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Production and Evaluation of Binary Blend "Canochia" Rich in Ω-3, Physicochemical Indices, Fatty Acid Profiles, DPPH-Radical Scavenging Activities of Phenolics and Oxidative Stability Index

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ABSTRACT

The studies seeds are good sources of total crude lipids (30.71%- 39.70%) and crude proteins. The qualitative screening of active secondary metabolites in individual oils and Canochia revealed the presence of 12 groups of bioactive compounds. The physicochemical properties of CSO, Chia-SO, and binary blend Canochia which composed newly with a ratio of 50:50%. These results are considered a positive indicator for oil blending. The highest level of ω-3 was in Chia-SO, followed by Canochia, and CSO was superior in its content of ω-9, as its concentration reached 70.23%. The concentrations of 12 fatty acids found in CSO, Chia-SO and Canochia were assayed. There are correlations between fatty acid composition and health lipid indices of chosen oils of plant seeds. Results of atherogenicity index, thrombogenicity index and Hypocholesterolimic /Hypercholesterolemic were calculated. Canola seeds superior in the concentrations of total phenolic compounds (2989.8 mg/100 GAE) followed by CSO (747.9) while Chia-SO ranked the lowest position (91.45). The total carotenoids and total chlorophylls in the raw seeds are always higher than in the oils. The highest values of DPPH-RSA% are found in canola seed extract (57.19%) followed by Chia-seed (38.43%). The OSI of 3 oil samples i.e. CSO, Chia-SO and Canochia are evaluated based on induction period (IP) measurement determined by Rancimat analysis. The individual pure canola oil has the highest OSI (18.77±0.19) among other pure oils. The binary blend Canochia have induction period 12.21±0.13. The OSI of the oil samples is ordered as CSO > Canochia > Chia-SO.

KEYWORDS: Antioxidants, bioactive secondary metabolites, Canochia, Canola, chia,

1. INTRODUCTION

The population of the whole world (PWW) is increasing by about 75 million people annually or 1.1% annually. The population has increased in the period from 1800 to 2012 seven times, as the population was one thousand million in 1800 and became seven thousand million after the passage of 212 years. And these increases will continue to grow, as it is estimated that the total population will reach 8.4 billion people by the mid-2030s and increase to 9.6 billion by the mid-2050s. As for the situation in Egypt, the population of Egypt increased from 59.6 million in 1996 to 72.6 million in 2006, and then it continued to rise to 94.8 million in 2017. The population of Egypt is now 105 million. Therefore, it is certain that the shortage of chains food and energy production will continue to be worse in the very near future (World Population Data Sheet, 2014).

The Kingdom of Bahrain imports a lot of fruits and vegetables from neighboring countries, although it is one of the largest producers of dates in the world (https://www.mordorintelligence.com/industry-reports/agriculture-in-bahrain-industry).

Recently, consumption rates have increased and the use of advanced technologies has increased, which are the main reasons behind the rise in prices and the shortage of supply of goods. Bahrain suffers from a lack of production of grains, oils, and other food and agricultural products, which has forced Bahrain to resort to increasing imports of food commodities to satisfy the Bahraini market. There is no doubt that the scarcity of water and the lack of arable land are the main reasons for the low production of crops in Bahrain. Dates, figs, pomegranates, mangoes, papaya, watermelons, tomatoes, potatoes, and turnips, in addition to poultry production, dairy products, and their products, are the main crops in the Bahraini market (https://www.mordorintelligence.com/industry-reports/agriculture-in-bahrain-industry).

The Bahraini government has formulated a new plan in 2022, the goals of which include training agricultural workers, increasing green spaces, stimulating and supporting agricultural processing industries, and increasing expertise, all in order to improve food security and increase Bahraini production (https://www.mordorintelligence.com/industry-reports/agriculture-in-bahrain-industry).

The Government of Bahrain is interested in establishing a factory for the production and packaging of dates produced in Bahrain in Hoorat A'ali, in cooperation with the public and private sectors to provide the necessary funding for this project. The markets will witness growth during the expected period with such initiatives. The government also contributes to agriculture through educational and training programs (https://www.mordorintelligence.com/industry-reports/agriculture-in-bahrain-industry)

The status of world oilseed and vegetable oil production in reference to that in Egypt was studied by El-Hamidi and Zaher (2018). During past 30 years, world oil crop production has increased by 240%, while the area has increased by 82% and production has increased by 48%. Oils suitable for human consumption include soybean oil, peanut oil, flaxseed oil, cottonseed oil, sunflower oil, canola, sesame, and moringa. Oilseeds that produce inedible oils such as rapeseed which is high in erucic acid and castor oil seeds are also evaluated for their appropriate uses for inedible purposes (El-Hamidi and Zaher 2018).

The process of mixing oils and fats is considered a safe physical process to adjust the proportions of fatty acids to an optimal level to make the oils and fats used in deep-frying and frying processes suitable and to minimize changes caused by hydrolysis and oxidation during high temperatures (Dhyani *et al.,* 2018).

Non-communicable diseases (NCDs) include a wide range of illnesses, including obesity and hyperlipidaemia, two major metabolic conditions that raise the risk of cardiovascular disease (Bennett *et al.,* 2018). According to WPT (2008) and ASMBS (2017), obesity is a chronic illness that is characterized by elevated adipose tissue, decreased adiponectin levels, and inflammation (Lonardo *et al.,* 2015).

Chia seeds are a super food; it is high fiber content (30-34%) and give energy value in kcal/100 g 370-375). Only one ounce of chia seeds can provide up to 5,000 mg of α-linolenic acid α-ALA, (ω-3 fatty acids) blowing the ALA recommendation out of the water. Chia seeds can be easily sprinkled over salads, yogurt, and cereals, or mixed into muffins, shakes, and smoothies to boost your ALA intake. Chia seeds can absorb 10 times their weight in water. Chia seeds are a potential source of antioxidants with chlorogenic acid, caffeic acid, myricetin, quercetin, and kaempferol that are thought to have heart and liver protective, anti-aging, and anti-cancer effects. Chia seeds are used to control diabetes, high blood pressure, as an anti-inflammatory, antioxidant, anticoagulant, laxative, antidepressant, anti-anxiety, sedative, and vision and immune enhancer (Ixtaina, *et al.,* 2008, Ozcan *et al.,* 2018)

In this article we introduce a proposed list for some future crops for food chain valid for Bahrain, these include (1)-Quinoa seeds, (2)-Canola seed, (3)-Chia seed, (4)-Cassava tubers, (5)-Stevia (6)-Cauliflower seeds (7)-Sorghum grains, (8)- Mint and Basil (9) Sweet potato tubers and (10)- Cassava tubers. Two technologies must be follows these are Soilless agriculture and Precision technology.

The main objectives of aims of the work are to (1)- Analyze of approximate composition of three oilseeds that can grow in Bahrain Kingdom (2)- Estimation the physicochemical properties of oils proposed to be evaluated (3)- Determination of the levels of some bioactive secondary metabolites in the extracted oils (4)- Production of a binary blend "Canochia" rich in ω-3 from 2 pure oil samples to obtain a specific, compatible and stable mixture in the final product (5)- Assay of antioxidant scavenging activities of Canochia by DPPH-free radical. (6)-To calculate some nutritional quality indexes (NQIs) or lipid health indices such as atherogenicity index (AI); thrombogenicity index (TI) Hypocholesterolemic / Hypercholesterolemic (h/H), (7) - Estimation of Oxidative stability index (OSI)

2. MATERIALS AND METHODS

In the present article, three samples were used one of which binary oil blend as follows in Table (A).

Table A. Samples used in the present work

	Samples	Abrev.	Description
1-	**Canola seed oil** *Brassica napus*, L. Variety b-12 Mousta.**,** season 2024	CSO	Canola seeds were provided from Prof. Mohamed Hamam, Prof. of oil crops in Shandaweel Research Station, Sohag Governorate, Egypt. The oil was obtained by cold press extraction of sound seed.
2-	**Chia seed** oil *Salvia Hispanica, L.*	Chia-SO	The oil was obtained by cold press extraction from seeds, which friendly provided from Prof. Dr. Darweesh, College of Agric. and Food Sci., Florida A&M Univ. Tallahassee, FL 32307, USA.
3-	**Canochia** *(Binary blend)*	Canochia	It newly composed from canola seed oil + chia seed oil with ratios 50:50w/w.

2.1.Preparation of oil samples:

The samples were fresh collected, purified by hands to remove the dust and unwanted seeds and sieved. The cleaned samples were cold pressed at room temperature, the oils were collected.

2.2.Oil preparation

The individual oils were prepared to do the analyses as well as to prepare a binary oil blend consists of two different oils i.e. canola + chia seed oil called Canochia (CC), which mixed at 40°C was prepared in the proportion of 50:50 w/w/w. This proportion was chosen to compose new binary blend valid to nutritional and therapeutical purposes in Arabic region (Bahrain Kingdom). The oil samples were stored in brown bottle protected by Aluminum Foils until the experiments were done. All experiments were done in triplicate.

2.3.Approximate analysis of whole oilseeds

Fine powdered samples of whole oilseed were used to determine the moisture (DM), total ash content (TAC), total fiber content (TFC), total crude lipid (TCL) and crude protein (CP) using the methods described by AOAC, (2000). Carbohydrate percent was calculated by difference according to the following equation [1]:

Carbohydrate % = (100 – (moisture + TAC+ TFC + TCL + CP) **[1]**

2.4. Determinations of physicochemical properties of oils:

The density, refractive index, kinematic viscosity and color were determined using the ordinary procedures stated by Erwa *et al*. (2019).

Acid value (AV) was determined and calculated according to the method described by Erwa *et al*. (2019). Saponification value (SV) was performed according to ISO I. 660: 2009(E)). Unsaponifiable matter (UM %) was determined according to ISO 3657:2013(E) with slight modifications described by Ishag, *et al.*, (2019). Ester value (EV) was calculated according to Akpan *et al.,* (2006), using the following equation Ester Value = SV–AV. Assay of peroxide value (PV) was determined according to ISO 3960: (2007). Iodine value (IV) is determined according to ISO 3960, (2007). *P-Anisidine* values (*p*-AV) were determined was determined by standard method according to AOCS (1998). Total oxidation (TOTOX) was calculated using the equation TOTOX= (2PV+*p*-AV) (Samaram *et al.*, 2013). Smoke point (°C) was determined when the thin and continuous bluish smokes were seen (Tarmizi and Ismail 2008).

2.5. GC-Mass identification of fatty acids profile of samples:-

Fatty acid profiles of Canola seed oil, Chia seed oil and Canochia were identified and quantified according to the method of **Qian, (2003**).

2.6. Nutritional quality indexes (NQIs):

NQIs including Atherogenicity index AI and Thrombogenicity index TI were calculated from fatty acid profiles by formulas given by **Ulbricht and Southgate (1991)** using the following equations:

$$AI = \frac{C12{:}0+4C14{:}0+C16{:}0}{\sum MUFA+\sum n6+\sum n3} \text{ (Ulbricht \& Southgate, 1991)}$$

$$TI = \frac{C14{:}0+C16{:}0+C18{:}0}{0.5\sum MUFA+0.5\sum n6+3\frac{\sum n3}{\sum n6}} \text{ (Ulbricht \& Southgate, 1991)}$$

$$h/H = \frac{C18{:}1+C18{:}2+C18{:}3+C20{:}4+C20{:}5+C22{:}5}{C12{:}0+C14{:}0+C16{:}0} \text{ (Fernandez et al., 2007)}$$

Hypocholesterolimic/Hypercholesterolemic (*h*/H) was calculated according to Fernandez *et al.*, (2007). These indicators were more helpful for the evaluation of the nutritional quality of oils and their autoxidation rates than the fatty acid profiles (Ulbricht and Southgate 1991).

2.7. FTIR Spectral analysis

FTIR spectroscopy analysis was used to analyze the oil samples in Faculty of Science, Assiut University. Pure individual oils were analyzed at room temperature for monitoring the oxidation process in oils. FTIR results were subjected to Microsoft program (ORIGEN-Prog) to calculate the percent of transmittance and/or absorbance of the band appears, according to the nature and composition of the sample (Jaggi, and Vij, 2006 and Fan, *et al.*, 2012).

2.8. Assay of bioactive secondary metabolites:

Bioactive secondary compounds included (1)-Total phenolic content (TPC) which determined by slightly modifying method described by Ahmed *et al.* (2021), (2)-Total flavonoids (TFs) was extracted and determined according to the method of Zhuang *et al.*, (1992), (3)-The lipophilic pigments content (total carotenoids and total chlorophylls) of oil samples was assayed following the protocol described by Mazaheri *et al*. (2019).

2.9. Extraction and determination of phytic acid:

Phytic acid (myo-inositol hexakisphosphate or (InsP6)) in the studied samples were extracted and determined according to the method described by **Ellis *et al*., (1977).**

2.10. DPPH radical scavenging activity (DPPH-RSA %) Assay

The synthetic free radical DPPH (2,2-diphenyl-1-picrylhydrazyl) was used to measure the radical scavenging activity of extracts containing TPCs where samples were diluted with dimethyl sulfoxide (DMSO) (Rekha *et al*., 2012).

Calculation: DPPH-RSA % = $(Abs_0 - Abs_1/Abs_0) \times 100$

A_0 = the A_{517} nm without extract.

A_1 = A_{517} nm in the presence of the extract or standard sample.

2.11. Determination of oxidative stability (OSI):

OSI of CSO, Chia-SO and Canochia were evaluated by a Metrohm Professional Rancimat model 892 (Herisau, Switzerland) was used to measure the Rancimat induction time (RIT). The tests were carried out using 3 g of oil sample at 100 and 110°C, respectively, at an airflow rate of 20 L/h. According to Metrohm's recommendation, the temperature correction factor ΔT was set to 1.6°C. OSI was reported as the number of hours of oxidation induction time (hs) (Anwar *et al.*, 2003, Kaseke *et al.*, 2020).

2.12. Statistical analysis

All experiments mentioned above were repeated three times. Data analysis was performed using SPSS 20.0 software (SPSS Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSION

The approximate analysis of chia and canola seeds indicate that they are good sources for TCL whereas reach to be 30.71% in chia and 39.70 in canola therefore called oilseeds for future (Table 1). These seeds are also good sources of TCP crude proteins. It is worth noting that chia seeds contain higher levels of TCF than TCL and protein.

The present results are in agreement with those stated by Anhar *et al.*, (2006), Ebrahimi *et al.*, (2009), and Roudbaneh *et al.*, (2010) who stated that whole canola seeds contained dry matter (94%), ash (2.8%), crude fiber (10.0%), oil (49.0%), crude protein (22.0%), and carbohydrate (10.20%), which are in agreement with those obtained by Nehmeh *et al.*, (2022). These findings indicate that studied oil seeds are excellent sources for constitutive metabolites such as proteins, lipids and total fibers, as well as these seeds tolerant the storage. Our results are in consistence with those reported by Petraru *et al.*, (2021), Claux *et al.*, (2021) and Nehmeh *et al.*, (2022).

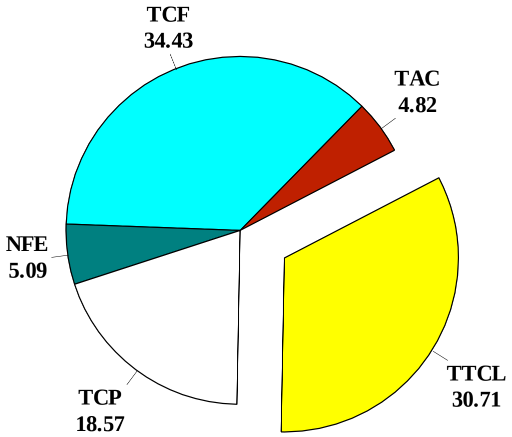

Figure 1. Chemical composition of chia seed (Dry weight basis).

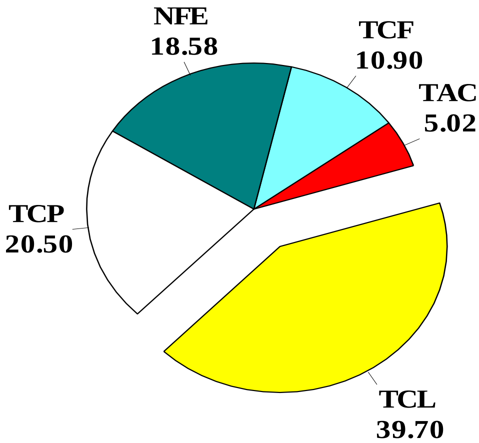

Figure 2. Chemical composition of canola seed (Dry weight basis).

The proximate composition of flax seed investigated by Ishag *et al.*, (2019) who stated that the oil yield of flax seed was high 21.95% and 28.29% with *n*-hexane and petroleum ether respectively. The results obtained for proximate composition were: moisture (8.50±0.49%), ash (1.96 ± 0.00%), fiber (20.23±3.47%), protein (21.00 ± 0.74%), fat (43.17 ± 0.99%) and carbohydrate (5.14 ± 2.73%).

Nitrogen-free extract (NFE) is designed to provide an estimate of water-soluble polysaccharides (sugars, starch) and is calculated by the difference between the original sample weight and the sum of weights of moisture (water), ether extract, crude protein, crude fiber, and ash.

These findings indicate that studied oil seeds are excellent sources for constitutive substances such as proteins, lipids and total fibers, as well as these seeds tolerant the storage.

Table 1. Chemical composition of the canola seeds and chia seed (Dry weight basis).

Constituents (%)*	The selected oilseeds	
	Chia seeds	Canola seeds
Total crude protein (TCP)	18.57±0.51	20.50±0.71
Total crude lipids (TCL)	30.71±1.31	39.70±0.50
Total Ash content (TAC)	4.82±0.10	5.02 ±0.09
Total crude Fiber (TCF)	34.43±1.43	10.90±0.52
Nitrogen free extract (NFE)**	5.09+0.05s	18.58+0.22

***** Means of three determinations ± SD. ****** Calculated by difference.

3.1. Qualitative screening of bioactive secondary metabolites in CSO, Chia-SO and Canochia oil:

Using certain colouring and precipitation procedures, a phytochemical screening was conducted. A variety of bioactive compounds were found by phytochemical screening using a non-aqueous ethanol extract as the extracting solvent. Eleven secondary metabolites, including steroids, terpenoids, saponins, alkaloids, and fatty acids, were found in all three of the oil samples analyzed for phytochemical screening in this research.

Twelve categories of beneficial substances were found in individual oils and Canochia after a descriptive screening of secondary metabolites. Eleven categories were found in the results, while anthocyanins were not present in chia oil. Twelve groups were also found in both canola seed oil and Canochia, according to the data (Table 2). The importance of detecting and identification such compounds has become very important because they act as good antioxidants, to evaluate thermal stability and oil quality.

Table 2. Qualitative screening of bioactive secondary metabolites in canola and chia seed.

	Group	Canola seed oil	Chia seed oil	Canochia
1.	**Steriods**	present	present	present
2.	**Terpenoids**	present	present	present
3.	**Tannins**	present	present	present
4.	**Saponins**	present	present	present
5.	**Anthocyanins**	present	absent	present
6.	**Coumarins**	present	present	present
7.	**Emadins**	present	present	present
8.	**Alkaloids**	present	present	present
9.	**Glycosides**	present	present	present
10.	**Phenolics**	present	present	present
11.	**Flavonoids**	present	present	present
12.	**Glycerol-acrolein**	Positive	Positive	Positive

CSO = canola seed oil, Chia-SO= chia seed oil, P = present; absent

It has become necessary to know the endogenous active compounds in vegetable oils, which play a key role in preserving oils from lipid oxidation and rancidity, increasing oxidative stability, and stopping distortions that occur during handling, use, and storage. Phytochemicals and phenolic compounds in edible oils possess several health benefits such as antioxidants, antibacterial, antiviral, anti-inflammatory, antitumor, cardioprotective, neuroprotective, anti-diabetic properties, and anti-obesity (Sumara *et al.*, 2023).

3.2. Physicochemical properties of cold pressed of CSO, Chia-SO and Canochia

The present results given in Table (3) showed the physicochemical properties of CSO, Chia-SO, and binary blend Canochia which is composed newly with ratio %. Density (g/cm^3) 20°C/water at 20°C) values for individual oils

Table 3. Physicochemical properties of cold pressed of CSO, Chia-SO and Canochia

Properties	Pure Individual vegetable oils		Blended oil
	CSO	Chia-SO	Canochia (50:50)
Acid value (mg KOH/g oil)	0.72±0.01	0.80±0.02	0.93±0.03
Saponification value (mg KOH/g oil)	180.56±4	197.20 ±4.0	187.83±4.0
Unsaponifiable matter %	1.46±0.01	1.29±0.05	1.38±0.05
Ester value (SV-AV)	179.84±1.8	196.40±2.0	186.90±1.9
Iodine value (gI_2/100g oil)	97±1.1	202±5	150±1.5
Peroxide value (meq O_2/kg oil)	2.87±0.01	2.23±0.02	3.21±0.03
***p*-AV (units)**	4.01±0.04	3.56±0.04	4.58±0.05
TOTOX (2PV +p-AV)	9.75±0.1	8.02±0.1	11.00±012
Smoke point (°C)	238±2.4	214±2.1	226±2.2
Density (g/cm^3) 20 C/water at 20°C)	0.922±0.02	0.928 ±0.02	0.931±0.03
Kinematic viscosity at 20°C, mm^2/sec)	78.56±1.5	81.05±1.5	79.83±1.4
Refractive index (40°C)	1.4669±0.005	1.4767±0.001	1.4769±0.005
Color	41.45±0.6	42.56±0.6	42.09±0.5

Ester Value = Saponification Value – Acid Value, Total oxidation (TOTOX) value was calculated from the PV and p-AV using the equation TOTOX = (2PV+p-AV) (Samaram et al., 2013).

are lower than Canochia (0.931±0.03). Viscosity measures the relative thickness or resistance of oil to flow. Values of kinematic viscosity at 20°C, mm2/sec) of Chia-SO are higher than all studied samples reaching 81.05±1.5 while it is 79.83±1.4 for Canochia. Our results also, show that Canochia recorded average values. Values of refractive index (40°C) were changed to a very close extent and the highest levels of RI were reported for Canochia 1.4769±0.005.

Results in Table 3 indicated that the oil colors are different and the CSO recorded 41.45±0.6 but Chia-SO recorded 42.56±0.6. These results are in agreement with those reported by Kılıc *et al.,* (2007) who stated that edible oils have colors ranging from light yellow to dark green or brown, depending on the type and concentration of the color pigments.

Most vegetable oils exhibit color due to the presence of pigments such as lutein, chlorophyll, and carotenoids that migrate from oil seeds. These pigments are easily oxidized to colored or colorless products during storage, which changes oil colors (Alonso-Salces *et al.,* 2021; Zhang, *et al.,* 2023).

Each oil has its characteristic color, primarily due to the presence of carotenoids and/or chlorophyll pigments or gossypol. Therefore, the oil color is often specified in the trade rules by various associations in different countries (Fengxia *et al.,* 2001).

Values of saponification values ranged from 180.56±4 for CSO to 197.20 ±4.0 for Chia-SO. Ester value of Chia-SO reached to be 196.40 lower values were reported for CSO and Canochia. Peroxide values (meq O_2/kg) for single oil are lower than Canochia, it could be concluded that blending process improved the important physicochemical properties.

The results concerning the levels of oxidation products either primary and/or secondary are given in Table (3) and Fig. (3). The *p*-anisidine value of Canochia is 4.58. While *p*-anisidine value for CSO reached to be 4.01±0.5. Results show that blending process in Canochia led to improved *p*-anisidine values.

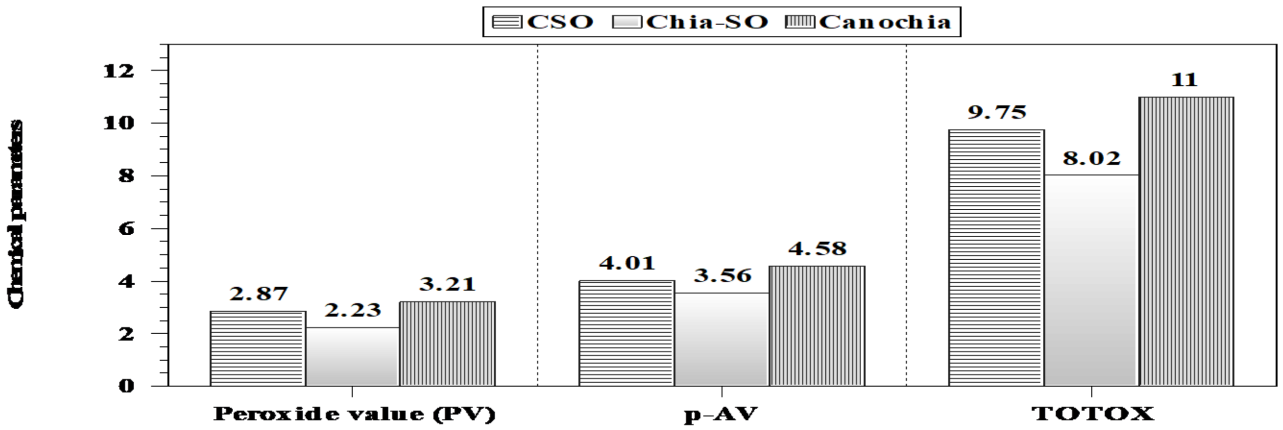

Figure 3. Peroxide value (PV), *p*-anisidine (p-AV) and TOTOX values of CSO, Chia-SO and Canochia

Total oxidation (TOTOX) value is a summation of the primary and secondary oxidation products and provides a better indication of fats and oils overall oxidative deterioration. Values of TOTOX for the studied samples were the highest in Canochia oil (11.0) followed by CSO (9.75) and Chia-SO (8.02) these results consider a positive indicator for oil blending (Fig. 3).
The recorded values of PV, *p*-anisidine and TOTOX values are within the safe range and did not exceed the limits of the Egyptian and Arab specifications. The process of blending vegetable oils also improved the physicochemical properties.

Four vegetable oils with typical fatty acid compositions were chosen and studied by Cao *et al*., (2014) to determine their indicators of lipid oxidation under the conditions of accelerated oxidation. Good linear correlations were observed between the total nonpolar carbonyl amount and the total oxidation value (TOTOX, R2= 0.89−0.97) or PV (PV, R2= 0.92−0.97) during 35 days of accelerated oxidation. Considering the change patterns of these four aldehydes, it was found that the oxidation stability was in the order sunflower oil < camellia oil < perilla oil < palm oil, which was same as peroxide value, TOTOX, and total nonpolar carbonyls. It was concluded that the four aldehydes nonanal, propanal, hexanal, and nonenal could be used as oxidation indicators for the four types of oils. Smoke point (°C) was determined when the thin and continuous bluish smokes were seen (Tarmizi and Ismail 2008).

3.3.Fatty acid profiles of CSO, Chia-SO and Canochia:

The present results existed in Table (3) show that ∑Saturated fatty acid (∑SFA), ∑Monounsaturated fatty acids ∑MUFA and ∑Polyunsaturated fatty acids in the three oil samples.

It is preferable for industrialists to use vegetable oils with a high smoke point, so that they do not burn during deep frying and frying and do not produce blue smoke. The present results introduce good alternatives for deep frying and/or frying whereas the smoke points of three samples ranged from 214 to 238.

3.4.Levels of Omega group fatty acids in studied oils:

After examining and studying the fatty acid profiles obtained from the GC Mass, it was found that the chemical composition of the three oils under study contain significant levels of omega-9, omega -6, omega-3 and traces of Omega-7. The highest level of Omega-3 was in Chia oil, followed by Canochia, and Canola seed oil was superior in its content of Omega-9, as its concentration reached 70.23% (Table 3 and Fig. 4).

Table (3) show the concentrations of 12 fatty acids found in CSO, Chia-SO and Canochia. There are correlations between fatty acid composition and health lipid indices of chosen oils of plant seeds. Nutritional quality indexes (NQIs) or health related lipid indices include atherogenicity index, thrombogenic index and *h*/H ratios.

Table 3. Fatty acid profile of CSO, Chia-SO and Canochia

Fatty acid (%)	CSO	Chia-SO	Canochia
$C_{14:0}$ Myristic acid	0.01±0.0	0.06±0.01	0.05
$C_{16:0}$ Palmitic acid	14.17±0.14	6.43±0.07	10.3
$C_{16:1}$Palmitoleic acid	1.49±0.01	0.09±0.02	0.82
$C_{17:0}$Margaric OCS-FAs	0.10±0.01	0.06±0.001	0.09
$C_{17:1}$Heptadecenoic (OCS-FAs) Ω-7	0.06±0.01	0.05±0.01	0.07
$C_{18:0}$ Stearic acid	2.45±0.02	4.01±0.0	3.35
$C_{18:1}$Oleic acid Ω-9	70.23±0.7	7.44±0.08	40.56
$C_{18:2}$Linoleic acid Ω-6	8.65±0.09	20.54±0.21	15.01
$C_{18:3}$Linolenic acid Ω-3	0.92±0.01	59.11±0.6	29.01
$C20_{:0}$Arachidic acid	0.43±0.03	0.42±0.004	0.41
$C20_{:1}$ Gadoleic acid	0.31±0.01	0.23±0.002	0.26
C22:0	-	0.08±0.001	0.07
∑Saturated fatty acids SFA	17.16±0.17	11.06±0.11	14.27
∑Monounsaturated fatty acids MUFA	72.09±0.70	7.81±0.8	41.71
∑Polyunsaturated fatty acids PUFA	9.57±0.1	79.65±0.8	44.02
∑PUFA/∑SFA ratio	0.55±0.05	7.2±0.07	3.08
Ω-6/Ω-3 ratio	9.4±0.1	0.34±0.003	0.518
Atherogenicity index (AI)	0.170	0.076	0.11
Thromogenicity index (TI)	0.384	0.054	0.116
Hypocholesterolimic/Hypercholesterolemic	5.62	13.41	8.17
Total Fatty acids	98.82	98.52	100

∑SFA = Total saturated fatty acids, ∑MUFA= Total monounsaturated fatty acids, ∑PUFA = Total polyunsaturated fatty acids. OCS-FAs = odd chain saturated fatty acids, OCUS-FAs= odd chain unsaturated fatty acids, odd monounsaturated fatty acid ($C_{17:1}$ Heptadecenoic acid) = Ω-7, COX= calculated oxidistaability value, AI= Atherogenicity index, thrombogenicity index (TI), the ratio of hypocholesterolemic to hypercholesterolemic (HH) fatty acids

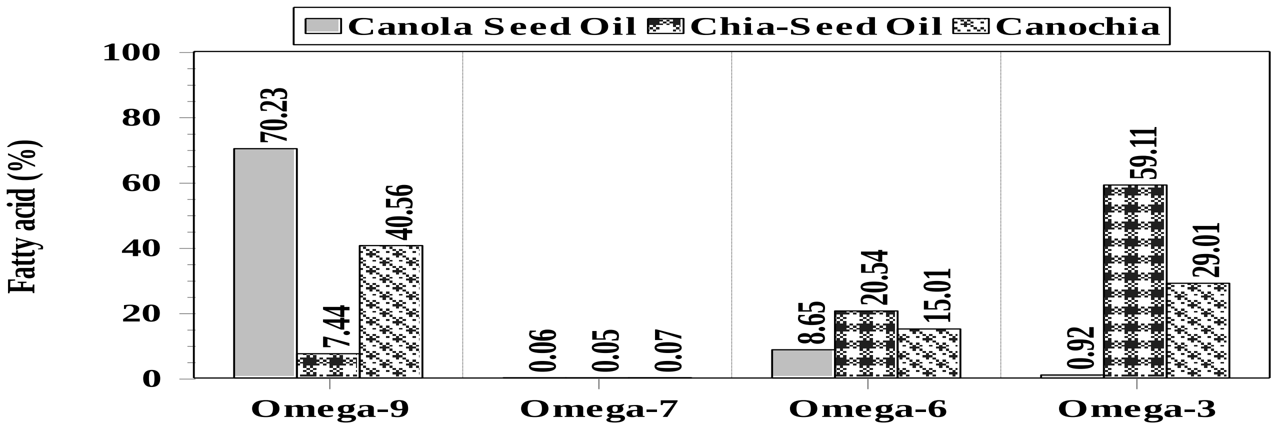

Figure 4. Levels of omega-9, omega -7, omega -6, omega-3 in CSO, Chia-SO and Canochia.

Fatty acid profiles and health lipids indices
(1)-Atherogenicity index (AI):

Results of atherogenicity index calculation indicate lower values while AI ranged from 0.076 for Chia-seed oil to 0.17 for CSO. Value of AI for Canochia reached to be 0.11 (Table 3 and Fig. 5). These relatively low values confirm that the use of CSO, Chia-SO and Canochia is safe and does not promote cardiovascular disease (CVD) and non-communicable disease (NCD).

The present results are in agreement with those reported by Moussavi Javardi *et al.* (2020). Also, our results are in agreement with those reported by Khalili Tilami and Kouˇrimská, (2020.

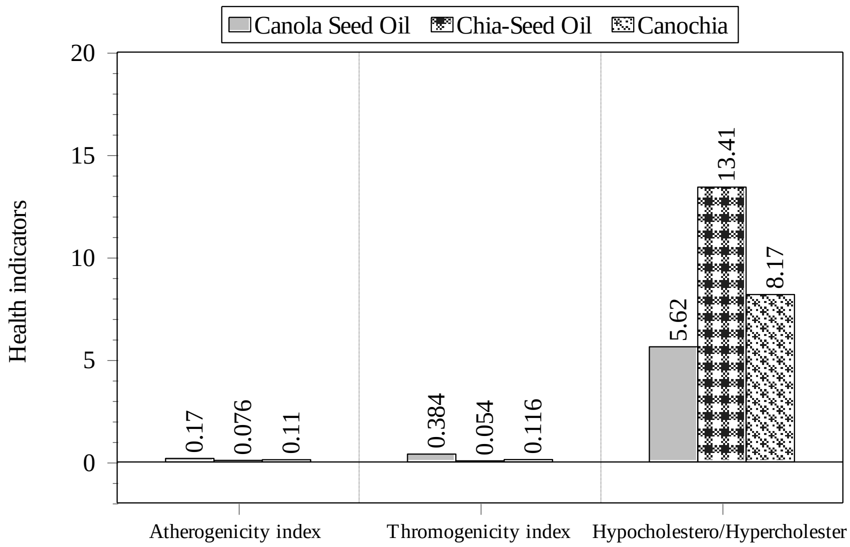

Figure 5. Atherogenicity index (AI), Thromogenicity index (TI) and Hypocholesterolimic/Hypercholesterolemic in CSO, Chia seed and Canochia.

AI indicates a correlation between the total saturated and unsaturated fatty acids. There are seven dietary factors that contribute to the occurrence of coronary heart disease, including the composition of saturated fatty acids and their ratio to ∑MUFA, ∑omega-6 and ∑omega-3 acids (Ulbricht and Southgate 1991 and Moussavi Javardi et al. (2020).

(2)-Thromogenicity index (TI)

Results of thromogenicity index (TI) for Chia-SO reached to be 0.054 and canola seed oil reported 0.384 while the Canochia recorded average value 0.116 these results are in agreement with those reported b Khalili Tilami and Kouˇrimská, (2020) who found that Chia seed oil had TI (0.04), and Murumuru butter had the highest (6.69). Lipids extracted from plants contain different compositions of free fatty acids (FA), which provide a diversity of physical and chemical properties with positive or negative health effects on humans. We resort to the assessment of some properties and indicators such as arteriosclerosis (AI) and thrombosis (TI) in order to evaluate the nutritional value of the fatty acid content of plants.

(3)Hypocholesterolimic/Hypercholesterolemic (*h*/H)

Results of Hypocholesterolimic / Hypercholesterolemic (*h*/H) ranged from 5.62 for CSO to 13.41 for Chia-SO while Canochia recorded higher value than CSO but lower than Chia-SO. Several studies have suggested the estimation of some indicators of dietary fat quality, including (1) atherosclerosis index (AI) and the thrombotic index (TI), (3) and the ratio of low-cholesterol fatty acids (*h*/H) in the diet, which may have effects on cardiovascular disease (CVD) and non-communicable disease (NCD) risk (Ulbricht and Southgate 1991 and Santos-Silva *et al.,* 2002).

3.5.Bioactive secondary metabolites in oil samples:

The secondary bioactive compounds found in oils are large and important groups that play essential roles and we will only address total phenolics, total flavonoids, total carotenoids, total chlorophylls, phytic acid and DPPH-scavenging antioxidant activities were also assayed and the results obtained in Table 4 and Figs. 6-7**.**

3.6.Total phenolic content and total flavonoid content:

Total phenolic compounds (TPCs) expressed as mg gallic acid equivalents GAE/100g oil extract and total flavonoids (TFC) of 3 oil samples are shown in Table (4) and Fig. (6). Results also showed that TPCs ranged in close extent and don't exceed 55 mg/100 g oil (Fig. 7).

Table 4. Bioactive constituents in oilseed and seed oils and DPPH-scavenging antioxidant activities of CSO, Chia-SO and Canochia

Phytochemical*	Samples				Blended Canochia
	Chia Seeds	Chia-SO	Canola Seeds	CSO	
Total phenolics (mg GAE/100g)	365.7±4.2	91.45±0.91	2989.8±30	747.9±7.5	420±4.9
Total flavonoids (mg rutin/100g)	73.2±0.82	18.3±0.21	598.1±0.98	149.6±0.10	170.2±1.7
Total carotenoids (mg rutin/100g)	3.86±0.04	1.93±0.02	2.56±0.026	1.26±0.013	1.69±0.02
Total chlorophylls (mg/100 g)	3.85±0.39	0.384±0.04	3.02±0.03	0.604±0.006	0.495±0.005
Phytic acid (mg/100g)	3187±32	1589±16	2489±25	1245±13	1417±15
DPPH-SA%	38.43±0.38	20.56±0.21	57.19±0.6	30.68±0.31	25.78±0.26

*Mean of three determinations ±SD; DPPH-SA%=DPPH-scavenging antioxidant activities; Total phenolics expressed per mg gallic acid equivalents GAE/100g sample
Total flavonoids expressed by mg rutin equivalents /100g sample)

3.7.Levels of total phenolics and phytic acid:

Results given in Figure (6) show the levels of phenolics and phytic acid in three oils i.e. CSO, Chia-SO, and Canochia, and canola seeds and Chia-Seeds used to obtain these oils. The levels of phenolics and phytic acid in the raw seeds are always higher than those found in the oils. Canola seeds were superior in the concentrations of TPCs (2989.8 mg/100 GAE) followed by CSO (747.9) while Chia-SO ranked in the lowest position (91.45). Both phenolics and phytic acid are endogenous antioxidants found in oilseed and cold-pressed oils and act as high-potential antioxidants and inhibit lipid peroxidation. The higher the levels of phenolics and phytic acid, the greater the storage capacity of these oils.

The present study also dealt with estimating the levels of PA (myo-inositol hexakisphosphate or (InsP6)), which is considered one of the compounds that act as an antioxidant and anti-cancer. The concentrations of phytic acid ranged from 1245 mg / 100 g for the CSO to 3187 mg / 100g for the Chia-seed sample, and both are source oils.

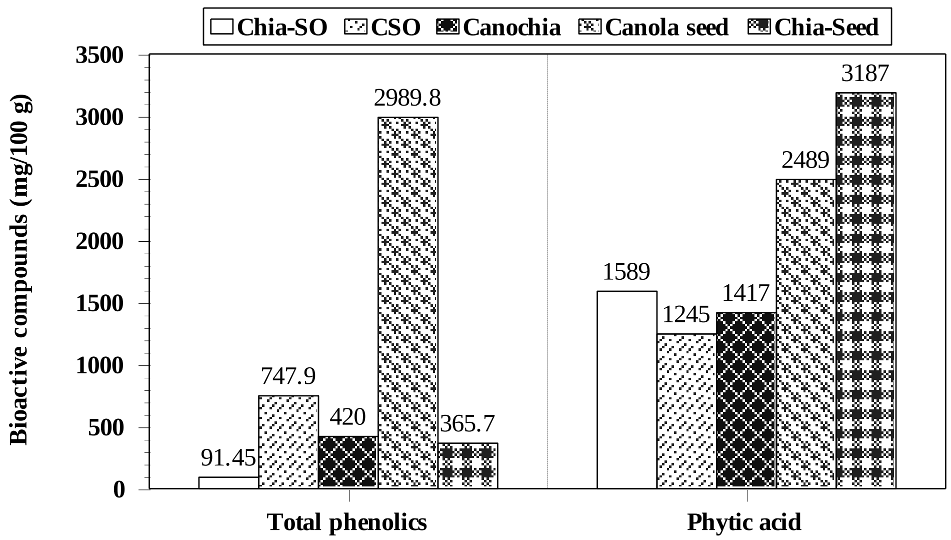

Figure 6. Levels of total carotenoids and total chlorophylls in Chia-seed, Canola seed, CSO, Chia-SO and Canochia.

The concentration of phytic acid in the blended oil Canochia reaches to 1417 mg/100g (Table 4 and Fig. 6). The present results are in consistent with those reported by Pujol *et al.,* (2023) who stated that phytate has a potent antioxidation and anti-inflammatory action. It is the main phosphorus reservoir that is present in almost all whole grains, legumes, and oilseeds. It is capable of inhibiting lipid peroxidation through iron chelation, reducing iron-related free radical generation.

3.8.Levels of total lipophilic carotenoids and total tetrapyrole chlorophylls:

The results in Figure (7) shows the levels of plant pigments namely total carotenoids and total chlorophylls, in three oils and the pressed seeds used to obtain these oils. It is clear that the levels of total carotenoids and total chlorophylls in the raw seeds are higher than in the oils. Also, Chia-Seed outperformed all samples in its content of TCs and total chlorophylls. It is obvious that the blending process of Canochia led to an increase in the concentrations of total carotenoids and total chlorophylls. Carotenoids are bioactive compounds biosynthesize from isoprene molecule these acts as antioxidants and inhibit the lipid peroxidation.

Chlorophylls are proven to have many positive functions these are anti-cancer properties anti-inflammatory (Derrien *et al.,* 2018 Ebrahimi *et al.,* 2023). Moreover, it is proven that chlorophylls have a high antioxidant activity (Leite *et al.,* 2018).

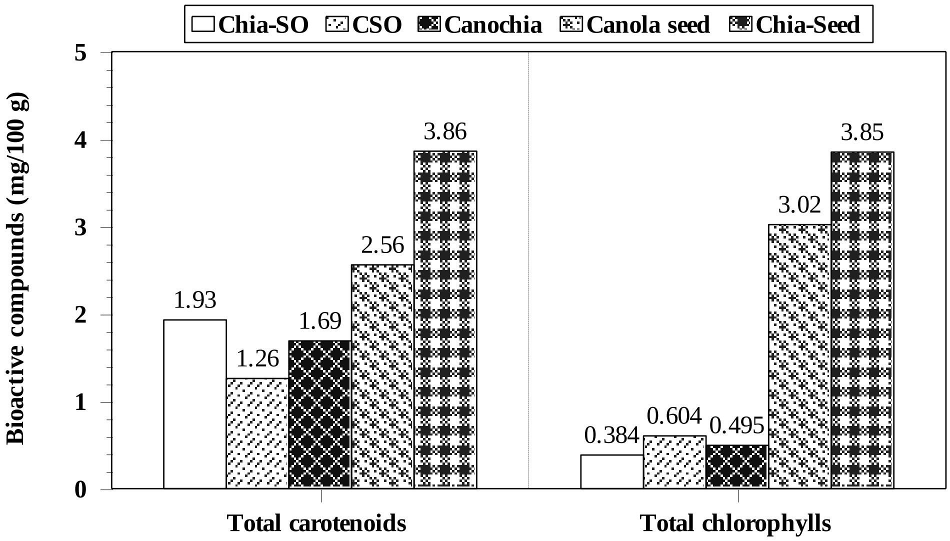

Figure 7. Levels of total carotenoids and total chlorophylls in Chia-seed, Canola seed, CSO, Chia-SO and Canochia.

Carotenoids are isoprenoid derivatives soluble in fats and have significant benefits for human health and these substances have antioxidant activities and functional properties. Carotenoids are natural pigments, these compounds are lipophilic isoprenoids associated with a wide range of health benefits and antioxidant properties (Yu *et al.,* 2022 and Kultys and Kurek 2020, Venturini *et al.,* 2023, and Monarca *et al.,* 2023).

3.9.DPPH-radical scavenging antioxidant of bioactive compounds:

Results in Table 4 and Fig. 8 show the DPPH radical scavenging activities (DPPH-RSA %) of three oils and two extracts obtained from two oilseeds. The highest values of DPPH-RSA% are found in canola seed extract (57.19%) followed by Chia-seed (38.43%). DPPH-RSA% for studied oils ranged from 20.56% for Chia-So to 30.68% while Canochia recorded average value.

Many investigators reported that the endogenous TPCs and TFs play an important role as antioxidant and as scavenging agents (Petraru *et al*., 2021, Claux *et al*., 2021 and Nehmeh *et al*., 2022).

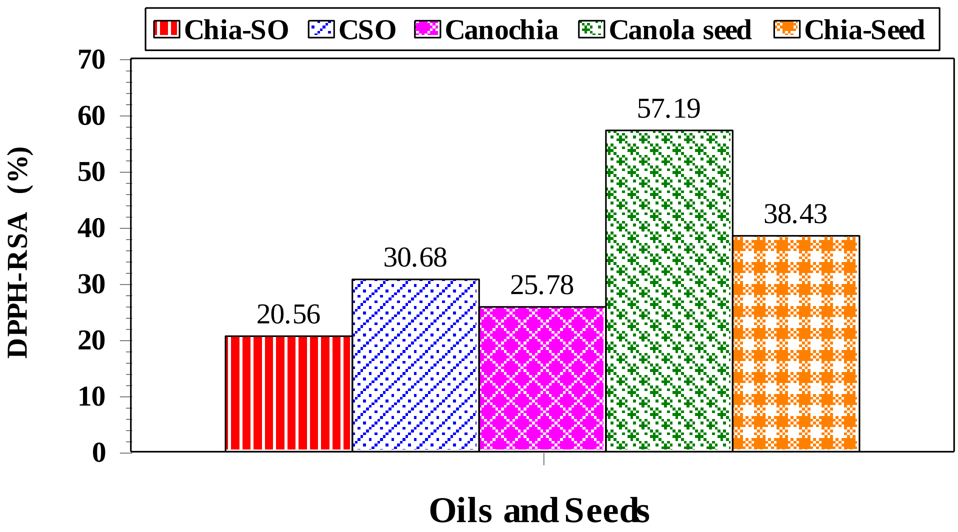

Figure 8. DPPH-radical scavenging antioxidant of bioactive compounds in Chia-seed, Canola seed, CSO, Chia-SO and Canochia.

In general, TPCs are more dominant than TFs in the oil samples studied. The current results show that the mixing process led to a clear improvement in the contents of TPC and TFC, which leads to an improvement in oxidative stability and a prolongation of the storage period, because these endogenous bioactive substances are high potential antioxidant compounds. The proven functions of TPCs in oilseeds are well studied; these could be high potential antioxidants, anti-rancidity, antimicrobial, anti-insect and defensive compounds.

The antioxidant sources could be (a) endogenous antioxidants, which naturally exist in oil (b) exogenous sources synthetic antioxidants that are added to the oils during the refining process Looking at the composition of vegetable oils, we find that 98 to 99% are triglycerides and 1-2% are different and multiple compounds that are natural compounds (pigments, carotenoids, tocopherols, phytosterols, hydrocarbons, triterpenes, and phenolic compounds). In addition to peroxides and oxidized fatty acids, aldehydes and ketones are generated in the oils. It was found that natural compounds, many of which act as natural antioxidants that protect the oil from oxidation and rancidity, but the industrialists carry out oil refining operations, so they intentionally remove the safe natural casteless antioxidants from the oil and add unsafe industrial additives, so in this research, we return to the use of natural materials Originally found in oil and used as safe defensive materials, and we save the costs of using unsafe industrial antioxidants.

The present results concerned with carotenoids content are in good agreement with those reported by Druzynska, *et al.*, (2021). The content of carotenoid compounds in the analyzed chia seeds reached 2.65 mg/100 g d.m.. In the available literature, carotenoids were also investigated in the seeds of such oil plants as soybean, rapeseed, and flaxseed, and their contents were found to range from 0.01 to 0.05 mg/100 g (Lipecki and Libik 2021). Hence, compared to other oil seeds, chia seeds were characterized by a high content of these compounds. Ixtaina *et al.* (2008) analyzed the β-carotene content in oil produced from chia seeds by pressing or extraction with solvents. In chia seed oil extracted with a solvent, its content accounted for about 0.058 mg/100 g, whereas in the pressed oil it accounted for about 0.121 mg/100 g.

3.10. Oxidative stability index (OSI):

The OSI results of oil samples are given in Table (5) and Fig. (9). To find out the time period required to predict oil spoilage, we resort to determining the value of oxidative stability, which expresses the ability of edible oil to oxidize fats, which causes rancidity of oils and the release of unacceptable odors and flavors.

Table 5. OSI, expressed as induction period (IP), (hrs) by Rancimat method:

Oil sample	Induction period (hrs)	Notes
Chia seed oil (Chia-SO)	5.87±0.04	Sensitive to oxidative reactions
Canola seed oil (CSO)	18.77 ±0.19	Highest oxidative stability
Canochia oil	12.21	Higher oxidative stability

LOS= Lowest oxidative stability = Higher susceptibility (HS)

The OSI of 3 oil samples i.e. CSO, Chia-SO and Canochia are evaluated based on induction period (IP) measurement determined by Rancimat analysis (Table 5). Oils rich in PUFA such as FSO are lesser stable than those poor in PUFA. The individual pure canola oil has the highest OSI (18.77±0.19) among other pure oils. The binary blend Canochia have induction period 12.21±0.13.

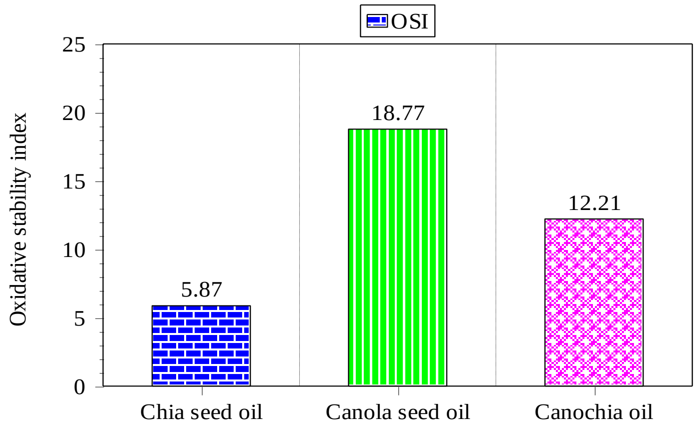

Figure 9. OSI, expressed as induction period (IP), (hrs) by Rancimat method:

The higher the oil content of unsaturated fatty acids, it makes it very sensitive to oxidation reactions. Pazzoti1, *et al.,* (2018), previously confirmed this information where Flax seed oil (FSO) presented the lowest OSI during treatments, compared to other oils. When comparing blended oils, it was found that Canochia remained relatively stable during treatment, possibly due to the synergism between Chia seed oil and canola oils.

Various factors affect the oxidative stability values of oils these are (a)- the nature of chemical composition of raw materials, (b)- scratches and mechanical damage, (c)- initial moisture and dry matter percent, (d)- presence of pollutants, (f)- and degree of maturity. (e) seed- and oil-treatment conditions (Ratusz *et al.,* 2016). In the current research, the studied oil samples show different OS indexes.

The OSI of the oil samples is ordered as CSO > Canochia > Chia-SO. The OSI of the oil samples contained a high amount of PUFA and could be increased by mixing them with high MUFA oils (Bhatnagar *et al.,* 2009). Hence, it can be concluded that the OS of the blended oils correlates with the content of both MUFA and PUFA (Bhatnagar *et al.,* 2009 and Arranz *et al.,* 2008).

3.11. Fourier transforms infrared (FTIR) spectroscopy of studied oils:

(1)-FTIR spectrum of CSO:-

FTIR spectrum of CSO strain Mostawrad-B12 is shown in Fig. (10). There are 16 peaks, of which 12 peaks are in the area confined from 1746.77 to 500 cm^{-1}, and four peaks are in the area between 3317.17 cm^{-1} and 2854.34. The spectrum also, shows that no peaks existed in the area between 2853 cm^{-1} and 1747 cm^{-1}.

(2)-FTIR spectrum of chia seed oil:

Figure 11 shows the FTIR spectrum of chia seed oil. The total number of peaks in chia seed oil spectrum reaches to be 14 peaks, of which 10 peaks are in the area confined from 1745.94 to 603.06 cm^{-1}, and four peaks are in the area between 3313.42 cm^{-1} and 2854.82. The spectrum also, shows that no peaks existed in the area between 2853 cm^{-1} and 1745 cm^{-1}, in this area the transmittance % don't raveled to 100%.

The FTIR spectrum of chia seed oil present strong triplet bands in 2926–2854.82 cm^{-1} range whose is assigned to C-H stretching of the CH_3 and CH_2 backbones of lipids.

(3)-FTIR spectrum of binary blend Canochia:-

Figure 12 shows the FTIR spectrum of Canochia. The total number of peaks in Canochia spectrum reaches to be 14 peaks, of which 10 peaks are in the area confined from 1746.12 to 577.70 cm^{-1}, and four peaks are in the area between 3318.82 cm^{-1} and 2854.70. There are two bands in the lowest frequencies at lower end of the spectrum of Flaxcanochia; these are 577.70 and 721.16. The present results indicate that blending process showed 2 bands concentrated in the end of spectrum and these bands don't existed in the individual pure oils (CSO and chia seed oil). The FT-IR of Canochia also showed the deepest band at 2926.01 cm^{-1} in addition to one band at 3010.01 cm^{-1}. The present results showed that Chia-SO contain a lower number of peaks (14), while CSO contains16 peaks.

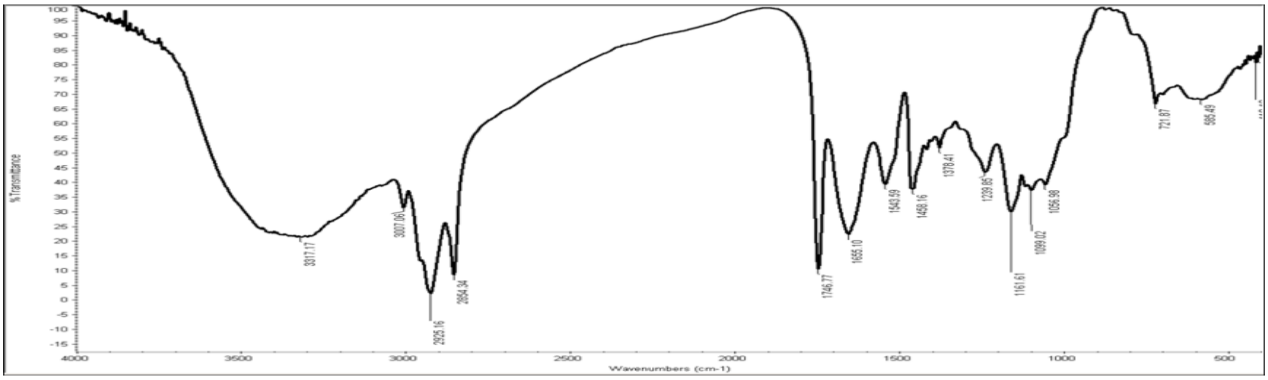

Figure 10. FTIR spectrum of canola seed oil (CSO) variety B12

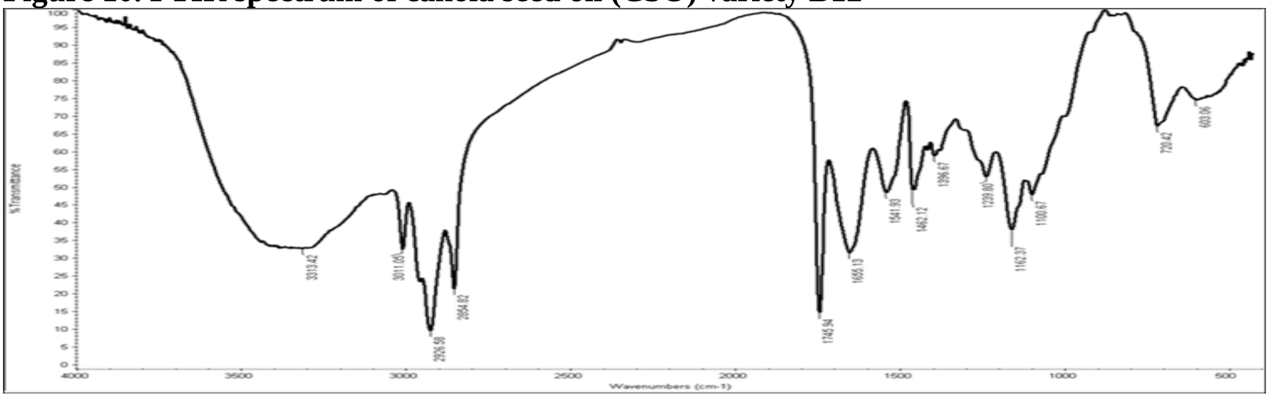

Figure 11. FTIR spectrum of chia seed oil

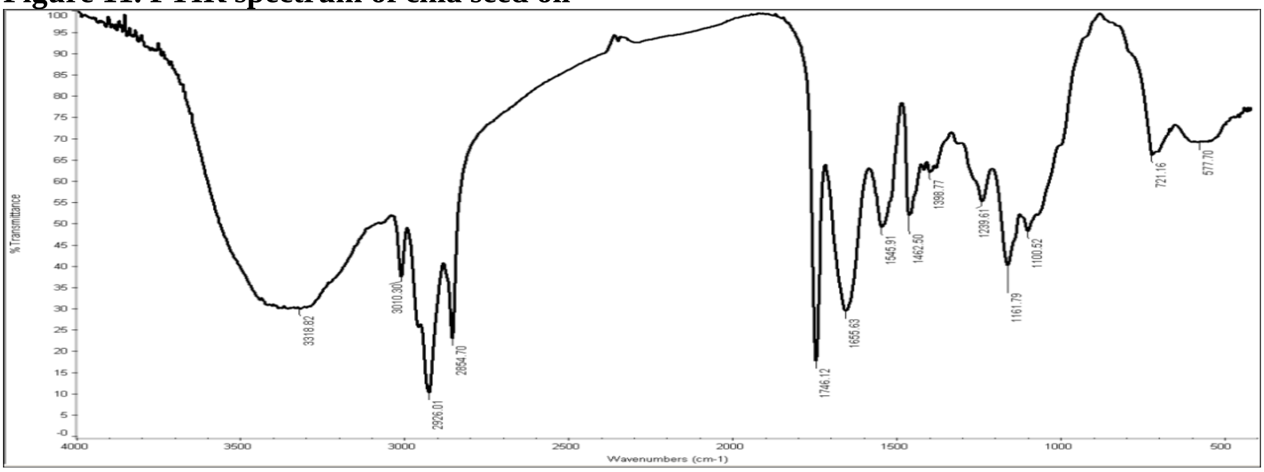

Figure 12. FTIR spectrum of Canochia

3.12. Analysis of FTIR spectra of TPN, LFBs and HFBs of CSO, Chia-SO and Canochia:

Table (6) show the total peaks number (TPN) in the spectra of oil samples. The individual pure oil CSO presented the highest peak number (16) followed by chia-SO (14). In the region of lower frequencies (500 to 1746 cm^{-1}) the peaks ranged from 10 for Chia-SO and Canochia and to 12 for CSO. From the FTIR-spectra could be noticed that the peaks at frequencies from 2800 to 3300 cm^{-1}only four peaks are observed.

The mechanism of degradation and decomposition of vegetable oils is affected by oxidation conditions and many factors. Although there are many possible mechanisms for the degradation of oils, the mechanism for the formation of free radical is the most acceptable of these mechanisms, as a group of primary oxidation nuts are formed called hydroperoxides, and these compounds successively converted to into aldehydes, ketones, lactones, alcohols, acids, etc. (de Souza, *et al.*, 2020).

Table 6. Analysis of FTIR spectra, total number of peaks (TPN), lower frequencies bands (LFBs) and higher frequencies bands (HFBs) of vegetable oil samples.

	Samples	TPN	LFBs 400 to 1746 cm^{-1}	HFBs 2800 to 3500 cm^{-1}
1.	**CSO**	16	12	4
2.	**Chia-SO**	14	10	4
3.	**Canochia**	14	10	4

TPN = Total peak numbers

4. CONCLUSION

Unfortunately, the Gulf countries such as Bahrain and the Sultanate of Oman suffer from a severe shortage of field crops, especially edible oil crops. Bahrain is characterized by high temperatures, limited arable land, water scarcity, and increasing groundwater salinity resulting in limited crops grown in the country. The national government is focusing on intensifying the finance for agriculture and livestock to attract foreign investments for agriculture projects to keep up with local demand.

However, in this research, we are trying hard to present 2 candidates for future crops: Canola seeds (zero erucic acid) and Chia seeds, both of which thrive in low-fertility areas and under high temperatures. These two plants have a promising and distinctive chemical composition, as they are characterized by high oil percent, crude protein and fiber content. The seeds are also rich in omega-3, antioxidants, carotenoids and flavonoids. Moreover, consumption of the oils are safe and do not lead to obesity, strokes or CVD.

In this article we introduce two promising oil seeds valid to grow under the difficult conditions in Arabic and Gulf regions. These candidates are Canola seed and Chia seeds. Also, we introduce a safe and promising binary blend Canochia.

5. RECOMMNDATIONS

1. Bringing canola seeds (zero erucic acid) from hot areas and trying to grow them in the lands and atmosphere of the Gulf region.
2. Cultivating chia seeds in low-fertility lands and under hot climates
3. Adopting a policy of mixing oils and obtaining new oil mixtures suitable for nutritional and therapeutic purposes
4. Using chia fibers to treat colon cancer as a therapeutic tool to exploit the high TFC ratio. Chia fibers reduce blood glucose levels
5. Preparing ground chia seeds powder to treat hepatic
6. Exploiting Seed cakes resulting from pressing canola and chia seeds in animal feed
7. Producing preparations with high levels of Omega-3 fatty acids from chia seed oil
8. Chia seeds contain rich fibers that provide the bulk of the stool, so these seeds can prevent constipation
9. In general, World Health Organizations recommend consuming a minimum of 250-500 mg of Omega-3 of EPA and DHA daily for adults Benefits of fatty acids.

10. The recommended dietary allowance for alpha-linolenic acid is 1.6 grams per day for men and 1.1 grams per day for women. Triglycerides.
11. We recommend taking care of growing chia seeds because of their high nutritional value
12. We also recommend chia seeds with juices, salads and meals because of their beneficial therapeutic benefits.
13. This study recommends making capsules from chia concentrate and the unconsolidated substance
14. The study recommends preparing concentrated feeds for poultry and livestock from chia meal
15. We recommend preparing therapeutic foods and nutritional supplements

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الملخص العربي

انتاج و تقييم توليفة الزيت الثنائية "كانوشيا" الغنية باوميجا-٣ و الخصائص الفيزيوكيميائية و تركيب الاحماض الدهنية و الانشطة المضادة للاكسدة بـ DPPH للمركبات الفينولية و دليل الثبات التاكسدي

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في هذا البحث، نقدم نوعين واعدين من البذور الزيتية الصالحة للنمو في ظل ظروف صعبة في المناطق العربية والخليجية. وهما بذور الكانولا وبذور الشيا. بالإضافة إلى ذلك، تم إنتاج مزيج ثنائي لأول مرة من الزيوت الجديدة يسمى "كانوشيا". يشير التحليل التقريبي لبذور الشيا والكانولا إلى أنها مصادر جيدة لـ TCL حيث تصل إلى ٣٠.٧١٪ في الشيا و ٣٩.٧٠٪ في الكانولا. كما تعد هذه البذور مصادر جيدة للبروتينات الخام. ومن الجدير بالذكر أن بذور الشيا تحتوي على مستويات أعلى من TCF من TCL والبروتين. كشف الفحص الوصفي للمركبات الثانوية في الزيوت الفردية والكانوشيا عن وجود ١٢ مجموعة من المركبات النشطة بيولوجيًا. أظهرت النتائج وجود ١١ مجموعة وغياب الأنثوسيانين في زيت الشيا. أشارت النتائج أيضًا إلى وجود ١٢ مجموعة في كل من زيت بذور الكانولا والكانوشيا.

تم تقدير بعض الخواص الفيزيوكيميائية لزيت CSO و Chia-SO والخليط الثنائي Canochia الذي تم تكوينه حديثًا بنسبة ٥٠:٥٠٪. قيم البيروكسيد ($meq\ O_2$ / kg) للزيت الفردي أقل من Canochia. يمكن الاستنتاج أن عملية المزج حسنت الخصائص الفيزيوكيميائية المهمة. قيمة البارا أنيسيدين لزيت Canochia هي ٤.٥٨. بينما وصلت قيمة البارا أنيسيدين لزيت CSO إلى ٤.٠١ ± ٠.٠٥. أدت عملية المزج في Canochia إلى تحسين قيم البارا أنيسيدين. كانت قيم TOTOX للعينات المدروسة هي الأعلى في زيت Canochia (11.0) تليها CSO (9.75) و Chia-SO (8.02) وتعتبر هذه النتائج مؤشرًا إيجابيًا لخلط الزيت.

وقد وجد أعلى تركيز للأوميجا ٣ في زيت بذور الشيا، يليه زيت بذور الكانولا، وكان زيت بذور الكانولا متفوقاً في محتواه من الأوميجا ٩، حيث بلغ تركيزه ٧٠.٢٣٪. وتم تحليل تركيزات ١٢ حمضاً دهنياً موجودة في زيت بذور الشيا وزيت بذور الكانولا، ووجدت علاقة بين تركيب الأحماض الدهنية ومؤشرات الدهون الصحية للزيوت المختارة من بذور النباتات. تم حساب مؤشر تصلب الشرايين (AI) و مؤشر تجلط الدم (TI) نقص الكوليسترول / ارتفاع الكوليسترول (h / H).

تم تقدير مستويات المركبات الفينولية الكلية وحمض الفايتيك في بذور CSO و Chia-SO و Canochia ومصادرها. تفوقت بذور الكانولا في تركيزات TPCs (2989.8 مجم/١٠٠ GAE) تليها CSO (747.9) بينما احتلت Chia-SO أدنى مرتبة (٩١.٤٥). كانت الكاروتينات الكلية والكلوروفيل الكلي في البذور الخام أعلى دائمًا من تلك الموجودة في الزيوت. أيضًا، تفوقت بذور الشيا على جميع العينات في محتواها من TCs والكلوروفيل الكلي. أدت عملية مزج Canochia إلى زيادة في تركيزات الكاروتينات والكلوروفيل الكلية.

تراوحت نسبة DPPH-RSA% للزيوت تحت الدراسة من ٢٠.٥٦٪ لزيت الشيا إلى ٣٠.٦٨٪ بينما سجلت الكانوشيا قيمة متوسطة. وتوجد أعلى قيم DPPH-RSA% في مستخلص بذور الكانولا (٥٧.١٩٪) تليها بذور الشيا (٣٨.٤٣٪).

تم تقدير دليل الثبات التاكسيدي OSI لثلاث عينات زيتية وهي CSO و Chia-SO و Canochia بناءً على قياس فترة الاستقراء (IP) التي تم تحديدها بواسطة تحليل Rancimat. يتمتع زيت الكانولا الفردي بأعلى مؤشر OSI الذي بلغ (18.77±0.19) بين الزيوت الفردية الأخرى. يتمتع مزيج Canochia الثنائي بفترة استقراء ١٢.٢١±٠.١٣. بناء علي مقياس OSI يمكن ترتيب عينات الزيت على النحو التالي CSO > Canochia > Chia-SO. و تشير نتائج الـ FTIR الي ان الزيوت الثلاثة غنية بنواتج التمثيل الغذائي الثانوية و التي تتميز بوجود مجموعات دالة و فعالة مثل الكحولات و الفينولات و الالدهيدات و الكيتونات – الكربوكسيل و الاسترات و الروابط الزوجية المتبادلة.