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Determination of fatty acid composition and antioxidant activity in vegetable oils

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Studies of the composition of vegetable oils are expedient in order to achieve quality product modelling. The goal of this research was to determine the composition of fatty acids using gas chromatography (GC) and antioxidant activity using DPPH and ABTS spectrophotometric methods. Analysed oils were castor seed, sunflower seed, sesame seed, fibrous hemp seed, black radish seed and olive oils. Different classes of fatty acids were determined: polyunsaturated, monounsaturated and saturated; omega-3, omega-6 and omega-9 acids and individual constituents. The study results showed that the dominant acids in all oils were oleic and linoleic fatty acids. The best ratio of omega-6 to omega-3 acids was found in fibrous hemp seed oil – 3:1. All analysed vegetable oils demonstrated a high antioxidant activity.

Keywords: gas chromatography (GC), antioxidant activity, fatty acid

INTRODUCTION

Oils obtained from plant sources have a rich history of use as a source of food and energy, with a valuable application in medicine, pharmacy and cosmetics. Bioactive compounds of natural oils are important because they can be used for both health benefits and the production of formulations because they contain phytochemicals with significant antioxidative properties [1]. Emulsion delivery systems are widely applied in pharmaceutical and cosmetic formulations; therefore, various oils are used as dispersion phase or continuous phase. There is an increasing consumer demand for high-quality skin care products of natural origin ingredients among which vegetable oils play an important role.

Natural seed oils contain a range of fatty acids which contribute several beneficial properties

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in skin care products. Fatty acids are divided into saturated acids (palmitic, stearic, arachidic, myristic, lauric, etc.) and unsaturated acids (oleic, linoleic, palmitoleic). Studies by researchers in the past have demonstrated that fatty acids have a beneficial effect on human body: have anti-proliferative and anti-inflammatory properties [2], significant antipsoriatic activity [3], and contribute to the acidification of the stratum corneum, promoting its structural integrity and barrier function [4]. Natural oils rich of essential fatty acids can promote increased collagen synthesis and decreased numbers of inflammatory cells during the wound-healing process [5]. Some of them like palmitic, oleic and stearic acids are synthesized in the body, but linoleic acid is not synthesized and its deficiency will cause various signs. The skin dries out and becomes scaly, nails crack, and hair loss as well as transepidermal water loss increase [6]. Linoleic acid is the most frequently used fatty acid in cosmetic products as it lowers the transepidermal water loss and increases skin moistness, aids in the healing process of dermatoses and sunburns and is used for the treatment of *acne vulgaris* [7, 8]. The oils are usually used as a carrier/vehicle for active ingredients, but the presence of certain fatty acids has also proven the enhancement of skin permeation of co-administered molecules. The effects of fatty acids as permeation enhancers have been shown to be dependent on their structure, alkyl chain length, and degree of saturation [9, 10]. Fatty acids are potential chemical penetration enhancers, therefore natural oils should not be treated as passive components of various preparations [11, 12].

The goal of this research was to determine the fatty acid composition of selected vegetable oils using gas chromatography (GC). The study objects were six oils pressed from seeds – fibrous hemp, sunflower, black radish, rapeseed, sesame oil – and one from fruit – olive oil. Antioxidant activity of vegetable oils was tested using DPPH and ABTS spectrophotometric methods [13]. Scientific literature data reveals large differences in the determined antioxidant properties of oil therefore in this study the correlation between activity and determined substances was analysed. The composition of fatty acids and other constituents can expand the functionality of vegetable oils.

EXPERIMENTAL

Materials

The unrefined cold pressed oils were studied: castor oil (Roth), sunflower oil (Arugula), sesame seed oil (House of Scents), fibrous hemp seed oil (Eugenijus Jakubauskas property), olive oil (Fluka) and black radish seed oil (Florance).

Reagents and standards

Ethanol 96% was produced by Stumbras, Kaunas, Lithuania. The standard for a mixture of methyl esters of 37 fatty acids was purchased from Carl Roth GmbH, Germany. The reagent of boron trifluoride (BF3) methanol was produced in Sigma-Aldrich® Chemie GmbH, Steinheim, Germany. Ethyl acetate, hexane and 2,2-diphenyl-1-picrylhydrazyl (DPPH reagent) were purchased from Sigma-Aldrich® Chemie GmbH, Steinheim, Germany. 2,2'-Azino-bis-(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS reagent) was produced by Alfa Aesar, Massachusetts, USA. Ultrapure water was purified with a Millipore water cleaning system (Bedford, USA).

Sample preparation

Oils of castor, olive, sunflower, sesame seeds, black radish seeds and hemp seeds were studied. To identify fatty acids, they were converted to methyl esters and then analysed [14]. Samples were prepared by derivatization using an alkylating reagent – boron trifluoride methanol (BF3-methanol). 0.1 g of oil samples was mixed with 2 ml of BF3-methanol reagent and heated in a glycerin bath at 70°C for 30 min. The mixtures were cooled, then 1 mL of purified water and 1 mL of hexane were added. The samples were shaken well and allowed to settle. The top layer of hexane was separated at 1 ml and injected onto a chromatographic column. The tests were repeated 3 times.

GC analysis

The chromatograph (Shimadzu GC-2010 PLUS, Shimadzu Corporation, Japan) with a flame ionization detector (FID) was used. The gas chromatographic separation was carried out using a 100 m × 0.25 mm, 0.2 μm RT-2560 capillary column. Ultra-high purity helium was used as a carrier gas at a column flow rate of 1.18 mL/min. The general elution flow rate was 27.8 mL/min.

The temperature of the column was carried out from 100 to 240°C in 71.67 min. The temperature of the injector was 230°C. The pressure was 258.7 kPa. The injection volume was 1 µL, with a split ratio 1:20 [15].

Antioxidant activity

Antioxidant activity was determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH•) free radical inactivation method with modifications [16, 17]. For the test, DPPH powders were dissolved in a small volume of ethyl acetate and diluted with ethyl acetate by adjusting the absorbance to 0.700 ± 0.020 at 520 nm. A 20 mg oil sample was weighed in a test tube, and 80 µL ethyl acetate as well as 2.9 ml DPPH• free radical solution were added. The samples were agitated and incubated for 30 min in darkness. Absorbance was measured at 520 nm against ethyl acetate. The other applied test was the 2,2-azino-bis-(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) [1, 18] method. ABTS radical cation stock solution was produced by reacting 7.0 mM ABTS stock solution with 2.45 mM (final concentration) potassium persulfate in the dark for 16 h. The resulting solution was diluted with ethanol by adjusting the absorbance to 0.700 ± 0.020 at 765 nm. 100 µL diluted oil samples in ethanol and 2.9 mL diluted ABTS solution were added. The solution was agitated with a vortex mixer for 20 s. The absorbance was measured after 6 min at 765 nm.

The percent inhibition was calculated according to the formula

$$AA_{(\%\ inhibition)} = [(A_{blank} - A_{sample})/A_{blank} \times 100,$$

where AA is antioxidant activity, A_{blank} is the absorbance of the blank solution and A_{sample} is the absorbance of oil and free radical solution after 30 min.

Statistical analysis

The results are presented as mean ± standard deviation. Statistical analysis was performed using the Student's *t*-test. A value of $p < 0.05$ was taken as the level of significance. Correlation analysis was performed applying the Spearman's rank coefficient.

RESULTS AND DISCUSSION

Determination by gas chromatography

Fatty acids were identified by comparing the chromatograms of the obtained samples with the standard chromatogram of methyl esters of 37 fatty acids (Fig. 1). Retention times, peak numbers, peak areas and each compound name of 37 fatty acid methyl esters standard mixture are presented in Table 1. The standard retention times were compared with the sample retention times. In the oil samples 24 fatty acids were identified.

The fatty acid content is determined from the linear regression equation of the calibration graphs

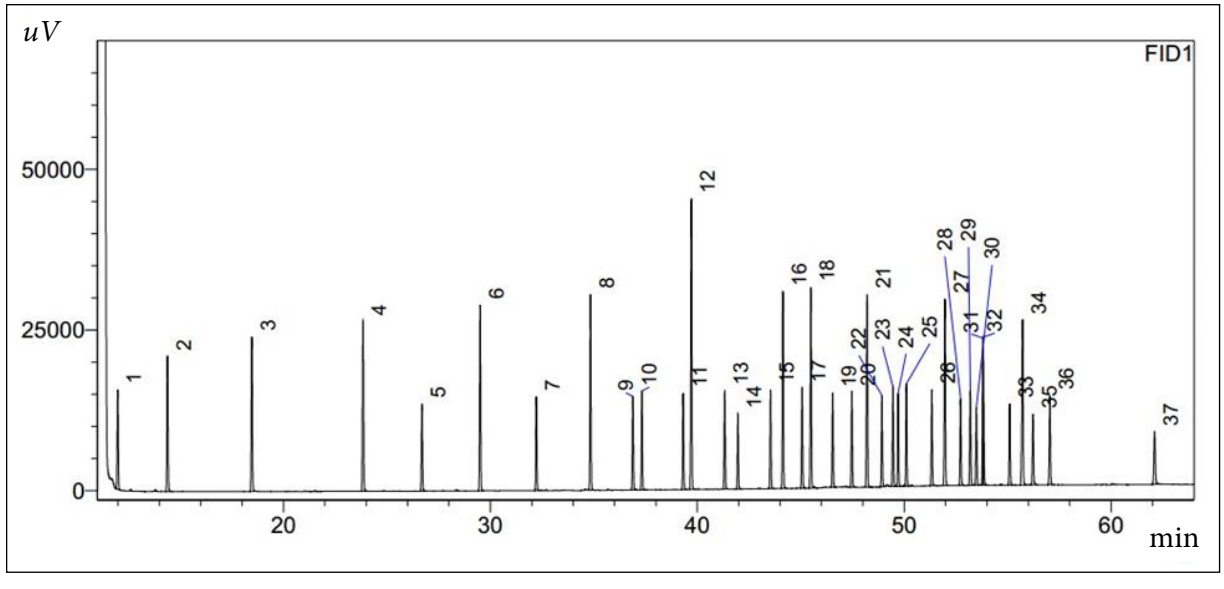

Fig. 1. GC chromatogram of the standard mixture of 37 fatty acids methyl esters

Table 1. **The names of compounds of the standard mixture of 37 fatty acids methyl esters**

Peak number	Retention time	Peak area	Compound name
1	11.991	56318	Methyl butyrate
2	14.395	75374	Methyl hexanoate
3	18.472	86728	Methyl octanoate
4	23,846	93355	Methyl decanoate
5	26.691	47467	Methyl undecanoate
6	29.505	99164	Methyl laurate
7	32.222	49379	Methyl tridecanoate
8	34.838	101809	Methyl myristate
9	36.887	50018	Myristoleic acid methyl ester
10	37.323	50802	Methyl pentadecanoate
11	39.317	50223	Cis-10-pentadecanoic acid methyl ester
12	39.712	155315	Methyl palmitate
13	41.324	50705	Methyl palmitoleate
14	41.960	38557	Methyl heptadecanoate
15	43.539	50925	Cis-10-heptadecanoic acid methyl ester
16	44.139	103692	Methyl stearate
17	45.066	51808	Trans-9-elaidic acid methyl ester
18	45.486	103821	Cis-9-oleic acid methyl ester
19	46.544	48564	Linolelaidic acid methyl ester
20	47.465	49940	Methyl linoleate
21	48.203	104583	Methyl arachidate
22	48.921	47419	Gamma-linolenic acid methyl ester
23	49.453	51115	Methyl eicosenoate
24	49.704	47851	Methyl linolenate
25	50.105	52379	Methyl heneicosanoate
26	51.331	49435	Cis-11,14-eicosadienoic acid methyl ester
27	51.969	104997	Methyl behenate
28	52.724	47265	Cis-8,11,14-eicosatrienoic acid methyl ester
29	53.191	51409	Methyl erucate
30	53.484	42213	Cis-11,14,17-eicotrienoic acid methyl ester
31	53.808	46705	Methyl tricosanoate
32	53.813	52627	Methyl cis-5,8,11,14-eicosatretraenoic acid methyl ester
33	55.097	45909	Cis-13,16-docosadienoic acid methyl ester
34	55.721	106179	Methyl lignocerate
35	56.220	42453	Methyl cis-5,8,11,14,17-eicosapentaenoate
36	57.039	52233	Methyl nervonate
37	62.098	39473	Cis-4,7,10,13,16,19-docosahexaenoic acid methyl ester

of the identified fatty acid methyl ester standards (Table 2). The obtained results allow an accurate quantitative analysis, as the correlation coefficient is higher than 0.99. The percentage of fatty acids was calculated from the calibration equations for each methyl ester determined.

When fatty acids are identified in oils, they must be converted to methyl esters of fatty acids by methylation using a BF3-methanol reagent. The most appropriate conditions for the analysis of fatty acids composition were set after screening of derivatization conditions. 0.1 castor oil was

Table 2. **Linear regression equations for the standard calibration graphs of identified fatty acid methyl esters, correlation coefficient equal to 0.999**

Compound name	Linear regression equation of the calibration graph
Palmitic acid methyl ester (Methyl palmitate)	$f(x) = 820.892*x + 1153.83$
Stearic acid methyl ester (Methyl stearate)	$f(x) = 815.781*x + 1199.71$
Oleic acid methyl ester (Methyl oleate)	$f(x) = 817.902*x + 1089.20$
Linoleic acid methyl ester	$f(x) = 797.567*x + 509.290$
Eicosanoic (arachidic) acid methyl ester	$f(x) = 808.950*x + 1550.92$
Gamma-linolenic acid methyl ester	$f(x) = 770.496*x + 560.307$
Eicosenoic (gondoic) acid methyl ester	$f(x) = 797.895*x + 738.785$
Alpha-linolenic acid methyl ester	$f(x) = 773.987*x + 363.926$
Eicosadienoic acid methyl ester	$f(x) = 776.389*x + 715.159$
Behenic acid methyl ester (Methyl behenate)	$f(x) = 791.908*x + 4302.93$
Arachidonic acid methyl ester	$f(x) = 814.247*x + 141.463$
Palmitoleic acid methyl ester	$f(x) = 811.681*x + 316.673$
Erucic acid methyl ester (Methyl erucate)	$f(x) = 788.344*x + 718.749$
Linolelaidic acid methyl ester	$f(x) = 770.755*x + 508.199$
Eicotrienoic acid methyl ester	$f(x) = 691.675*x + 596.228$
Margaric acid methyl ester	$f(x) = 608.551*x + 410.163$
Docosahexaenoic acid methyl ester	$f(x) = 615.791*x-27.8713$
Palmitoleic acid methyl ester	$f(x) = 811.681*x + 316.673$
Lauric acid methyl ester	$f(x) = 785.458*x – 79.7767$
Nervonic acid methyl ester (Methyl nervonate)	$f(x) = 790.325*x + 323.639$
Pentadecanoic acid methyl ester	$f(x) = 805.777*x + 225.369$
Heneicosanoic acid methyl ester	$f(x) = 808.063*x + 579.720$
Lignoceric acid methyl ester (Methyl lignocerate)	$f(x) = 797.695*x + 854.773$
Caproic acid methyl ester	$f(x) = 600.740*x – 265.120$

weighed, added to 2 mL of BF3-methanol, and stored in a glycerol bath at different temperatures and different time intervals. The samples were heated to 50, 60 and 70°C temperatures lasting for 10, 15, 20 and 30 min time intervals. The percentage of the main acids, linoleic and oleic acids was evaluated by gas chromatography. Comparing the fatty acid content determined under different temperature and time conditions, it was observed that the maximum levels were determined by heating the samples in a 70°C glycerol bath for 30 min, so it was decided to apply these conditions for analysis. The results for fatty acid content at other temperatures were not significantly different.

Determination of fatty acids in vegetable oils

The percentage distribution of fatty acids was determined in all samples of the analysed vegetable oils. The determined amounts are presented in Fig. 2.

In castor oil the main fatty acid is ricinoleic acid (*cis*-12-hidroksioktadec-9-ene acid), but our standard mixture of fatty acids does not have this component, so we did not identify it. The highest content of linoleic acid in castor oil was 42.39 ± 0.78%. Oleic acid also accounts for the highest level, which was found to be 26.7 ± 0.55%. Eicosanoic, margaric and caproic acids were detected in amounts less than 1%.

The results can be compared with studies conducted by other researchers. Huang et al. conducted a study in which fatty acids in castor oil were determined by the gas chromatography method using a mass spectrometer as a detector [19]. Samples were prepared by methylation using BF3-methanol. In addition, isooctane, sodium chloride solution and anhydrous sodium sulfate was added. The highest content of fatty acids in castor oil was found to be ricinoleic acid – 85.75%, linoleic acid 6.05%, oleic acid 4.24%, stearic 1.39%,

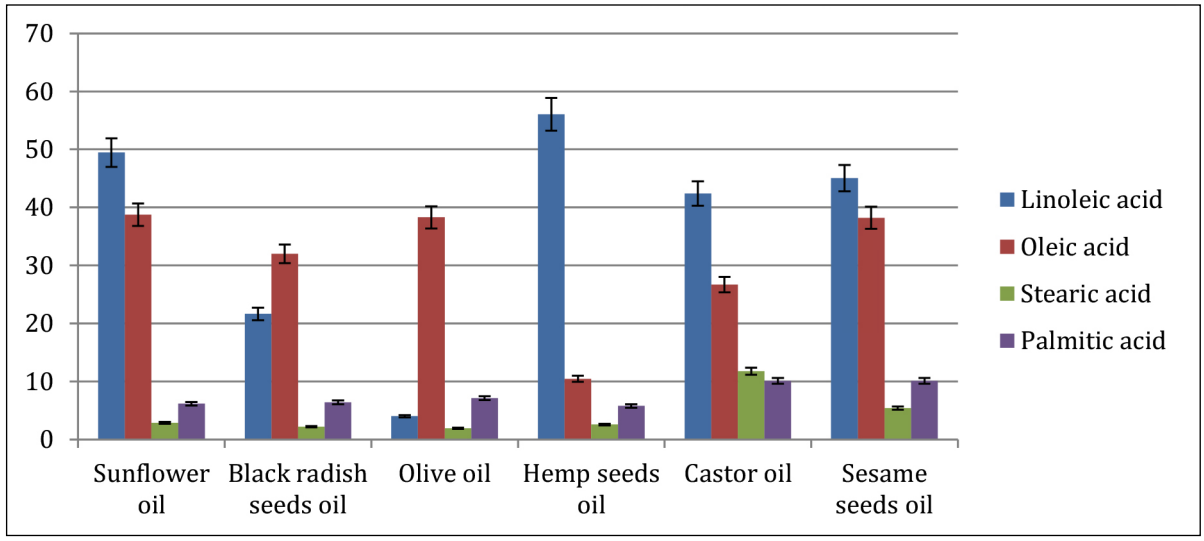

Fig. 2. Comparison of linoleic, oleic, stearic and palmitic acid percentage composition in analysed vegetable oils

palmitic 1.38%, alpha-linolenic acid 0.65%, arachidonic acid 0.48% and arachidic acid 0.06% [19]. Comparing the study by Huang et al. and assessing the results of our work, we can state that the fatty acid composition of castor oil, except for ricinoleic acid, is similar to that described by other scientists [19, 20].

The main fatty acids of sesame seed oil were linoleic 45.05 ± 0.82% and oleic 38.2 ± 0.63% acids. The lowest levels of alpha-linolenic, eicosanoic, arachidonic and palmitoleic acids were detected, which were less than 1%. Orsavova et al. published the analysis of the fatty acid composition of various oils, including sesame seed oil [21]. The determination was performed by gas chromatography using BF3-methanol, using a flame ionization detector, and additionally adding sodium hydroxide in methanol. Sesame seed oil was found to contain 41.5% oleic acid, 40.9% linoleic acid, 9.7% palmitic acid and 6.5% stearic acid. Fatty acids – eicosanoic, eicosenoic, alpha-linolenic, behenic and palmitoleic – were found in amounts below 1% [21]. Comparing the composition of sesame seed oil determined in this study with the composition of the oil studied in the mentioned research, the similarity can be seen. In both studies, linoleic and oleic acids were mainly detected, as well as other fatty acids.

The analysis of black radish seed oil showed the highest amount of oleic acid 31.98 ± 0.53% and linoleic acid 21.65 ± 0.46%. Low amounts (less than 1%) of eicosanoic, eicosadienoic, eicotrienoic, lignoceric and palmitoleic fatty acids were determined.

The analysis of olive oil showed the highest amount of eicotrienoic acid 46.81 ± 0.69% and oleic acid 38.29 ± 0.59%. Low amounts (less than 1%) of linolelaidic, arachidic, butyric, myristic, heptadecanoic and pentadecanoic acids were determined. Wisrasnita et al. conducted a study to determine the composition of olive oil using a modified methylation method [22]. The reagent BF3 in methanol and hexane was also used in the experiment. Additional NaOH in methanol, saturated NaCl solution, petroleum ether was added. The formed organic layer was cleaned using a distillation apparatus. Fatty acids were analysed by gas chromatography using a flame ionization detector. The highest content of fatty acid in olive oil tested by this modified method was oleic acid, which was 77.79 ± 0.17%. The oil also contains palmitic acid, which was found to be 10.82 ± 0.10%. Linoleic and stearic acids were 6.53 ± 0.04%, respectively, and 3.75 ± 0.06%. Myristic and alpha-linolenic acids were also detected [22].

The analysis of sunflower oil showed that linoleic acid is a major part of the fatty acid composition, the amount corresponding to 49.52 ± 0.73%. The oleic acid amount is slightly lower – 38.81 ± 0.65%. The least detectable in the oil are erucic, eicosenoic, behenic and eicotrienoic acids, the amounts of which are less than 1%. Orsavova et al. investigated the fatty acid

composition of sunflower oil and determined 62.2% of linoleic acid, 28.0% of oleic acid, 6.2% of palmitic acid and 2.8% of stearic acid. Margaric, palmitoleic, eicosanoic, eicosenoic and eicotrienoic acids were also detected [21]. Comparing the composition of the oil with the composition of the oil determined in this work, it is similar. It can be stated that the same acids are dominant in different sunflower seeds oil.

The main acids in fibrous hemp seed oil were determined: linoleic acid 56.05 ± 0.84% and alpha-linolenic acid 20.49 ± 0.72%. Eicosadienoic, eicosanoic, eicosenoic and behenic acids were also detected in amounts less than 1%. Kirilan and others performed a fatty acid analysis of fibrous hemp seed oil [23]. Fatty acids were converted to methyl esters and analysed using a gas chromatograph and a flame ionization detector. Fibrous hemp seed oils purchased from various parts of Turkey were investigated. The highest level of linoleic acid was 59.64–55.41%. Alpha-linolenic acid was detected in 20.40–16.51%. The oleic acid content of various types of fibrous hemp seed oils ranged from 15.88 to 11.40%. Palmitic acid varied in the 6.82–6.08% range, and stearic acid varied in the 2.67–2.34% range [23]. Comparing the composition of the oil with the composition of the oil studied in this work, it is similar – linoleic and alpha-linolenic acids predominate.

The following essential acids were found in all vegetable oils: oleic, linoleic, stearic and palmitic. Oleic and linoleic fatty acids are a major part of the oils. Comparing the studied vegetable oils with the studies performed by other researchers, the composition of all oils was similar.

Comparison of fatty acid composition in vegetable oils

The identified fatty acids in each vegetable oil were grouped into the main groups: saturated, monounsaturated and polyunsaturated acids. The determined amounts (percent) are presented in Fig. 3.

The highest content of saturated fatty acids was found in castor oil (24.55 ± 0.28%). The lowest amount of these acids was found in fibrous hemp seed oil (9.16 ± 0.13%). The highest content of monounsaturated fatty acids was detected in black radish seed oil (51.28 ± 0.48%), and the lowest content was found in fibrous hemp seed oil (10.78 ± 0.18%). The highest content of polyunsaturated fatty acids (80.06 ± 0.71%) was found in fibrous hemp seed oil, the lowest content was found in black radish seed oil (39.26 ± 0.38%).

The identified acids were also grouped into omega-3, omega-6 and omega-9 acids and their amounts are presented in Fig. 4.

The highest content of omega-3 acids was found in olive oil (47.09 ± 0.37%). The lowest content of omega-3 acids is in sesame seed oil (0.47 ± 0.02%). The highest content of omega-6 acids (59.57 ± 0.59%) was found in fibrous hemp seed oil. The lowest content of omega-6 acids was found in

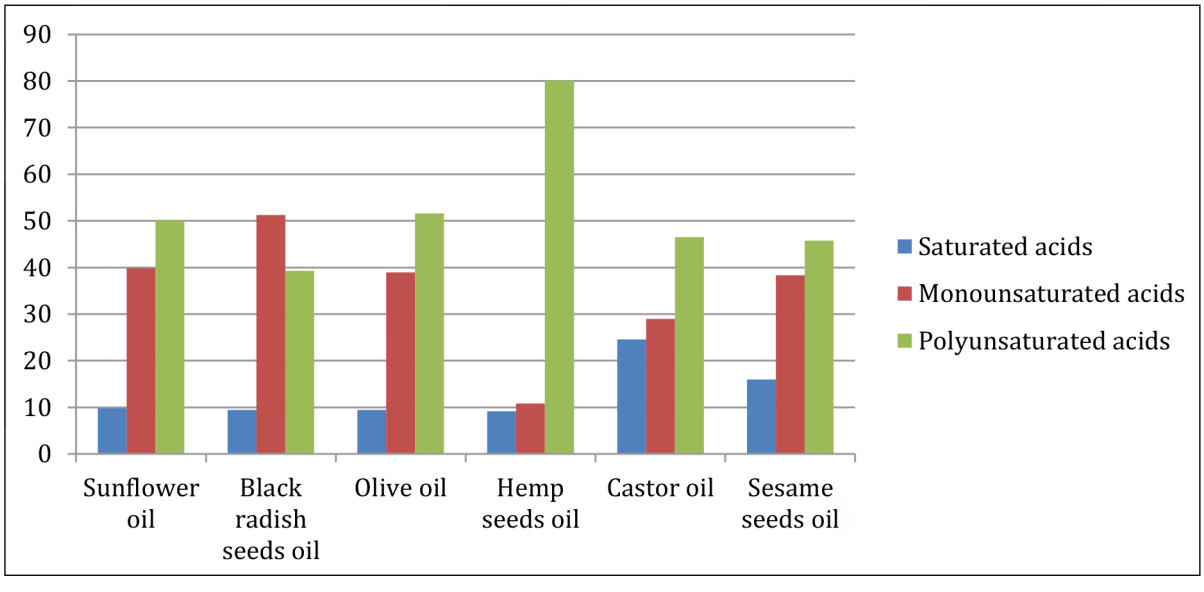

Fig. 3. Comparison of percentage composition for main groups of fatty acids in analysed vegetable oils

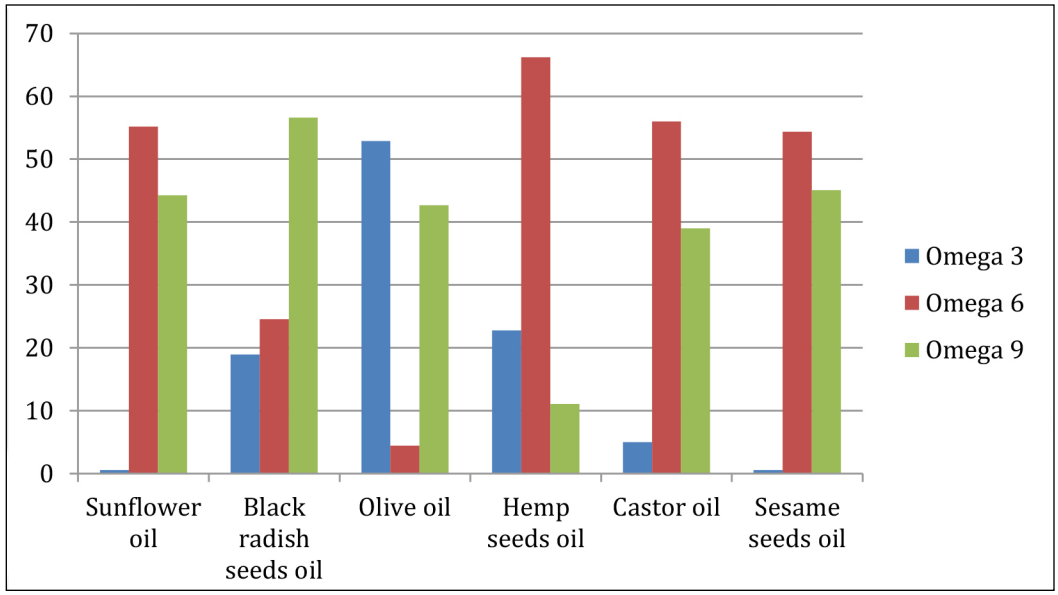

Fig. 4. Comparison of percentage composition for omega-3, omega-6 and omega-9 acids in analysed vegetable oils

olive oil (4.52 ± 0.08%). Omega-9 acids were mostly found in black radish seed oil – 51.11 ± 0.78%. The lowest content of these acids is in fibrous hemp seed oil – 10.78 ± 0.14%.

The ratio of omega-6/omega-3 acids was estimated, which according to the World Health Organization should be from 2:1 to 5:1. The best ratio was found in fibrous hemp seed oil, in which omega-6/omega-3 acids were detected as 3:1. The ratio of omega-6/omega-3 in black radish seed oil was 1:1. The lowest ratios were in sesame (96:1) and sunflower (101:1) oils, which were found to be too high in omega-6 acids. Castor oil has a 10:1 ratio of omega-6/omega-3 acids.

Antioxidant activity

Antioxidant activity of oils was determined using DPPH and ABTS free radicals and the results are presented in Fig. 5. In the test of antioxidant activity by the DPPH method, the highest activity was observed for sunflower oil – 73.1 ± 3.1% of inhibition. Sesame oil had the lowest 46.1 ± 1.9% antioxidant activity and other tested oils had the same percentage (about 66%). In the ABTS method the highest antioxidant activity was in hemp seed oil – 87.7 ± 2.2% and in olive oil – 86.9 ± 1.6%. The lowest activity was determined for sunflower oil – 54.9 ± 4.1%. There was a statistically significant difference between these methods ($p < 0.05$).

A review by other researchers has noted a high antioxidant activity of castor oil, which may be due to the ricinoleic acid content of the oil [24]. The antioxidant activity of castor oil determined in this work by DPPH method was 63.7 ± 2.1%, and by ABTS method 73.9 ± 1.9%. Comparing these results with other research antioxidant activity was about 30% for castor oil and about 20% for olive oil by DPPH method [25], so it can be stated that the origin and quality of oils can affect their biological activity. The antioxidant activity of black radish seed oil using DPPH method was 67.9 ± 4.9% and using ABTS method it was 59.5 ± 4.0%. The results of the determination of the antioxidant activity of black radish seed oil by the method of DPPH using methanol as a solvent in Bors's publication ranged from 34.95 to 44.79% [26]. The antioxidant activity of fibrous hemp seed oil was 65.5 ± 4.5% by DPPH method and 87.7 ± 2.2% by ABTS method. Siger et al. conducted a study examining the antioxidant activity of fibrous hemp seed oil. One of these methods was DPPH, in which methanol was used as the solvent, and the antioxidant activity was found to be 76.2% [27]. Both methods of antioxidant activity determination showed that the compounds in the oils have a high activity. The results differed between the methods due to the possible involvement of different substances in the coupling of DPPH and ABTS free radicals [28]. Comparing the results, we can see that the ABTS method is more sensitive than DPPH. Determination using the ABTS method gives higher results of antioxidant activity.

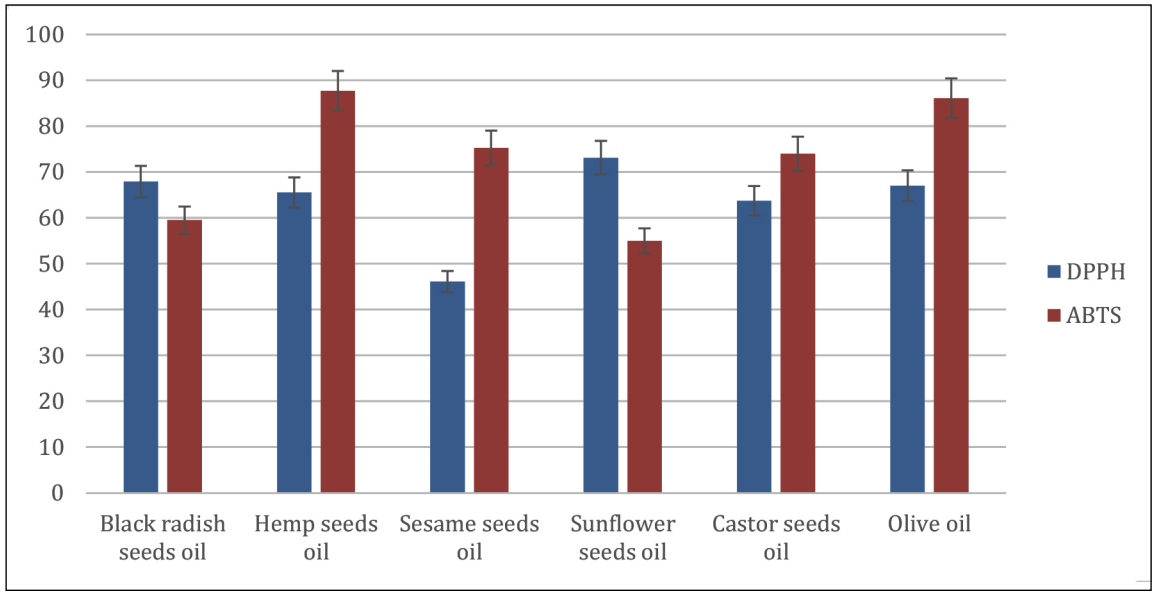

Fig. 5. Comparison of the antioxidant activity tested by DPPH and ABTS methods for analysed vegetable oils

One goal of this study was to calculate a correlation between the amounts of fatty acids in oils and the results of antioxidant activity using two different methods (ABTS and DPPH). The total amounts of polyunsaturated, monounsaturated and saturated acids, omega-9, omega-6 and omega-3, as well as the amounts of linoleic, oleic, stearic and palmitic acids were evaluated, as these acids were detected in all oils tested. The calculated coefficients did not show a clear correlation between indicators and the dominant data presents a weak correlation (Table 3). The correlation between the antioxidant activity determined by the DPPH method and the amount of polyunsaturated fatty acids was weak $r = 0.13$, but strongly associated with the amount of palmitic fatty acid $r = -0.74$. The positive correlation $r = 0.61$ was determined between the antioxidant activity using the ABTS method and the total amount of polyunsaturated fatty acids and the amount of omega-3 acids.

The significant positive correlation (about 0.7) between the antioxidant DPPH activity and the proportions of unsaturated and polyunsaturated fatty acids was determined in the Grela et al.

Table 3. **Correlation between the total amounts of polyunsaturated, monounsaturated and saturated acids; omega-9, omega-6 and omega-3 amounts; individual amounts of linoleic, oleic, stearic and palmitic acids, and the antioxidant activity determined by DPPH and ABTS methods**

Indicator	Correlation coefficient (r)	
	AA* using DPPH method	AA* using ABTS method
Polyunsaturated acids	0.13	0.61
Monounsaturated acids	0.04	–0.65
Saturated acids	–0.4	0.04
Omega-9	0.04	–0.66
Omega-6	–0.17	–0.09
Omega-3	0.29	0.59
Linoleic acid	–0.18	–0.13
Oleic acid	–0.12	–0.46
Stearic acid	–0.30	0.02
Palmitic acid	–0.74	0.12

* AA is antioxidant activity.

study [29]. In contrast, no correlation between the fatty acids content and DPPH antioxidant activity was reported in the investigations carried out by Zhang et al. [30]. Concluding the results of this study, we suggest that the antioxidant activity of tested oils can be related to other groups or individual components with biological activity.

CONCLUSIONS

Fatty acids in the analysed oils were identified and quantified by gas chromatography. The predominant acids in all oils studied are oleic and linoleic fatty acids. The amounts of saturated fatty acids and unsaturated omega-3, omega-6 and omega-9 acids in oils were analysed and compared. The best ratio of omega-6 to omega-3 acids was found in fibrous hemp seed oil – 3:1. Polyunsaturated fatty acids were determined as a dominant class and varied in the 80.06–39.26% range. Statistically different results of the antioxidant activity for the analysed oils were determined by two spectrophotometric methods – DPPH and ABTS. All oils inhibited more than 46% of free radicals what confirms valuable bioactive compounds. The highest antioxidant activity was found for the fibrous hemp seed and olive oils (88 and 87%) using an ABTS reagent.

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RIEBALŲ RŪGŠČIŲ SUDĖTIES IR ANTIOKSIDACINIO AKTYVUMO NUSTATYMAS AUGALINIUOSE ALIEJUOSE

S a n t r a u k a

Tikslinga atlikti augalinių aliejų sudėties tyrimus siekiant išsiaiškinti kokybiškų produktų modelį. Šio tyrimo tikslas buvo įvertinti riebalų rūgščių sudėtį naudojant dujų chromatografiją (DC) ir antioksidacinį aktyvumą, taip pat DPPH ir ABTS spektrofotometrinius metodus. Analizei pasirinkti ricinos, saulėgrąžų, sezamo, kanapių, juodųjų ridikų sėklų ir alyvuogių aliejai. Nustatytos skirtingos riebalų rūgščių klasės: polinesočiosios, mononesočiosios ir sočiosios; omega-3, omega-6 ir omega-9 rūgštys bei atskiros riebalų rūgštys. Tyrimo rezultatai parodė, kad visuose aliejuose dominavo oleino ir linolo riebalų rūgštys. Geriausias omega-6 ir omega-3 rūgščių santykis nustatytas pluoštinių kanapių sėklų aliejuje – 3 : 1. Visi analizuoti augaliniai aliejai pasižymėjo dideliu antioksidaciniu aktyvumu.