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A COMPARATIVE STUDY BETWEEN SUNFLOWER OIL AND FLAXSEED OIL AS OILS WITH HIGH NUTRITIONAL VALUE

Saher A. Dabor; Salah M. Abdelgwad and Medhat M. Abozid

Biochemistry department, Faculty of Agriculture, Menoufia University.

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ABSTRACT: The types of fats that people eat have a significant impact on public health and can lead to various diseases, including fatty liver and coronary heart diseases. Fats are an indispensable part of human diets. The point of the study was to compare the nutritional value and constituents of sunflower, and flaxseed oils—two types of oils that are frequently used in Egyptian cuisine. Every oil's refractive index, color, oxidative stability index, saponification value, iodine value, acid value, ester value, peroxide value, and unsaponifiable matter (%) were estimated. The GC was used to estimate the fatty acid composition of these oils as well as the amount of sterols contained in each one; while the HPLC was used to estimate fat-soluble vitamins in sunflower oil and flaxseed oil. The most important results indicated that linoleic acid was the largest component in sunflower oil (54.5 %), while alpha-linolenic acid was the largest component in flaxseed oil (51.49 %). For sterols, β-sitosterol (57.63 %), stigmasterol (24/09%), and campesterol (9.5 %), were the largest components in sunflower oil; while β-sitosterol (51.52 %), campesterol (28.6 %); Delta 5-avenasterol (10.8 %) and stigmasterol (8.51%) were the largest sterols in flaxseed oil. The results of the vitamin analysis in these oils revealed that, vitamin D at 11.9 ppm, is the second most abundant vitamin in sunflower oil, while vitamin E is the most abundant at 626 ppm. In the same way, flaxseed oil had 2962 ppm of vitamin E and 46.7 ppm of vitamin D concentration. The data unmistakably demonstrate sunflower oil's high omega-6 fatty acid content, while flaxseed oil stood out for having high omega-3 fatty acid content. These oils are therefore well suited for use in nutrition, and further research is required to determine the ideal ratios for this combination of oils to be used in biological experiments.

Keywords: Sunflower oil, Flaxseed oil, Omega 3 fatty acids, Omega 6 fatty acids, Sterols.

INTRODUCTION

One of the main risk factors for the development of many serious diseases, including cardiovascular disease, type 2 diabetes, and certain cancers, is obesity (WHO, 2005). Numerous human studies have demonstrated that dietary fats are a major factor in the development of obesity. Obesity results from meal compositions that contain more fat than thirty percent of the meal's total energy (Jequier, 2002; Hill *et al.*, 2000; Schrauwen and Westerterp, 2000).

A multitude of studies have demonstrated the potential benefits of eating food derived from natural sources for improving several vital indicators in the body of the organism, particularly those related to fat metabolism (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.*, 2012; Farid *et al.*, 2015; Sakr *et al.*, 2019).

Conversely, dietary fat consumption is crucial and indispensable for a healthy diet. For a healthy, balanced meal, the Food and Agriculture Organization (FAO) suggests consuming 55 grams of fat on average each day (Kabyemela *et al.*, 1992). Thus, not all fats are harmful. Studies suggest that using omega-3 and omega 6 fats promotes weight loss, enhances fat metabolism, and reduces the buildup of cholesterol in blood vessel walls, despite the strong link between high fat intake and obesity (He *et al.*, 2002; Iso *et al.*, 2001). So, it can be argued that the biggest risk comes from the quality of fats, namely the kind and amount of various fatty acids found in dietary fats, rather than from consuming fats in the food itself.

*Corresponding author: daboursaher@gmail.com

Due to its high content of essential fatty acids, both omega-3 (n-3) and omega-6 (n-6), flaxseed oil has gained popularity as a food oil recently. It contains a good amount of linoleic acid (C18:2 n-6), ranging between 15-17%, and a very large content of α-linolenic acid (C18:3 n-3), ranging between 49-64% (Shadyro *et al.*, 2017). But because of its nutritional value, sunflower oil is the second most widely consumed edible oil produced worldwide, behind soybean oil, which is considered one of the best plant oils for a human diet (Nandha *et al*. 2014). Sixty-nine percent of the linoleic acid, 20% of the oleic acid, and 11% of the saturated fatty acids are found in regular sunflower oil (Skoric *et al.*, 2008).

It is evident from the previous presentation how important it is to investigate the nutritional value of oils that are frequently used in Egyptian cuisine to suggest healthful oils—either single oils or blends of them—for various meals. The physicochemical characteristics and chemical makeup of sunflower and flaxseed oils were assessed in this study with this objective in mind.

MATERIALS AND METHODS

Materials

Sunflower *(Helianthus annuus*), a hybrid cultivar named strawby, flaxseed (*Linum usitatissimum*), and Golden cultivar were obtained from Agriculture Research Center, Giza, Egypt. All chemicals were obtained from El-Nasr Pharmaceutical Chemicals, El-America, Cairo, Egypt.

Methods

Extraction of oils

The seeds of flaxseed were cleaned, and after that, oil was extracted using a hydraulic piston (model number: 6Y) and filtered (filter press). Sunflower seeds were cleaned and washed. A hydraulic piston (model number: 811) was used to extract the oil, which was then filtered (filter press).

Physical characteristics of oils

The refractive index (RI), of oils was determined at 25oC according to A.O.A.C, (2000) by using a refractometer (NXRL-3 Poland). A lovibond tintometer was applied to measure the color using 5.25-inch cell according to the method of A.O.C.S. (1985). The oxidative stability of oils was evaluated by the Rancimat method (Mendez, 1997). Stability was expressed as the oxidation induction time (hours), measured with the Rancimat 679 apparatus (Metrohm Co., Switzerland), using an oil sample of 5 g heated to 100ºC with airflow of 20 L/h.

Chemical characteristics of oils

The acid value was measured as described in A.O.A.C., (2003). The saponification value was determined by following the method of A.O.A.C., (1995). The iodine value was measured by the method of Singh *et al.*, (1981). The peroxide value was determined in line with the procedure outlined in A.O.A.C., (1984). The ester value was calculated based on the equation outlined in A.O.AC., (2003). Unsaponifiable matters were identified by using the procedure outlined in A.O.A.C., (2000).

Determination of fatty acid composition

The fatty acids methyl esters of oils were prepared using trans-esterification with cold methanolic solution of potassium hydroxide. The fatty acids methyl esters were identified by GC-capillary column according to the method of IOOC (2001). The fatty acid methyl esters were determined by gas chromatography (PERKIN ELMER) models 8400 equipped with flame ionization under the following conditions:

- Column temperature: 180ºC isothermal.
- Detector: Flame ionization (FID).
- Carrier gas: Nitrogen, Foil gases air 0.5 ml/min.
- Detector temperature: 270ºC, sensitivity 10^2*16 and chart speed 2.5 mm/min.
- The peaks were identified by comparison with pure methyl ester standards through their retention time under identical conditions.

Determination and identification of sterols

The GC-MS analysis of the sterols samples was carried out according to (Soupas *et al.*, 2004). Instrument: a TRACE GC Ultra Gas Chromatograph (THERMO Scientific Corp.,

USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TR- 5MS column (30 m x 0.32 mm i.d., 0.25 µm film thickness). Analyses were carried out using helium as carrier gas at a flow rate of 0.8 mL/min at a split ratio of 1:10 and the following temperature program: 50 °C for 3 min; rising at 5 C/min to 300°C and held for 15 min. The injector and detector were held at 220° C and 200°C, respectively. Diluted samples (1:10 hexane, v/v) of 1 µL of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. The compounds were identified using mass spectra (authentic chemicals and Wiley spectral library collection).

Determination and identification of fat-soluble vitamins

Determination of vitamins (A, D, E and K): Vitamins A, D, E, and K were determined according to the methods of Noll (1996); Wittiy *et al.* (2013); Gimeno *et al.* (2000) and Perez-Ruiz (2007), respectively. The carotenoids of oil samples were determined according to the method of Mosquera *et al.* (1991). HPLC analysis was performed with the Agilent 1100 series HPLC system (Agilent; USA), including a diode array detector. For fat-soluble vitamins, the Agilent Eclipse XDB-C18 column was used (5 µm, 4.6 × 150 mm), the solvent was methanol, and UV detection was recorded at 325 nm for vitamin A, 265 nm for vitamin D3, 290 nm for vitamin E, and 244 nm for vitamin K. Separation of all vitamins was based on isocratic elution and the solvent flow rate was maintained at 1 mL/min.

RESULTS AND DISCUSSION

Physiochemical properties and oxidative stability index of flaxseed and sunflower oils

Table (1), present physiochemical properties and oxidative stability index of sunflower and flaxseed oils. Flaxseed showed reflective index value (1.479) followed by sunflower oil (1.472). The results also indicated that there was a clear discrepancy in color (by using lovibond tintometer) between the two oils, for the red color, flaxseed oil was (8.2), and sunflower oil was (1.4). Flaxseed oil also had the highest percentage of unsaponified matter (1.29%) when compared to sunflower oil (1.14%).

The results (Table 1) showed that the values of the acid value, saponification value, and ester value of flaxseed oil (1.85 mg KOH/g oil, 196.02 mg KOH/g oil, 194.17, respectively) are higher than those of their sunflower oil counterparts (1.27 mg KOH/g oil, 192.09 mg KOH/g oil, 190.82, respectively). The values of iodine value and the peroxide value also showed the same behavior, as the values for flaxseed oil (194.38 gI2/100g oil; 4.2 Meq oxygen/kg, respectively) were higher than for their counterparts for sunflower oil (128.08 gI2/100g oil; 2.06 Meq oxygen/kg, respectively), which may be explained by the fact that flaxseed oil contains a large amount of alpha-linolenic acid, which makes its iodine number values high, as well as because it is more susceptible to oxidation, which increases peroxide value. These findings are in excellent agreement with those of earlier investigations on these oils for sunflower oil (Aboki *et al.,* 2012) and flaxseed oil (Shimada *et al.,* 1992; Zhang *et al.,* 2011).

Table 1: Physiochemical properties and oxidative stability index of flaxseed and sunflower oils.

Physical and chemical properties	Type of Oil	
	Flaxseed	Sunflower
Refractive index at 25° C	1.479	1.472
Color (Red)	8.2	1.4
Acid value (mg KOH/g oil)	1.85	1.27
Saponification value (mg KOH/g oil)	196.02	192.09
Ester Value	194.17	190.82
Iodine value (gI2/100g oil)	194.38	123.08
Peroxide value (Meq oxygen/kg)	4.2	2.06
Unsaponifiable Matter (%)	1.29	1.14
Stability induction period at 100◦C in hour	7.65	12.95

Fatty acids composition of flaxseed and sunflower oils

The findings displayed in Table (2) demonstrate the various fatty acid composition of sunflower and flaxseed oils. The findings unambiguously show that each oil is distinguished by the presence of a major fatty acid that makes up more than half of all of its constituent parts. Of the total components of flaxseed oil, α-linolenic acid (18:3 n3) makes up 51.49%, and of the total fatty acids in sunflower oil, linoleic acid (18:2 n6) makes up 54.5%. Each oil contains two fatty acids that make up the majority of its components to the other fatty acids, in addition to the primary fatty acid. Oleic (20.59%) and linoleic (15.8%) acids are found in flaxseed oil, while oleic (35.09%) and palmitic (5.7%) acids are found in sunflower oil. The proportions of the primary fatty acids in the flaxseed oil components in our study are comparable to those of earlier research on flaxseed oil (Bernacchia *et al.,* 2014; Ogunronbi *et al.,* 2011; Hosseinian *et al.,* 2004), and the results of research on sunflower oil are comparable to those of earlier research (Fox *et al.*, 2004; Skoric *et al.,* 2008). These results indicate that flaxseed oil is considered a very important source of alpha-linolenic acid, which is considered the primary fatty acid responsible for the synthesis of the rest of the members of the omega-3 family within the human body, which makes it one of the most promising oils as additives to various oil blends, especially with the very low content of alpha-linolenic acid in most common food oils such as corn oil, sunflower oil, and also soybean oil.

Table 2: GC results for Fatty acids composition for of flaxseed and sunflower oils.

Fatty acids	% for each fatty acid	
	Flaxseed oil	Sunflower oil
Palmitic acid (C16:0)	5.69	5.7
Stearic acid (C18:0)	5.58	2.9
Oleic acid (C18:1n9)	20.59	35.09
α-Linoleic acid (C18:2n6)	15.8	54.5
Linolenic acid (C18:3n6)	51.49	0.5

Sterols composition of flaxseed and sunflower oils

The findings displayed in Table 3 demonstrate the various sterol contents of sunflower and flaxseed oils. Comparable to research by Teneva *et al.* (2014), Herchi *et al.* (2012), and Han *et al.* (2015), β-sitosterol accounted for 51.52 % and campesterol for 28.6% of the total sterols in flaxseed oil. Also, β-sitosterol makes up 57.63 % and stigmasterol accounts for 24.9 % of the total sterols in sunflower oil, these findings are in line with those of other researchers (Aguirre *et al.,* 2012; Grompone, 2011), who found that both β-sitosterol and stigmasterol are the two main constituents of the total sterols in sunflower oil.

It is well known that phytosterols, which are plant-based analogs of cholesterol, lower blood cholesterol levels by either controlling intestinal absorption of cholesterol or by competing with cholesterol for intestinal absorption (Calpe-Berdiel, *et al.,* 2009). It has been determined that there are over 200 distinct phytosterols (Piironen *et al.,* 2000), with stigmasterol and β-sitosterol being the most frequently found types. It has been suggested that consuming 2.0–2.5 g of phytosterols daily can reduce LDL-cholesterol levels by up to 10 % and reduce the risk of cardiovascular diseases (Brufau *et al.,* 2008) therefore, sunflower and flaxseed oils can be considered candidates for daily intake because they contain large amounts of stigmasterol and β-sitosterol.

Table 3: GC-MS results for sterols composition of flaxseed and sunflower oils.

Sterols	% for each Sterol	
	Flaxseed oil	**Sunflower oil**
Campesterol	28.6	9.5
Stigmasterol	8.51	24.9
β-sitosterol	51.52	57.63
Delta-5-Avenasterol	10.8	3.9
Delta-7-Avenasterol	0.15	4.25

Fat soluble vitamins and carotenoids of flaxseed and sunflower oils

The results in Table 4 indicate that flaxseed oil is considered very rich in vitamin E (2962 ppm) when compared to sunflower oil (626 ppm), and as for vitamin A, flaxseed oil also contains an amount that represents more than three times the amount found in sunflower oil. As for the carotenoids content of oils, we find that flaxseed oil contains an amount more than eight times the amount found in sunflower oil (Table 4).

The richness of flaxseed oil in vitamin E represents a major distinguishing point for this oil. It is known for the high antioxidant action of tocopherols, which makes them present in nutritional recommendations to reduce the effects resulting from oxidative stress and the resulting diseases such as atherosclerosis and Alzheimer's (Morris *et al.,* 2005). Important ingredients in sunflower oil are vitamin E and other tocopherols. Naturally occurring fat-soluble antioxidant vitamins that are viable in vitro as well as in vivo are tocopherols (Kamal-Eldin and Appelqvist, 1996). Cultivated sunflower seeds include modest concentrations of tocopherols, primarily alpha-tocopherol. Despite being necessary for healthy bodily function, tocopherol cannot be produced by the body and must be obtained through diet (Sen *et al.,* 2006).

Table 4: HPLC analysis of fat-soluble vitamins and carotenoids for flaxseed and sunflower oils.

Fat – soluble vitamins and Carotenoids (ppm)	Type of Oil	
	Flaxseed	**Sunflower**
Vitamin A	3.1	0.65
Vitamin D	46.7	11.9
Vitamin E	2962	626
Vitamin K	5.75	1.95
Carotenoids	4.77	0.55

Conclusion

TO determine the optimal oils or the best combination of them, this study intends to assess the fatty acid, fat-soluble vitamin, and sterol content of flaxseed and sunflower oils that have spread throughout Egypt. According to the results, sunflower oil has high omega-6 fatty acid content, whereas flaxseed oil stands out for having high omega-3 fatty acid content. Flaxseed oil also contains a significant amount of vitamin E, vitamin A, and carotenoids in terms of their physical and chemical characteristics. 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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دراسة مقارنة بين زيت عباد الشمس وزيت بذور الكتان كزيوت ذات قيمة غذائية عالية

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قسم الكيمياء الحيوية – كلية الزراعة – جامعة المنوفية

الملخص العربي

تتميز أنواع الدهون التي يتناولها الإنسان بأن لها تأثير كبير على الصحة العامة ويمكن أن تؤدي إلى الإصابة بأمراض مختلفة، بما في ذلك الكبد الدهني وأمراض القلب التاجية. فالدهون عبارة عن جزء لا يتجزأ من النظام الغذائي للإنسان. ويتمثل الهدف من الدراسة في مقارنة القيمة الغذائية ومكونات زيوت عباد الشمس وبذور الكتان، وهما نوعان من الزيوت التي تستخدم بشكل متكرر في المطبخ المصري. تم استخدام جهاز ال **GC** لتقدير الأحماض الدهنية لهذه الزيوت بالإضافة إلى كمية الاستيرولات الموجودة في كل منها؛ بينما تم استخدام جهاز ال **HPLC** لتقدير الفيتامينات الذائبة في الدهن في زيت عباد الشمس وزيت بذور الكتان. كما تم تقدير معامل الانكسار، واللون، ومؤشر الثبات التأكسدي، وقيمة التصبن، وقيمة اليود، وقيمة الحمض، وقيمة الإستر، وقيمة البيروكسيد، والمواد غير القابلة للتصبن (٪) لكل زيت منهم. أشارت أهم النتائج إلى أن حمض اللينوليك كان أكبر مكون في زيت دوار الشمس (٥٤,٥%)، في حين كان حمض ألفا لينولينيك أكبر مكون في زيت بذور الكتان (٥١,٤٩%).أشارت أهم النتائج إلى أن حمض اللينوليك كان أكبر مكون في زيت عباد الشمس (٥٤,٥%)، في حين كان حمض ألفا لينولينيك أكبر مكون في زيت بذور الكتان (٥١,٤٩%). بالنسبة للاستيرولات، كان بيتا سيتوستيرول (٥٧,٦٣%)، ستيغماستيرول (٢٤/٠٩%)، كامبستيرول (٩,٥%)، أكبر المكونات في زيت عباد الشمس؛ بينما بيتا سيتوستيرول (٥١,٥٢%)، كامبستيرول (٢٨,٦%)؛ دلتا ٥-أفيناستيرول (١٠,٨%) وستيجماستيرول (٨,٥١%) تمثل أكبر المكونات في زيت بذور الكتان. كما كان فيتامين د بنسبة ١١,٩ جزء في المليون يمثل ثاني أكثر الفيتامينات وفرة في زيت عباد الشمس في حين كان فيتامين **E** هو الأكثر وفرة بنسبة ٦٢٦ جزء في المليون. وبنفس الطريقة، يحتوي زيت بذور الكتان على ٢٩٦٢ جزء في المليون من فيتامين **E** و٤٦,٧ جزء في المليون من تركيز فيتامين د. كما تظهر البيانات بشكل لا لبس فيه أن زيت عباد الشمس يحتوي على نسبة عالية من الأحماض الدهنية أوميجا ٦، في حين أن زيت بذور الكتان يتميز باحتوائه على نسبة عالية من الأحماض الدهنية أوميجا ٣. ولذلك فإن هذه الزيوت مناسبة تمامًا للاستخدام في التغذية، ويلزم إجراء المزيد من الأبحاث لتحديد النسب المثالية لهذا المزيج من الزيوت لاستخدامه في التجارب البيولوجية.

الكلمات المفتاحية: زيت عباد الشمس، زيت بذور الكتان، الأحماض الدهنية أوميجا ٣، الأحماض الدهنية أوميجا ٦، الاستيرولات.