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EVALUATION OF CHIA SEED AND SUNFLOWER OILS AS RICH SOURCES OF ESSENTIAL FATTY ACIDS

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ABSTRACT: Researchers are continuously engaged in the search for various sources of oils that are acceptable to consumers and offer high nutritional value and storage properties. This study aimed to analyze the physical properties of chia seeds and sunflower oils, including refractive index, color, specific gravity, as well as chemical properties such as acid value, saponification value, ester value, iodine value, and peroxide value. Additionally, the percentage of unsaponifiable matter and stability induction period at 120◦C were determined. The nutritional value of these oils was assessed by analyzing their fatty acid content using gas chromatography and their sterol content using GC-MS. The physical characteristics of chia seeds and sunflower oils were determined, and it was observed that the refractive index for chia seeds was 1.48, whereas for sunflower oils it was 1.47. Similarly, the color intensity for chia seeds was measured to be 0.75, while for sunflower oils it was 0.95. Furthermore, the specific gravity for chia seeds was found to be 0.93, whereas for sunflower oils it was 0.92. On the contrary, the chemical properties of chia seeds and sunflower oils were evaluated, and it was found that the saponification value for chia seeds was 194.05 mg KOH/g oil, whereas for sunflower oils it was 191.91 mg KOH/g oil. Additionally, the acid value for chia seeds was determined as 1.03 mg KOH/g oil, while for sunflower oils it was 1.27 mg KOH/g oil. Moreover, the iodine value for chia seeds was measured to be 189.5 g I_2/100 g oil, whereas for sunflower oils it was 120.6 g I_2/100 g oil. Finally, the peroxide value for chia seeds was found to be 0.85 Meq oxygen/Kg, while for sunflower oils it was 0.76 Meq oxygen/Kg. Alpha linolenic acid accounted for most of the fatty acid composition in chia seed oil, comprising 61.29% of the total. In contrast, linoleic acid constituted the primary fatty acid in sunflower oil, making up 55.87% of the total. In both chia seed and sunflower oils, β-sitosterol emerged as the predominant sterol, comprising 46.61% and 57.63% of the total, respectively. These findings indicate that both oils possess significant amounts of essential fatty acids, including omega-3 and omega-6, which make them promising candidates to incorporate into diets requiring essential fatty acids.

Key words: Alpha- linolenic acid, Linoleic acid, Chia seed oil, Sunflower oil, Physical and chemical properties of oils, Sterols, Fatty acids.

INTRODUCTION

The issuance of a recommendation on food fats and oils in October 1993 was carried out by The Food and Agriculture Organization of the United Nations. According to this recommendation, fatty acids, as essential omega-3 and omega-6 fatty acids, fulfill a crucial function in the composition of cell membranes and eicosanoids, specifically arachidic acids. (World Health Organization, 1994). Numerous studies have shown how much bettering numerous vital indicators in the body of the organism—particularly those related to fat metabolism—may be achieved by consuming food derived from natural sources (Abozid and Ahmed, 2013; Abozid, and Farid, 2013; Abozid *et al.,* 2014; Abozid *et al.,* 2018; Ashoush *et al.,* 2017; El-Shennawy and Abozid, 2017; Farid *et al.,* 2015; Sake *et al.,* 2019).

Substituting polyunsaturated fatty acids (PUFAs) for saturated fatty acids (SFAs) is a crucial approach in dietary recommendations for lowering the likelihood of cardiovascular disease. (Lenighan *et al.,* 2019; Lovegrove, 2020). LA and ALA are polyunsaturated fatty acids (PUFAs) belonging to the n-6 and n-3

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categories, respectively. These PUFAs are abundantly found in certain vegetable oils, including sunflower oil, chia seed oil, and soybean oil. (Chen *et al.,* 2022; Russo, 2009). Both LA and ALA are essential fatty acids, with their relative proportions playing a significant role in the facilitation of well-being and the prevention of ailments. (Mukhametov *et al.,* 2022). Both n-3 and n-6 polyunsaturated fatty acids (PUFAs) exhibit advantageous properties, however, an immoderate intake of n-6 PUFAs and an imbalanced consumption of n-3 and n-6 PUFAs can lead to detrimental metabolic disorders (Lands, 2012). N-3 PUFA and their resultant metabolites possess significant promise in the treatment of metabolic disorders, exerting direct impacts on hepatocytes, adipocytes, and endothelial cells (Duan *et al.,* 2021). ALA possesses anti-metabolic syndrome, anti-inflammatory, and antioxidant characteristics, with its therapeutic impacts being reliant on the dosage (Yuan *et al.,* 2022). The structure of intestinal flora and the adherence of intestinal probiotics to colonic cells could be enhanced by ALA (Liu *et al.,* 2022). Rats fed a high-fructose diet may experience improvements in inflammation, dyslipidemia, and liver oxidative stress if ALA is partially substituted for LA. (Sakamuri *et al.,* 2020). Consequently, n-6/n-3 PUFA (LA/ALA) and PUFA/SFA ratios are crucial indicators for assessing the nutritional content of food (Chen & Liu, 2020). Chia oil has a higher content of ω-3 fatty acids than any other plant source that is currently known (Cruz-Tirado *et al.,* 2022). Chia oil has an advantage over products made from fish, which have high cholesterol content, in that it doesn't contain cholesterol like other vegetable oils do. Because chia seeds are low in sodium compared to other sources of ω-3 fatty acid, they are a great dietary choice for those with high blood pressure (Khalid *et al.,* 2022). Shen *et al.,* (2018), obtained a PUFA/SFA ratio of 8.85 for chia oil, and these authors hypothesized that because chia oil contains a high concentration of PUFAs, including it in the diet could have a positive impact on the cardiovascular system. Marineli et al., (2015), examined the antioxidant capacity of chia seeds and oil in diet-induced obese rats. The authors confirmed that consuming seeds and chia oil on a daily basis enhanced the liver's plasma and antioxidant status, reducing plasma lipid peroxidation and promoting a protective effect against oxidative stress brought on by obesity. Mohamed *et al.,* (2020), investigated using in vitro systems the anti-inflammatory properties of pure chia seed oil as well as its synergistic effects with other vegetable oils. At concentrations of 10 to 40 µL/mL, there was an increase in anti-inflammatory activity as the dose of chia oil increased. Furthermore, because of their high concentration of tocopherols, phytosterols, carotenoids, and phenolic compounds—all of which have the potential to protect consumers against a wide range of diseases and promote positive effects on human health—chia oil and chia seed are regarded as novel sources of natural antioxidants (Marineli *et al.,* 2014). For vegetarians and those allergic to fish, chia oil may provide an alternative source of n-3. This is because neither the oil nor the seed have demonstrated any negative effects on digestive systems or other health issues linked to flaxseed and other marine products. These issues include fish taste and animal weight loss (Venegas-Calerón and Napier, 2023). After rapeseed, safflower, and soybeans as the most lucrative and economical oilseed crop, sunflower is ranked as the fourth most important oilseed crop globally. (Sharma *et al.,* 2023). The major composition of sunflower oil is linoleic acid (polyunsaturated fat) and oleic acid (mono-unsaturated fat). The variation in the fatty acid content of sunflower oil might be due to the plant species and the processing treatment employed during its production (Narayana and Premnath, 2023). SFO like other oil crops contains carotenoids, tocopherols, tocotrienols, and sterols, with light-yellowish coloration containing high polyunsaturated fatty acids (linoleic acid and mono-unsaturated oleic acid, this accounts for 48%–74% of the total fatty acids of sunflower oil with low levels of saturated fatty acids—palmitic and stearic acids (15%) unlike other seed oils such as soybean and rapeseed which contain less amount of linoleic acid (Al-Amrousi, 2024). Due to the high oleic and linoleic acids in sunflower oil, its consumption has reduced the chances of

high cholesterol, total cholesterol, and coronary artery diseases (Saedi *et al.,* 2017). The sunflower oil containing essential vitamin E is beneficial in lowering atherosclerosis, artery disease, and stroke. Magnesium is also an important element required for the proper functioning of body nerve and muscle (Houston, 2014). The oil extract from sunflower serves as excellent phenolic antioxidants, which account for about 1%–4% of the total mass chlorogenic acid. It also contains phytosterols, which help in the alteration of cholesterol synthesis, thereby reducing the cholesterol level in the serum through cholesterol excretion (Romani *et al.,* 2017). Carotenoids and tocopherol are antioxidants found in sunflower oil that neutralize free radicals, scavenge them and prevent oxidative damage to cells or tissues, thus exhibiting antitumor, anti-inflammatory, and cardio-protective responses (Atasoy *et al.,* 2021).

Therefore, the purpose of this study is to determine the physical and chemical properties as well as the chemical composition (fatty acids and sterols) of chia seed and sunflower oils.

MATERIALS AND METHODS

Materials

1- **Seeds:** Chia seeds (*Salvia hispanica* L.) and sunflower seeds (*Helianthus annuus*) were obtained from National Research Center, Giza, Egypt.

2- **Chemicals and reagents:** Methanol, ethanol, acetone, chloroform, hexane, diethyl ether, glacial acetic acid, hydrochloric acid, iodine bromide, potassium iodide, potassium hydroxide, sodium hydroxide, Sodium thiosulphate, phenolphthalein, starch, sodium sulphate, δ -dianisidine were obtained from El-Nasr Pharmaceutical Chemicals, El-Ameriea, Cairo, Egypt.

Methods

Extraction of oils

The seeds of chia (*Salvia hispanica* L.) and sunflower (*Helianthus annuus*) were dust-free and cleaned, after which oil was extracted using a hydraulic piston (model number: 6Y) and filtered using a filter press.

Physical properties of oils

1- Measuring of refractive index

Using an Abbè refractometer (Carl Zeiss JENA, GDR, manufactured in China) at 25ºC, the refractive index of oil samples was determined using the Method of (A.O.A.C. 2000).

2- Color determination

Using a 5.25-inch cell, a Lovibond tintometer (Model F, Visual, manufactured in China) was used to measure the color in accordance with the (A.O. C. S. 1989).

3- Determination of specific gravity

A 10-ml automatic gas pyrometer was used to measure the specific gravity of oil samples at 30ºC using the procedure of (A.O.A.C. 2000).

Chemical properties of oils

1- Determination of acid value (AV)

Based on (A.O.A.C. 2003), the acid value was determined. Acid value was determined by dissolving 4 grams of oil in 25 milliliters of ethanol, titrating the mixture with 0.1 N alcoholic potassium hydroxide and using phenolphthalein indicator. acid value was calculated as follows:

$$\text{Acid value (mg KOH/g oil)} = \frac{56.1 \times N \times V}{W}$$

Where:
N = Normality of KOH.
W = Oil's weight in grams.
V = Volume of KOH (ml).
56.1 = Equivalent weight of KOH.

2- Saponification value (SV) determination

The method used to determine saponification value was (A.O.A.C. 1995). A 100 ml, 0.5% alcoholic potassium hydroxide solution was added to 5 g of filtered oil and cooked for approximately 30 minutes. After the reaction mixture had cooled, it was titrated using a 0.5 N hydrochloric acid solution and an indicator called

phenolphthalein. The oil sample was not added to another experiment, which was conducted as a blank. The calculation was made according to the following equation:

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

Where:

B = Volume of 0.5 N hydrochloric acid solution needed for the blank.

S = Volume of 0.5 N hydrochloric acid solution needed by oil.

N = Hydrochloric acid solution normalty.

56.1= Equivalent weight of KOH.W = Oil's weight in grams.

3-Ester value (EV) calculation

The ester value was determined using the subsequent formula in accordance with (A.O.A.C. 2003).

Ester value = (Saponification value - Acid value).

4- Using (Wijs method) to determine iodine value (IV):

According to (Singh *et al.,* 1981), the iodine value was determined. An excess of iodine bromide (IBr) in glacial acetic acid is added to 0.25g of the oil sample. Iodine is produced when unreacted iodine bromide reacts with potassium iodide. Next, the concentration of iodine can be determined through titration using standard sodium thiosulphate (0.1N). The following equation was used to determine the iodine value:

$$\text{Iodine Value (g}I_2\text{/100g oil)} = \frac{(B-S)\times N\times 127\times 100}{W\times 1000}$$

Where:

B = Volume in ml of $Na_2S_2O_3$ used in blank.

S = Volume in ml of $Na_2S_2O_3$ used in sample.

N = The normality of thiosulphate solution.

W = Oil's weight in grams.

127 = Iodine equivalent weight.

5- Determination of peroxide value (PV)

According to (A.O.A.C. 1984), the peroxide value was determined. The amount of iodine released from KI by the oxidative action of peroxides present in the oil is measured by titrating with standard sodium thiosulphate using starch solution as an indicator. Five grams of oil sample was dissolved in a solution of acetic acid and chloroform (3:2 v/v). Saturated KI solution was then added to the sample. Titration for the blank's peroxide value was also carried out. The following equation was used for calculating peroxide value.:

$$\text{Peroxide value (Meq oxygen/kg)} = \frac{(S-B)\times N\times 1000}{W}$$

Where:

B: Volume of sodium thiosulphate used in blank.

W: Weight of oil in g.

S: Volume of sodium thiosulphate consumed by the sample oil.

N: Standard sodium thiosulphate normality.

6- Oxidative stability index determination

The well-known rancimate method is used to measure the oxidative stability index through an accelerated oxidation test. The measurement of stability is determined by measuring the oxidation induction time (hour) using an oil sample of 5 g that has been heated to 120ºC and an air flow rate of 20 liters per hour using a Rancimat 679 apparatus (Metrohm Co., Switzerland). It was determined how long it took for the conductivity to reach a certain level. (Laubli and Bruttel., 1986). The Oils & Fats Research Department of the Food Technology Research Institute, Agriculture Research Center, Egypt, carried out this assay.

7- Determining the percentage of unsponifiable material

Unsaponifiable matter was determined using the procedure outlined in (A.O.A.C. 2000). KOH solution (10% w/v) was added after a known weight of the oil (2-4g) had been dissolved in 25 ml of ethanol. Under a reflux air condenser, the oil was saponified for thirty minutes in a water bath. Using a combined volume of 50 ml of distilled water and 50 ml of petroleum ether, the alcoholic soap solution was quantitatively transferred into a separator funnel. Three extractions using petroleum ether, multiple distilled water washes, drying over anhydrous sodium sulfate, and filtering into a weighted flask were the processes used to extract the

unsaponifiable matter. After utilizing a boiling water bath to evaporate the solvent, the flask was dried at 105°C until its weight remained constant. The following equation was used to determine the percentage of unsaponifiable matter: % unsaponifiable matter = (weight of the residue/weight of oil) ×100

8- Sterols identification and determination

At the National Research Center's Laboratory of Medicinal and Aromatic Plants, the GC-MS analysis of the sterol samples was performed in accordance with (Soupas *et al.,* 2004), using the following specifications for the gas chromatography–mass spectrometry instrument stands. The instrument is an ISQ Single Quadrupole Mass Spectrometer thermo mass spectrometer coupled with a Thermo Scientific Corp., USA, TRACE GC Ultra Gas Chromatograph. 30 m x 0.32 mm i.d., 0.25 µm film thickness TR-5MS column was fitted with the GC-MS system. With helium serving as the carrier gas and a temperature program of the following, analyses were performed at a flow rate of 0.8 mL/min and a split ratio of 1:10. 50°C for three minutes; after that, it rose at a rate of five degrees Celsius per minute to 300°C, where it stayed for fifteen minutes. 200°C was the holding temperature for the detector and injector, respectively. All injections of 1 µL of the mixtures were always done with diluted samples (1:10 hexane, v/v). Using a spectral range of m/z 40-450, mass spectra were obtained by electron ionization (EI) at 70 eV. Using mass spectra (real chemicals and the Wiley spectral library collection), the compounds were identified.

9- Analysis of fatty acids

Gas chromatography (GC) was used to analyze the fatty acids in oils. On a gas chromatograph equipped with a FID detector (Perkin Elmer Auto System XL) and an auto sampler and Ezchrom integration system, samples were converted into fatty acid methyl esters (FAME) using a methanolic boron trifluoride (12%) methanolic solution. He carrier gas; about 25 Psi; air flow rate: 450 ml/min; hydrogen flow rate: 45 ml; split flow rate: 100 ml/min. the oven's temperature was 200 °C, while the injector and detector's temperature were 250 °C according to (A.O.A.C. 2012).

10- Statistical analysis

A minimum of three replications for every oil sample were performed with each test of physical and chemical properties. The statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS 18.0 software and Microsoft Excel 2010) and all data were expressed as mean ± SD. Tests were conducted using a one-way analysis of variance (ANOVA) with repeated measures and post-hoc comparisons (LSD test) to analyze differences between oils. At $P < 0.05$, differences were deemed statistically significant. (Landue and Everitt; 2004).

RESULTS AND DISCUSSION

1- Physical Characteristics of chia seed and sunflower oils

Data in Table (1) showed that chia seed oil recorded the highest value in both parameters; refractive index and specific gravity (1.48 and 0.93 respectively) followed by sunflower oil (1.47 and 0.92 respectively). On the other hand, color (red) showed different order; sunflower oil was the highest (0.95) followed by chia seed oil (0.75). These findings show that while the specific gravity and refractive index of chia seed oil and sunflower oil do not differ significantly, red color (Lovibond tintometer) in the sunflower oil was significantly higher than in the chia oil.

Specific gravity and refractive index are important factors for determining the quality of any vegetable oil. Both parameters are essential for the optimization of any processing technique. Specific gravity is directly proportional to chain length but inversely related to the degree of unsaturation. The refractive index is a suitable and low-cost method to measure the authenticity of oil; it measures the degree of unsaturation and presence of uncommon components in the oil. It increases with the increase in chain length and double bonds.

Color is an important physical parameter for consumer acceptance. The color of refined edible oils should be a light yellow; the Lovibond tintometer can measure this, typically providing a range of reds and yellows (Shahidi and Wanasundara, 2008). Vegetable oils are primarily colored by two kinds of pigment. One is the lipid-soluble pigments found naturally in the environment, like chlorophylls and carotenoids. The other type of pigments is those created during the processing of oil; these include the byproducts of non-enzymatic browning reactions and oxidative polymerization. These pigments are referred to as processing pigments (Chen and Sun, 2023).

In general, the results obtained by measuring the physical properties of chia seed and sunflower oils were close to the results of previous studies conducted by many researchers on the same oils, (Aboki *et al.,* 2012; Basuny *et al.,* 2021; Codex Alimentarius Commission, 1999; Gadallah *et al.,* 2023).

Table (1): Physical characteristics of chia seed and sunflower oils.

Physical characteristics	Type of Oil	
	Chia seed	Sunflower
Refractive Index	1.48 ± 0.016	1.47 ± 0.041
Color (red)	0.75 ± 0.17	0.95 ± 0.033*
Specific Gravity	0.93± 0.024	0.92 ± 0.008

Values represent means ± S.D obtained from (3) samples, * refer to significant difference at ($p \geq 0.05$).

2- Chemical characteristics of chia seed and sunflower oils

A number of fundamental estimates are estimated that clearly show the nature of the edible oil and its quality, enabling us to determine the oil's quality, its chemical and structural properties, and its stability. The estimations of the acid value, saponification value, iodine value, ester value, peroxide value, un-saponifiable matter (%), and stability induction period of the oil are the most significant of these.

Data in Table (2) showed that chia seed oil recorded the highest value in parameters of saponification value (SV) (mgKOH/g oil), ester value (EV), iodine value (IV) (gI_2/100g oil), and peroxide value (PV) (Meq oxygen/kg). (194.05, 193.02, 189.5, and 0.85 respectively) followed by sunflower oil (191.91, 190.64, 120.6, and 0.76 respectively). These findings show that while the (SV), (EV), and (PV) of chia seed oil and sunflower oil do not differ significantly, (IV) in the chia seed oil was significantly higher than in the sunflower oil.

Saponification value (SV) is an index of the average molecular mass of fatty acid in the oil sample. The lower value of saponification values suggests that the mean molecular weight of fatty acids is lower or that the number of ester bonds is less (Denniston *et al.,* 2004). Peroxide value (PV) is used as a measure of the extent to which rancidity reactions have occurred during storage. It could be used as an indication of the quality and stability of fats and oils. The peroxide value was also found to increase with the storage time, temperature and contact with air of the oil samples (Ekwu and Nwagu, 2004).

Iodine value (IV) measures the degree of unsaturation in a fat or vegetable oil. It determines the stability of oils to oxidation and allows the overall unsaturation of the fat to be determined qualitatively. The oxidative and chemical changes in oils during storage are characterized by an increase in free fatty acid contents and a decrease in the total unsaturation of oils (Asuquo *et al.,* 2012).

On the other hand, sunflower oil was significantly higher than chia seed oil in the parameters of acid value (AV) (mg KOH/g oil),

(1.27 and 1.03 respectively), un saponifiable Matter (%), (2.15 and 1.22 respectively), and stability induction period at (120◦C in hour), (4.86 and 3.94 respectively).

Oils with lower values of acid value are more acceptable for edible applications while the high un saponifiable matter value indicates the presence of lignans, crude fiber, protein, and minerals. Refining edible oils is important to remove any undesirable elements (trace metals, pigments, waxes, and gums) present in crude oil. This is because they might cause damage to human health and also act as a prooxidant during the storage of edible oil, (Dhyani *et al.,* 2022).

Oxidation stability is one of the crucial parameters for measuring the deterioration in edible oils due to oxidation. Oxidative stability index (OSI) is defined as the time required for decomposition of primary oxidation products produced by oxidation in the oil; it also indicates the oil's shelf life and is measured through rancimat test. The rancimat test is a technique in which oil is exposed to a higher temperature in the presence of excess air and temperature. Oils containing a high amount of unsaturated fatty acids are more prone to oxidation, (Maszewska *et al.,* 2018).

These results are in line with (Aboki *et al.,* 2012), (Basuny *et al.,* 2021), (Codex Alimentarius Commission, 1999), and (Gadallah *et al.,* 2023). The reason for the rapprochement of these values is that they are normal values for these oils at ideal conditions of storage especially acid value, peroxide value, and stability induction.

Table (2): Chemical Characteristics of chia seed and sunflower oils.

Chemical characteristics	Type of Oil	
	Chia seed	Sunflower
Acid value (mg KOH/g oil)	1.03±0.02	1.27±0.12*
Saponification number (mg KOH/g oil)	194.05±7.03	191.91±6.55
Ester Value	193.02±7.86	190.64±7.56
Iodine number (gI_2/100g oil)	189.5±7.30*	120.6±5.67
Peroxide number (Meq oxygen/kg)	0.85±0.36	0.76±0.34
Un saponifiable Matter (%)	1.22±0.06	2.15±0.09*
Stability induction period at 120°C in hour	3.94±0.19	4.86±0.22*

Values represent means ± S.D obtained from (3) samples, * refer to significant difference at ($p \geq 0.05$).

3- Sterols composition of chia seed and sunflower oils (%)

Phytosterols are plant-derived sterols that have similar physiological functions to cholesterol in vertebrate animals. Phytosterols are important micronutrients in human diets. Evidence has shown that phytosterols play an essential role in the reduction of cholesterol in blood and therefore decrease cardiovascular morbidity, (Miras-Moreno *et al.,* 2016). Characterizations of sterols composition in % were obtained by using gas chromatography–mass spectrometry (GC-MS).

Data in Table (3) showed that B-sitosterol is the major sterols in investigated oils, chia seed and sunflower oil (46.61 and 57.63% respectively) followed by stigmasterol in chia seed oil (19.55%) and Delta-7-Stigmasterol in sunflower oil (15.02%).

On the other hand, chia seed oil recorded high content of stigmasterol, campesterol and Delta-5-Avenasterol (19.55, 16.93 and 10.2% respectively) more than sunflower oil (9.7, 9.5 and 3.9% respectively).

Finally, Lanosterol recorded only in chia sed oil (6.71%) while Delta-7-Avenasterol and Delta-

7-Stigmasterol recorded only in sunflower oil (4.25 and 15.02% respectively).

The results of this study's analysis of the sterol content in chia and sunflower oils are generally in line with the findings of other researchers (Aguirre *et al.,* 2014), (Codex Alimentarius Commission, 1999), and (Ghena *et al.,* 2020); because the sterol content in similar types of vegetable oils is fairly similar, regardless of variety or cultivation locations. B-Sitosterol, campesterol, stigmasterol, brassicasterol, and Δ5-avenasterol are the main phytosterols in plants, (Yang *et al.,* 2019).

Table (3): Sterols composition of chia seed and sunflower oils (%).

Sterols	Type of Oil	
	Chia seed	Sunflower
B-Sitosterol	46.61	57.63
Campesterol	16.93	9.5
Stigmasterol	19.55	9.7
Lanosterol	6.71	ND
Delta-5-Avenasterol	10.2	3.9
Delta-7-Avenasterol	ND	4.25
Delta-7-Stigmasterol	ND	15.02

4- Fatty acids composition of chia seed and sunflower oils:

Lipids consist of fatty acids (FAs) classified mostly according to the presence or absence of double bonds as saturated (SFAs—without double bonds) monounsaturated (MUFAs—with one double bond) and polyunsaturated fatty acids (PUFAs—with two or up to six double bonds); further, as cis or trans based on the configuration of the double bonds and as ω-3 or ω-6 PUFAs depending on the position of the first double bond from the fatty acid methyl-end. The human body cannot synthesize PUFAs with the first double bond on C3 and C6 from the methyl-end because of the absence of appropriate enzymes. Thus, these fatty acids are essential (EFAs) and they have to be obtained from a diet, (Orsavova *et al.,* 2015).

Characterizations of fatty acids composition in % of total methylester of fatty acids (FAMEs) of oils were obtained by using gas chromatography (GC).

Data in Table (4) showed that the highest amount of α-linolenic acid (C18:3, ω-3), was in chia seed oil followed by sunflower oil (61.29% and 0.93% respectively) while the highest amount of linoleic acid (C18:2, ω-6) was in sunflower oil followed by chia seed oil (55.87% and 18.55% respectively). Oleic acid (C18:1, ω-9) also recorded the highest amount in sunflower oil, followed by chia seed oil (25.71% and 8.49% respectively).

On the other hand, sunflower oil recorded higher amount of palmitic acid (C16:0), stearic acid (C18:0), and γ-linolenic acid (C18:3, ω-6), (10.09%, 4.88%, and 2.11% respectively) more than chia seed oil (6.71%, 4.39%, and 0.20% respectively).

Data also showed that total saturated: total unsaturated fatty acid ratio was (1:5.64) at sunflower oil while (1:7.73) at chia seed oil respectively.

On the other hand, the ratio of ω-6 to ω-3 fatty acid showed the highest level in sunflower oil (1:0.16) followed by (1:3.3) in chia seed oil. Also, ω-9: ω-3 ratio recorded the highest level in sunflower oil (1:0.04) followed by chia seed oil (1:7.04) respectively.

The ω-6/ω-3 ratio is the key factor for balanced synthesis of eicosanoids and its nutritional importance has been frequently discussed as well as dependence of ω-6/ω-3 ratio value on a dietary pattern. In the analyzed oils, ω-3 PUFAs were represented by α-linolenic acid (ALA, C18:3, ω-3), The group of ω-6 PUFAs was represented by linoleic (LA, C18:2, ω-6) and γ-linolenic (GLA, C18:3, ω-6) acids.From a physiological point of view, chia seed and

sunflower oils may be a potentially interesting food ingredient thanks to their health benefits from its high levels of PUFA especially essential fatty acids.

These results are in line with (Akkaya, 2018), (Basuny *et al.,* 2021), (Codex Alimentarius Commission, 1999), and (Ghena *et al.,* 2020).

As Venegas- Calerón and Napier, noted in (2023), the significance of chia oil as a promising new source of ω-3 in food is evident from the earlier results. Additionally, mixes of both oils (chia and sunflower) can be made to get the ideal ratio of ω-6 to ω-3, which is necessary to get the necessary balance in the oil mixture.

Table (4): Fatty acids composition of chia seed and sunflower oils.

Fatty acids	Type of oil	
	Chia seed	Sunflower
C16:0	6.71	10.09
C18:0	4.39	4.88
C20:0	0.17	0.09
C22:0	0.19	ND
Total saturated	11.46	15.06
C16:1	0.07	0.08
C18:1	8.49	25.71
C18:2 ω-6	18.35	55.87
C18:3 ω-6	0.20	2.11
C18:3 ω-3	61.29	0.93
C20:1	0.14	0.24
Total unsaturated	88.54	84.94
Total saturated: Total unsaturated	1:7.73	1:5.64
ω-3	61.29	0.93
ω-6	18.55	57.98
ω-9	8.7	26.03
ω-6: ω-3 Ratio	1:3.3	1:0.02
ω-9: ω-3 Ratio	1:7.04	1:0.04

Conclusion

In an effort to determine the optimal oils or the optimal combination of them, this study will assess two significant edible oils based on their physical and chemical characteristics as well as their fatty acid and sterol content. The findings unmistakably demonstrate sunflower oil's high omega-6 fatty acid content, while chia seed oil stood out for having high omega-3 fatty acid content. As a result, these oils are a good fit for use in nutrition; however, further research is required to determine the ideal ratios for using this combination in biological experiments.

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تقييم زيوت بذرة الشيا وعباد الشمس كمصادر غنية بالأحماض الدهنية الأساسية

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الملخص

تعتبر الزيوت عنصراً مهماً جداً في الأنظمة الغذائية المختلفة، مما يجعل من المهم للباحثين البحث المستمر عن مصادر متنوعة لهذه الزيوت تكون مقبولة لدى المستهلكين من جهة، وتتميز بقيمتها الغذائية العالية وخصائصها التخزينية على المستوى الغذائي من جهة اخري .أجريت هذه الدراسة لتحديد الخواص الفيزيائية لزيوت بذور الشيا وعباد الشمس (معامل الانكسار، اللون، الوزن النوعي) وكذلك الخواص الكيميائية (رقم الحامض، رقم التصبن، رقم الإستر، الرقم اليودي ورقم البيروكسيد) .كما تم تقدير النسبة المئوية للمادة الغير قابلة للتصبن وفترة الثبات عند درجة حرارة ١٠٠ درجة مئوية ولتحديد القيمة الغذائية لهذه الزيوت من خلال تقييم محتواها من الأحماض الدهنية (مقيم بواسطة جهاز كروماتوغرافيا الغاز) ومحتوها من الإستير ولات مقيم بواسطة (GC-MS) أظهرت الخصائص الفيزيائية لزيوت بذور الشيا وعباد الشمس مايلي: كان معامل الانكسار ١.٤٨ و١.٤٧ على التوالي، في حين كانت شدة اللون (الأحمر) ٠.٧٥ و٠.٩٥ على التوالي وكان الوزن النوعي ٠.٩٣ و٠.٩٢ على التوالي .ومن ناحية أخرى أظهرت الخواص الكيميائية لزيوت بذور الشيا وعباد الشمس أن رقم التصبن كان (١٩٤.٠٥ و١٩١.٩١) ملجم KOH/ جم زيت على التوالي، بينما كان رقم الحامض (١.٠٣ و١.٢٧) ملجم KOH/جم زيت على التوالي، وكان الرقم اليودي (١٨٩.٥ و١٢٠.٦) جمI_2/ ١٠٠ جم زيت على التوالي . وأخيرًا، كانت رقم البيروكسيد ٠.٨٥ و٠.٧٦ (مكافئ الأكسجين/كجم زيت) على التوالي .كان حمض ألفا لينولينيك هو الحمض الدهني الرئيسي في زيت بذور الشيا (٦١.٢٩%)، بينما كان حمض اللينوليك هو الحمض الدهني الرئيسي في زيت عباد الشمس (٥٥,٨٧ %) .كان بيتا سيتوستيرول هو الإستيرول الرئيسي في كل من زيوت بذور الشيا وعباد الشمس (٤٦.٦١ و٥٧.٦٣% على التوالي) .وكما أظهرت النتائج، فإن كلا الزيتان تحت الدراسة يحتويان على نسبة عالية من الأحماض الدهنية الأساسية (كل من أوميجا ٣ وأوميجا ٦)، مما يجعلها زيوت واعدة لدعم الأنظمة الغذائية بالأحماض الدهنية الأساسية.

الكلمات المفتاحية: حمض ألفا لينولينيك، حمض اللينوليك، زيت بذور الشيا، زيت عباد الشمس، الخواص الفيزيائية والكيميائية للزيوت، الإستيرولات، الأحماض الدهنية.