Bulgarian Chemical Communications, Volume 46, Number 3 (pp. 465 – 472) 2014

Lipid composition of flaxseeds

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Received July 4, 2013; Revised August 12, 2013

The content and composition of glyceride oil of four genotypes of flaxseeds (A900013, A900015, A900017 and A900018) were investigated with a view to their application as food or as a source of oil for technical and pharmaceutical purposes. The flaxseeds contain 34.2 %, 39.1 %, 37.2 % and 44.4 % glyceride oil, respectively. The content of phospholipids, mainly phosphatidylcholine, phosphatidylinositol and phosphatidylethanolamine of the four varieties was 0.9 %, 0.8 %, 1.0 % and 0.6 %, respectively. The total amounts of sterols were found to be 0.2 - 0.3 % in all oils. β-Sitosterol predominated (more than 55.0 %), followed by campesterol (13.1 - 26.1 %) and stigmasterol (3.4 - 15.0 %). In the tocopherol fraction analyzed by high performance liquid chromatography γ-tocopherol predominated (766 mg/kg, 770 mg/kg, 775 mg/kg and 602 mg/kg, respectively), followed by γ-tocotrienol. In the triacylglycerols linolenic acid predominated (37.6 %, 33.5 %, 42.9 % and 45.8 %, respectively), followed by oleic and linoleic acids. Higher quantities of palmitic and oleic acids were established in the phospholipids and the sterol esters than in the triacylglycerols.

Keywords: flaxseed glyceride oil, fatty acids, phospholipids, sterols, tocopherols.

INTRODUCTION

The plant linen (flax) *Linum usitatissimum* L., fam. Linaceae has been cultivated as a source of fibers and glyceride oil since antiquity in West Asia and the Mediterranean. The flaxseeds are the richest ones in glyceride oil which has been used as food, for medicinal purposes to treat inflammatory and vascular problems, for manufacturing of paints, linoleum, varnishes, etc. [1 - 3]. The oil contains polyunsaturated fatty acids, as linolenic (ω - 3) and linoleic (ω - 6) acid. The beneficial effect of flaxseed oil on coronary heart disease, tumours, hormonal diseases and the usage of the oil as a food supplement is due to linolenic acid [1, 4 – 8, 11].

The content of oil in the seeds is about 40.0 % according to several reports [2, 9, 10, 12]. The fatty acid profile varies depending on the conditions of growth. In the triacylglycerol fraction, predominant is the α-linolenic acid (50.0 - 60.0 % according to [2, 3, 8, 11, 13 – 19, 21], 30.0 - 50.0 % according to El-Beltagi *et al.* [1], Herchi *et al.* [20]). Other major components are the oleic acid (about 30.0 %) and the linoleic acid (10.0 - 20.0 %). The oil contains relatively low quantities of saturated palmitic acid (5.0 - 7.0 %) and stearic acid (3.0 - 6.0%) [1 - 3, 13, 15, 17 - 21].

Besides triacylglycerols, other micro components, such as phospholipids, sterols and tocopherols, are of great significance for estimating the food value of the flaxseed oil.

Sterols are present in the oil in a relatively lower amount (about 0.2 - 0.4%) [19, 22]. β-Sitosterol is the main component (more than 50.0 %), followed by campesterol, stigmasterol and Δ^5- avenasterol [3, 12].

The total content of phospholipids, mainly phosphatidylcholine, phosphatidylinositol and phosphatidylethanolamine was found to be 1.0 - 1.5 % [19].

According to Przybylski [3], Bozan and Temelli [16], and Gunstone [22], the total amount of tocopherols in the oil was found to be 300 - 700 mg/kg. γ-Tocopherol predominates in the tocopherol fraction (more than 70.0 %), α-tocopherol and γ-tocotrienol are also detected.

In the present investigation we have attempted to characterize the composition of seeds, the fatty acid composition of triacylglycerols; the main individual phospholipids and sterol esters; the content and composition of sterols, phospholipids, tocopherols, free and esterified sterols of glyceride oils recovered from seeds of four Bulgarian flax genotypes with a view to their implementation in breeding programs focused on the usage of flax seeds as a source of food oil, as well as for technical and pharmaceutical purposes.

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MATERIALS AND METHODS

All solvents and reagents were of analytical grade and were used without additional purification. Reference phospholipids and fatty acid methyl esters were purchased from Fluka (Chemie Gmbh, Switzerland). Reference tocopherol isomers and individual sterols were purchased from Merck (Darmstadt, Germany). Thin-layer chromatography (TLC) plates were prepared in the laboratory using silica gel 60 G (Merck, Darmstadt, Germany).

Samples. Four genotypes of *Linum usitatissimum* L. - *A900013* - *var. elatum-multicaule, A900015 and A900017* - *var. usitatissimum* and *A900018* - *var. caesium* were cultivated in a trial field of the IPGR Sadovo - Southern Bulgaria in 2011. The accessions are local landraces and were obtained by expeditions in Bulgaria. Characterization, evaluation and conservation were executed at the National genebank in IPGR Sadovo. They are representative for the various purposes of the plant: *A900013* may be used as primary technical crop for fibre production, *A900018* is an oil crop, *A900015* and *A900017* are intermediate species for both usages. Standard crop production system was applied.

Isolation of glyceride oil and determination of the oil content. The seeds (20 g sample) were air-dried (10 % humidity). The humidity was determined by drying at 105^0C to constant weight. Flaxseed oil was extracted from finely ground seeds with hexane in a Soxhlet apparatus for 8 h [23]. After extraction the solvent was removed in a rotary vacuum evaporator and the oil was determined by weight.

Fatty acids. Fatty acid composition of triacylglycerols and sterol esters was determined by gas chromatography (GC) of fatty acid methyl esters (FAME) [24]. FAME were prepared by pre-esterification with sulfuric acid in methanol as catalyst [25] and were purified by TLC on silica gel 60 G with mobile phase hexane : acetone = 100 : 8 (by volume). The operating conditions were as follows: GC HP 5890 gas chromatograph (Hewlett Packard GmbH, Austria) equipped with 60 m × 0.25 mm × 0.25 μm DB – 23 column (Agilent Technologies, Santa Clara CA, USA) and flame ionization detector. The temperature gradient was: 130^0C for 1 min, 130 - 170^0C at 6.5^0C/min, 170 - 215 ^{0}C at 30^0C/min, 215^0C for 9 min, 215 - 230^0C at 40^0C/min to 230^0C for 1 min. Hydrogen was the carrier gas, split 100 : 1. The temperature of detector and injector was kept at 270^0C. Identification of fatty acids was performed by comparison with a standard mixture of FAME.

Phospholipids. The phospholipid composition was determined following a previously reported procedure [26]. The air-dried seeds were subjected to Folch extraction [25]. Polar lipids were isolated from the total lipids by column chromatography. Briefly, the sample (100 mg) was applied on a 40 cm × 2 cm glass column packed with silica gel Unisil 100 - 200 mesh (Clarkson Chemicals Co., USA) and was eluted in sequence with chloroform (for neutral lipids, sterols and sterol esters), and methanol (for phospholipids). The phospholipid classes were isolated by two-dimensional thin-layer chromatography on 20 cm × 20 cm glass plates with 0.2 mm Silica gel 60 G layer impregnated with aqueous $(NH_4)_2SO_4$ (1.0 %). In the first direction the plate was developed with chloroform : methanol : ammonia, 65 : 25 : 5 and in the second – with chloroform : acetone : methanol : acetic acid : water, 50 : 20 : 10 : 10 : 5 (by volume) [27]. The individual phospholipids were detected and identified by spraying with specific reagents [25]: Dragendorff test (detection of choline-containing phospholipids); ninhydrin spray (for phospholipids with free amino groups), and Shiff's reagent (for inositol containing phospholipids). Additional identification was performed by comparing the respective R_f values with those of authentic commercial standards subjected to silica gel TLC under identical experimental conditions. The quantification was carried out spectrophotometrically against a calibration curve by measuring the phosphorus content at 700 nm after scrapping the respective phospholipid spot and mineralization of the substance with a mixture of perchloric acid and sulphuric acid, 1:1 (by volume). The calibration curve was constructed by using a standard solution of KH_2PO_4 (1 - 130 μg/ml, as phosphorus).

Sterols. The glyceride oil (sample size of 100 mg) was applied on 20 cm × 20 cm glass plates (1 mm thick silica gel G layer) and was developed with n-hexane : acetone, 100 : 8 (by volume). Free (R_f = 0.4) and esterified sterols (R_f = 0.8) were detected under UV light by spraying the edges of each plate with 2′,7′- dichlorofluorescein, they were then scraped, transferred to small glass columns and eluted with diethyl ether. The solvent was evaporated under a stream of nitrogen and the residue was weighed in a small glass container to a constant weight. Free sterols were then subjected to GC without derivatization. Sterol esters were hydrolyzed with ethanolic KOH, sterols were extracted with n-hexane and purified by TLC under the above conditions prior to GC analysis [28]. The sterol composition was determined on a HP 5890

gas chromatograph (Hewlett Packard GmbH, Austria) equipped with a 30 m × 0.25 mm DB – 5 capillary column (Agilent Technologies, Santa Clara CA, USA) and flame ionization detector. The temperature gradient varied from 90ºC (hold 2 min) up to 290ºC at a rate of 15ºC/min and then up to 310ºC at a rate of 4ºC/min (hold 10 min); the injector temperature was 300ºC and the detector temperature was 320ºC. Hydrogen was the carrier gas at a flow rate of 0.8 ml/min; split 100:1. Identification was confirmed by comparison of retention times with those of a standard mixture of sterols.

Tocopherols. High performance liquid chromatography (HPLC) on a Merck-Hitachi (Merck, Darmstadt, Germany) instrument equipped with 250 mm × 4 mm Nucleosil Si 50-5 column (Merck, Darmstadt, Germany) and fluorescent detector Merck-Hitachi F 1000 was used directly in the oil for determination of the total content and the individual composition of tocopherols [29]. The operating conditions were as follows: mobile phase of n - hexane : dioxane, 96 : 4 (by volume), flow rate 1 ml/min, excitation 295 nm, emission 330 nm. A 20 μl solution of crude oil (2.0 %) was injected. Tocopherols were identified by comparing the retention times with those of authentic individual pure tocopherols. The tocopherol content was calculated based on the tocopherol peak areas in the sample *vs.* tocopherol peak area of a standard tocopherol solution.

Statistical analysis. All analyses were made in triplicate. Statistical differences between samples were tested using ANOVA. Data were expressed as mean ± SD. The level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION

General characteristics of the seeds and oils

The content of oil in the seeds and the main lipid components are shown in Table 1.

The highest oil content (44.4 %) was found to be in the *A900018* flaxseed variety. The other studied species contain quantities close to the data reported earlier [2, 10]. The phospholipid content (0.6 - 1.0 %) and the sterol value are lower than the data reported by Piłat and Zadernowski [19] and Gunstone [22]. Tocopherol content is higher than results found in other varieties of flax seed oils excluding *A900018* where the content is the same as reported earlier [19, 22].

Fatty acid composition of triacylglycerols

Fatty acid composition of triacylglycerols is presented in Table 2.

The qualitative and quantitative composition of all investigated oils is different. The main components are linolenic, oleic and linoleic acids. The content of linolenic acid in the A900018 flaxseed oil (45.8%) is higher than that of other species at the expense of a lower level of oleic acid. This quantity is lower than the values reported by Bera et al. [15] – 50.0 - 60.0 %, but very close to the data announced earlier by El-Beltagi et al. [1], and Herchi et al. [20] – 30.0 - 50.0 %. In addition, flax oil contains 15.2 - 17.8 % of the important omega-6 linoleic acid (all cis-9,12 – C18:2), which

Table 1 Oil content in the seeds and content of biologically active compounds in glyceride oils

№	Compounds	Varieties			
		A900013	*A900015*	*A900017*	*A900018*
1	Oil content, % wt	34.2 ± 0.7	39.1 ± 0.8	37.2 ± 1.5	44.4 ± 1.3
2	Phospholipids, % wt	0.9 ± 0.01	0.8 ± 0.01	1.0 ± 0.04	0.6 ± 0.01
3	Sterols, % wt				
	Free Sterols	0.26 ± 0.01	0.20 ± 0.01	0.26 ± 0.01	0.14 ± 0.01
	Est. Sterols	0.07 ± 0.002	0.03 ± 0.006	0.04 ± 0.008	0.04 ± 0.008
4	Tocopherols, mg/kg	766 ± 22	770 ± 31	775 ± 31	602 ± 25
5	Triacylglycerols, % wt	98.8±1.3	99.0±1.3	98.7±1.1	99.2±1.1

Table 2. Fatty acid composition of triacylglycerols*, % wt

Fatty acids, % wt	Varieties			
	A900013	*A900015*	*A900017*	*A900018*
$C_{8:0}$	n.d.	0.1 ± 0.03	n.d.	n.d.
$C_{10:0}$	n.d.	0.1 ± 0.03	n.d.	n.d.
$C_{12:0}$	n.d.	0.1 ± 0.02	n.d.	0.1 ± 0.03
$C_{14:0}$	0.2 ± 0.04	0.1 ± 0.02	0.1 ± 0.02	0.1 ± 0.05
$C_{14:1}$	0.1 ± 0.03	n.d.	n.d.	n.d.
$C_{15:0}$	n.d.	n.d.	n.d.	n.d.
$C_{16:0}$	9.0 ± 0.3	10.4 ± 0.2	8.4 ± 0.2	7.7 ± 0.2
$C_{16:1}$	0.1 ± 0.02	0.2 ± 0.06	0.1 ± 0.04	0.1 ± 0.02
$C_{17:0}$	0.1 ± 0.04	0.1 ± 0.03	0.1 ± 0.04	0.1 ± 0.02
$C_{18:0}$	4.8 ± 0.2	5.7 ± 0.3	4.0 ± 0.1	5.5 ± 0.2
$C_{18:1}$	30.6 ± 0.6	31.6 ± 0.6	28.8 ± 0.9	24.6 ± 0.7
$C_{18:2}$	17.5 ± 0.7	17.8 ± 0.7	15.2 ± 0.6	15.6 ± 0.6
$C_{18:3}$	37.6 ± 1.1	33.5 ± 1.1	42.9 ± 0.9	45.8 ± 1.4
$C_{20:0}$	n.d.	n.d.	0.1 ± 0.03	0.2 ± 0.04
$C_{20:1}$	n.d.	n.d.	0.3 ± 0.06	0.2 ± 0.04
$C_{20:2}$	n.d.	n.d.	n.d.	n.d.
$C_{22:0}$	n.d.	0.3 ±0.02	n.d.	n.d.
SFA	14.1	16.9	12.7	13.7
MUFA	30.8	31.8	29.2	24.9
PUFA	55.1	51.3	58.1	61.4

*Average of three determinations, n.d. – not detected, SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids

increases the content of essential fatty acids to over 50.0 %. The amount of oleic acid varies in the interval 24.6 - 31.6 %. The total content of saturated fatty acids is 12.7-16.9%, mainly palmitic and stearic acids, while $C_{12:0}$, $C_{14:0}$, $C_{16:1}$, $C_{20:0}$, $C_{20:1}$, and $C_{22:0}$ were found around 0.1 - 0.3 %. The total quantity of the saturated fatty acids is also close to the literature data [1, 15]. Some differences in the triacylglycerol composition between obtained and reported data can be explained by different agricultural, mainly temperature conditions, for the cultivation of the plants.

Phospholipids

The phospholipid composition of flaxseeds is presented on Figure 1.

Phospholipids comprise the main classes typical for plant oils, with phosphatidylcholine (PC) (26.1 %, 42.8 %, 36.8 % and 35.7 %, respectively) and phosphatidylinositol (PI) (38.8 %, 35.5 %, 40.1 % and 37.5 %, respectively) as main components followed by phosphatidylethanolamine (PEA), phosphatidic acids (PA), diphosphatidylglycerol

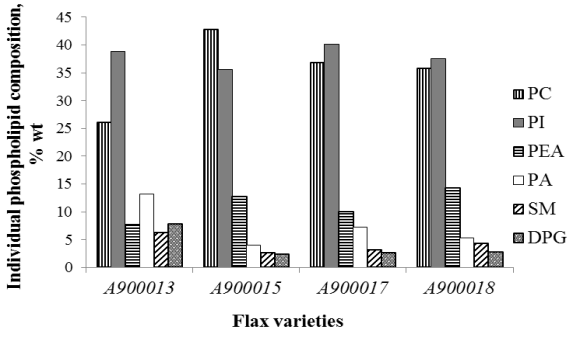

Fig.1 Phospholipid composition of flax seed oils, % wt
PC – Phosphatidylcholine; PI – Phosphatidylinositol; PEA – Phosphatidylethanolamine; PA – Phosphatidic acids; SM – Sphingomyelin; DPG – Diphosphatidylglycerol

and sphingomyelin. These percentages are different from the data reported earlier by Herchi *et al.* [20] where the content of phosphatidylcholine was 7.0 - 18.0 %; of phosphatidylinositol – 29.0 - 32.0 % and of phosphatidylethanolamine – 27.0 - 40.0 %.

Figure 2 presents the fatty acid composition of the individual phospholipid classes.

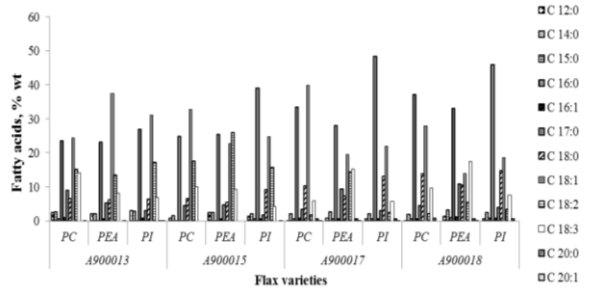

Fig. 2 Fatty acid composition of individual phospholipid classes:
PC – Phosphatidylcholine; PI – Phosphatidylinositol*;* PEA – Phosphatidylethanolamine

The qualitative fatty acid profile of the separate individual phospholipids is similar, but the quantitative composition is different. Palmitic acid was found to be the main component in all phospholipid classes (23.3 - 48.5 %), followed by oleic acid (14.0 - 39.8 %). Linoleic and linolenic acids are found in relatively low contents. Highest content of saturated fatty acids, mainly palmitic and stearic was observed in phosphatidylinositol (43.5 - 69.7 %), while their values in phosphatidylcholine and phosphatidylethanolamine are relatively lower (39.1 - 59.6 % and 39.7 - 61.1 %, respectively) at the expense of a higher level of linolenic acid. Significant quantities of monounsaturated fatty acids were established in phosphatidylcholine (25.6 - 41.0 %) and of polyunsaturated fatty acids in phosphatidylethanolamine (21.7 - 35.3 %).

Sterols

Free sterols comprise more than 75.0 % of the total sterols as β-sitosterol (54.8 - 72.9 %) being the main component in all four varieties and in both free and esterified sterol fractions. Campesterol (13.1 – 26.1 %) and stigmasterol (3.4 – 15.0 %) are next main components in free sterols and sterol esters (Figure 3).

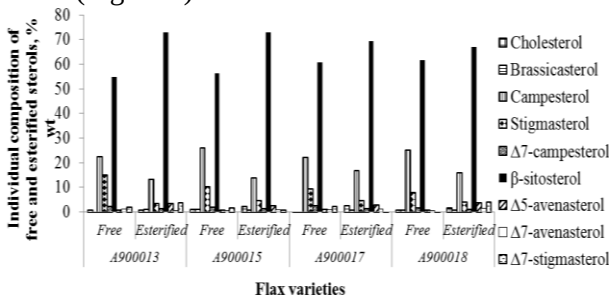

Fig. 3 Individual composition of free and esterified sterols

Free sterols and sterol esters have the same individual composition but quantitative differences between the components. Thus, the content of campesterol is higher in free sterols (22.1 - 26.1 % *vs*. 13.1 - 16.8 %) than in sterol esters. Stigmasterol also substantially predominates in free sterols (8.0 - 15.0 %) than in sterol esters (3.4 - 4.7 %). On the other hand the quantity of β-sitosterol is significantly higher in sterol esters than in the free sterol fraction (72.9 % *vs*. 54.8 %, 72.8 % *vs*. 56.3 %, 69.2 % *vs.* 60.6 % and 67.0 % *vs*. 61.5 %, respectively). In agreement with recent data for other plant oils (Herchi *et al.* [32]; Phillips *et al.* [30]; Alasalvar *et al*. [31]), minor amounts of cholesterol are detected in free and esterified sterols of all four samples and in each analyzed variety. The content of cholesterol in sterol esters is higher than in free sterols (0.8 - 2.5 % *vs*. 0.6 - 1.1 %). The presence of cholesterol is believed to be a result of the same biosynthetic pathway as that of plant sterols, i.e. *via* cycloartenol as a key intermediate.

Twelve fatty acids were identified in sterol esters (Table 3), oleic acid being the major component (43.5 %, 39.8 %, 42.7 % and 38.0 %, respectively), followed by palmitic acid (32.9 %, 34.6 %, 29.2 % and 31.3 %, respectively) and stearic acid (8.2 %, 14.9 %, 16.0 % and 20.5 %, respectively). Linolenic and linoleic acids vary between 0.3 - 1.3 % and 0.3 -1.5 %, respectively.

Tocopherols

The tocopherol composition is given in Table 4 and results show that these are represented mainly by γ-tocopherol (over 65.0 %), followed by γ-tocotrienol (~ 30.0 %) and minor amounts of α-tocopherol. These results about qualitative composition are similar to data reported earlier [3, 16], but the content of γ-tocotrienol is significantly higher than in other investigated flax seed oils.

Fatty acid composition and distribution of fatty acids between the lipid classes

Figure 4 presents the ratio of unsaturated *vs.* saturated fatty acids in each lipid class (phospholipids are presented with an average value) outlining the respective relative unsaturation (saturation) of triacylglycerols, sterol esters and phospholipids.

The picture clearly shows that among the lipid classes studied, triacylglycerols are the most highly unsaturated where the content of polyunsaturated acids was found to be more than 50.0 %, followed by monounsaturated acids – about 30.0 %.

Table 3 Fatty acid composition of esterified sterols, wt %

Fatty acids, % wt	Varieties			
	A900013	*A900015*	*A900017*	*A900018*
$C_{14:0}$	9.1 ± 0.3	3.1 ± 0.1	2.8 ± 0.2	2.2 ± 0.3
$C_{14:1}$	0.4 ± 0.01	0.4 ± 0.01	2.9 ± 0.1	1.3 ± 0.1
$C_{15:0}$	1.0 ± 0.2	0.6 ± 0.01	0.6 ± 0.01	0.6 ± 0.01
$C_{16:0}$	32.9 ± 1.3	34.6 ± 1.4	29.2 ± 0.9	31.3 ± 1.1
$C_{16:1}$	0.8 ± 0.02	0.9 ± 0.02	0.8 ± 0.02	0.5 ± 0.01
$C_{17:0}$	0.3 ± 0.01	0.5 ± 0.01	0.6 ± 0.02	0.8 ± 0.03
$C_{18:0}$	8.2 ± 0.3	14.9 ± 0.5	16.0 ± 0.5	20.5 ± 0.6
$C_{18:1}$	43.5 ± 0.9	39.8 ± 1.2	42.7 ± 1.3	38.0 ± 0.8
$C_{18:2}$	0.3 ± 0.01	1.5 ± 0.1	1.4 ± 0.4	0.5 ± 0.01
$C_{18:3}$	0.6 ± 0.01	1.3 ± 0.1	0.3 ± 0.01	0.5 ± 0.01
$C_{20:0}$	2.0 ± 0.1	1.4 ± 0.2	2.1 ± 0.2	3.1 ± 0.1
$C_{20:2}$	0.8 ± 0.02	1.0 ± 0.03	0.6 ± 0.01	0.7 ± 0.02
SFA	53.5	55.1	51.3	58.5
MUFA	45.5	41.1	46.4	39.8
PUFA	1.0	3.8	2.3	1.7

SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids

Table 4 Individual tocopherol composition of flax seed oils, % wt

Tocopherols, % wt	Varieties			
	A900013	*A900015*	*A900017*	*A900018*
α-Tocopherol	1.2 ± 0.1	1.8 ± 0.1	0.6 ± 0.1	4.8 ± 0.1
γ-Tocopherol	69.6 ± 2.1	67.6 ± 2.7	67.3 ± 1.3	68.8 ± 2.7
γ-Tocotrienol	29.2 ± 1.2	30.6 ± 0.7	32.1 ± 0.8	26.4 ± 0.6

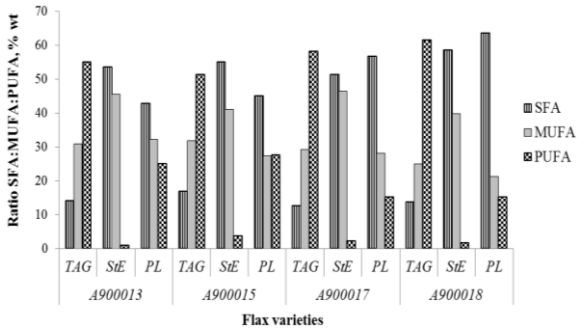

Fig. 4 Distribution of fatty acid classes in triacyglycerols, sterol esters and phospholipids
SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; TAG – triacylglycerols; StE – sterol esters; PL – phospholipids

Monounsaturated and saturated acids predominate in the sterol ester fraction while polyunsaturated acids were detected in small quantities. The saturated fatty acids were found in high amounts (42.8 – 63.5 %) in phospholipids. The same trend was found for other oils – sunflower oil [33], walnut, hazelnut, almond oils [34], tomato seed oil [35] displaying the lipid features outlined above.

Finally, some rare or uncommon fatty acids (at amounts of approximately 1.0 %) were identified and quantified in the sterol esters and phospholipids (purified by TLC and preconcentrated prior to analysis): $C_{12:0}$, $C_{14:1}$, $C_{15:0}$ and $C_{17:0}$. Evidently, these could not be detected in the total fatty acid composition because the quantities were below the detection limits of the GC-FID system in use (note the low content of these fatty acids and the low content of sterol esters and phospholipids in the oil). These fatty acids, especially with odd chain, are considered not typical for plants and are rarely

and only recently detected when a detailed analysis of individual lipid classes has been performed. In conclusion, the quantitative fatty acid composition is specific for each phospholipid and sterol ester species in a given variety and differs between the same phospholipid species.

CONCLUSION

The lipid composition of the investigated flax seeds (oil content in the seeds, triacylglycerols, phospholipids, sterols, tocopherols in the oils) has some quantitative differences as a result of the genotype, climatic, agrometeorologic conditions, but these differences are not significant between the separate varieties and data from earlier investigations. The fatty acid composition of the separate lipid classes: triacylglycerols, phospholipids and sterols is various which is due to different stages of the biosynthesis of fatty acid and respective substances. The obtained information can be useful for estimation of the food value of the flaxseed oils with a view to future flax breeding programs.

Acknowledgements: *The investigations were carried out with the partial financial support of the Science Research Department to Plovdiv University "Paisii Hilendarski", contract SI 13FC 006/2013*

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ЛИПИДЕН СЪСТАВ НА ЛЕНЕНИ СЕМЕНА

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Постъпила на 4 юли 2013 г.; коригирана на 12 август 2013 г.

(Резюме)

Изследвани са съдържанието и съставът на глицеридно масло, изолирано от четири генотипа ленени семена (A900013, A900015, A900017 и A900018) с оглед тяхното приложение като храна и като източник на масло за технически и фармацевтични цели. Ленените масла съдържат 34,2%, 39,1%, 37,2% и 44,4% глицеридно масло. Съдържанието на фосфолипиди, основно на фосфатидилхолин, фосфатидилинозитол и фосфатидилетаноламин на четирите сорта е съответно 0,9%, 0,8%,1,0% и 0,6%. Във всички масла общото съдържание на стероли е 0,2 – 0,3%, като бета-ситостерол преобладава (повече от 55,0%), следвано от кампестерол (13,1 – 26,1%) и стигмастерол (3,4 – 15,0%). Във фракцията токофероли (общо съдържание 766 мг/кг, 770 мг/кг, 775 мг/кг и 602 мг/кг), анализирана с високоефективна течно-течна хроматография, гама-токоферолът преобладава, следвано от гама-токотриенол. В триацилглицеролите основен компонент е линоленовата киселина (37,6%, 33,5%, 42,9% и 45,8%), следвана от олеинова и линолова киселина. В сравнение с триацилглицеролите, по-високи количества палмитинова и олеинова киселина, са установени във фосфолипидната фракция и в стероловите естери.