] and our in-house library [26].

**Table 1.** Vegetable oils and fats and their country of origin.

| Oils and Fats | Origin |
|---|---|
| Nangai nut, pili nut, shea butter, baobab, passion fruit, sesame, kukui, avocado, moringa, marula, and pomegranate seed | Kenya |
| Tamanu oil | Madagascar |
| Sea buckthorn berry, grape seed, pumpkin seed, flax seed, hemp seed, castor, and roasted coconut | India |
| Brazil nut, sunflower, and macadamia | Brazil |
| Black seed | Egypt |
| Milk thistle, rosehip, and carrot seed | Bulgaria |
| Walnut, almond, canola, evening primrose, soybean, red raspberry seed, and chia seed | USA |
| Olive | Italy |
| Argan | Morocco |
| Jojoba | Mexico |
| Medium-chain triglyceride (MCT) coconut | Philippines |
| Mustard | Nepal |
| Apricot kernel | France |
| Camellia seed | Japan |

### *2.4. Statistical Analysis*

Analyzing the consistency and credibility of the collected data required performing a statistical analysis. The experimental data were employed to assess the mean and standard deviation. Thus, all the data are presented in mean ± standard deviation using Microsoft® Excel 2010.

## **3. Results and Discussions**

### *3.1. Fatty Acid Compositions*

Table 2 below showcases various vegetable oils and fats that contain high amounts of saturated FAs, including nangai (*Canarium indicum*) nut, pili (*Canarium ovatum*) nut, shea butter (*Vitellaria paradoxa*), sea buckthorn (*Hipphophae rhamnoides*), baobab (*Adansonia digitata*), Brazil nut (*Bertholletia excelsa*), and tamanu (*Calophyllum inophyllum*) oil. The table also provides information on the different types of FAs and minor phytosterols found in these oils. Except for sea buckthorn, all of these oils were abundant in (*Z*)-oleic acid. Sea buckthorn, on the other hand, was rich in palmitoleic acid along with palmitic acid and (*Z*)-oleic acid, which was in close agreement with sea buckthorn pulp oil composition as described in [27]; they found comparably high linolenic acid in seed oil than in the pulp of sea buckthorn berry from Mongolia [27]. It is worth noting that sea buckthorn contained a significant amount of linolenic acid exclusively. In nangai oil, palmitic acid was the second most abundant FA, followed by stearic acid and linoleic acid; in contrast to our study, research from Indonesia shows a low percentage of saturated FAs [28]. Similarly, pili nut primarily contained palmitic acid, (*E*)-oleic acid, linoleic acid, and stearic acid as its major FAs. Interestingly, a study conducted by Kakuda et al. did not report the presence of (*E*)-FAs in pili nuts from the Philippines, which was significantly present in our study [29]. In both tamanu and Brazil nut oil, linoleic acid was the second major component, while stearic acid and palmitic acid occurred in almost equal ratios. Similarly, Crane et al. studied the *C. inophyllum* oil composition and showed a similar composition to our study [30]. Another study from Brazil that conducted a composition analysis of Brazil nut showed a similar result of FA percentages [31]. In shea butter, stearic acid took the position of the second major FA, followed by palmitic acid and linoleic acid in the same proportion. Interestingly, in a study from northern Ghana by Garti et al., a high percentage of stearic acid, 52.36%, followed by oleic acid, 36.29%, was reported [32]. Conversely, in baobab oil, the major FAs were linoleic acid, palmitic acid, and stearic acid; a similar result was obtained by Razafimamonjison et al. for *A. digitata* species from Madagascar while studying different species of *Adansonia* [33]. Pili nut oil stood out for its high content of palmitic acid, while shea butter had the lowest concentration of this FA. Brazil nut, on the other hand, contained a notable quantity of linoleic acid, whereas pili nut had a comparatively lower amount compared with the other oils. Interestingly, pili nut oil contained a significant amount of (*E*)-oleic acid, whereas shea butter had the least amount of it. Moreover, shea butter had the highest concentration of stearic acid among these oils, while sea buckthorn oil had minimal levels of stearic acid. Furthermore, γ-sitosterol was present in all of these oils except for Brazil nut, tamanu oil, and baobab oil.

Saturated fats have a longer shelf life compared with unsaturated fats. Therefore, oils rich in saturated FAs can be used as food preservatives. Such oils help to extend the shelf life of certain products by providing a protective barrier against oxidation and spoilage [34]. Saturated FAs have emollient properties, which means they can help moisturize and soften the skin and hair [35]. Oils like coconut oil, shea butter, and cocoa butter, which are rich in saturated FAs, are commonly used in skincare products, such as lotions, balms, and hair conditioners, to provide hydration and nourishment. Saturated fats are often used in the production of soaps, candles, and cosmetics; they contribute to the hardness and stability of the final product [36]. Saturated FAs provide a rich and creamy texture to various food products. They can contribute to the smoothness and mouthfeel of items such as ice cream, chocolate, and pastries [37]. It is important to note that while saturated FAs have their uses, it is recommended to consume them in moderation as part of a balanced diet. High intake of saturated FAs has been associated with an increased risk of certain health conditions, such as heart disease [38].

Table 3 shows the major and minor components of grape seed (*Vitis vinifera*), black seed (*Nigella sativa*), evening primrose (*Oenothera biennis*), passion fruit (*Passiflora edulis*), milk thistle (*Silybum marianum*), sunflower (*Helianthus annuus*), pumpkin (*Cucurbita pepo*) seed, and sesame (*Sesamum indicum*) seed oils. All of these oils contained linoleic acid as the major compound. Firstly, in grape seed oil, linoleic acid was the major constituent followed by (*Z*)-oleic acid, which was in close agreement with a study from Iraq [39]. Besides these components, sunflower oil contained the least amount of palmitic acid and the highest linoleic acid, which is comparable to TL1 accessions from Tunisia [40], while the FA result of black seed was in close agreement with black seed oil of Indian origin rather than Ethiopian origin, which contains a very high percentage of linoleic acid, 61.25% [41]. Interestingly, evening primrose oil contains γ-linolenic acid in significant amounts, which was supported by the study by Timoszuk et al. from Poland [42]. Sesame oil FA composition was similar to that of sesame seed oil from India [43]; only a few studies have reported the presence of sesamin in sesame oil, which contributes to the medicinal properties of the oil [44]. Interestingly, milk thistle contained the lowest amount of (*E*)-oleic acid compared with other oils. The lowest amount of (*E*)-oleic acid in milk thistle was incorporated with its extraction process using the cold-pressed method, while the role of heat in the extraction process increased the amount of (*E*)-FA. The FA composition of milk thistle was similar to the study by Nasrollahi et al. from the Zarghan region of Iran. However, in our study, milk thistle oil contained significant amounts of unsaturated FAs (arachidic acid and behenic acid), which was not reported by Nasrollahi et al. [45]. Our result of the FA composition of passion fruit was supported by the work of Ramaiya et al. who studied three different species of *Passiflora* and our result was in close agreement with *P. edulis* species [46]. Among these oils, grape seed, black seed, passion fruit, milk thistle, sunflower, pumpkin seed, and sesame oil had (*Z*)-oleic acid as a second major component followed by saturated FAs (palmitic acid and stearic acid). Interestingly, evening primrose oil contained γ-linolenic acid as a second major component followed by (*Z*)-oleic acid and saturated FAs. Besides these, sesame seed, grape seed, evening primrose, and sunflower oil contained methyl cholesterol. Interestingly, pumpkin seed oil did not contain any phytosterols, while the FA composition of pumpkin seed oil was supported by a study by Bardaa et al. from Tunisia [47].

**Table 2.** Fatty acid composition of different vegetable oils and fats with higher contents of saturated fats.

| Synonyms | RI | Compound Name | Nangai Nut | | Pili Nut | | Shea Butter | | Tamanu | | Baobab | | Sea Buckthorn Berry | | Brazil Nut | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| | 1389 | (*E*)-Cinnamic acid | | | | | 0–0.04 | 0.02 ± 0.02 | 0–0.15 | 0.05 ± 0.05 | | | | | | |
| C12:0 | 1523 | Lauric acid | | | | | | | | | | | 0–0.01 | 0.01 ± 0.01 | 0.01–0.12 | 0.05 ± 0.04 |
| C14:0 | 1758 | Myristic acid | 0.01–0.05 | 0.04 ± 0.03 | 0.08–0.16 | 0.11 ± 0.07 | 0–0.02 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | 0.1–0.19 | 0.15 ± 0.04 | 0.11–0.16 | 0.13 ± 0.02 | 0.02–0.16 | 0.08 ± 0.05 |
| C15:0 | 1821 | Pentadecanoic acid | 0–0.02 | 0.01 ± 0.01 | 0.01–0.04 | 0.02 ± 0.02 | | | | | 0.02–0.05 | 0.04 ± 0.01 | 0.04–0.06 | 0.05 ± 0.01 | 0–0.02 | 0.01 ± 0.01 |
| *trans*-7,10, C16:2 | 1887 | 7,10-Hexadecadienoic acid | | | | | | | | | 0–0.01 | 0.01 ± 0.01 | | | | |
| *cis*-7, C16:1 | 1894 | (*Z*)-7-Hexadecenoic acid | 0.01–0.04 | 0.02 ± 0.02 | 0.76–1.06 | 0.97 ± 0.17 | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | 0–0.03 | 0.02 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | 0–0.32 | 0.05 ± 0.11 |
| *cis*-9, C16:1 | 1901 | Palmitoleic acid | 0.17–0.29 | 0.25 ± 0.12 | 0.24–0.36 | 0.31 ± 0.15 | 0.01–0.05 | 0.03 ± 0.02 | 0.08–0.25 | 0.14 ± 0.05 | 0.12–0.2 | 0.15 ± 0.03 | 28.96–31.1 | 29.87 ± 0.86 | 0–0.45 | 0.26 ± 0.19 |
| C16:0 | 1924 | Palmitic acid | 25.36–31.12 | 28.99 ± 3.96 | 26.47–33.65 | 29.81 ± 4.86 | 2.09–4.50 | 3.25 ± 1.13 | 11.14–16.03 | 13.08 ± 1.37 | 21.59–25.7 | 23.84 ± 1.8 | 23.73–27.13 | 25.2 ± 1.37 | 7.90–17.81 | 14.49 ± 3.33 |
| *cis*-9,12, C17:2 | 1990 | 9,12-Heptadecadienoic acid | | | | | | | | | 0.13–0.22 | 0.17 ± 0.03 | 0–0.04 | 0.01 ± 0.02 | 0–0.01 | 0.01 ± 0.01 |
| *cis*-10, C17:1 | 1996 | (*Z*)-10-Heptadecenoic acid | | | 0–0.05 | 0.03 ± 0.03 | | | 0–0.04 | 0.02 ± 0.01 | 0.18–0.33 | 0.27 ± 0.06 | 0.05–0.07 | 0.06 ± 0.01 | 0.01–0.04 | 0.03 ± 0.01 |
| C17:0 | 2026 | Heptadecanoic acid | 0.08–0.15 | 0.13 ± 0.06 | 0.11–0.16 | 0.14 ± 0.08 | 0.03–0.09 | 0.06 ± 0.03 | 0.06–0.19 | 0.12 ± 0.04 | 0.17–0.27 | 0.23 ± 0.04 | 0.03–0.05 | 0.04 ± 0.01 | 0.02–0.12 | 0.08 ± 0.03 |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 10.04–15.23 | 13.63 ± 2.86 | 2.74–3.86 | 3.17 ± 0.88 | 2.51–6.55 | 4.14 ± 1.83 | 22.48–33.78 | 26.48 ± 3.48 | 25.29–29.6 | 27.34 ± 1.72 | 5.99–8.41 | 7.38 ± 1.2 | 29.44–50.34 | 34.62 ± 6.92 |
| *cis*-9,12,15, C18:3 | 2096 | Linolenic acid | | | | | | | | | | | 1.06–2.48 | 1.75 ± 0.65 | | |
| *cis*-9, C18:1 | 2102 | (*Z*)-Oleic acid | 32.14–38.56 | 36.52 ± 5.63 | 36.62–43.28 | 39.82 ± 5.63 | 50.62–68.86 | 56.83 ± 7.15 | 28.58–45.97 | 39.03 ± 4.89 | 32.17–36.84 | 34.88 ± 2.17 | 18.97–20.87 | 19.86 ± 0.88 | 25.30–48.31 | 35.15 ± 6.96 |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 0.78–2.41 | 1.39 ± 0.86 | 18.14–23.68 | 20.62 ± 4.21 | 0.08–0.84 | 0.39 ± 0.28 | 0.53–1.14 | 0.85 ± 0.17 | 0.91–1.3 | 1.08 ± 0.14 | 8.53–10.38 | 9.6 ± 0.7 | 0.05–1.41 | 0.93 ± 0.47 |
| C18:0 | 2126 | Stearic acid | 12.84–17.95 | 16.62 ± 2.47 | 3.21–4.93 | 4.12 ± 0.83 | 21.69–39.01 | 32.1 ± 6.47 | 13.75–18.09 | 16.79 ± 1.38 | 4.42–5.82 | 5.02 ± 0.65 | 1.57–1.95 | 1.78 ± 0.15 | 7.87–14.15 | 12.73 ± 2.77 |
| C20:2 | 2183 | Ethyl linoleate | | | | | 0–0.04 | 0.01 ± 0.02 | 0–0.07 | 0.02 ± 0.03 | | 0.01 ± 0.03 | 0–0.05 | 0.02 ± 0.02 | 0.01–0.14 | 0.05 ± 0.04 |
| *cis*-10, C19:1 | 2193 | (*Z*)-10-Nonadecenoic acid | | | | | 0–0.04 | 0.02 ± 0.02 | 0–0.05 | 0.01 ± 0.02 | 0.05–0.1 | 0.07 ± 0.02 | | | 0–0.02 | 0.01 ± 0.01 |

**Table 2.** *Cont.*

| Synonyms | RI | Compound Name | Nangai Nut | | Pili Nut | | Shea Butter | | Tamanu | | Baobab | | Sea Buckthorn Berry | | Brazil Nut | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | | | | | | | | | 1.93–3.04 | 2.45 ± 0.4 | | | 0–0.01 | 0.01 ± 0.01 |
| C19:0 | 2222 | Nonadecanoic acid | | | | | 0.02–0.06 | 0.04 ± 0.02 | 0–0.05 | 0.02 ± 0.02 | | | | | 0–0.01 | 0 ± 0.01 |
| | 2267 | (*Z*)-9-Tricosene | | | | | | | | | | | 0–0.02 | 0.01 ± 0.01 | | |
| *cis*-11, C20:1 | 2296 | (*Z*)-11-Eicosenoic acid | 0.11–0.23 | 0.16 ± 0.08 | 0.08–0.15 | 0.13 ± 0.08 | 0.14–0.4 | 0.28 ± 0.12 | 0.22–0.42 | 0.32 ± 0.08 | 0.27–0.39 | 0.34 ± 0.05 | 0.12–0.29 | 0.22 ± 0.07 | 0.02–0.32 | 0.12 ± 0.09 |
| C20:0 | 2322 | Arachidic acid | 0.58–0.75 | 0.69 ± 0.17 | 0.25–0.34 | 0.31 ± 0.09 | 1.02–2.01 | 1.41 ± 0.44 | 0.81–1.60 | 1.20 ± 0.34 | 1.06–2.16 | 1.4 ± 0.45 | 0.28–0.5 | 0.39 ± 0.11 | 0.14–0.66 | 0.49 ± 0.16 |
| C21:0 | 2422 | Heneicosanoic acid | | | | | 0.01–0.02 | 0.01 ± 0 | 0–0.06 | 0.03 ± 0.03 | 0.03–0.07 | 0.04 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 |
| | 2467 | 1-Heneicosyl formate | | | | | | | | | | | 0–0.04 | 0.02 ± 0.02 | | |
| | 2498 | Pentacosane | | | | | | | | | | | 0.05–0.19 | 0.11 ± 0.05 | | |
| *cis*-13, C22:1 | 2499 | Erucic acid | | | | | | | | | 0–0.01 | 0 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | | |
| C22:0 | 2522 | Behenic acid | 0.09–0.15 | 0.13 ± 0.05 | 0.04–0.09 | 0.07 ± 0.04 | 0.17–0.32 | 0.22 ± 0.06 | 0.21–0.76 | 0.47 ± 0.22 | 0.46–1.15 | 0.64 ± 0.29 | 0.11–0.34 | 0.21 ± 0.1 | 0.04–1.54 | 0.31 ± 0.5 |
| | 2600 | Hexacosane | | | | | | | | | | | 0–0.01 | 0 ± 0.01 | | |
| C23:0 | 2622 | Tricosanoic acid | 0.02–0.09 | 0.06 ± 0.04 | | | 0.02–0.04 | 0.03 ± 0.01 | 0–0.09 | 0.04 ± 0.04 | 0.08–0.19 | 0.11 ± 0.05 | 0–0.06 | 0.03 ± 0.02 | 0–0.05 | 0.03 ± 0.02 |
| | 2698 | Heptacosane | | | | | | | | | | | 0.06–0.2 | 0.11 ± 0.06 | | |
| *cis*-15, C24:1 | 2699 | (*Z*)-15-Tetracosenoic acid | | | | | | | | | | | 0–0.07 | 0.04 ± 0.04 | | |
| C24:0 | 2722 | Lignoceric acid | 0.14–0.26 | 0.23 ± 0.11 | 0.02–0.08 | 0.06 ± 0.03 | 0.18–0.3 | 0.22 ± 0.05 | 0–0.33 | 0.17 ± 0.12 | 0.36–1.04 | 0.58 ± 0.28 | 0.12–0.48 | 0.29 ± 0.15 | 0.03–0.54 | 0.17 ± 0.17 |
| | 2791 | Octacosane | | | | | | | | | | | 0–0.01 | 0 ± 0.01 | | |
| | 2803 | (*E*)-Squalene | 0.06–0.10 | 0.08 ± 0.03 | | | 0–0.03 | 0.02 ± 0.01 | 0.02–3.15 | 0.89 ± 1.24 | 0.01–0.04 | 0.02 ± 0.01 | 0–0.05 | 0.02 ± 0.02 | 0–0.35 | 0.16 ± 0.12 |
| C25:0 | 2830 | Pentacosanoic acid | 0.04–0.08 | 0.06 ± 0.03 | 0–0.03 | 0.01 ± 0.02 | 0.02–0.03 | 0.02 ± 0.01 | | | 0.07–0.17 | 0.1 ± 0.05 | 0–0.07 | 0.03 ± 0.03 | 0–0.03 | 0.02 ± 0.01 |
| | 2899 | Nonacosane | 0–0.02 | 0.01 ± 0.01 | | | | | | | | | 0.1–0.48 | 0.27 ± 0.14 | | |
| C26:0 | 2926 | Hexacosanoic acid | 0.01–0.08 | 0.06 ± 0.04 | 0–0.03 | 0.02 ± 0.01 | 0.06–0.09 | 0.07 ± 0.02 | | | 0.09–0.23 | 0.14 ± 0.06 | 0.09–0.5 | 0.29 ± 0.16 | 0–0.04 | 0.02 ± 0.01 |
| | 3091 | β-Sitosteryl acetate | | | | | | | | | 0–0.06 | 0.03 ± 0.02 | | | | |
| | 3096 | Untriacontane | | | | | | | | | | | 0–0.28 | 0.14 ± 0.11 | | |
| C28:0 | 3130 | Octacosanoic acid | | | | | 0–0.01 | 0.01 ± 0 | | | 0.03–0.05 | 0.04 ± 0.01 | 0.22–0.81 | 0.53 ± 0.24 | | |
| | 3303 | γ-Sitosterol | 0.46–0.54 | 0.51 ± 0.12 | 0.01–0.06 | 0.04 ± 0.03 | | | | | 0.41–1.06 | 0.64 ± 0.26 | 0–1.24 | 0.69 ± 0.45 | | |
| C30:0 | 3328 | Triacontanoic acid | | | | | | | 0–0.18 | 0.04 ± 0.06 | | | 0–0.3 | 0.18 ± 0.12 | | |

**Table 2.** *Cont.*

| Synonyms | RI | Compound Name | Nangai Nut | | Pili Nut | | Shea Butter | | Tamanu | | Baobab | | Sea Buckthorn Berry | | Brazil Nut | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| | 3445 | Stigmast-4-en-3-one | 0–0.03 | 0.02 ± 0.02 | | | | | | | | | 0–0.04 | 0.01 ± 0.02 | | |
| | 3496 | Lupeol acetate | | | | | 0.17–0.72 | 0.49 ± 0.22 | | | | | | | | |
| C32:0 | 3522 | Lacceroic acid | | | | | | | | | | | 0–0.08 | 0.04 ± 0.04 | | |

RI = retention index. MSD = mean ± standard deviation.

**Table 3.** Fatty acid composition of different vegetable oils rich in linoleic acid.

| Synonyms | RI | Compound Name | Grape Seed Oil | | Black seed Oil | | Evening Primrose Oil | | Passion Fruit Oil | | Milk Thistle Oil | | Sunflower Oil | | Pumpkin Seed Oil | | Sesame Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 8) | Range | MSD (n = 10) | Range | MSD (n = 4) | Range | MSD (n = 10) | Range | MSD (n = 2) | Range | MSD (n = 10) |
| *trans*-2, C6:1 | 957 | (*E*)-2-Hexenoic acid | | | | | 0–0.02 | 0.01 ± 0.01 | | | | | | | | | | |
| *trans*-2, C8:1 | 1162 | (*E*)-2-Octenoic acid | | | | | 0–0.02 | 0.01 ± 0.01 | | | | | | | | | | |
| C12:0 | 1523 | Lauric acid | | | | | | | 0–0.26 | 0.04 ± 0.08 | | | 0–0.04 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | | |
| C14:0 | 1758 | Myristic acid | 0.01–0.07 | 0.04 ± 0.02 | 0.1–0.22 | 0.16 ± 0.04 | 0.02–0.05 | 0.03 ± 0.01 | 0.02–0.2 | 0.07 ± 0.06 | 0.03–0.09 | 0.06 ± 0.04 | 0.01–0.08 | 0.05 ± 0.02 | 0.05–0.12 | 0.08 ± 0.06 | 0–0.08 | 0.02 ± 0.02 |
| C15:0 | 1821 | Pentadecanoic acid | 0–0.01 | 0.01 ± 0 | 0.02–0.04 | 0.03 ± 0.01 | 0–0.01 | 0.01 ± 0 | 0–0.03 | 0.02 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | | |
| *trans*-7,10, C16:2 | 1887 | 7,10-Hexadecadienoic acid | | | | | 0–0.01 | 0.01 ± 0 | 0–0.01 | 0 ± 0.01 | | | | | 0–0.02 | 0.02 ± 0.01 | | |
| *cis*-7, C16:1 | 1894 | (*Z*)-7-Hexadecenoic acid | 0.01–0.03 | 0.02 ± 0.01 | 0.01–0.03 | 0.01 ± 0.01 | 0.01–0.03 | 0.02 ± 0.01 | 0.01–0.06 | 0.03 ± 0.02 | | | 0.01–0.02 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | 0.01–0.03 | 0.02 ± 0 |
| *cis*-9, C16:1 | 1901 | Palmitoleic acid | 0.02–0.16 | 0.08 ± 0.05 | 0.12–0.28 | 0.18 ± 0.05 | 0.01–0.06 | 0.04 ± 0.02 | 0.04–0.31 | 0.17 ± 0.1 | 0.04–0.08 | 0.06 ± 0.03 | 0.03–0.11 | 0.07 ± 0.02 | 0.03–0.14 | 0.12 ± 0.05 | 0.04–0.15 | 0.11 ± 0.03 |
| *trans*-9,12, C16:2 | 1905 | 9,12-Hexadecadienoic acid | | | | | | | 0–0.04 | 0.02 ± 0.01 | | | | | | | | |
| C16:0 | 1924 | Palmitic acid | 4.46–8.51 | 7.1 ± 1.61 | 12–14.32 | 12.86 ± 0.83 | 6.05–9.74 | 7.59 ± 1.2 | 7.74–17.5 | 11.51 ± 2.98 | 5.14–9.56 | 7.17 ± 1.86 | 4.47–8.35 | 6.39 ± 1.2 | 8.58–13.94 | 11.59 ± 2.75 | 8.21–11.54 | 9.69 ± 1.3 |

**Table 3.** *Cont.*

| Synonyms | RI | Compound Name | Grape Seed Oil | | Black seed Oil | | Evening Primrose Oil | | Passion Fruit Oil | | Milk Thistle Oil | | Sunflower Oil | | Pumpkin Seed Oil | | Sesame Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Range** | **MSD (n = 5)** | **Range** | **MSD (n = 9)** | **Range** | **MSD (n = 8)** | **Range** | **MSD (n = 10)** | **Range** | **MSD (n = 4)** | **Range** | **MSD (n = 10)** | **Range** | **MSD (n = 2)** | **Range** | **MSD (n = 10)** |
| *cis*-9,12, C17:2 | 1990 | 9,12-Heptadecadienoic acid | 0.01–0.02 | 0.01 ± 0.01 | 0.01–0.02 | 0.01 ± 0 | 0.02–0.04 | 0.03 ± 0.01 | 0.01–0.05 | 0.03 ± 0.02 | | | 0–0.01 | 0.01 ± 0.01 | 0–0.02 | 0.02 ± 0.01 | | |
| *cis*-10, C17:1 | 1996 | (*Z*)-10-Heptadecenoic acid | 0.01–0.03 | 0.02 ± 0.01 | 0.03–0.05 | 0.04 ± 0.01 | 0.02–0.03 | 0.03 ± 0.01 | 0.01–0.06 | 0.03 ± 0.02 | | | 0–0.04 | 0.02 ± 0.01 | 0.01–0.04 | 0.03 ± 0.02 | 0.01–0.04 | 0.02 ± 0.01 |
| C17:0 | 2026 | Heptadecanoic acid | 0.03–0.06 | 0.05 ± 0.02 | 0.05–0.08 | 0.07 ± 0.01 | 0.06–0.09 | 0.07 ± 0.01 | 0.02–0.15 | 0.07 ± 0.04 | 0.01–0.06 | 0.04 ± 0.03 | 0.02–0.08 | 0.04 ± 0.02 | 0.04–0.10 | 0.09 ± 0.05 | 0.02–0.08 | 0.05 ± 0.02 |
| *cis*-6,9,12, C18:3 | 2077 | γ-Linolenic acid | | | | | 8.34–11.5 | 9.7 ± 1.08 | | | | | | | | | | |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 51.06–72.89 | 60.96 ± 8.4 | 44.6–52.64 | 49.71 ± 2.63 | 60.8–70.59 | 65.93 ± 3.55 | 57.61–76.77 | 66.23 ± 6.72 | 45.74–52.16 | 49.01 ± 4.34 | 47.38–56.24 | 52.34 ± 2.99 | 38.96–44.74 | 44.56 ± 4.63 | 36.66–54.91 | 42.41 ± 4.91 |
| *cis*-9, C18:1 | 2102 | (*Z*)-Oleic acid | 15.98–34.37 | 23.84 ± 7.53 | 24.74–30.56 | 27.34 ± 2.07 | 8.44–10.34 | 9.45 ± 0.6 | 11.55–19.72 | 16.34 ± 2.59 | 27.16–33.12 | 31.59 ± 3.02 | 26.23–38.68 | 31.64 ± 4.18 | 28.69–35.88 | 33.5 ± 6.5 | 25.36–41.45 | 37.31 ± 4.65 |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 0.79–1.33 | 1.1 ± 0.21 | 1.05–2.15 | 1.45 ± 0.36 | 0.74–1.44 | 0.96 ± 0.22 | 0.01–1.46 | 0.6 ± 0.52 | 0.54–0.63 | 0.59 ± 0.14 | 0.13–1.66 | 0.97 ± 0.47 | 0.56–1.03 | 0.81 ± 0.69 | 0.8–1.97 | 1.23 ± 0.36 |
| *trans*-13, C18:1 | 2113 | (*E*)-13-Octadecenoic acid | | | | | | | 0–0.09 | 0.01 ± 0.03 | | | | | 0–0.01 | 0.01 ± 0.01 | | |
| C18:0 | 2126 | Stearic acid | 3.79–6.86 | 5.1 ± 1.11 | 2.94–4.57 | 3.82 ± 0.55 | 2.35–3.58 | 3.05 ± 0.45 | 1.84–7.64 | 3.85 ± 1.69 | 4.10–6.89 | 5.13 ± 1.03 | 3.74–8.15 | 5.3 ± 1.59 | 3.56–8.19 | 5.28 ± 1.81 | 4.01–8.33 | 6.58 ± 1.4 |
| C20:2 | 2183 | Ethyl linoleic acid | 0.01–0.41 | 0.12 ± 0.17 | 0–0.03 | 0.01 ± 0.01 | 0.03–0.06 | 0.04 ± 0.01 | 0.01–0.07 | 0.03 ± 0.02 | | | 0.03–0.15 | 0.07 ± 0.04 | 0–0.01 | 0.01 ± 0.01 | 0–0.07 | 0.03 ± 0.02 |
| *cis*-10, C19:1 | 2193 | (*Z*)-10-Nonadecenoic acid | 0.01–0.02 | 0.01 ± 0 | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.02 ± 0.01 | 0–0.03 | 0.01 ± 0.01 | | | 0.01–0.02 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | 0–0.02 | 0.01 ± 0.01 | | | 0–0.03 | 0.02 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | | | 0–0.01 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | | |
| C19:0 | 2222 | Nonadecanoic acid | 0–0.01 | 0 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | | | | | | | | | 0–0.02 | 0.01 ± 0.01 |
| *cis*-11,14, C20:2 | 2284 | (*Z*)-11,14-Eicosadienoic acid | 0–0.04 | 0.02 ± 0.02 | 2.09–4.8 | 2.92 ± 0.92 | 0.05–0.07 | 0.06 ± 0.01 | 0.01–0.06 | 0.03 ± 0.02 | | | 0–0.02 | 0.01 ± 0.01 | | | 0–0.03 | 0.02 ± 0.01 |
| *cis*-11, C20:1 | 2296 | (*Z*)-11-Eicosenoic acid | 0.18–0.27 | 0.23 ± 0.04 | 0.35–0.87 | 0.52 ± 0.18 | 0.27–0.9 | 0.49 ± 0.2 | 0–0.35 | 0.15 ± 0.1 | 0.42–0.78 | 0.69 ± 0.19 | 0.15–0.35 | 0.23 ± 0.07 | 0.09–0.19 | 0.15 ± 0.06 | 0.17–0.57 | 0.26 ± 0.11 |
| C20:0 | 2322 | Arachidic acid | 0.21–0.42 | 0.28 ± 0.08 | 0.16–0.36 | 0.26 ± 0.06 | 0.35–0.62 | 0.49 ± 0.1 | 0.1–0.56 | 0.24 ± 0.13 | 1.74–3.40 | 2.42 ± 0.86 | 0.28–0.64 | 0.43 ± 0.14 | 0.45–0.69 | 0.56 ± 0.21 | 0.48–1.11 | 0.77 ± 0.17 |

**Table 3.** *Cont.*

| Synonyms | RI | Compound Name | Grape Seed Oil | | Black seed Oil | | Evening Primrose Oil | | Passion Fruit Oil | | Milk Thistle Oil | | Sunflower Oil | | Pumpkin Seed Oil | | Sesame Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 8) | Range | MSD (n = 10) | Range | MSD (n = 4) | Range | MSD (n = 10) | Range | MSD (n = 2) | Range | MSD (n = 10) |
| C21:0 | 2422 | Heneicosanoic acid | 0–0.02 | 0.01 ± 0.01 | | | 0–0.03 | 0.02 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | | | 0–0.01 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0 |
| *cis*-13–16, C22:2 | 2495 | (*Z*)-13,16-Docasadienoic acid | | | 0–0.08 | 0.03 ± 0.03 | | | | | | | | | | | | |
| *cis*-13, C22:1 | 2499 | Erucic acid | | | 0–0.05 | 0.02 ± 0.02 | 0–0.43 | 0.16 ± 0.13 | 0–0.06 | 0.02 ± 0.02 | | | | | | | 0–0.02 | 0.01 ± 0.01 |
| C22:0 | 2522 | Behenic acid | 0.04–1.28 | 0.44 ± 0.57 | 0.03–0.23 | 0.1 ± 0.07 | 0.16–0.39 | 0.25 ± 0.09 | 0.05–0.26 | 0.11 ± 0.06 | 1.42–2.59 | 2.05 ± 0.71 | 0.81–2.18 | 1.39 ± 0.46 | 0.10–0.21 | 0.16 ± 0.09 | 0.14–0.72 | 0.25 ± 0.17 |
| C23:0 | 2622 | Tricosanoic acid | 0.01–0.06 | 0.03 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | 0.02–0.05 | 0.03 ± 0.01 | 0–0.06 | 0.02 ± 0.02 | 0–0.04 | 0.03 ± 0.02 | 0.03–0.09 | 0.05 ± 0.02 | 0.01–0.03 | 0.02 ± 0.03 | 0–0.04 | 0.02 ± 0.01 |
| | 2698 | Heptacosane | | | | | | | 0–0.08 | 0.02 ± 0.03 | | | | | | | | |
| *cis*-15, C24:1 | 2699 | (*Z*)-15-Tetracosenoic acid | | | | | 0–0.33 | 0.11 ± 0.1 | 0–0.02 | 0.01 ± 0.01 | | | 0–0.01 | 0.01 ± 0.01 | | | | |
| C24:0 | 2722 | Lignoceric acid | 0.02–0.54 | 0.17 ± 0.23 | 0.02–0.1 | 0.06 ± 0.03 | 0.07–0.22 | 0.12 ± 0.05 | 0.05–0.28 | 0.12 ± 0.08 | 0.51–0.78 | 0.69 ± 0.17 | 0.27–0.83 | 0.53 ± 0.19 | 0.07–0.13 | 0.10 ± 0.07 | 0.09–0.35 | 0.17 ± 0.08 |
| | 2791 | Octacosane | | | | | | | | | | | | | | | | |
| | 2803 | (*E*)-Squalene | 0–0.02 | 0.01 ± 0.01 | 0–0.04 | 0.01 ± 0.01 | 0–0.07 | 0.02 ± 0.02 | 0.01–0.08 | 0.04 ± 0.03 | 0.01–0.07 | 0.05 ± 0.04 | 0–0.02 | 0.01 ± 0.01 | 0.10–0.19 | 0.15 ± 0.08 | | |
| C25:0 | 2830 | Pentacosanoic acid | | | 0–0.02 | 0.01 ± 0.01 | 0–0.03 | 0.02 ± 0.01 | 0.01–0.05 | 0.02 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.02 | 0.01–0.05 | 0.03 ± 0.01 |
| | 2899 | Nonacosane | 0–0.01 | 0 ± 0.01 | | | 0–0.04 | 0.01 ± 0.01 | 0–0.05 | 0.01 ± 0.02 | 0.02–0.05 | 0.04 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | | | | |
| C26:0 | 2926 | Hexacosanoic acid | 0.01–0.04 | 0.02 ± 0.01 | 0–0.04 | 0.01 ± 0.01 | 0–0.04 | 0.02 ± 0.01 | 0.01–0.07 | 0.03 ± 0.02 | 0–0.03 | 0.02 ± 0.01 | 0.01–0.23 | 0.05 ± 0.07 | 0.02–0.04 | 0.03 ± 0.02 | 0.02–0.09 | 0.05 ± 0.03 |
| | 3091 | β-Sitosteryl acetate | 0–0.06 | 0.02 ± 0.03 | | | 0.01–0.68 | 0.19 ± 0.29 | | | | | 0–0.05 | 0.01 ± 0.02 | | | 0–0.06 | 0.01 ± 0.02 |
| | 3096 | Untriacontane | 0–0.02 | 0.01 ± 0.01 | | | 0–0.03 | 0.01 ± 0.01 | | | | | 0–0.02 | 0.01 ± 0.01 | | | | |
| C28:0 | 3130 | Octacosanoic acid | 0–0.03 | 0.01 ± 0.01 | | | 0–0.01 | 0 ± 0.01 | | | | | 0–0.02 | 0.01 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 |
| | 3163 | Sesamin | | | | | | | | | | | | | | | 0.02–0.81 | 0.25 ± 0.22 |

**Table 3.** *Cont.*

| Synonyms | RI | Compound Name | Grape Seed Oil | | Black seed Oil | | Evening Primrose Oil | | Passion Fruit Oil | | Milk Thistle Oil | | Sunflower Oil | | Pumpkin Seed Oil | | Sesame Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 5) | Range | MSD (n = 9) | Range | MSD (n = 8) | Range | MSD (n = 10) | Range | MSD (n = 4) | Range | MSD (n = 10) | Range | MSD (n = 2) | Range | MSD (n = 10) |
| | 3227 | Methyl cholesterol | 0–0.03 | 0.01 ± 0.02 | | | 0–0.15 | 0.04 ± 0.06 | | | | | 0–0.04 | 0.01 ± 0.02 | | | 0–0.29 | 0.13 ± 0.09 |
| | 3246 | Stigmasterol | 0–0.04 | 0.02 ± 0.02 | 0–0.04 | 0.01 ± 0.02 | | | 0–0.1 | 0.02 ± 0.04 | | | 0–0.06 | 0.02 ± 0.02 | | | 0–0.1 | 0.02 ± 0.03 |
| | 3253 | 3β-Methoxystigmast-5-ene | | | | | 0–0.14 | 0.04 ± 0.05 | | | | | | | | | | |
| | 3303 | γ-Sitosterol | 0–0.41 | 0.22 ± 0.17 | 0–0.22 | 0.06 ± 0.09 | 0–1.93 | 0.83 ± 0.78 | 0–0.14 | 0.05 ± 0.06 | 0.25–0.33 | 0.28 ± 0.11 | 0–0.5 | 0.23 ± 0.14 | | | 0–0.9 | 0.46 ± 0.3 |
| C30:0 | 3328 | Triacontanoic acid | | | | | | | | | | | 0–0.07 | 0.02 ± 0.02 | | | | |
| | 3445 | Stigmast-4-en-3-one | | | 0–0.02 | 0 ± 0.01 | 0.02–0.14 | 0.06 ± 0.04 | | | | | | | | | | |

RI = retention index. MSD = mean ± standard deviation.

Oils that are rich in linoleic acid can be beneficial for various purposes. Linoleic acid is an essential omega-6 FA that plays a crucial role in maintaining the health of our bodies [48]. It is known for its moisturizing and nourishing properties, making it a popular ingredient in skincare products. Oils such as sunflower oil and evening primrose oil, which are high in linoleic acid, are often used in moisturizers, serums, and facial oils. They can help improve skin hydration, reduce inflammation, and maintain a healthy skin barrier [49]. Linoleic acid is beneficial for hair health as well. It helps to moisturize the scalp, promote hair growth, and prevent hair breakage [50]. Linoleic acid is an essential FA that our bodies cannot produce on their own, so it needs to be obtained through our diet [51].

The FA composition analysis of soybean (*Glycine max*) oil, flaxseed (*Linum usitatissimum*) oil, kukui (*Aleurites moluccanus*) oil, red raspberry (*Rubus idaeus*) seed oil, walnut (*Juglans regia*) oil, chia (*Salvia hispanica*) seed oil, hemp (*Cannabis sativa*) seed oil, and rosehip (*Rosa rubiginosa*) oil is presented in Table 4. These oils are grouped in this table due to their significant contents of linolenic acid. Although they contained a substantial amount of linolenic acid, all of these oils, except chia seed oil, were primarily rich in linoleic acid. Chia seed oil stands out as it contains linolenic acid as the major compound. The present FA analysis of chia seed was in close agreement with a study from Canada in which a slightly higher percentage of (*Z*)-oleic acid and linolenic acid and less linoleic acid were reported than in this study [52]. Moreover, our study showed chia seed oil did not contain any (*E*)-FAs. In contrast, soybean oil had the highest amount of it. Similarly, soybean oil was abundant in (*Z*)-oleic acid. In addition to these differences, soybean oil also had the highest content of saturated FAs, namely palmitic acid and stearic acid, and our study was similar to the result reported by Cherif and Slama from Tunisia [53]. A study by Guney from Turkey showed high (*Z*)-oleic acid and low linolenic acid compared with the results of our study on rosehip oil; however, other FAs like linoleic acid, palmitic acid, and stearic acid are almost comparable to our result [54]. In this study, methyl cholesterol was found in soybean oil, chia seed oil, and hemp seed oil. Hemp seed oil primarily contains linoleic acid as a major compound followed by linolenic acid and (*Z*)-oleic acid. This result of hemp seed FAs was supported by a Porto et al. study from Italy, where they studied four different cultivars of hemp seed and the finola cultivar showed an almost similar FA composition compared with our study, with slightly higher $\gamma$-linolenic acid reported in their study [55]. FAs like linoleic acid and linoleic acid are in the same ratio in flax seed, whereas (*Z*)-oleic acid is slightly less; however, a study by Qiu et al. from China showed very high linolenic acid and much less linoleic acid while studying four different varieties of flax seed [56]. Moreover, in kukui oil, the ratio of linolenic acid to linoleic acid was almost 1:2, but in another study by Ako et al. from Hawaii, high linolenic acid was found while linoleic acid and (*Z*)-oleic acid were comparable to the present study [57]. In another study, red raspberry seed oil contained an approximately 1:2 ratio of (*Z*)-oleic acid and linoleic acid in contrast to our result; Abdul et al. from Iraq reported high linoleic and linolenic acid and low (*Z*)-oleic acid compared with our result [58]. These changes in FA percentage may be due to differences in cultivars (genetic differences), geographical variation, harvesting period, and method of extraction. Walnut oil was rich in linoleic acid followed by (*Z*)-oleic acid. The FA composition of walnut oil was comparable to the six cultivars of walnut found in north Tunisia [59].

**Table 4.** Fatty acid composition of different vegetable oils rich in linolenic acid.

| Synonyms | RI | Compound Name | Soybean Oil | | Flax Seed Oil | | Kukui Oil | | Red Raspberry Seed Oil | | Walnut Oil | | Chia Seed Oil | | Hemp Seed Oil | | Rosehip Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 8) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 4) | Range | MSD (n = 7) |
| C12:0 | 1523 | Lauric acid | | | 0–0.02 | 0.01 ± 0.02 | 0–0.01 | 0.01 ± 0 | | | | | | | | | 0–0.01 | 0.01 ± 0.01 |
| C14:0 | 1758 | Myristic acid | 0.01–0.08 | 0.06 ± 0.02 | 0.02–0.06 | 0.04 ± 0.03 | 0.05–0.09 | 0.07 ± 0.01 | | | 0.02–0.05 | 0.04 ± 0.03 | 0.01–0.04 | 0.03 ± 0.02 | 0.01–0.03 | 0.03 ± 0.01 | 0.02–0.06 | 0.04 ± 0.01 |
| | 1817 | Hexadecanal | | | | | | | 0.71–1.06 | 0.92 ± 0.23 | | | | | | | | |
| C15:0 | 1821 | Pentadecanoic acid | 0–0.02 | 0.01 ± 0.01 | 0.01–0.03 | 0.02 ± 0.02 | 0.01–0.03 | 0.02 ± 0.01 | | | 0–0.04 | 0.02 ± 0.02 | 0.00–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | 0–0.04 | 0.02 ± 0.01 |
| | 1836 | Neophytadiene | | | | | | | 0.24–0.37 | 0.33 ± 0.12 | | | | | | | | |
| *cis*-7, C16:1 | 1894 | (Z)-7-Hexadecenoic acid | 0–0.02 | 0.01 ± 0.01 | 0.02–0.04 | 0.03 ± 0.02 | 0.01–0.04 | 0.02 ± 0.01 | 0.17–0.25 | 0.21 ± 0.09 | 0–0.05 | 0.03 ± 0.04 | 0.01–0.02 | 0.01 ± 0 | 0–0.03 | 0.01 ± 0.02 | 0.02–0.04 | 0.02 ± 0.01 |
| *cis*-9, C16:1 | 1901 | Palmitoleic acid | 0.01–0.09 | 0.07 ± 0.03 | 0.05–0.09 | 0.07 ± 0.05 | 0.08–0.12 | 0.11 ± 0.07 | 0.11–0.17 | 0.15 ± 0.06 | 0.08–0.13 | 0.10 ± 0.04 | 0.01–0.06 | 0.05 ± 0.03 | 0.03–0.12 | 0.09 ± 0.04 | 0–0.19 | 0.11 ± 0.06 |
| C16:0 | 1924 | Palmitic acid | 5.41–13.14 | 11.49 ± 2.53 | 4.23–7.87 | 5.46 ± 1.32 | 6.27–8.57 | 7.47 ± 1.02 | 3.21–6.32 | 4.88 ± 1.56 | 5.28–8.64 | 7.52 ± 1.23 | 5.04–8.10 | 7.45 ± 1.43 | 4.53–8.98 | 7.52 ± 2.07 | 3.35–6.0 | 4.51 ± 0.82 |
| *cis*-9,12, C17:2 | 1990 | 9,12-Heptadecadienoic acid | 0.01–0.04 | 0.03 ± 0.01 | | | | | | | | | | | 0.01–0.03 | 0.02 ± 0.01 | 0–0.15 | 0.06 ± 0.05 |
| | 1992 | (Z)-9-Octadecenal | | | | | | | 0.86–2.35 | 1.72 ± 0.43 | | | | | | | | |
| *cis*-10, C17:1 | 1996 | (Z)-10-Heptadecenoic acid | 0.01–0.06 | 0.05 ± 0.02 | 0.01–0.04 | 0.02 ± 0.03 | 0.01–0.04 | 0.03 ± 0.02 | | | 0.01–0.06 | 0.03 ± 0.03 | 0.01–0.02 | 0.01 ± 0 | 0–0.04 | 0.03 ± 0.02 | 0.01–0.09 | 0.05 ± 0.02 |
| | 2018 | Octadecanal | | | | | | | 2.01–4.51 | 3.28 ± 1.03 | | | | | | | | |
| C17:0 | 2026 | Heptadecanoic acid | 0.03–0.12 | 0.1 ± 0.03 | 0.03–0.06 | 0.04 ± 0.05 | 0.02–0.06 | 0.05 ± 0.01 | | | 0.02–0.06 | 0.04 ± 0.03 | 0.03–0.06 | 0.04 ± 0.02 | 0.02–0.07 | 0.06 ± 0.02 | 0.02–0.11 | 0.07 ± 0.03 |
| *cis*-6,9,12, C18:3 | 2077 | γ-Linolenic acid | | | | | | | | | | | | | 0.25–0.78 | 0.55 ± 0.22 | | |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 46.35–55.97 | 48.26 ± 3.18 | 28.54–32.14 | 30.24 ± 3.26 | 40.35–45.75 | 43.02 ± 3.86 | 37.86–44.25 | 41.63 ± 4.66 | 52.61–56.28 | 54.48 ± 4.27 | 19.89–23.19 | 22.09 ± 1.65 | 51.03–59.63 | 53.85 ± 3.91 | 41.38–56.70 | 47.81 ± 4.65 |
| *cis*-9,12,15, C18:3 | 2096 | Linolenic acid | 0–6.91 | 2.55 ± 3.22 | 25.78–35.26 | 29.89 ± 6.87 | 20.27–24.18 | 22.08 ± 2.75 | 8.63–13.41 | 10.15 ± 2.15 | 3.12–6.44 | 4.92 ± 1.45 | 56.25–60.73 | 58.25 ± 3.98 | 15.7–19.4 | 17.85 ± 1.62 | 20.45–29.44 | 26.09 ± 3.06 |
| *cis*-9, C18:1 | 2102 | (Z)-Oleic acid | 22.42–30.63 | 27.11 ± 3.14 | 20.27–25.63 | 23.19 ± 3.47 | 15.20–19.84 | 17.99 ± 1.96 | 17.47–23.72 | 19.45 ± 3.02 | 24.74–29.21 | 26.27 ± 2.89 | 0.80–1.46 | 1.02 ± 0.82 | 10.34–14.64 | 11.95 ± 2.03 | 6.25–23.24 | 13.24 ± 5.54 |

**Table 4.** *Cont.*

| Synonyms | RI | Compound Name | Soybean Oil | | Flax Seed Oil | | Kukui Oil | | Red Raspberry Seed Oil | | Walnut Oil | | Chia Seed Oil | | Hemp Seed Oil | | Rosehip Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 8) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 4) | Range | MSD (n = 7) |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 0.78–2.31 | 1.9 ± 0.48 | 0.84–1.06 | 0.96 ± 0.65 | 0.44–0.76 | 0.61 ± 0.32 | 0.56–0.77 | 0.69 ± 0.27 | 0.78–1.24 | 1.16 ± 0.69 | | | 0.55–1.66 | 1.02 ± 0.46 | 0.17–1.52 | 0.89 ± 0.44 |
| *trans*-13, C18:1 | 2113 | (*E*)-13-Octadecenoic acid | | | | | | | | | | | | | | | | |
| C18:0 | 2126 | Stearic acid | 3.09–7.52 | 5.77 ± 1.44 | 4.41–6.58 | 5.14 ± 1.68 | 3.87–7.21 | 5.40 ± 1.12 | 1.86–3.42 | 2.55 ± 0.56 | 2.14–5.12 | 3.73 ± 1.09 | 3.28–5.26 | 4.56 ± 0.58 | 2.78–4.37 | 3.75 ± 0.71 | 2.37–4.96 | 3.29 ± 0.86 |
| | 2163 | (2*E*)-Nonadecenal | | | | | | | | | | | 0–0.1 | 0.01 ± 0 | | | | |
| C20:2 | 2183 | Ethyl linoleate | 0.04–0.1 | 0.07 ± 0.02 | 0.16–0.28 | 0.24 ± 0.17 | 0.04–0.08 | 0.06 ± 0.03 | | | | | 0–0.02 | 0.01 ± 0.01 | 0.01–0.05 | 0.03 ± 0.02 | 0.02–0.21 | 0.09 ± 0.07 |
| *cis*-10, C19:1 | 2193 | (*Z*)-10-Nonadecenoic acid | 0.01–0.02 | 0.02 ± 0.01 | 0.09–0.14 | 0.12 ± 0.08 | 0.01–0.04 | 0.03 ± 0.02 | | | | | | | | | 0–0.04 | 0.02 ± 0.02 |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | 0.01–0.03 | 0.02 ± 0.01 | 0.06–0.10 | 0.07 ± 0.05 | 0–0.02 | | | | | | | | 0–0.01 | 0.01 ± 0.01 | 0–0.05 | 0.02 ± 0.02 |
| C19:0 | 2222 | Nonadecanoic acid | | | | | | | | | | | 0.01–0.2 | 0.01 ± 0.01 | 0–0.01 | 0 ± 0.01 | 0–0.12 | 0.03 ± 0.04 |
| *cis*-11,14, C20:2 | 2284 | (*Z*)-11,14-Eicosadienoic acid | 0.02–0.06 | 0.04 ± 0.01 | 0.06–0.09 | 0.07 ± 0.04 | 0.05–0.07 | 0.06 ± 0.01 | | | 0–0.05 | 0.03 ± 0.03 | 0.01–0.04 | 0.03 ± 0.02 | 0.04–0.13 | 0.09 ± 0.04 | 0.01–0.27 | 0.17 ± 0.09 |
| *cis*-11, C20:1 | 2296 | (*Z*)-11-Eicosenoic acid | 0.09–0.34 | 0.28 ± 0.09 | 0.21–0.32 | 0.26 ± 0.19 | 0.32–0.36 | 0.34 ± 0.12 | 0.19–0.27 | 0.24 ± 0.11 | 0.16–0.28 | 0.25 ± 0.12 | 0.25–0.43 | 0.40 ± 0.21 | 0.37–0.77 | 0.56 ± 0.18 | 0.13–0.87 | 0.59 ± 0.26 |
| C20:0 | 2322 | Arachidic acid | 0.23–0.73 | 0.56 ± 0.16 | 0.22–0.27 | 0.25 ± 0.20 | 0.35–0.39 | 0.37 ± 0.13 | 0.51–0.76 | 0.68 ± 0.19 | 0.19–0.24 | 0.22 ± 0.09 | 0.21–0.41 | 0.35 ± 0.15 | 0.8–1.34 | 1.02 ± 0.25 | 0.2–1.93 | 1.14 ± 0.54 |
| C21:0 | 2422 | Heneicosanoic acid | 0.02–0.05 | 0.04 ± 0.01 | | | | | | | | | 0.01–0.06 | 0.05 ± 0.03 | 0–0.02 | 0.01 ± 0.01 | 0–0.08 | 0.04 ± 0.02 |
| *cis*-13, C22:1 | 2499 | Erucic acid | | | | | | | | | | | | | 0.02–0.03 | 0.03 ± 0.01 | | |
| | 2498 | Pentacosane | | | | | | | 0.14–0.29 | 0.22 ± 0.12 | | | | | | | | |
| C22:0 | 2522 | Behenic acid | 0.38–0.88 | 0.68 ± 0.16 | 0.48–0.54 | 0.51 ± 0.41 | 0.95–1.05 | 1.01 ± 0.08 | 0.74–1.08 | 0.97 ± 0.18 | 0.61–0.76 | 0.68 ± 0.21 | 0.08–0.12 | 0.10 ± 0.02 | 0.27–0.64 | 0.43 ± 0.16 | 0.13–0.49 | 0.31 ± 0.13 |
| C23:0 | 2622 | Tricosanoic acid | 0.04–0.1 | 0.07 ± 0.02 | 0.03–0.05 | 0.04 ± 0.02 | | | | | 0.01–0.06 | 0.04 ± 0.03 | 0.01–0.04 | 0.03 ± 0.01 | 0.03–0.06 | 0.05 ± 0.02 | 0.02–0.12 | 0.06 ± 0.04 |
| | 2698 | Heptacosane | | | | | | | 3.64–6.89 | 5.26 ± 1.78 | | | | | | | 0–0.03 | 0.01 ± 0.01 |
| *cis*-15, C24:1 | 2699 | (*Z*)-15-Tetracosenoic acid | | | | | 0–0.03 | 0.01 ± 0.01 | | | | | | | 0–0.03 | 0.02 ± 0.01 | | |

**Table 4.** *Cont.*

| Synonyms | RI | Compound Name | Soybean Oil | | Flax Seed Oil | | Kukui Oil | | Red Raspberry Seed Oil | | Walnut Oil | | Chia Seed Oil | | Hemp Seed Oil | | Rosehip Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Range** | **MSD (n = 8)** | **Range** | **MSD (n = 7)** | **Range** | **MSD (n = 5)** | **Range** | **MSD (n = 6)** | **Range** | **MSD (n = 7)** | **Range** | **MSD (n = 5)** | **Range** | **MSD (n = 4)** | **Range** | **MSD (n = 7)** |
| C24:0 | 2722 | Lignoceric acid | 0.16–0.42 | 0.28 ± 0.1 | 0.19–0.26 | 0.23 ± 0.14 | 0.62–0.67 | 0.64 ± 0.15 | 0.32–0.49 | 0.44 ± 0.14 | 0.20–0.62 | 0.40 ± 0.24 | 0.09–0.15 | 0.12 ± 0.05 | 0.11–0.36 | 0.23 ± 0.12 | 0.06–0.25 | 0.15 ± 0.06 |
| | 2791 | Octacosane | | | | | | | 0.27–0.33 | 0.31 ± 0.07 | | | | | | | | |
| | 2803 | (*E*)-Squalene | 0–0.01 | 0.01 ± 0.01 | 0.01–0.04 | 0.02 ± 0.03 | | | 0.74–0.95 | 0.88 ± 0.09 | | | | | | | | |
| C25:0 | 2830 | Pentacosanoic acid | 0.01–0.05 | 0.03 ± 0.01 | 0.01–0.05 | 0.03 ± 0.04 | 0.03–0.07 | 0.05 ± 0.02 | | | | | 0–0.05 | 0.04 ± 0.02 | 0–0.04 | 0.02 ± 0.02 | 0–0.04 | 0.02 ± 0.02 |
| | 2871 | Cyclotetracosane | | | | | | | | | | | | | | | 0–0.03 | 0.01 ± 0.01 |
| | 2886 | Nonacos-1-ene | | | | | | | 0.54–0.71 | 0.65 ± 0.18 | | | | | | | 0–0.27 | 0.18 ± 0.1 |
| | 2899 | Nonacosane | | | 0.02–0.06 | 0.04 ± 0.03 | | | 2.14–4.65 | 3.94 ± 1.05 | | | | | 0–0.02 | 0.01 ± 0.01 | 0–0.19 | 0.1 ± 0.06 |
| C26:0 | 2926 | Hexacosanoic acid | 0.01–0.06 | 0.03 ± 0.02 | 0.01–0.04 | 0.03 ± 0.02 | 0.08–0.12 | 0.10 ± 0.05 | | | 0.01–0.06 | 0.04 ± 0.03 | 0.01–0.05 | 0.03 ± 0.01 | 0–0.04 | 0.02 ± 0.02 | 0–0.03 | 0.02 ± 0.01 |
| | 3091 | β-Sitosteryl acetate | | | | | | | | | | | 0.02–0.11 | 0.08 ± 0.04 | | | | |
| | 3096 | Untriacontane | | | 0–0.03 | 0.01 ± 0.02 | | | 0.49–0.58 | 0.55 ± 0.07 | | | 0–0.02 | 0.01 ± 0.01 | | | | |
| | 3087 | Ethyl octacosyl ether | | | | | | | | | | | | | | | 0–0.21 | 0.1 ± 0.07 |
| C28:0 | 3130 | Octacosanoic acid | | | | | | | | | | | 0–0.03 | 0.02 ± 0.01 | | | | |
| | 3227 | Methyl cholesterol | 0–0.16 | 0.03 ± 0.06 | | | | | | | | | 0.01–0.15 | 0.08 ± 0.04 | 0–0.17 | 0.06 ± 0.08 | | |
| | 3246 | Stigmasterol | 0–0.15 | 0.03 ± 0.05 | | | 0.06–0.11 | 0.08 ± 0.04 | | | | | 0.01–0.05 | 0.04 ± 0.02 | | | 0–1.18 | 0.66 ± 0.52 |
| | 3253 | 3β-Methoxystigmast-5-ene | | | | | 0–0.03 | 0.01 ± 00.01 | | | | | | | | | 0–0.06 | 0.01 ± 0.02 |
| | 3303 | γ-Sitosterol | 0–0.48 | 0.27 ± 0.18 | 0.21–0.26 | 0.23 ± 0.18 | 0.22–0.27 | 0.25 ± 0.13 | | | | | 0.15–1.02 | 0.56 ± 0.39 | 0–0.93 | 0.59 ± 0.41 | | |
| | 3445 | Stigmast-4-en-3-one | | | | | | | | | | | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | | |

RI = retention index. MSD = mean ± standard deviation.

Oils that are rich in linolenic acid, an essential omega-3 FA, offer a range of potential benefits for various purposes [60]. Linolenic acid has been associated with promoting heart health by helping to reduce inflammation and support proper cardiovascular function [61]. Oils such as flaxseed oil, chia seed oil, and hemp seed oil, which are rich in linolenic acids, are often used as dietary supplements to support heart health. Omega-3 FAs are vital for optimal brain function. Consuming oils high in linolenic acid, like flaxseed oil or walnut oil, may help support cognitive function, memory, and overall brain health [62]. Linolenic acid has anti-inflammatory properties that can be beneficial for conditions such as arthritis, asthma, and inflammatory skin conditions. Flaxseed oil and hemp seed oil, which contain high levels of linolenic acid, can be used as dietary supplements or added to a balanced diet to help reduce inflammation in the body [63]. Linolenic acid plays a role in maintaining the health and integrity of the skin. Oils rich in linolenic acid improve skin hydration, reduce redness and irritation, and support a healthy complexion [64]. Linolenic acid is an essential nutrient, but the body's ability to convert it into other beneficial forms of omega-3 FAs, such as eicosapentaenoic acid and docosahexaenoic acid is limited. In some cases, direct consumption of eicosapentaenoic acid and docosahexaenoic acid from marine sources like fish oil may be more effective for certain health benefits [60].

Table 5 presents the composition analysis of various vegetable oils, including almond (*Prunus amygdalus*) oil, avocado (*Persea americana*) oil, carrot (*Daucus carota*) seed oil, moringa (*Moringa oleifera*) oil, apricot (*Prunus armeniaca*) kernel oil, camellia (*Camellia oleifera*) seed oil, macadamia (*Macadamia integrifolia*) oil, olive (*Olea europaea*) oil, marula (*Sclerocarya birrea*) crude oil, and argan (*Argania spinosa*) oil. All of these oils were abundant in omega-9 FAs, specifically (*Z*)-oleic acid. Among them, camellia seed oil contained the highest concentration of (*Z*)-oleic acid. Liu et al. studied the ten different cultivars of *C. oleifera* from southwest China and the result was very much comparable to our study [65]. Macadamia oil had the lowest (*Z*)-oleic acid; on the other hand, it possessed the highest content of palmitoleic acid. Aquino-Bolaños et al. from Mexico studied nine different varieties of macadamia nut and our result was very much comparable to a slightly high percentage of palmitoleic acid reported in their study [66]. Almond oil was rich in (*Z*)-oleic acid followed by linoleic acid and a comparable result was obtained by Gouta et al. while studying 17 different cultivars of almonds from Tunisia, Italy, Spain, and France; their results showed a slightly higher percentage of (*Z*)-oleic acid and less linoleic acid compared with this study [67]. Furthermore, olive oil had the highest level of palmitic acid compared with other oils, while the major compound was (*Z*)-oleic acid, and a study from Greece by Revelou et al. on four different cultivars of olive oil showed a comparable result for the Megaritiki cultivar [68]. Similarly, in argan oil, (*Z*)-oleic acid was the predominant compound followed by linoleic acid and palmitic acid; this result was very much comparable to the argan oil growing in the Tindouf region of Algeria as reported by Kouidri et al. [69]. While moringa oil had the lowest content of linoleic acid and highest (*Z*)-oleic acid in this study, a study of *M. oleifera* oil by Zhao et al. from China showed 70.2% of (*Z*)-oleic acid, which was much higher than this study, and other FAs like arachidic acid and behenic acid were in low percentages compared with this study [70]. In addition, marula oil had the highest percentage of (*Z*)-oleic acid followed by two saturated FAs: palmitic acid and stearic acid. However, a study from Swaziland showed marula oil with 85.24% (*Z*)-oleic acid, which is much higher than our study, whereas other FAs are almost comparable [71]. Additionally, apricot kernel oil had the highest (*Z*)-oleic acid followed by linoleic acid, and this result was supported by research conducted by Stryjecka et al. from Poland in five different cultivars of *P. armeniaca* [72]. Moreover, avocado oil contained (*Z*)-oleic acid as the major compound followed by palmitic acid and linoleic acid which was in close agreement with a study conducted by Nasri et al. in four different avocado varieties cultivated in Morocco [73]. Only moringa oil contained methyl cholesterol, while $\gamma$-sitosterol was present in all oil samples except marula crude oil and camellia seed oil. Lastly, carrot seed oil contained a high amount of (*Z*)-oleic acid followed by linoleic acid. Similarly, a study in New Zealand by Gao et al. reported a similar composition of FAs in carrot seed oil [74].

**Table 5.** Fatty acid composition of different vegetable oils rich in oleic acid.

| Synonyms | RI | Compound Name | Almond Oil | | Avocado Oil | | Carrot Seed Oil | | Moringa Oil | | Apricot Kernel Oil | | Camellia Seed Oil | | Macadamia Oil | | Olive Oil | | Marula Crude Oil | | Argan Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 10) | Range | MSD (n = 10) | Range | MSD (N = 9) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| | 1371 | Isoledene | | | | | 0–1.2 | 0.22 ± 0.37 | | | | | | | | | | | | | | |
| | 1376 | β-Cubebene | | | | | 0–0.13 | 0.02 ± 0.04 | | | | | | | | | | | | | | |
| | 1380 | Daucene | | | | | 0.25–3.23 | 1.26 ± 1.21 | | | | | | | | | | | | | | |
| | 1443 | Acora-2,4(15)-diene | | | | | 0.23–1.64 | 0.76 ± 0.63 | | | | | | | | | | | | | | |
| | 1492 | *trans*-Muurola-4(14),5-diene | | | | | 0–0.09 | 0.02 ± 0.03 | | | | | | | | | | | | | | |
| | 1500 | α-Muurolene | | | | | 0–0.18 | 0.03 ± 0.06 | | | | | | | | | | | | | | |
| | 1520 | *trans*-Calamenene | | | | | 0–0.17 | 0.05 ± 0.05 | | | | | | | | | | | | | | |
| | 1611 | 1-[1-Methoxy-3,3-dimethyl-2-(3-methylbuta-1,3-dienyl)cyclopentyl]-ethanone | | | | | 0–0.36 | 0.06 ± 0.12 | | | | | | | | | | | | | | |
| C12:0 | 1523 | Lauric acid | | | 0–0.05 | 0.01 ± 0.02 | | | 0.01–0.03 | 0.01 ± 0.01 | | | | | 0.01–0.06 | 0.04 ± 0.02 | | | | | | |
| C14:0 | 1758 | Myristic acid | 0–0.05 | 0.03 ± 0.01 | 0.02–0.27 | 0.08 ± 0.10 | 0.02–0.06 | 0.03 ± 0.01 | 0.06–0.13 | 0.08 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | 0–0.03 | 0.02 ± 0.02 | 0.40–0.76 | 0.6 ± 0.02 | 0–0.04 | 0.01 ± 0.01 | 0.02–0.07 | 0.05 ± 0.03 | 0.05–0.14 | 0.11 ± 0.03 |
| C15:0 | 1821 | Pentadecanoic acid | 0–0.01 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | 0–0.03 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0 | 0–0.01 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | | | 0.01–0.05 | 0.04 ± 0.01 |
| *cis*-7, C16:1 | 1894 | (Z)-7-Hexadecenoic acid | 0–0.03 | 0.02 ± 0.01 | 0.02–0.11 | 0.08 ± 0.03 | 0.02–0.12 | 0.06 ± 0.05 | 0.04–0.11 | 0.07 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | 0.01–0.02 | 0.01 ± 0.01 | 0.05–0.09 | 0.07 ± 0.02 | 0–0.02 | 0.01 ± 0.01 | 0.01–0.02 | 0.01 ± 0 |
| *cis*-9, C16:1 | 1901 | Palmitoleic acid | 0.08–0.65 | 0.42 ± 0.17 | 1.22–10.65 | 4.78 ± 3.12 | 0.07–0.29 | 0.17 ± 0.1 | 1.08–1.68 | 1.37 ± 0.26 | 0.49–0.71 | 0.56 ± 0.23 | 0.03–0.08 | 0.06 ± 0.03 | 16.23–21.70 | 19.65 ± 1.95 | 0.53–2.58 | 1.62 ± 0.7 | 0.07–0.12 | 0.09 ± 0.06 | 0.01–0.09 | 0.08 ± 0.01 |
| C16:0 | 1924 | Palmitic acid | 4.95–9.83 | 7.1 ± 1.43 | 11.79–21.68 | 15.85 ± 3.31 | 3.88–4.86 | 4.28 ± 0.34 | 5.01–7.33 | 6.14 ± 0.84 | 3.78–6.09 | 4.86 ± 1.02 | 5.45–9.28 | 7.60 ± 1.05 | 5.57–9.5 | 8.90 ± 1.08 | 14.34–19.33 | 17.31 ± 1.95 | 11.86–15.75 | 13.65 ± 2.54 | 6.02–14.91 | 12.65 ± 2.85 |
| *cis*-9,12, C17:2 | 1990 | 9,12-Heptadecadienoic acid | | | | | | | | | | | | | 0–0.02 | 0.01 ± 0.01 | | | | | | |
| *cis*-10, C17:1 | 1996 | (Z)-10-Heptadecenoic acid | 0.03–0.17 | 0.11 ± 0.04 | 0.03–0.11 | 0.08 ± 0.03 | 0.03–0.06 | 0.04 ± 0.01 | 0.02–0.07 | 0.04 ± 0.02 | 0.10–0.17 | 0.14 ± 0.07 | 0.01–0.06 | 0.02 ± 0.01 | 0.02–0.07 | 0.04 ± 0.02 | 0.07–0.32 | 0.18 ± 0.11 | 0.03–0.06 | 0.04 ± 0.03 | 0.01–0.04 | 0.02 ± 0.01 |

**Table 5.** *Cont.*

| Synonyms | RI | Compound Name | Almond Oil | | Avocado Oil | | Carrot Seed Oil | | Moringa Oil | | Apricot Kernel Oil | | Camellia Seed Oil | | Macadamia Oil | | Olive Oil | | Marula Crude Oil | | Argan Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 10) | Range | MSD (n = 10) | Range | MSD (N = 9) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| C17:0 | 2026 | Heptadecanoic acid | 0–0.08 | 0.05 ± 0.02 | 0.02–0.07 | 0.03 ± 0.02 | 0.02–0.04 | 0.03 ± 0.01 | 0.06–0.11 | 0.09 ± 0.02 | 0.01–0.05 | 0.03 ± 0.02 | 0.02–0.06 | 0.02 ± 0.01 | 0.01–0.03 | 0.02 ± 0.01 | 0.04–0.24 | 0.14 ± 0.10 | 0.10–0.14 | 0.12 ± 0.08 | 0.05–0.10 | 0.08 ± 0.02 |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 23.26–37.72 | 27.81 ± 5.12 | 7.05–14.45 | 10.31 ± 2.08 | 7.54–12.85 | 9.75 ± 2.14 | 0.23–1.08 | 0.62 ± 0.27 | 24.26–28.87 | 26.54 ± 3.21 | 4.36–8.34 | 5.45 ± 1.01 | 1.09–2.99 | 2.53 ± 0.4 | 5.95–17.09 | 11.95 ± 4.59 | 4.26–8.74 | 6.33 ± 2.08 | 28.50–30.86 | 29.95 ± 0.69 |
| *cis*-9, C18:1 | 2102 | (*Z*)-Oleic acid | 49.74–67.3 | 60.32 ± 6.11 | 44.08–68.14 | 60.27 ± 7.70 | 72.89–80.86 | 77.56 ± 2.77 | 47.61–67.15 | 56.51 ± 7.39 | 61.49–67.61 | 64.97 ± 6.03 | 74.89–83.02 | 78.57 ± 8.01 | 42.89–47.53 | 45.56 ± 4.01 | 52.22–64.78 | 59.01 ± 5.44 | 65.47–72.29 | 68.86 ± 4.38 | 42.38–55.80 | 46.77 ± 4.11 |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 0.14–1.99 | 1.03 ± 0.83 | 1.14–7.08 | 4.51 ± 2.13 | 0.08–0.88 | 0.51 ± 0.33 | 5.33–6.89 | 6.09 ± 0.63 | 1.03–1.86 | 1.46 ± 0.89 | 0.10–1.06 | 0.34 ± 0.24 | 1.8–4.84 | 3.89 ± 0.75 | 2.08–4.16 | 3.33 ± 0.77 | 0.48–0.56 | 0.53 ± 0.22 | 0.20–1.28 | 0.59 ± 0.43 |
| *trans*-13, C18:1 | 2113 | (*E*)-13-Octadecenoic acid | | | | | | | 0.09–0.22 | 0.15 ± 0.04 | | | | | 0.01–0.03 | 0.02 ± 0.01 | | | | | | |
| C18:0 | 2126 | Stearic acid | 1.52–4.31 | 2.34 ± 0.78 | 0.65–3.70 | 1.89 ± 1.26 | 0.82–4.4 | 2.57 ± 1.46 | 5.42–9.13 | 6.83 ± 1.17 | 1.42–2.69 | 1.78 ± 1.14 | 2.01–3.04 | 2.15 ± 0.40 | 1.56–4.29 | 3.50 ± 1.98 | 3.05–5.27 | 4.17 ± 0.91 | 6.23–10.41 | 8.58 ± 2.63 | 4.26–8.37 | 7.2 ± 1.4 |
| C20:2 | 2183 | Ethyl linoleate | 0–0.07 | 0.04 ± 0.02 | 0–0.06 | 0.03 ± 0.02 | 0–0.03 | 0.01 ± 0.01 | 0–0.13 | 0.04 ± 0.04 | 0.01–0.03 | 0.02 ± 0.01 | 0.01–0.07 | 0.04 ± 0.02 | 0.01–0.04 | 0.02 ± 0.03 | 0–0.03 | 0.02 ± 0.01 | | | 0–0.13 | 0.02 ± 0.05 |
| *cis*-10, C19:1 | 2193 | (*Z*)-10-Nonadecenoic acid | 0–0.03 | 0.02 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | 0.03–0.06 | 0.05 ± 0.01 | | | 0.02–0.04 | 0.03 ± 0.01 | | | 0–0.06 | 0.02 ± 0.02 | 0.02–0.06 | 0.04 ± 0.03 | 0.02–0.04 | 0.03 ± 0.01 |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | 0–0.01 | 0.01 ± 0 | | | 0–0.01 | 0.01 ± 0.01 | 0.01–0.01 | 0.01 ± 0 | | | 0.02–0.03 | 0.02 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | | |
| C19:0 | 2222 | Nonadecanoic acid | | | | | | | 0–0.03 | 0.02 ± 0.01 | | | | | | | 0–0.03 | 0.01 ± 0.01 | 0–0.03 | 0.01 ± 0.02 | | |
| *cis*-11,14, C20:2 | 2284 | cis-11,14-Eicosadienoic acid | | | | | | | | | | | | | | | | | | | 0–0.04 | 0.01 ± 0.02 |
| *cis*-11, C20:1 | 2296 | (*Z*)-11-Eicosenoic acid | 0.03–0.26 | 0.12 ± 0.06 | 0.16–0.74 | 0.35 ± 0.21 | 0.13–0.35 | 0.25 ± 0.07 | 1.88–3.59 | 2.95 ± 0.57 | 0.09–0.21 | 0.15 ± 0.09 | 0.45–0.68 | 0.53 ± 0.23 | 1.45–3.09 | 2.41 ± 1.02 | 0.27–0.37 | 0.32 ± 0.04 | 0.23–0.56 | 0.41 ± 0.23 | 0.38–0.60 | 0.48 ± 0.08 |
| C20:0 | 2322 | Arachidic acid | 0.08–0.35 | 0.14 ± 0.08 | 0.08–0.86 | 0.30 ± 0.32 | 0.14–0.43 | 0.29 ± 0.1 | 3.63–7.03 | 4.9 ± 1.1 | 0.11–0.19 | 0.16 ± 0.08 | 0.05–0.08 | 0.04 ± 0.02 | 0.75–3.57 | 3.45 ± 1.13 | 0.55–0.83 | 0.71 ± 0.12 | 0.52–0.89 | 0.72 ± 0.31 | 0.42–0.70 | 0.55 ± 0.11 |
| C21:0 | 2422 | Heneicosanoic acid | 0–0.01 | 0.01 ± 0 | | | | | 0.04–0.11 | 0.07 ± 0.02 | | | | | 0–0.01 | 0.01 ± 0.01 | 0.01–0.03 | 0.02 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 |
| | 2464 | (*Z*)-Docos-13-en-1-ol | | | | | | | | | | | | | 0–0.02 | 0.01 ± 0.01 | | | | | | |
| | 2498 | Pentacosane | | | | | | | | | | | | | | | 0–0.01 | 0 ± 0.01 | | | | |

**Table 5.** *Cont.*

| Synonyms | RI | Compound Name | Almond Oil | | Avocado Oil | | Carrot Seed Oil | | Moringa Oil | | Apricot Kernel Oil | | Camellia Seed Oil | | Macadamia Oil | | Olive Oil | | Marula Crude Oil | | Argan Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 10) | Range | MSD (n = 10) | Range | MSD (N = 9) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| *cis*-13, C22:1 | 2499 | Erucic acid | | | 0–0.10 | 0.03 ± 0.04 | 0–0.04 | 0.01 ± 0.01 | 0.07–0.26 | 0.18 ± 0.07 | | | 0.09–0.11 | 0.10 ± 0.04 | 0.13–0.38 | 0.30 ± 0.12 | | | | | 0.01–0.04 | 0.02 ± 0.01 |
| C22:0 | 2522 | Behenic acid | 0–1.27 | 0.15 ± 0.39 | 003–1.53 | 0.40 ± 0.61 | 0.07–1.36 | 0.69 ± 0.58 | 5.53–15.51 | 9.74 ± 3.58 | 0.05–0.09 | 0.07 ± 0.03 | 0.08–0.13 | 0.12 ± 0.05 | 0.75–1.29 | 0.95 ± 0.69 | 0.15–0.32 | 0.23 ± 0.07 | 0.12–0.16 | 0.15 ± 0.06 | 0.14–1.61 | 0.39 ± 0.49 |
| | 2561 | Meadowlactone | | | | | | | | | | | | | 0–0.01 | 0.01 ± 0.01 | | | | | | |
| C23:0 | 2622 | Tricosanoic acid | 0–0.04 | 0.01 ± 0.01 | 0.01–0.07 | 0.03 ± 0.02 | 0–0.05 | 0.03 ± 0.02 | 0.06–0.2 | 0.14 ± 0.06 | 0.01–0.03 | 0.02 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | 0–0.02 | 0.01 ± 0.01 | 0.02–0.06 | 0.04 ± 0.02 | 0–0.03 | 0.02 ± 0.01 | 0.02–0.08 | 0.03 ± 0.02 |
| | 2698 | Heptacosane | | | | | 0–0.06 | 0.02 ± 0.02 | | | | | | | | | | | | | | |
| *cis*-15, C24:1 | 2699 | (*Z*)-15-Tetracosenoic acid | | | 0–0.04 | 0.01 ± 0.02 | | | | | | | 0.05–0.08 | 0.06 ± 0.03 | 0.01–0.02 | 0.01 ± 0 | | | | | 0.02–0.05 | 0.03 ± 0.01 |
| C24:0 | 2722 | Lignoceric acid | 0–0.42 | 0.06 ± 0.13 | 0.06–0.80 | 0.25 ± 0.30 | 0.06–0.59 | 0.28 ± 0.2 | 1.31–3.82 | 2.68 ± 0.96 | 0.02–0.08 | 0.05 ± 0.06 | 0.02–0.07 | 0.05 ± 0.02 | 0.23–0.73 | 0.58 ± 0.25 | 0.08–0.22 | 0.15 ± 0.06 | 0.16–0.24 | 0.21 ± 0.09 | 0.07–0.77 | 0.22 ± 0.23 |
| | 2803 | (*E*)-Squalene | | | 0.01–0.11 | 0.05 ± 0.04 | | | | | 0.01–0.04 | 0.03 ± 0.07 | | | 0.01–0.04 | 0.03 ± 0.02 | 0.02–0.47 | 0.24 ± 0.15 | | | 0.09–0.74 | 0.45 ± 0.26 |
| C25:0 | 2830 | Pentacosanoic acid | | | 0.02–0.07 | 0.04 ± 0.02 | | | 0.02–0.06 | 0.04 ± 0.02 | 0.01–0.03 | 0.02 ± 0.01 | 0–0.01 | 0.01 ± 0.01 | 0.01–0.03 | 0.02 ± 0.01 | 0–0.03 | 0.02 ± 0.01 | 0–0.04 | 0.03 ± 0.01 | 0–0.02 | 0.02 ± 0.01 |
| | 2899 | Nonacosane | | | 0.01–0.06 | 0.03 ± 0.02 | 0–0.33 | 0.08 ± 0.11 | 0–0.03 | 0.01 ± 0.01 | | | | | | | | | | | | |
| C26:0 | 2926 | Hexacosanoic acid | | | 0.02–0.10 | 0.05 ± 0.02 | 0.01–0.06 | 0.03 ± 0.02 | 0.08–0.28 | 0.19 ± 0.08 | 0.01–0.04 | 0.03 ± 0.05 | 0–0.01 | 0.01 ± 0.01 | 0.09–0.16 | 0.12 ± 0.06 | 0.02–0.12 | 0.06 ± 0.04 | 0.04–0.09 | 0.07 ± 0.05 | 0.03–0.14 | 0.07 ± 0.04 |
| | 3091 | β-Sitosteryl acetate | 0–0.02 | 0.01 ± 0.01 | 0–0.53 | 0.07 ± 0.16 | 0–0.04 | 0.01 ± 0.02 | 0–0.04 | 0.01 ± 0.02 | 0.01–0.05 | 0.03 ± 0.02 | | | 0–0.03 | 0.02 ± 0.01 | | | 0–0.03 | 0.02 ± 0.01 | | |
| | 3096 | Untriacontane | | | 0–0.06 | 0.02 ± 0.02 | 0–0.09 | 0.02 ± 0.03 | | | | | | | | | | | | | | |
| C28:0 | 3130 | Octacosanoic acid | | | 0–0.03 | 0.01 ± 0.01 | 0–0.11 | 0.03 ± 0.04 | 0–0.05 | 0.02 ± 0.02 | | | | | 0–0.02 | 0.01 ± 0.01 | 0–0.11 | 0.03 ± 0.04 | | | | |
| | 3227 | Methyl cholesterol | | | | | | | 0–0.29 | 0.14 ± 0.11 | | | | | | | | | | | | |
| | 3246 | Stigmasterol | | | | | 0–0.16 | 0.04 ± 0.07 | 0–0.38 | 0.17 ± 0.14 | | | | | | | | | | | | |
| | 3253 | 3β-Methoxystigmast-5-ene | | | | | | | | | | | | | | | | | 0–0.04 | 0.02 ± 0.02 | | |

**Table 5.** *Cont.*

| Synonyms | RI | Compound Name | Almond Oil | | Avocado Oil | | Carrot Seed Oil | | Moringa Oil | | Apricot Kernel Oil | | Camellia Seed Oil | | Macadamia Oil | | Olive Oil | | Marula Crude Oil | | Argan Oil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 10) | Range | MSD (n = 10) | Range | MSD (N = 9) | Range | MSD (n = 7) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 5) | Range | MSD (n = 6) | Range | MSD (n = 5) | Range | MSD (n = 8) |
| | 3299 | Chondrillasterol | | | | | | | | | | | | | | | | | | | 0–0.11 | 0.03 ± 0.04 |
| | 3303 | $\gamma$-Sitosterol | 0–0.55 | 0.14 ± 0.19 | 0–0.75 | 0.42 ± 0.25 | 0–0.44 | 0.09 ± 0.17 | 0–1.02 | 0.4 ± 0.4 | 0.22–0.35 | 0.27 ± 0.21 | | | 0.08–0.37 | 0.30 ± 0.13 | 0.13–0.63 | 0.31 ± 0.18 | | | 0–0.29 | 0.07 ± 0.12 |
| C30:0 | 3328 | Triacontanoic acid | | | | | 0–0.14 | 0.02 ± 0.05 | 0–0.09 | 0.03 ± 0.03 | | | | | | | | | | | | |
| | 3445 | Stigmast-4-en-3-one | | | 0–0.02 | 0.01 ± 0.01 | | | 0–0.02 | 0.01 ± 0.01 | 0.01–0.06 | 0.04 ± 0.08 | | | | | | | | | | |

RI = retention index. MSD = mean ± standard deviation.

Oleic acid-rich oils are commonly utilized for various purposes due to their high contents of this beneficial fatty acid. These oils offer numerous advantages and find applications in different industries. In the culinary realm, oils rich in oleic acid, such as almond oil, avocado oil, camellia seed oil, macadamia oil, olive oil, and argan oil, are highly sought after. Additionally, their oleic acid content contributes to their heart-healthy properties, as it is known to support cardiovascular health [75]. Oleic acid-rich oils are also commonly found in the skincare and cosmetic industries. These oils possess excellent moisturizing and nourishing properties, making them ideal for skincare products. They help to hydrate and replenish the skin, promoting a healthy and youthful appearance. Avocado oil, almond oil, and macadamia oil, in particular, are popular choices for moisturizers, serums, and hair care products [76]. Furthermore, oleic acid-rich oils have been extensively studied for their potential health benefits. They have shown promising effects in reducing inflammation, supporting brain health, and aiding in weight management. Incorporating these oils into a balanced diet can contribute to overall well-being [77]. Overall, oils rich in oleic acid have a wide range of applications, from culinary uses to skincare and potential health benefits. The abundance of oleic acid in such oils makes them valuable ingredients in various products, providing both functional and nutritional advantages.

Table 6 shows the major and minor constitutions present in castor oil. Ricinoleic acid is a unique hydroxy FA predominantly present in castor oils [78]. It is the most important inedible oil commercially because the major compound ricinoleic acid can be easily converted to high-value commercial products like biodiesel, ink, lubricants, and biopolymers via simple chemical transformation [79]. Castor oil is viscous and non-volatile with certain toxic compounds, such as ricin, ricinine, and different allergens [80,81]. The chemical compositions of castor oil samples (7 samples) are presented in Table 5. Altogether, 20 compounds were identified including FAs and sterols. In this study, castor oils were dominated by ricinoleic acid (84.52–96.09%) followed by linoleic acid (1.33–5.48%), while other compounds were <1%. The compositions of castor oils in the current study are similar to those of other castor oils studied. The castor oil from Chile had a maximum of 89.83% ricinoleic acid in the H-08 accession and a minimum of 87.64% in the H-04 accession [82]. In another study from India, the highest percentage of ricinoleic acid (91.29%) was found in the VI-9 castor genotype, while the lowest percentage (86.37%) was present in the SKI-370 castor genotype [83]. Similarly, the castor oils from Tanzania contained ricinoleic acid ranging from 83.5% to 93.2% of the total FAs [84].

**Table 6.** Major and minor constituents present in castor oil.

| Synonyms | RI | Compound Name | Castor Oil | |
|---|---|---|---|---|
| | | | Range | MSD (n = 7) |
| C16:0 | 1924 | Palmitic acid | 0.32–1.51 | 0.87 ± 0.37 |
| C17:0 | 2026 | Heptadecanoic acid | 0.01–0.02 | 0.02 ± 0.01 |
| | 2057 | Ricenalidic acid lactone | 0–0.31 | 0.05 ± 0.11 |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 1.33–5.48 | 3.58 ± 1.23 |
| *cis*-9,12,15, C18:3 | 2096 | Linolenic acid | 0.13–0.51 | 0.32 ± 0.12 |
| *cis*-9, C18:1 | 2102 | (*Z*)-Oleic acid | 0.93–4.0 | 2.74 ± 0.92 |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 0.15–0.79 | 0.47 ± 0.2 |
| C18:0 | 2126 | Stearic acid | 0.42–1.81 | 1.16 ± 0.44 |
| C20:2 | 2183 | Ethyl linoleate | 0–0.18 | 0.05 ± 0.07 |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | 0–0.08 | 0.04 ± 0.03 |
| *cis*-9, C18:1 | 2305 | Ricinoleic acid | 84.52–96.09 | 89.89 ± 3.51 |
| C20:0 | 2322 | Arachidic acid | 0–0.75 | 0.16 ± 0.26 |
| *cis*-13, C22:1 | 2499 | Erucic acid | 0–0.89 | 0.52 ± 0.36 |

**Table 6.** *Cont.*

| Synonyms | RI | Compound Name | Castor Oil | |
|---|---|---|---|---|
| | | | Range | MSD (n = 7) |
| C22:0 | 2522 | Behenic acid | 0–0.02 | 0.01 ± 0.01 |
| C23:0 | 2622 | Tricosanoic acid | 0–0.01 | 0.01 ± 0.01 |
| C24:0 | 2722 | Lignoceric acid | 0–0.02 | 0.01 ± 0.01 |
| | 3091 | γ-Sitosteryl acetate | 0–0.04 | 0.01 ± 0.01 |
| | 3246 | Stigmasterol | 0–0.03 | 0.03 ± 0.05 |
| | 3253 | 3β-Methoxystigmast-5-ene | 0–0.12 | 0.03 ± 0.05 |

RI = retention index. MSD = mean ± standard deviation.

The data presented in Table 7 show the constituents present in authentic (four each) canola oil and mustard oil (*Brassica campestris*). Mustard oil is rich in erucic acid (51.99–56.14%), linoleic acid (10.65–13.57%), (*Z*)-oleic acid (9.26–12.37%), linolenic acid (5.72–7.95%), and (*Z*)-11-eicosenoic acid (5.69–7.52%). Mustard oil has been used in Southeast Asian cuisine for centuries and is an integral part of the culinary tradition and culture. Moreover, mustard oil is relatively inexpensive, provides several health benefits, and is widely available in India, Pakistan, Bangladesh, and Nepal [85]. Mustard oil contains a high concentration of monounsaturated FAs (erucic acid, oleic acid, and (*Z*)-11-eicosenoic acid) and a relatively high concentration of polyunsaturated FAs (linoleic acid and linolenic acid). The FAs compositions revealed in this article demonstrate quantitative correlations with an investigation by Schwarzinger et al. [86]. Interestingly, the mustard oil obtained by the cold press method showed that the oleic acid was the major component, whereas the erucic acid was a minor component [87,88]. However, differences in genotype, edaphic variables, pedo-climatic conditions, harvest time, extraction procedure, and analytical procedures can all contribute to variations in the FA composition of mustard oil [89]. In our investigation, (*E*)-oleic acid (0.80–1.24%) was present in all samples. Unsaturated FAs present in the mustard oil changed into (*E*)-FAs upon deep frying. The formation of (*E*)-FAs is linked to the temperature, time, and number of cycles used [90]. In vivo experiments showed that the consumption of fried mustard oil induced detrimental effects on various organs of Wistar rats [91]. When mustard oil is heated to high temperatures, it can produce acrolein, a toxic compound that may cause respiratory problems. Therefore, it is important to avoid heating it to high temperatures [92]. Mustard oil is not considered suitable for human consumption due to its high content of erucic acid and its incomplete metabolism, which is toxic if consumed in large quantities. Therefore, some countries regulate the levels of erucic acid in food products [93,94].

The origin of canola oil (*Brassica napus*) can be traced back to the rapeseed plant (*B. napus*). Canadian scientists developed a new variety of rapeseed with low levels of erucic acid and high levels of oleic acid, which is suitable for both human and animal consumption [95]. The composition of FAs in canola oil revealed (*Z*)-oleic acid (67.08–73.84%), palmitic acid (3.14–6.07%), (*E*)-oleic acid (3.26–5.35%), stearic acid (2.54–4.86%), (*Z*)-11-eicosenoic acid (2.72–4.68%), and linoleic acid (2.85–4.12%). Canola oil was shown to be abundant in monounsaturated FAs and low in saturated FAs. Canola oil has higher monounsaturated FA contents compared with mustard oil, making it a healthier option for cooking and baking. The low saturated FA content of canola oil makes it a better choice for those looking to reduce their saturated fat intake and minimize the risk of heart disease [96]. Canola oil generally contains significant concentrations of linolenic acid, which is an omega-3 FA that acts as a potential anti-inflammatory and improves brain functioning [97,98]. However, it was absent in our sample. In our study, (*E*)-FAs were detected in significant amounts in both canola (3.26–5.35%) and mustard oil (0.80–1.24%), and consumption of such FAs leads to an increased risk of heart diseases, cancer, and obesity [99]. It is recommended to limit the intake of (*E*)-FAs in food products and choose monounsaturated- and polyunsaturated-rich FAs in the supplementary diet.

**Table 7.** Major and minor constituents present in canola and mustard oils.

| Synonyms | RI | Compound Name | Canola Oil | | Mustard Oil | |
|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 4) | Range | MSD (n = 4) |
| C12:0 | 1523 | Lauric acid | 0–0.01 | 0.01 ± 0.01 | | |
| *cis*-9, C14:1 | 1702 | Myristoleic acid | 0–0.03 | 0.02 ± 0.02 | | |
| C14:0 | 1758 | Myristic acid | 0.02–0.07 | 0.05 ± 0.03 | 0.03–0.04 | 0.03 ± 0.01 |
| C15:0 | 1821 | Pentadecanoic acid | 0.03–0.05 | 0.04 ± 0.02 | 0.01–0.01 | 0.01 ± 0 |
| *trans*-7,10, C16:2 | 1887 | 7,10-Hexadecadienoic acid | 0.04–0.08 | 0.07 ± 0.03 | 0–0.01 | 0.01 ± 0.01 |
| *cis*-7, C16:1 | 1894 | (*Z*)-7-Hexadecenoic acid | 0.08–0.14 | 0.10 ± 0.04 | 0.03–0.11 | 0.05 ± 0.04 |
| *cis*-9, C16:1 | 1901 | Palmitoleic acid | 0.34–0.62 | 0.42 ± 0.19 | 0.01–0.16 | 0.1 ± 0.06 |
| C16:0 | 1924 | Palmitic acid | 3.14–6.07 | 4.66 ± 1.86 | 1.77–1.97 | 1.84 ± 0.09 |
| *cis*-10, C17:1 | 1996 | (*Z*)-10-Heptadecenoic acid | 0.91–2.03 | 1.38 ± 0.72 | 0.01–0.01 | 0.01 ± 0 |
| C17:0 | 2026 | Heptadecanoic acid | 0.57–1.86 | 1.02 ± 0.59 | 0.01–0.02 | 0.02 ± 0.01 |
| *cis*-9,12, C18:2 | 2087 | Linoleic acid | 2.85–4.12 | 3.22 ± 1.05 | 10.65–13.57 | 11.81 ± 1.36 |
| *cis*-9,12,15, C18:3 | 2096 | Linolenic acid | | | 5.72–7.95 | 6.77 ± 1.19 |
| *cis*-9, C18:1 | 2102 | (*Z*)-Oleic acid | 67.08–73.84 | 71.66 ± 4.54 | 9.26–12.37 | 10.81 ± 1.69 |
| *trans*-9, C18:1 | 2109 | (*E*)-Oleic acid | 3.26–5.35 | 4.18 ± 1.19 | 0.80–1.24 | 0.97 ± 0.21 |
| C18:0 | 2126 | Stearic acid | 2.54–4.86 | 3.32 ± 0.86 | 1.01–1.16 | 1.10 ± 0.07 |
| C20:2 | 2183 | Ethyl linoleate | 0.06–0.12 | 0.09 ± 0.04 | | |
| *cis*-10, C19:1 | 2193 | (*Z*)-10-Nonadecenoic acid | 0.86–1.67 | 1.07 ± 0.47 | 0–0.01 | 0.01 ± 0.01 |
| *trans*-10, C19:1 | 2205 | 10-Nonadecenoic acid | 0.49–0.93 | 0.62 ± 0.23 | | |
| C19:0 | 2222 | Nonadecanoic acid | 0.06–0.23 | 0.12 ± 0.13 | 0–0.01 | 0.01 ± 0.01 |
| *cis*-11,14, C20:2 | 2284 | (*Z*)-11,14-Eicosadienoic acid | 0.02–0.18 | 0.11 ± 0.09 | 0.38–0.65 | 0.52 ± 0.15 |
| *cis*-11, C20:1 | 2296 | (*Z*)-11-Eicosenoic acid | 2.72–4.68 | 3.29 ± 1.26 | 5.69–7.52 | 6.44 ± 0.89 |
| C20:0 | 2322 | Arachidic acid | 0.96–2.23 | 1.56 ± 0.76 | 0.82–1.06 | 0.95 ± 0.1 |
| C21:0 | 2422 | Heneicosanoic acid | 0.09–0.26 | 0.13 ± 0.15 | 0–0.02 | 0.01 ± 0.01 |
| *cis*-13, C22:1 | 2499 | Erucic acid | 0.08–0.24 | 0.14 ± 0.07 | 51.99–56.14 | 54.32 ± 2.13 |
| C22:0 | 2522 | Behenic acid | 0.82–1.24 | 0.99 ± 0.21 | 0.94–1.55 | 1.26 ± 0.32 |
| C23:0 | 2622 | Tricosanoic acid | 0.11–0.17 | 0.14 ± 0.05 | 0.03–0.05 | 0.04 ± 0.01 |
| *cis*-15, C24:1 | 2699 | (*Z*)-15-Tetracosenoic acid | 0.24–0.39 | 0.37 ± 0.05 | 1.21–3.41 | 2.15 ± 0.97 |
| C24:0 | 2722 | Lignoceric acid | 0.63–0.89 | 0.84 ± 0.19 | 0.30–1.26 | 0.73 ± 0.45 |
| C25:0 | 2830 | Pentacosanoic acid | 0.01–0.07 | 0.05 ± 0.03 | 0–0.02 | 0.01 ± 0.01 |
| | 2899 | Nonacosane | 0.01–0.06 | 0.04 ± 0.03 | | |
| C26:0 | 2926 | Hexacosanoic acid | 0–0.08 | 0.06 ± 0.05 | 0–0.08 | 0.04 ± 0.04 |
| | 3091 | β-Sitosteryl acetate | | | 0–0.03 | 0.01 ± 0.01 |
| | 3303 | γ-Sitosterol | 0.06–0.13 | 0.09 ± 0.07 | | |

RI = retention index. MSD = mean ± standard deviation.

The data presented in Table 8 show the constituents present in seven authentic jojoba oils. It was observed that all of the jojoba oils were rich in unsaturated long straight-chain (C20:1 and C22:1) FAs and alcohols; both the acids and alcohols were (*Z*)-monounsaturated. The principal components present in the jojoba oil were (*Z*)-11-eicosenoic acid (29.55 ± 4.80), (*Z*)-docos-13-en-1-ol (27.96 ± 2.77), (*Z*)-eicos-9-en-1-ol (18.45 ± 3.1), and erucic acid (10.6 ± 1.46). Our sample showed a nearly 1:1 ratio of unsaturated FAs and fatty alcohols.

**Table 8.** Major and minor constituents present in jojoba oil.

| RI | Synonyms | Compound Name | Jojoba Oil | |
|---|---|---|---|---|
| | | | Range | MSD (n = 8) |
| 1758 | C14:0 | Myristic acid | 0–0.01 | 0.01 ± 0.01 |
| 1894 | *cis*-7, C16:1 | (*Z*)-7-Hexadecenoic acid | 0.03–0.06 | 0.05 ± 0.01 |
| 1901 | *cis*-9, C16:1 | Palmitoleic acid | 0–0.01 | 0.01 ± 0 |
| 1924 | C16:0 | Palmitic acid | 0.17–0.33 | 0.26 ± 0.05 |
| 1996 | *cis*-10, C17:1 | (*Z*)-10-Heptadecenoic acid | 0–0.01 | 0.01 ± 0 |
| 2064 | | (*Z*)-9-Octadecen-1-ol | 0–0.20 | 0.1 ± 0.06 |
| 2087 | *cis*-9,12, C18:2 | Linoleic acid | 0.01–0.05 | 0.02 ± 0.01 |
| 2096 | *cis*-9,12,15, C18:3 | Linolenic acid | 0–0.03 | 0.02 ± 0.01 |
| 2102 | *cis*-9, C18:1 | (*Z*)-Oleic acid | 2.38–3.68 | 3.01 ± 0.39 |
| 2109 | *trans*-9, C18:1 | (*E*)-Oleic acid | 0.14–0.29 | 0.22 ± 0.05 |
| 2126 | C18:0 | Stearic acid | 0.01–0.02 | 0.01 ± 0 |
| 2205 | *trans*-10, C19:1 | 10-Nonadecenoic acid | 0–0.02 | 0.01 ± 0.01 |
| 2260 | | (*Z*)-Eicos-9-en-1-ol | 15.41–25.48 | 18.45 ± 3.1 |
| 2284 | *cis*-11,14, C20:2 | (*Z*)-11,14-Eicosadienoic acid | 0–0.10 | 0.04 ± 0.04 |
| 2296 | *cis*-11, C20:1 | (*Z*)-11-Eicosenoic acid | 23.88–35.41 | 29.55 ± 4.80 |
| 2322 | C20:0 | Arachidic acid | 0.04–0.07 | 0.05 ± 0.01 |
| 2464 | | (*Z*)-Docos-13-en-1-ol | 24.7–31.94 | 27.96 ± 2.77 |
| 2487 | | *n*-Docosanol | 0–1.03 | 0.21 ± 0.37 |
| 2499 | *cis*-13, C22:1 | Erucic acid | 8.97–13.26 | 10.6 ± 1.46 |
| 2522 | C22:0 | Behenic acid | 0.12–0.75 | 0.25 ± 0.20 |
| 2671 | | (*Z*)-Tricos-14-enyl formate | 0–10.64 | 6.78 ± 3.75 |
| 2699 | *cis*-15, C24:1 | (*Z*)-15-Tetracosenoic acid | 0.9–3.94 | 2.16 ± 0.85 |
| 2722 | C24:0 | Lignoceric acid | 0.03–0.43 | 0.1 ± 0.14 |
| 3091 | | β-Sitosteryl acetate | 0–0.09 | 0.02 ± 0.03 |
| 3303 | | γ-Sitosterol | 0–0.28 | 0.07 ± 0.1 |

RI = retention index. MSD = mean ± standard deviation.

Jojoba seeds contain more than 50% of oil by weight. Since the 1970s, jojoba oil has been used as a replacement for sperm whale oil due to its high structural similarity [100]. Interestingly, the jojoba oil from Mexico showed lower saturated FA concentrations, approximately 7.9%, while it showed 92.02% unsaturated FAs [101], which is higher than our authenticated jojoba oil. The major FAs from Egypt were comparable to the major compounds (*Z*)-11-eicosenoic acid, erucic acid, and oleic acid [102]. However, (*Z*)-11-eicosenoic acid was comparatively higher than in our sample of jojoba oil. Unfortunately, the fatty alcohol contents were not characterized in the Egyptian jojoba oil analysis.

(*Z*)-11-Eicosenoic acid is an unsaturated omega-9 FA similar to human sebum, which acquires high absorption in human skin owing to its dermatological characteristics. The higher content of (*Z*)-11-eicosenoic acid in the oils makes it an ideal candidate for use in the pharmaceutical and cosmetic industries [103]. Jojoba oil-based cosmetic formulations are more resistant to oxidation than other lipids used for this purpose. As a result, it is an excellent carrier oil for essential oils, facial moisturizers, and bath oils. In vivo experimentation demonstrated no acute toxicity when crude jojoba oil was fed to mice; i.e., the $LD_{50}$ is more than 160 g/kg [104]. Jojoba oil is considered a non-edible oil, but its use as a raw material for the creation of biodiesel has also been considered [105–107].

The GC-MS analysis of 10 pomegranate (*Punica granatum*) seed oil samples revealed punicic acid (74.77 ± 6.35), (*Z*)-oleic acid (6.77 ± 1.91), linoleic acid (6.85 ± 2.36), palmitic acid (3.14 ± 0.83), and stearic acid (3.11 ± 0.88) as the major components. The relative percentages of individual components present in the pomegranate seed oil are listed in Table 9. It was observed that all the pomegranate seed oils were rich in polyunsaturated FAs followed by saturated FAs. Besides these components, phytosterols were detected as minor compounds. The FA compositions presented in this work show quantitative similarities from previously published studies on pomegranate seed oil from different geographical locations [108–111].

**Table 9.** Major and minor constituents present in pomegranate seed oil.

| RI | Synonyms | Compound Name | Pomegranate Seed Oil | |
|---|---|---|---|---|
| | | | Range | MSD (n = 10) |
| 1758 | C14:0 | Myristic acid | 0.01–0.02 | 0.02 ± 0.01 |
| 1821 | C15:0 | Pentadecanoic acid | 0–0.02 | 0.01 ± 0.01 |
| 1924 | C16:0 | Palmitic acid | 2.20–4.88 | 3.14 ± 0.83 |
| 2026 | C17:0 | Heptadecanoic acid | 0.04–0.08 | 0.05 ± 0.01 |
| 2087 | *cis*-9,12, C18:2 | Linoleic acid | 4.54–11.47 | 6.85 ± 2.36 |
| 2102 | *cis*-9, C18:1 | (*Z*)-Oleic acid | 5.11–10.73 | 6.77 ± 1.91 |
| 2109 | *trans*-9, C18:1 | (*E*)-Oleic acid | 0.38–1.02 | 0.74 ± 0.22 |
| 2126 | C18:0 | Stearic acid | 2.14–4.74 | 3.11 ± 0.88 |
| 2183 | C20:2 | Ethyl linoleic acid | 0–0.39 | 0.15 ± 0.18 |
| 2193 | *cis*-10, C19:1 | (*Z*)-10-Nonadecenoic acid | 0.02–0.1 | 0.05 ± 0.02 |
| 2241–2286 | *cis*-9,*trans*-11,*cis*-13, C18:3 | Punicic acid | 62.37–80.92 | 74.77 ± 6.35 |
| 2284 | *cis*-11,14, C20:2 | (*Z*)-11,14-Eicosadienoic acid | 0–0.13 | 0.06 ± 0.05 |
| 2296 | *cis*-11, C20:1 | (*Z*)-11-Eicosenoic acid | 0.49–1.64 | 1.02 ± 0.3 |
| 2322 | C20:0 | Arachidic acid | 0.52–1.12 | 0.79 ± 0.22 |
| 2422 | C21:0 | Heneicosanoic acid | 0–0.07 | 0.04 ± 0.02 |
| 2522 | C22:0 | Behenic acid | 0.13–0.38 | 0.23 ± 0.08 |
| 2622 | C23:0 | Tricosanoic acid | 0.03–0.10 | 0.06 ± 0.02 |
| 2722 | C24:0 | Lignoceric acid | 0.08–0.31 | 0.18 ± 0.07 |
| 2803 | | (*E*)-Squalene | 0.06–1.01 | 0.39 ± 0.3 |
| 2830 | C25:0 | Pentacosanoic acid | 0.03–0.14 | 0.09 ± 0.03 |
| 2926 | C26:0 | Hexacosanoic acid | 0.04–0.22 | 0.14 ± 0.05 |
| 3091 | | β-Sitosteryl acetate | 0–0.27 | 0.06 ± 0.09 |
| 3130 | C28:0 | Octacosanoic acid | 0–0.08 | 0.03 ± 0.02 |
| 3227 | | Methyl cholesterol | 0–0.17 | 0.04 ± 0.06 |
| 3303 | | γ-Sitosterol | 0.23–1.37 | 0.81 ± 0.32 |
| 3406 | | Lupeol | 0–0.11 | 0.06 ± 0.04 |

RI = retention index. MSD = mean ± standard deviation.

Pomegranate seed oils are good sources of polyunsaturated FAs, which is why this oil is considered a potential oil for use in nutraceuticals, functional foods, pharmaceuticals, and cosmetic industries [112–114]. Punicic acid is considered to enhance the oil quality and is of importance to human health [115]. Additionally, pomegranate seed oil shows good antioxidant activity [116] and anti-mycotoxigenic activity [109]; therefore, it could be used in lieu of synthetic chemicals to counter food spoilage. Interestingly, there is no significant difference between the FA compositions of oil extracted using cold and microwave-assisted solvent extraction methods. However, higher antioxidant activity and higher peroxide value were observed in the case of oil extracted using the cold extraction method [117].

In vivo demonstration of pomegranate seed oil has shown a protective effect on ovarian ischemia and reperfusion injury by decreasing oxidative stress, improving inflammatory marker levels, and increasing the antioxidant defense system [118]. Furthermore, despite the high degree of unsaturation in its FA composition, pomegranate seed oil has remarkable oxidative stability [111,116]; therefore, its oil could be used in the formulation of cosmetic products. However, we encourage taking the appropriate precautions before and after formulation because of the presence of polyunsaturated FAs [119].

The data presented in Table 10 show the constituents present in roasted and MCT coconut oils. The roasted coconut oils were rich in lauric acid (38.05–53.12%), myristic acid (20.89–23.26%), palmitic acid (6.75–11.78%), (*Z*)-oleic acid (3.39–10.69%), capric acid (3.8–7.51%), and caprylic acid (2.55–6.29%). When heated, triglycerides undergo thermal decomposition or pyrolysis, which breaks down the triglyceride molecules into their constituent FAs and glycerol [120]. For example, MCTs changed into lauric acid, capric acid, caprylic acid, myristic acid, and palmitic acid upon roasting.

**Table 10.** Major and minor constitutions present in medium-chain triglyceride (MCT) and roasted coconut oils.

| RI | Synonyms | Compound Name | MCT Coconut Oil | | Roasted Coconut Oil | |
|---|---|---|---|---|---|---|
| | | | Range | MSD (n = 3) | Range | MSD (n = 7) |
| 920 | C6:0 | Caproic acid | | | 0.03–0.17 | 0.10 ± 0.06 |
| | | Benzoic acid | 0.01–0.01 | 0.01 ± 0 | | |
| 1124 | C8:0 | Caprylic acid | 43.41–47.94 | 46.41 ± 2.60 | 2.55–6.29 | 4.34 ± 1.35 |
| 1278 | C9:0 | Pelargonic acid | 0.04–0.07 | 0.06 ± 0.02 | | |
| 1320 | C10:0 | Capric acid | 51.91–56.37 | 53.42 ± 2.56 | 3.8–7.51 | 5.58 ± 1.29 |
| 1421 | C11:0 | Undecanoic acid | 0.02–0.04 | 0.03 ± 0.01 | 0.01–0.04 | 0.03 ± 0.01 |
| 1523 | C12:0 | Lauric acid | 0.05–0.12 | 0.07 ± 0.04 | 38.05–53.12 | 46.13 ± 4.75 |
| 1622 | C14:0 | 12-Methyl Tridecanoic acid | | | 0.03–0.06 | 0.04 ± 0.01 |
| 1758 | C14:0 | Myristic acid | | | 20.89–23.26 | 22.33 ± 0.90 |
| 1821 | C15:0 | Pentadecanoic acid | | | 0–0.01 | 0.01 ± 0.00 |
| 1901 | *cis*-9, C16:1 | Palmitoleic acid | | | 0–0.02 | 0.01 ± 0.01 |
| 1924 | C16:0 | Palmitic acid | | | 6.75–11.78 | 9.48 ± 1.80 |
| 2026 | C17:0 | Heptadecanoic acid | | | 0–0.01 | 0.01 ± 0.00 |
| 2087 | *cis*-9,12, C18:2 | Linoleic acid | | | 0.47–2.08 | 1.13 ± 0.54 |
| 2102 | *cis*-9, C18:1 | (*Z*)-Oleic acid | | | 3.39–10.69 | 6.76 ± 2.57 |
| 2109 | *trans*-9, C18:1 | (*E*)-Oleic acid | | | 0.03–0.16 | 0.07 ± 0.04 |
| 2126 | C18:0 | Stearic acid | | | 2.23–5.3 | 3.79 ± 1.20 |
| 2296 | *cis*-11, C20:1 | (*Z*)-11-Eicosenoic acid | | | 0.01–0.07 | 0.03 ± 0.02 |
| 2322 | C20:0 | Arachidic acid | | | 0.03–0.15 | 0.08 ± 0.04 |
| 2522 | C22:0 | Behenic acid | | | 0–0.03 | 0.01 ± 0.01 |
| 2622 | C23:0 | Tricosanoic acid | | | 0–0.04 | 0.01 ± 0.01 |
| 2722 | C24:0 | Lignoceric acid | | | 0–0.06 | 0.03 ± 0.02 |
| 2926 | C26:0 | Hexacosanoic acid | | | 0–0.01 | 0.01 ± 0.01 |
| 3091 | | β-Sitosteryl acetate | | | 0–0.02 | 0.01 ± 0.01 |

RI = retention index. MSD = mean ± standard deviation.

Coconut oil was used to develop an anti-aging serum formulation and, after two weeks of use, it significantly reduced the wrinkles and reduced skin recovery time in a mouse model of skin aging [121]. Due to its antibacterial and antifungal properties, coconut oil is used in oral hygiene products [122]. MCT coconut oils were found to be rich in capric acid (51.91–56.37%) and caprylic acid (43.41–47.94%). MCTs are quickly absorbed and used for energy, making them a popular ingredient in ketogenic diets and other low-carb diets as well as in pharmaceutical and cosmetic products [123–125].

While the coconut is heated at a high temperature to give it a roasted flavor, the process can change the composition of the FA profile, including its nutritional contents [126]. Overall, considering the specific health benefits associated with MCTs, such as increased energy and improved cognitive function, MCT coconut oil may be a better choice than roasted oil [127].

### *3.2. Uses of Vegetable Oils*

#### 3.2.1. Biofuel Production

Biofuel production using vegetable oils and fats is primarily carried out using a process called transesterification [128]. In this process, the vegetable oil or fat is combined with an alcohol (typically methanol or ethanol) and a catalyst (such as sodium hydroxide or potassium hydroxide) to convert the triglycerides in the oil or fat into FA methyl or ethyl esters (biodiesel) and glycerin. This reaction takes place in a reactor under controlled conditions [129]. The produced biodiesel can be used as a drop-in replacement for conventional diesel fuel or blended with petroleum diesel in various ratios. Biodiesel has similar properties to diesel fuel but with lower levels of harmful emissions, making it a more environmentally friendly fuel option.

It is important to note that while vegetable oils can be used for biodiesel production, considerations regarding sustainability, land use, and potential impacts on food availability and prices should be taken into account [130]. Several oils are commonly used in biofuel production as they contain high amounts of FAs suitable for biodiesel production like soybean oil [131], canola oil [132], palm oil [133], and waste vegetable oil, which includes used cooking oil from restaurants and food processing industries that can be recycled and converted into biodiesel. Waste vegetable oil is considered a sustainable feedstock for biofuel production as it utilizes waste material that would otherwise be discarded [130].

#### 3.2.2. Culinary Use

Vegetable oils are used in a variety of cooking techniques. Their versatility makes them suitable for different types of cuisines and recipes. When it comes to selecting oils for culinary use, the choice depends on various factors such as flavor, smoke point, nutritional profile, the quality of the oil, the method of extraction, and individual dietary needs [134]. Different vegetable oils offer varying nutritional profiles, providing essential FAs, such as omega-3 and omega-6 FAs, which are beneficial for overall health. The omega-3 to omega-6 ratio in oil is an important consideration for culinary purposes. The ideal ratio is generally considered to be a lower omega-6 to higher omega-3 ratio [19]. $\alpha$-Linolenic acid, which is an omega-3 fatty acid, is susceptible to oxidation and degradation when exposed to heat. Heating can accelerate the oxidation process, leading to the formation of free radicals and potentially harmful compounds. This oxidative degradation can diminish the health benefits associated with consuming omega-3 FAs [135].

Oils high in $\alpha$-linolenic acid, such as flaxseed oil, typically have low smoke points. Heating beyond the smoke point can lead to the formation of acrid smoke and the release of potentially harmful compounds. Alternatively, oils with higher smoke points, such as canola oil or olive oil, can be used for cooking at moderate temperatures. Oils high in saturated FAs, such as coconut oil, palm oil, and butter, have a high smoke point and are stable at high temperatures. This makes them suitable for cooking methods that require high heat. The conversion of vegetable oil to ($E$)-FAs can occur to some extent during the heating. When vegetable oils, which naturally contain unsaturated FAs, are exposed to high temperatures, the heat can induce partial hydrogenation and isomerization reactions, leading to the formation of (*E*)-FAs. Also, heat can cause the thermal decomposition of some components in the oil, leading to chemical reactions such as oxidation [136]. The formation of (*E*)-FAs is undesirable from a health perspective. (*E*)-FAs have been found to have negative effects on cholesterol levels and increase the risk of heart disease when consumed in excessive amounts. As a result, many health organizations and regulatory bodies have recommended reducing the consumption of (*E*)-fats in the diet [137]. Higher levels of saturated FAs present in different vegetable oils, such as coconut oil or palm oil, are less susceptible to (*E*)-FA formation [138]. Additionally, using healthier cooking methods, such as baking, grilling, or steaming instead of deep-frying or prolonged high-heat frying, can help reduce the formation of (*E*)-isomers. The total (*E*)-FA content in commercially processed foods, such as baked goods and fried snacks, can be significantly higher than what may occur during regular home cooking.

#### 3.2.3. Cosmetic Products

Vegetable oils offer numerous benefits for the skin and hair, making them popular choices in cosmetics as they contain essential nutrients, vitamins, and antioxidants. Their moisturizing, nourishing, and gentle properties, along with their ability to carry active ingredients, contribute to their widespread use in various cosmetic formulations [139]. Vegetable oils serve as excellent carriers for other active ingredients in cosmetics. They help to solubilize and deliver these ingredients to the skin effectively, enhancing their absorption and efficacy. They can be customized and blended with other ingredients to create formulations that cater to specific skin and hair needs. Vegetable oils are rich in fatty acids, which help to moisturize and hydrate the skin. They form a protective barrier on the skin's surface, preventing moisture loss and keeping the skin soft and supple. Vegetable oils can effectively nourish dry and dehydrated skin, restoring its natural moisture balance. They have emollient properties, which means they help to soften and smooth the skin. Vegetable oils can improve the texture and feel of cosmetic products, leaving the skin feeling silky and conditioned. These oils are generally well-tolerated by most skin types and have a lower risk of causing skin irritation or allergic reactions compared with synthetic or mineral oils. They are considered more natural and gentle options for cosmetic formulations [76]. Vegetable oils can serve as carriers for natural fragrances and essential oils in perfumes, body sprays, and scented products. They help to disperse and retain fragrance, ensuring a longer-lasting scent on the skin [140]. Additionally, the FAs are derived from plants, making them a renewable and sustainable resource. Vegetable oils are often preferred by consumers who prioritize natural and eco-friendly cosmetic products.

## 4. Conclusions

To the best of our knowledge, for the first time, thirty-nine vegetable oils and fats were studied to understand their composition. This research provides the actual composition of pure vegetable oils and fats obtained from reliable sources. Previously, many researchers ignored the presence of minor compounds like phytosterols and (*E*)-FAs. However, phytosterols and (*E*)-FAs play important roles in the beneficial and adverse effects of the oils, respectively. This research reports all the minor compounds present in each oil sample. Our exploration of the FA compositions of various vegetable oils and fats has illuminated the distinct characteristics that make each oil suitable for specific purposes. The unique FA profiles inherent in each oil provide a better understanding for informed decision making in diverse applications across culinary, nutritional, and industrial domains. Crucially, moving forward, people using vegetable oils globally will have access to information about the FA compositions of these oils. This will empower consumers to choose the most suitable oil according to their health and dietary requirements. Additionally, industries involved in cosmetics and biofuels stand to gain advantages by comprehending the chemical makeup of various oils and fats.

In this research endeavor, our primary emphasis was directed toward the comprehensive analysis of FAs and minor compounds inherent in diverse vegetable oils and fats. This study, therefore, confines its scope to the examination of the compositional aspects characterizing distinct vegetable oils and fats. Despite this limitation, the finding of our research holds significant relevance for the authentication of vegetable oils and fats, given the escalating apprehensions surrounding adulteration in the contemporary oil market. By establishing a chemical fingerprint through this study, we aim to contribute to the robust authentication of vegetable oils and fats, addressing a pertinent issue within the current landscape of the oil industry.

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## Abbreviations

| | |
|---|---|
| EI | Electron impact |
| eV | Electron volt |
| FA | Fatty acid |
| FAME | Fatty acid methyl ester |
| GC-MS | Gas chromatography–mass spectrometry |
| MCT | Medium-chain triglyceride |
| MSD | Mean ± standard deviation |
| RI | Retention index |
| USA | United States of America |

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