

NUTRITIONAL POTENTIAL OF SOME COLD PRESSED VEGETABLE OILS IN TERMS OF FATTY ACIDS

Adriana Laura Mihai¹, Mioara Negoită^{1*}, Gabriela-Andreea Horneț¹

¹ National Research & Development Institute for Food Bioresources, IBA Bucharest, 6 Dinu Vintilă Street, District 2, 021102, Bucharest, Romania



Abstract

The objective of this study was to evaluate the nutritional potential of some unrefined vegetable oils in terms of fatty acid composition which was determined by gas chromatography coupled with mass spectrometry.

Eight types of vegetable oils, obtained by cold pressing of raw plant materials of sunflower, rapeseed, soybean, flaxseed, sesame, pumpkin, hempseed and walnut were used in the experiments. For all samples, the fatty acid composition was determined individually or as sum of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids, and omega-6 (ω -6) and omega-3 (ω -3) were also evaluated.

Compared with the other tested oils, walnut oil was characterized by the lowest concentrations in SFA (5.33%) and MUFA (15.97%) and the highest concentrations in PUFA (78.70%). Soybean oil had the highest content in SFA (18.70%), while the rapeseed oil was characterized by the highest content in MUFA (67.49%) and the lowest content in PUFA (24.74%). Nutritional claims regarding the MUFA content can be made for rapeseed oil, while for the other tested oils can be mentioned that are high in PUFA. The soybean, rapeseed, flaxseed, hempseed and walnut cold pressed oils can be considered to have nutritional potential due to the high amounts of ω -3 PUFA.

Keywords: cold pressed oils, GC-MS, fatty acid, nutritional potential, unrefined vegetable oils.

1. INTRODUCTION

Nowadays, consumers concern regarding their health lead to the use of safer processed food, which are economical and environmentally friendly. Cold pressed oils started to be a trend as these oils are obtained by less processing of the raw materials, without the use of solvents, and are consider to have nutritional potential and better quality than refined oils. Cold pressed oils are oxidatively more stable than the oils obtained by other conventional extraction methods (Raman, 2013). By using chemical and hot press extraction some essential fatty acids are lost, as well as tocopherols and phytosterols, thus the quality of the obtained oil being affected (Ananth et al., 2019).

The fatty acid composition of oils is dependent on several factors such as seed variety, growing conditions, harvesting time, environmental conditions, storage conditions, seed treatment before extraction, extraction methods, and also processing conditions (Nederal et al., 2014, De Carvalho et al., 2019, Gao et al., 2019b).

Fatty acid composition as well as stability are important qualities of vegetable oils, having impact on their consumption. Saturated fatty acids determine the stability of the oil, while unsaturated fatty acids (UFA) are responsible for the health benefits. The content and the carbon-chain length of

saturated fatty acids are important due to the risk of developing myocardial infarction, a coronary heart disease (Kleber et al., 2018, Praagman et al., 2019), increasing blood cholesterol concentrations, also having effect on the metabolic syndrome (Yang et al., 2018).

Vegetable oils provide a high content of PUFA which are needed in a good balanced diet. Also, the content of PUFA and the double-bond location is a determinant factor for the beneficial effects of these fatty acids on the human health. This category of fatty acids is classified into omega-3 (ω -3), omega-6 (ω -6) and omega 9 (ω -9) of which ω -3 and ω -6 are consider essential fatty acids. These essential fatty acids are required because they cannot be synthesized by humans, therefore being consider essential in the human diet. The most known essential ω -3 PUFA is α -linolenic acid (ALA), while linoleic acid (LA) is the most known essential ω -6 PUFA.

It is known that ω -6 fatty acids have inflammatory and atherogenic properties, while ω -3 PUFA presents anti-inflammatory and antioxidant activity, lowers the risk of cardiovascular disease, and it is also an adjuvant therapy for depressive disorder and anxiety (Park et al., 2015, Subash-Babu and Alshatwi, 2018, Thesing et al., 2018, Hinojosa et al., 2020, Trebatická et al., 2020). Mirmiran et al. (2012) showed that the dietary intake of LA decreased the risk for the metabolic syndrome, while ALA intake was inversely associated with the metabolic syndrome in Tehranian adults. Also, a higher dietary intake of ω -3 PUFA improves the glucose metabolism in high-risk individuals (Sartorelli et al., 2010), but in the same time increases the symptoms of coronary disease (Subash-Babu and Alshatwi, 2018).

These ω -6 and ω -3 PUFA are the precursors for the synthesis of long-chain PUFA eicosapentaenoic and docosahexaenoic acids, implicated in control of lipid accumulation and coronary heart disease (Subash-Babu and Alshatwi, 2018), while ω -6 can be converted into arachidonic acid (Park et al., 2015).

The ω -6/ ω -3 PUFA ratio is important for a balanced diet. However, EFSA (2010) didn't set a specific value for the ω -6/ ω -3 ratio, but several studies were conducted to determine the optimum value for human health benefits. A high ω -6/ ω -3 ratio significantly increased lipid accumulation in macrophages and foam cell conversion, overproduction of proinflammatory cytokines (Subash-Babu and Alshatwi, 2018), reduced muscles mass in patients with diabetes undergoing hemodialysis (Wong et al., 2016), while a diet with low ω -3/ ω -6 ratio prevented the metabolic syndrome (Liu et al., 2020).

In some oils it can also be found erucic acid, especially in rapeseed oil. This fatty acid has harmful effects on human health (EFSA, 2017). Due to these concerns, the maximum level of erucic acid in vegetable oils was established to be less than 5% of total fatty acids (Commission Regulation (EU) no 696/2014). Based on the low erucic acid content (<2%) and low glucosinolate content (<30 micromoles), oils obtained from the seeds of the genus *Brassica* are called canola oils.

In order to have nutritional potential, European Commission (based on Regulation (EC) no 1924/2006) set some nutrition and health claims regarding the fatty acid composition of food products. It can be considered that a food is low in saturated fat if the sum of SFA and *trans* fatty acids in the product does not exceed 1.5 g/100 g for solids or 0.75 g/100 ml for liquids and do not provide more than 10% of energy (E). EFSA (2010) recommends that the SFA and *trans* fatty acid intake should be as low as possible, while the Joint FAO/WHO (2008) recommends that the intake of SFA not to exceed 10% of E and should be replaces with PUFA in the diet, thus reducing the risk of coronary heart disease.

In regards to ω -3 PUFA, a product can be considered as a source of ω -3 if it contains at least 0.3 g ALA/100 g and per 100 kcal, or at least 40 mg of the sum of eicosapentaenoic and docosahexaenoic

acids per 100 g and per 100 kcal. Moreover, a claim that a food product is rich in ω -3 PUFA may be made when the food product contains at least 0.6 g ALA/100 g and per 100 kcal, or at least 80 mg of the sum of eicosapentaenoic and docosahexaenoic acids per 100 g and per 100 kcal. EFSA (2010) set an adequate intake of 0.5% of E for ALA, and 4 of E for LA, respectively.

Also, there are claims that a food product is high in MUFA, PUFA and UFA, that may be made when the product contains at least 45%, 45% and 70%, respectively of the fatty acids present in the products, under the consideration that MUFA, PUFA and UFA provides more than 20% of E of the product.

Taking into consideration that the energy value of 1 g fat is 9 kcal (Regulation (EU) no 1169/2011), therefore 100 g oil provides 900 kcal. In order to make a claim that the cold pressed oil analysed is low in SFA, it should contain less than 90 kcal of E provided by SFA. In the case of MUFA, PUFA and UFA, the claim that the oil analysed is rich in these fatty acids, should be made when more than 180 kcal of E of the oil is provided by MUFA, PUFA and UFA, respectively.

The aim of this study was to evaluate the fatty acid composition of eight types of cold pressed vegetable oils. The fatty acid composition was expressed individually or as sum of SFA, MUFA and PUFA. It was also demonstrated the nutritional potential of these cold pressed oil by showing which one can be considered a source or is high in ω -3 PUFA, which one have a low content of SFA, or a high content of MUFA, PUFA and UFA, nutritional claims which were set by the European Commission.

2. MATERIALS AND METHODS

Reference standards, reagents

Two reference standards were used in experiments, F.A.M.E. Mix, C4-C24 (mixture of 37 fatty acids methyl esters (FAME), Bellefonte, PA, USA) and SRM[®]2377 (mixture of 26 FAME, NIST certified, USA).

All solvents and reagents were of analytical grade, specially for chromatography and were used for the preparation and analysis of FAME: 5.4 M methanolic solution of sodium hydroxide (Acros, New Jersey), 14% methanolic solution of boron trifluoride (Sigma Aldrich, Switzerland), sodium chloride (Sigma Aldrich, Denmark), methanol picograde and 2,2,4-trimethylpentane (isooctane) picograde (LGC Standards GmbH, Germany).

Oil samples

In this study, eight unrefined vegetable oils obtained by the cold press processing of vegetable raw materials, supplied by the company SC ECO EXTRACT SRL were used. These oils were extracted by cold pressing of raw materials of sunflower (*Heliantus annuus L.*), rapeseed (*Brassica napus*), soybean (*Glycine max L.*), flaxseed (*Linum usitatissium L.*), sesame (*Sesamum indicum L.*), pumpkin (*Cucurbita pepo L.*), hempseed (*Cannabis sativa L.*), and walnut (*Juglans regia L.*).

Fatty acid determination

Before analysis, fatty acids (FA) were converted to FAME by shaking of 50 mg oil with 4 mL of 0.5 M methanolic solution hydroxide and 5 mL of 14% methanolic solution of boron trifluoride (BF₃). The obtained extract was diluted with 3 mL isooctane and transferred to an autosampler vial for GC-MS injection.

The FAMEs composition of oil samples analysed was performed by using a gas chromatograph coupled with a mass spectrometer (Trace GC Ultra/TSQ Quantum XLS, Thermo Fisher Scientific, USA). The GC is equipped with a high polarity capillary column, TR-FAME (stationary phase consisting of 70% cyanopropyl and 30% polysilphenyl-siloxane (60 m x 0.25 mm inner diameter

and 0.25 μm stationary film thickness), provided by Thermo Fisher Scientific. The oven temperature was programmed at 100°C for 0.2 min, followed by a 20°C/min ramp to 240°C and held for 15 min. Helium was the carrier gas, at a constant flow rate of 1 mL/min. A volume of 0.5 μL extract was injected at 240°C in split mode with a 1:50 split ratio and a 50 mL/min splitting rate. For the applied method, the MS detector was operated in the positive electron impact ionization mode (EI^+), selected ion monitoring mode (SIM), using 24 segments. The temperature of the ion source was 250°C. Injections were performed in duplicate. Instrument control, data acquisition and processing were performed using the Xcalibur Program. The recording time of a GC-MS chromatogram is 85 minutes.

Identification of chromatographic peaks in the oil samples was achieved by comparing their retention times with those of appropriate FAMES reference standards, and the mass/charge (m/z) ratio characteristic of each component.

The fatty acids content of oil samples studied were calculated based on correction factors (CF) determined from the calibration solutions (Mihai et al., 2019). CF were determined from both reference standards, SRM[®]2377 and F.A.M.E. Mix. C4-C24 (23 FAME common to both standards, 3 FAME specific to SRM[®]2377 and 14 FAME specific to F.A.M.E. Mix C4-C24).

Results were expressed as weight percentage of FAME/FA individually determined or as sum of SFA, MUFA, PUFA, expressed as triacylglycerol per 100 g fat (Mihai et al., 2019) and are presented as mean \pm standard deviation. It was calculated also the ω -6 and ω -3 content.

Among ω -6 fatty acids, C18:2n6 (linoleic acid- LA), C18:3n6 (γ -linolenic acid- GLA), C20:2n6 (cis-11,14-eicodienoic acid), C20:3n6 (dihomo- γ -linolenic acid-DGLA) were quantified in the cold pressed oils, while among ω -3 fatty acids, the ones that were found were C18:3n3 (α -linolenic acid- ALA) and C20:3n3 (eicosatrienoic acid- ETE).

3. RESULTS AND DISCUSSIONS

Fatty acid composition of the eight cold pressed oils analysed by GC-MS are presented in table 1.

The tested oils varied in the content of SFA, MUFA and PUFA. By analysing the results, it was found that the main SFA of the tested oils were palmitic acid (C16:0), and stearic acid (C18:0). The highest content of palmitic acid was recorded for soybean oil (12.01%) and sesame oil (9.38%), followed by sunflower and pumpkin oils (~7%). The content of stearic acid varied between 0.24% and 4.88%, the highest content being found for soybean oil.

Oleic acid (C18:1n9) was the predominant MUFA for all analysed oils, ranging between 14.73% and 63.66%. The highest percent was found in rapeseed oil, followed by sesame and pumpkin oils (~35%).

LA (C18:2n6) was the main PUFA in all tested oils, with a percent ranging between 18.51% and 66.73%. For walnut, sunflower and hempseed oils, the percent was more than 60%. Also, ALA (C18:3n3) was found in all oils analysed, the highest content being found in flaxseed oil (51.39%), followed by walnut and hempseed oils with a content of 11.95% and 11.47%, respectively.

Among the tested vegetable oils, erucic acid was found in rapeseed, pumpkin and hempseed oils in a percent less than 1%.

Sunflower oil

Sunflower oil is one of the most consumed oils used for cooking and frying. Based on the content of oleic acid, three types of sunflower oil can be found: a low oleic or traditional sunflower oil (14-39.4%), a mid-oleic sunflower oil (43.1-71.8%) and a high oleic sunflower oil (75- 90.7%) (Codex, 2015). According to our results (table 1) it can be concluded that the sunflower oil analysed is a low

oleic type of sunflower oil. For the tested sunflower oil, oleic acid was the main MUFA, with a percent of 20.81%, followed by *cis*-vaccenic acid (0.67%) and gondoic acid (0.17%). Also, Veličkovska et al. (2018) when studying the fatty acid composition of cold pressed sunflower oil found a percent of 29.9% for oleic acid and a small amount of *cis*-vaccenic acid (0.4%).

Table 1. Fatty acid composition (%) of cold pressed oils tested

No.	Fatty acid	Type of cold pressed oils							
		sun-flower	rape-seed	soy-bean	flax-seed	sesame	pump-kin	hemp-seed	walnut
1	C14:0 myristic acid	0.07	-	0.06	0.04	-	0.09	0.03	0.03
2	C15:0* pentadecanoic acid	0.01	0.02	0.01	0.02	-	0.02	0.01	0.01
3	C16:0 palmitic acid	7.32	4.79	12.01	3.67	9.38	7.07	4.71	4.41
4	C16:1n7 palmitoleic acid	0.18	0.34	0.12	0.13	0.25	0.22	0.15	0.08
5	C17:0* margaric acid	0.04	0.13	0.10	0.08	0.10	0.09	0.06	0.05
6	C17:1n7* <i>cis</i> -10-heptadecenoic acid	0.02	-	0.04	0.04	-	-	-	0.02
7	C18:0 stearic acid	3.07	1.68	4.88	2.44	4.63	3.35	2.37	0.24
8	C18:1n9t elaidic acid	-	-	-	-	-	-	-	0.02
9	C18:1n7t <i>trans</i> vaccenic acid	-	-	0.03	-	-	-	-	-
10	C18:1n9 oleic acid	20.81	63.66	17.68	15.29	35.65	34.91	14.94	14.73
11	C18:1n7 <i>cis</i> -vaccenic acid	0.67	2.12	1.33	0.47	0.62	0.93	0.79	0.70
12	C18:2n6 linoleic acid (LA)	66.42	18.51	54.50	25.05	46.95	49.63	60.72	66.73
13	C18:3n6 γ -linolenic acid (GLA)	-	-	-	-	-	-	2.59	-
14	C18:3n3 α -linolenic acid (ALA)	0.09	6.17	7.21	51.39	1.20	1.96	11.47	11.95
15	C20:0 arachidic acid	0.34	0.49	0.60	0.33	0.61	0.40	0.95	0.15
16	C20:1n9 gondoic acid	0.17	1.14	0.35	0.24	0.16	0.45	0.37	0.41
17	C21:0* heneicosanoic acid	0.01	-	0.02	0.01	0.01	0.01	0.02	0.01
18	C20:2n6* <i>cis</i> -11,14-eicodienoic acid	0.01	0.07	0.04	0.03	0.02	0.02	0.05	0.02
19	C20:3n6* dihomo- γ -linolenic acid (DGLA)	-	-	-	0.04	-	-	-	-
20	C20:3n3* eicosatrienoic acid (ETE)	-	-	-	0.06	-	-	-	-
21	C22:0 behenic acid	0.51	0.44	0.70	0.47	0.23	0.48	0.53	0.34
22	C22:1n9* erucic acid	-	0.09	-	-	-	0.04	0.03	-
23	C23:0* tricosanoic acid	0.04	0.02	0.05	0.03	0.03	0.18	0.03	0.01
24	C24:0 lignoceric acid	0.22	0.19	0.28	0.21	0.17	0.13	0.22	0.08
25	C24:1n9 nervonic acid	-	0.14	-	-	-	0.04	-	-
Sum of FAME/FA, g/100 g fat		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SFA (g/100 g fat)		11.64	7.77	18.70	7.27	15.15	11.81	8.90	5.33
MUFA (g/100 g fat)		21.85	67.49	19.55	16.16	36.68	36.58	16.27	15.97
PUFA (g/100 g fat)		66.51	24.74	61.75	76.57	48.17	51.61	74.83	78.70
UFA (g/100 g fat)		88.36	92.23	81.30	92.72	84.85	88.18	91.10	94.67
TFA (g/100 g fat)		-	-	0.03	-	-	-	-	0.02
ω-3		0.09	6.17	7.21	51.45	1.2	1.96	11.47	11.95
ω-6		66.42	18.58	54.54	25.12	46.97	49.64	63.36	66.74
ω-6/ω-3 ratio		758	3.01	7.56	0.49	39.14	25.33	5.52	5.58

*identification based on the reference standard F.A.M.E. Mix C4-C24

Results are given as mean \pm standard deviation (n = 2); SFA - saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids; UFA - unsaturated fatty acids; TFA - total *trans* fatty acids

LA was the main PUFA present in sunflower oil (66.42%) and a very small percent of ALA (0.09%) was found as well. The quality of sunflower oil analysed is determined by the high content of linoleic and oleic acids, summing 87.23% of the total composition of fatty acids. Similar results were obtained in the study realized by Veličkovska et al. (2018) who showed that the major UFA of cold pressed sunflower oil were linoleic (58.3%) and oleic (29.9%) acids, summing 88.2% of the total composition of fatty acids.

Considering that the oils quality depends on the fatty acids composition, and the stability of sunflower oils is influenced by the amount of oleic acid, Bendini et al. (2011) analysed 14 samples of cold pressed sunflower oils commercialized on Italian market, and found that 6 samples had a low content of oleic acid ranging between 26.94 and 36.54%, and a content of linolenic acid ranging between 52.24 and 60.83%, results being in accordance with the ones obtained in our study. For the cold pressed sunflower oil analysed in our study it was found a SFA content of 11.64%, the predominant SFA being palmitic and stearic acids, and a MUFA content of 21.85%, while the PUFA content was high (66.51%). The fatty acid composition of sunflower oil tested was comparable with the one reported by Symoniuk et al. (2018) who found for one of the two analysed sample of cold pressed sunflower oil a content of 10.40%, 18.62%, and 70.41% for SFA, MUFA and PUFA, respectively.

Based on the PUFA content (66.51%) that is higher than 45% of the fatty acids present in the product and under the condition that PUFA provides more than 20% of E (598.58 Kcal) of the sunflower oil it can be considered that this oil is a high PUFA fat, confirming its beneficial health effect. It also can be made the nutritional claim that this oil is high in UFA as it contains 88.36% of the fatty acids so more than 70% and UFA provides more than 20% of E (795.24 kcal) of the sunflower oil.

Rapeseed oil

Rapeseed oil is considered one of the healthiest vegetable oils due to its fatty acid profile. This cold pressed oil, as the other tested oils, has as the main saturated acids, palmitic and stearic acids, in a percent of 4.79% and 1.68%, respectively. Between all tested oils, the highest amount of oleic acid (63.66%) was found in the rapeseed oil. Oleic acid is known to be more heat-stable than LA, thus this particularity of rapeseed oil contributes to its nutritional effects and also stability (Chew et al., 2020). Moreover, oleic acid is known to have beneficial effects on the blood total cholesterol and LDL cholesterol (EFSA, 2011). LA and ALA were found in a percent of 18.51% and 6.17%, respectively. Considering that the ALA content is higher than 0.6 g/100 g oil and per 100 kcal, it can be said that the rapeseed oil has a high content of ω -3 PUFA, having nutritional potential. Also, the low ω -6/ ω -3 ratio of this oil (3.01) confirms its nutritional potential.

A similar fatty acid composition was obtained by Konuskan et al. (2019) who found in cold pressed rapeseed oil an amount of oleic acid, LA and ALA of 63.68%, 17.43% and 6.75%, respectively. Also, Tańska et al. (2018) when studied the fatty acid content of cold pressed rapeseed oil found a content of 60.03%, 20.67% and 10.10% for oleic acid, LA and ALA, comparable with the one obtained in our study.

In rapeseed oil was found gondoic acid (C20:1n9) in a percent higher (1.14%) than the one of the other oil analysed. When analysing the fatty acid composition of cold pressed and refined rapeseed oil, Tańska et al. (2018) found that gondoic acid was present in a smaller percent for cold pressed oil (1.47%), while for refined oil the percent was higher (1.55%).

Also, erucic acid (C22:1n9), known for having harmful effect on human health, was found in this oil in a percent of 0.09%, but under the maximum level of 5% set by Commission Regulation (EU) no 696/2014.

The rapeseed oil analysed is rich in MUFA and PUFA (67.49% and 24.74%), and contains a small amount of SFA of 7.77%. Our results are in accordance with the one obtained by Symoniuk et al. (2018) who found for the five cold pressed rapeseed oils analysed in the study an amount of ~66%, 27%, and 7%, for MUFA, PUFA, and SFA, respectively. Ghazani et al. (2013, 2014) compared the fatty acid composition of cold pressed, hot pressed, solvent extracted and refined canola oils and

showed that the cold pressed oil had a smaller amount of SFA, and a higher amount of PUFA compared with the oils obtained using the other extraction methods. All the cold pressed canola oils had a higher content of LA and a smaller content of oleic acid than the other oils extracted through hot pressed, solvent extraction and refined oils. Taking this into consideration, it can be concluded that cold pressed canola oil has a better nutritional quality due to the higher amount of polyunsaturated ω -3 fatty acids, and has lower oxidative stability.

From all the tested oils, only for rapeseed oil it can be made the nutritional claim that is high in MUFA (67.49%) as it contains more than 45% of the fatty acids present in the product and it provides more than 20% of E (607.41 kcal) of the oil. This oil has as well nutritional potential due to its high content of UFA (92.23%) as it contributes with more than 70% of the fatty acids and UFA provides more than 20% of E (830.07 kcal) of product.

Soybean oil

For soybean oil, the main SFA were palmitic (12.01%) and stearic (4.88%) acids, followed by small content of behenic (0.7%) and arachidic (0.60%) acids. Similar results were obtained by Warner and Dunlap (2006) who studied the composition of expeller-pressed and refined soybean oil and found that the main SFA were palmitic, stearic, arachidic and behenic acids.

Between MUFA, the main fatty acids were oleic acid (17.68%) and *cis*-vaccenic acid (1.33%). The cold pressed soybean oil is the only tested oil in which was found the *trans*-vaccenic acid in a percent of 0.03%.

This oil is an important source of LA (54.50%). The ALA content of the soybean oil was 7.21%, which means that this oil has nutritional potential, being high in ω -3 fatty acids, containing more than 0.6 g ALA per 100 g and per 100 kcal. For soybean oil, the ω -6/ ω -3 ratio was 7.56, proving its health benefits.

Between all the analysed samples, the cold pressed soybean oil had the highest content of SFA (18.72%) making it more stable. The MUFA and PUFA content was 19.55% and 61.75%, respectively. Similar results were obtained in the study realized by Ivanov et al. (2010) who found for soybean oil a SFA, MUFA and PUFA content of 23.89%, 16.44% and 59.68%, respectively.

Due to the fact that for this oil more than 45% of the total of fatty acids present in the product derives from PUFA (61.75%) and the PUFA content provides more than 20% of E (555.75 kcal) of product, it can be concluded that this cold pressed oil has a high content of PUFA, confirming its nutritional potential. As well this oil is high in UFA (81.30%), providing more than 20% of E (731.7 Kcal) of product and more than 70% of the fatty acids of the oil derive from UFA.

Flaxseed oil

Flaxseed oil, also known as linseed oil, is characterized by a high content of ALA, being the richest natural source of this ω -3 PUFA. The human interest of consumption high ω -3 PUFA food products is increased due to the nutritional potential and health benefits, but in the same time, the flaxseed oil is more susceptible to oxidation (Choo et al., 2007, Khattab and Zeitoun, 2013). Intake of ALA increases the concentration of ω -3 PUFA in blood, thus reducing the risk of coronary heart disease and metabolic syndrome (Jang and Park, 2020). The EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) considers that the dietary intake of ALA has beneficial effect on maintaining the normal blood cholesterol concentration and the normal blood pressure (EFSA, 2009).

From all eight samples of cold pressed oil tested, flaxseed oil had the highest amount of ALA (51.39%), being considered a high source of ω -3 PUFA as it contains more than 0.6 g/100 g and per 100 kcal. Also, when Prescha et al. (2014) studied the fatty acid composition of twelve kinds of cold pressed oils found that between all tested oils, flaxseed oil contained the highest content of

ALA (51.2%). As well, Tańska et al. (2018), Symoniuk et al. (2018), and Veličkovska et al. (2018) showed that flaxseed oil is an important source of ALA, finding in the cold pressed oils analysed a content of 48.94%, 54.88%, and 56.9%, respectively. In a study realized by Choo et al. (2007) seven cold pressed flaxseed oil samples were analysed and the content of ALA ranged between 51.8% and 60.42%.

This cold pressed oil is characterized by a low content of SFA (7.27%) primarily palmitic and stearic acids being found, and a MUFA content of 16.16% of which oleic acid represents 15.29%. In contrary, the content of PUFA is high (76.57%), due to the increased levels of ω -3 PUFA ALA (51.39%) but it also contains the ω -6 PUFA LA (25.05%). It should be noted that the flaxseed oil contains a small amount of dihomo- γ -linolenic acid (DGLA, C20:3n6, 0.04%), and eicosatrienoic acid (ETE, C20:3n3, 0.06%), that were not detected in the other cold pressed oils analysed in this study. The results are comparable with those reported by Symoniuk et al. (2018) who analysed 5 samples of cold pressed linseed oil and found an average content of SFA, MUFA and PUFA of 9.89%, 19.00% and 70.55%, respectively.

For the flaxseed oil it can be made the nutritional claim that is high in PUFA (76.57%) and UFA (92.72%) as more than 45% and 70% of the total of fatty acids present in the product derive from PUFA, respectively UFA, and it provides more than 20% of E of the oil tested.

Its beneficial effect on human health can be proved as well by the low ratio of ω -6/ ω -3, which was 0.49, the lowest obtained for all the tested oils. Similarly, Teh and Birch (2013) found for flaxseed oil a low ratio of ω -6/ ω -3 of 0.28.

Sesame oil

For the sesame oil analysed sample, the major fatty acids found were LA (46.95%) and oleic acid (35.65%), followed by palmitic (9.38%) and stearic acids (4.63%). The results are in agreement with the ones obtained by Ozulku et al. (2017), who found for the cold pressed sesame oil analysed a content of 45.4% LA, 39.8% oleic acid, while palmitic acid was in a percent of 8.3%, and the percent of stearic acid was 5.2%. Also, Ananth et al. (2019) when studying the fatty acid composition of cold pressed sesame oil found a high amount of oleic acid and LA, followed by palmitic and stearic acids in a percent of 11% each. Similar results were obtained by Veličkovska et al. (2018) who found for sesame oil a high content of LA (44.1%) and oleic acid (39.0%), followed by palmitic acid (10.1%). The content of *cis*-vaccenic acid (0.8%) was comparable with the one obtained in our study (0.62%).

The cold pressed sesame oil analysed had a content of SFA, MUFA and PUFA of 15.15%, 36.68%, and 48.17%, respectively, comparable with the one obtained in the study realized by Prescha et al. (2014) who reported the content of 16.7%, 39.8%, and 43.4%, respectively.

Considering that the PUFA content of the sesame oil (48.17%) is higher than 45% of the fatty acids present in the product and it provides more than 20% of E (433.53 Kcal) of the oil, the nutritional claim that this product is high in PUFA can be made. The sesame oil has as well a high content of UFA as it contains 84.85% of the fatty acids and provides more than 20% of E (763.65 Kcal) of the oil.

Pumpkin oil

The cold pressed pumpkin oil analysed in this study contained palmitic and stearic acids as the major SFA. The most abundant UFA of the tested oil were LA (49.63%) and oleic acid (34.91%), followed by a small content of ALA (1.96%) and *cis*-vaccenic acid (0.93%). Similar results were obtained by Banaś et al. (2020) who studied the fatty acid composition of pumpkin oil before storage and found that palmitic and stearic acid were the major SFA, while LA and oleic acid were

the main UFA, followed by small amounts of *cis*-vaccenic acid and ALA. Ogradowska et al. (2020) studied the fatty acid composition of pumpkin cold pressed oil and reported that the main fatty acids were LA (52.66%), oleic (27.05%), palmitic (12.86%) and stearic acids (5.78%), followed by a small content of *cis*-vaccenic acid (0.55%), but no content of ALA was found.

In a study realized by Rabrenović et al. (2014) on six samples of cold pressed pumpkin seeds oil of which four were naked and two were with husk, it was also reported that the main UFA were oleic and linoleic acids. For the four naked pumpkin seed oil, the ratio of oleic and linoleic acids was almost the same, while for the two husk pumpkin seeds oil, the content of oleic acid was negative correlated with the LA acid content.

When Nederal et al. (2014) analysed the fatty acid composition of roasted and cold pressed pumpkin seed oil it was shown that the main fatty acids were LA, oleic, palmitic and stearic acids, and the content varies depending on the processing technology. In the case of cold pressed pumpkin oil, the content of SFA and MUFA was higher than the one of roasted pumpkin seed oil, while the PUFA content was lower. In a previous study realized by Nederal et al. (2012), it was shown that SFA and MUFA content of husked and naked pumpkin oil was higher when processing temperature increased, while the PUFA content decreased.

Cold pressed pumpkin seed oil analysed in our study was characterized by a SFA, MUFA and PUFA content of 11.81%, 36.58% and 51.61%, respectively. This content is comparable with the one reported by Vujasinovic et al. (2010) who studied the fatty acid composition of three cold pressed pumpkin seed oil and obtained an average content of 15.96%, 35.30%, and 48.74%, for SFA, MUFA and PUFA, respectively.

The pumpkin oil has nutritional potential as it has a high content of PUFA, 51.61% of the fatty acids present in the product deriving from PUFA and it provides more than 20% of the E (464.49 Kcal) of this product. It also can be said that this oil is high in UFA (88.19%).

Hempseed oil

For the hempseed cold pressed oil, the main SFA were palmitic and stearic acids, followed by a small amount of arachidic acid (~1%). The results showed that this oil contains as the main MUFA, oleic acid in a percent of 14.94%. Hempseed oil contains LA (60.72%), and ALA (11.47%) as the major ω -6 and ω -3 PUFA. As a result of the content of ALA which is higher than 0.6 g per 100 g and per 100 kcal, hempseed oil can be considered a product with a high ω -3 PUFA, having nutritional potential. Taking in consideration the low ω -6/ ω -3 ratio of 5.52, it can be concluded that this cold pressed oil has health benefits.

From all eight samples of cold pressed oil tested, only in hempseed cold pressed oil was found the ω -6 PUFA, γ -linolenic acid (GLA, C18:3n6), in a percent of 2.59%. These results are comparable with the ones reported by Prescha et al. (2014) who analysed 12 kinds of cold pressed oils and only in the hempseed oil and rose hip oil found the ω -6 PUFA, GLA, in a percent of 2.2% and 0.1%, respectively. Also, Siudem et al. (2019) when studying the fatty acid composition of six samples of cold pressed hempseed oil found a GLA content ranging between 0.46% and 4.51%, while Teh and Birch (2013) found for the cold pressed hemp oil analysed a content of 4.76% GLA.

The cold pressed hempseed oil had a content of SFA, MUFA and PUFA of 8.90%, 16.27% and 74.83%, respectively, comparable with the one reported by Symoniuk et al. (2018) who found the percent of 10.90%, 14.41% and 73.69%, respectively.

Due to the high content of PUFA (74.83%) and UFA (91.10%) this oil has nutritional potential, more than 45%, and 70%, respectively of the fatty acids present in the hempseed oil being derived

from PUFA and UFA, respectively, providing more than 20% of E (673.47 Kcal for PUFA and 819.81 Kcal for UFA) of the product.

Walnut oil

Walnut oil is extracted from the walnut kernel, having high nutritional value due to the high amount of PUFA. In the walnut oil, the main SFA identified was palmitic acid (4.41%), followed by traces amount of behenic (0.34%) and stearic (0.24%) acids. Oleic acid was the major MUFA presented in walnut oil with a percentage of 14.73%. From all analysed samples of cold pressed oils, walnut oil presented the highest content of ω -6 PUFA LA (66.73%). This oil contains as well ALA in a percent of 11.95%, which makes it a high ω -3 PUFA as it contains more than 0.6 g/100 g product and per 100 kcal. A comparable content of UFA was obtained in the study realized by Costa-Singh and Jorge (2015) who found for the cold pressed walnut oil a content of oleic acid, LA and ALA of 15.66, 61.52 and 12.71%. Also, Gao et al. (2019a) when analysing three cold pressed oils of walnut *Junglas regia* variety found that oleic acid, LA and ALA were the main UFA. In another study realized by Gao et al. (2019b) it was shown that by using the cold pressing process, the LA content of walnut oil (67.05%) was significantly higher than that obtained when extraction solvents were used (62.95- 66.65%), like this the content of ω -6 PUFA from walnut being maintained in the oil. Similarly, Jugaimi et al. (2018) found a higher content of LA (63.56%) when walnut oil was obtained by cold pressing than when it was obtained by Soxhlet extraction (62.41%).

In regards to the TFA content, the walnut oil was the only one which contained elaidic acid (C18:1n9t) in a percent of 0.02%.

Between all the analysed samples, the cold pressed walnut oil had the smallest content of SFA (5.33%) and MUFA (15.97%), and the highest content of PUFA (78.70%). Similar results regarding the fatty acids composition of this oil were reported by Rabadán et al. (2018) who found a SFA, MUFA and PUFA content of 8.49%, 14.79% and 76.65%, respectively.

From all the tested oils, walnut oil had the highest content of PUFA (78.70%) and UFA (94.67%). The nutritional claim that this oil is high in PUFA and UFA can be made as it contains more than 45% and 70% of the fatty acid content derives from PUFA and UFA, respectively, and it provides more than 20% of E (708.30 Kcal for PUFA and 852.03 Kcal for UFA) of the product.

Also, cold pressed walnut oil had a low ω -6/ ω -3 ratio of 5.58 which makes it an oil with nutritional potential.

4. CONCLUSIONS

In this study was evaluated the fatty acid composition of eight types of cold pressed oils and it was showed their nutritional potential. By evaluation of nutritional quality of fatty acids profile, besides rapeseed oil which is high in MUFA, all the other tested oils have a high content of PUFA. All the cold pressed oils tested have high nutritional value in term of UFA which represents more than 80% of total of fatty acids present in the products. Cold pressed oils of rapeseed, soybean, flaxseed, hempseed and walnut can be considered rich sources of ω -3 essential fatty acids, especially ALA, confirming their nutritional potential.

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