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OIL CONTENT AND FATTY ACID PROFILE IN SEEDS OF POLISH BREEDING LINES AND CULTIVARS OF LEGUMES

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Abstract. Current studies aimed at replacing soya bean meal with other legumes should take into consideration not only protein content and quality, but also the content and quality of oil. The aim of this study was to assess the Polish breeding lines and cultivars of yellow, blue and white lupine, faba bean as well as hairy and common vetch with regard to their raw oil (crude fat) content and fatty acid profile. The study involved 9 lines and cultivars of yellow lupine and 8 of blue lupine, 2 cultivars of white lupine, 2 cultivars of faba bean, 1 cultivar of hairy vetch and 1 cultivar of common vetch. The content of oil in seeds of the yellow lupine lines and cultivars was within the range 5.1-6.6%, blue lupine 6.2-6.9%, white lupine 9.3-10.6%, faba bean 1.7-1.8%, hairy vetch 1.2% and common vetch 1.1%. Linoleic acid was the main fatty acid in the faba bean, hairy and common vetch and in most of the yellow lupine genotypes oils. Oleic acid dominated in the white lupine oil, whereas in the blue lupine oil linoleic and oleic acids occurred usually in similar quantities. The highest content of α-linolenic acid was in the two vetch species (8.4-8.5%), the next highest in white lupine (6.8-7.6%) and yellow lupine (5.4--9.0%) with the lowest in faba bean (3.2-5.8%) and blue lupine (3.2-5.2%). Yellow lupine genotypes were more differentiated in respect of their oil content, α-linolenic acid and the value of the n-6/n-3 acids ratio than were the blue lupine genotypes.

Key words: α-linolenic acid, crude fat, linoleic acid, *Lupinus*, vegetable oil, *Vicia*

INTRODUCTION

Specialists in human and animal nutrition recommend vegetable oils because of their usually high content of unsaturated acids: oleic, linoleic (LA C18:2, n-6) and alpha-linolenic (ALA C18:3, n-3). The ratio of n-6/n-3 (omega-6/omega-3) fatty acids is an important determinant in decreasing the risk of coronary heart and other chronic

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diseases and the most desirable ratio is between 2.5:1 and 5.0:1 [Simopoulos 2008]. Seeds of annual legumes seem to be a promising source of such valuable oils. Among the species of the genus *Lupinus,* white lupine (*Lupinus albus* L.) is most often the subject of interest for experts in human and animal nutrition, mainly because of its seed yield potential and oil content, which ranges from 5.73 to 11.5% [Erbaş *et al.* 2005, Boschin *et al.* 2008, Sami *et al.* 2010, Borquez *et al.* 2011, Laudadio and Tufarelli 2011, Chiofalo *et al.* 2012, Calabrò *et al.* 2015]. The oil content in seeds of other species is lower: in yellow lupine (*Lupinus luteus* L.) it accounts for 4.86-8.76% [Chiofalo *et al.* 2012, Rybiński *et al.* 2013], and in blue lupine (*Lupinus angustifolius* L.) 3.28-8.18% [Chiofalo *et al.* 2012, Barczak *et al.* 2013, Rybiński *et al.* 2013]. There is considerably less data in the available literature on the oil content in the seeds of plants from the genus *Vicia.* Yoshida *et al.* [2009] report that oil content in the faba bean (*Vicia faba* ssp. *maior* L.) seeds amounts to 2.3-2.9%.

As is the case in many vegetable oils, unsaturated acids dominate in the oil of species from the genera *Lupinus* and *Vicia*, but the proportions of mono- and polyunsaturated acids are different. Oleic acid prevails in the oil from white lupine, accounting for 40.8-62.4% of the whole fatty acid profile [Erbaş *et al.* 2005, Boschin *et al.* 2008, Chiofalo *et al.* 2012, Rybiński *et al.* 2013, Calabrò *et al.* 2015]. The most important acid in oil from yellow lupine is linoleic acid, and its percentage in the fatty acid profile accounts for 47.2-55.3% [Chiofalo *et al*. 2012, Rybiński *et al*. 2013]. Species from the genus *Vicia* [Kökten *et al.* 2010, Renna *et al.* 2014], including also the species *Vicia faba* [Yoshida *et al.* 2009], are characterized by a similar content of linoleic acid.

The percentage of α-linolenic acid in oil from white lupine has been found to be 9.01-10.06%, from yellow lupine 6.74-9.46%, and from blue lupine 3.90-7.66% [Erbaş *et al.* 2005, Chiofalo *et al.* 2012, Rybiński *et al.* 2013]. In different vetch species growing in Turkey the content of this acid ranged from 3.98 to 21.98% [Kökten *et al.* 2010], and in Tunisia from 4.20 to 9.77% [Renna *et al.* 2014].

Palmitic acid is the most important saturated acid in vegetable oils. The highest content of this acid, up to 28%, was determined in the species from the genus *Vicia* [Yoshida *et al.* 2009, Renna *et al.* 2014], then in blue lupine – 12.1% [Chiofalo *et al.* 2012; Rybiński *et al.* 2013] and in Andean lupine (*Lupinus mutabilis* Sweet) – 11.9% [Rybiński *et al.* 2013].

The aim of this study was to assess the differentiation in some Polish breeding lines and cultivars in respect of the content of crude fat in seeds and fatty acid profile within the species *Lupinus albus* L., *Lupinus luteus* L., *Lupinus angustifolius* L., *Vicia faba* ssp. *maior* L., *Vicia villosa* Roth. and *Vicia sativa* L.

MATERIAL AND METHODS

Seeds for analyses were obtained from Poznańska Hodowla Roślin LTD, Plant Breeding Station Wiatrowo (52°45’ N; 17°08’ E) and from the didactic collection of the Research Station Mochełek (53°12’ N; 17°51’ E) of the University of Science and Technology in Bydgoszcz. Seeds came from the harvest in 2011. Seeds from 2 breeding lines and 7 cultivars of yellow lupine, 2 breeding lines and 6 cultivars of blue lupine, 2 cultivars of white lupine, 2 cultivars of faba bean, 1 cultivar of hairy vetch (*Vicia*

villosa Roth.) and 1 cultivar of common vetch (*Vicia sativa* L.) were analysed both for raw oil (crude fat) content and fatty acid profile.

Raw oil content was determined using the Dionex ASE 150 apparatus for fast extraction. Fragmented material was dried to a fixed weight at 105^{o}C, and then it was cooled in the desiccator and stored. The weighed sample for the desiccator cell was 0.5 g. Extraction was conducted at 130^{o}C, using changing high pressure of inert gas – nitrogen 5.0 and solvents hexane: acetone (4:1). The time of extraction was 40 minutes. After the extraction the cell was cooled in the desiccator for at least 24 h, and then weighed together with the sample. The loss of sample weight related to the weight of the initial sample determined the proportion of fat in the initial sample. The weight was determined with an accuracy of 0.001 g.

Oil extracted from the seeds was subjected to esterification. At the first stage fat was saponified using a 0.5N KOH methanol solution at 70^{o}C until clarity was obtained. Esterification with methanol was conducted in the presence of sulphuric acid as a catalyst. Obtained esters were suspended in n-hexane.

Chromatographic analysis was performed using a DANI GC gas chromatograph equipped with a injector of the Split/Splitless type, the polar column Thermo Scientific TRACE™ TR-FAME (length 50 m, diameter 0.22 mm and film thickness 0.25 µm) and the flame-ionization detector (FID).The carrying gas was helium, with flow set at 1.2 ml·min.$^{-1}$. The temperature of the injector was 230^{o}C, and 1 µl of the sample was dosed, with division in the feeder set at 1:15. The following temperature program was applied: 140^{o}C for 4 min.; increase in temperature 3.5^{o}C·min.$^{-1}$ up to 170^{o}C; increase in temperature 2.0^{o}C·min.$^{-1}$ up to 230^{o}C and this kept for 1 min. The temperature in the detector was 250^{o}C. The 37-component standard Supelco FAME Mix (Silma-Aldrich) was applied to identify fatty acid methyl esters.

Analyses for the crude fat content were made in three replications and for the fatty acid composition in one replication. The results of oil content in each cultivar were given as means ± standard deviation. The results of fatty acid contents were given as means from all cultivars ± standard deviation. Additionally, coefficients of variation were used in order to compare cultivars within the species.

RESULTS

The mean oil content in the seeds of yellow lupine was 0.63% lower in comparison to that from blue lupine (Table 1). Coefficients of variation show that the cultivars of blue lupine were more similar (CV – 0.04) than the cultivars of yellow (CV – 0.09) and white lupine (CV – 0.10). The difference between blue lupine cultivars with the highest and lowest oil content amounted to only 0.73 percentage points (p.p.), while between those of yellow lupine it was 1.56 p.p. Only two cultivars of white lupine were studied, but the difference in oil content between them was also substantial and amounted to 1.33 p.p.

Table 1. Oil content in seeds of yellow, blue and white lupine (% ± standard deviation)
Tabela 1. Zawartość oleju w nasionach łubinu żółtego, wąskolistnego i białego (% ± odchylenie standardowe)

No. Lp.	Yellow lupine – Łubin żółty		Blue lupine – Łubin wąskolistny		White lupine – Łubin biały	
	line/cultivar ród/odmiana	oil – olej % ±SD	line/cultivar ród/odmiana	oil – olej % ±SD	line/cultivar ród/odmiana	oil – olej % ±SD
1	Dukat (W)	6.64±0.72	Regent(M)	6.88±0.03	Boros(M)	10.60±0.72
2	Baryt (W)	6.51±0.40	Kadryl (W)	6.77±0.27	Butan(M)	9.27±0.40
3	Perkoz(M)	6.34±0.34	WTD 1811(W)	6.61±0.17	–	–
4	Mister (W)	6.16±0.84	WTD 1710(W)	6.59±0.50	–	–
5	Talar (W)	5.84±0.78	Zeus(M)	6.52±0.45	–	–
6	WTD2911 (W)	5.73±0.70	Tango (W)	6.46±0.31	–	–
7	WTD2811(W)	5.49±1.02	Sonet (W)	6.16±0.29	–	–
8	Taper (W)	5.48±0.71	Karo(M)	6.15±0.42	–	–
9	Lord(M)	5.08±1.13	–	–	–	–
Mean – Średnia		5.92±0.53	–	6.55±0.27		9.94±0.94
Coefficient of variation Współczynnik zmienności		0.09	–	0.04	–	0.10

(M) – seeds from Research Station in Mochełek – nasiona ze Stacji Badawczej Mochełek
(W) – seeds from Poznańska Hodowla Roślin LTD, Plant Breeding Station Wiatrowo – nasiona z Poznańskiej Hodowli Roślin Sp. z o.o., Oddział Wiatrowo

In the oil from yellow lupine linoleic acid was the most abundant (46.73%), followed by oleic (24.09%) (Table 2). The content of palmitic, α-linolenic and behenic acids was similar and amounted to 5.60, 6.86 and 5.61%, respectively. Also, stearic acid (2.70%) and arachidic acid (2.58%) occurred in values above 2%. In the oil from blue lupine the content of linoleic and oleic acids was very similar (respectively 37.64 and 34.94%). Additionally, palmitic acid (12.47%) and stearic acid (6.40%), and to a smaller degree, α-linolenic acid (4.53%), occurred in higher amounts than in the oils from the other two lupine species.

In the oil from white lupine, oleic acid dominated (54.29%), and the content of linoleic acid was more than 3.5 times lower. Next there was palmitic acid (8.57%) and α-linolenic acid (7.22%). Regarding other acids, the presence of monounsaturated gadoleic acid (4.14%) and saturated behenic acid (2.73%) were recorded. The oil from white lupine represented the monounsaturated fatty acids (MUFA) and in comparison to the oil from both other lupine species, it was characterized by a very narrow n-6/n-3 ratio.

Within the yellow lupine species the outstanding cultivar was Taper (Table 3). The oil from this cultivar was characterized by a relatively high content of α-linolenic acid, and thus a lower n-6/n-3value as compared with all the other genotypes. The widest n-6/n-3value was noted for cultivar Lord.

Of the genotypes of blue lupine, the cultivars Regent differed in respect of the oil quality (Table 4). In oil from the cultivar Regent oleic acid dominated (45.3%), and there was the lowest levels of linoleic and α-linolenic acids, respectively 25.7% and 3.2%. Therefore, the oil from this cultivar represented the MUFA type, and it also contained more saturated acids than the other cultivars (SFA – 24.5%). Other blue lupine genotypes represented the polyunsaturated fatty acids type (PUFA), except for WTD 1710 where the proportion between monounsaturated and polyunsaturated fatty acids was almost 1:1. The value of n-6/n-3 ratio for the lines and cultivars of blue lupine ranged from 7.48 (WTD 1710) to 10.0 (Tango).

Table 2. Fatty acid profiles of oil from yellow, blue and white lupine – mean for lines and cultivars (% ± standard deviation)

Tabela 2. Profile kwasów tłuszczowych oleju z łubinu żółtego, wąskolistnego i białego – średnia dla rodów i odmian (% ± odchylenie standardowe)

No. Lp.	Fatty acid Kwas tłuszczowy	Yellow lupine Łubin żółty	Blue lupine Łubin wąskolistny	White lupine Łubin biały
		X±SD	X±SD	X±SD
1	myristic C14:0 mirystynowy	0.18±0.03	0.25±0.07	0.14±0.05
2	pentadecanonic C15:0 pentadekanowy	0.08±0.01	0.09±0.02	0.08±0.02
3	palmitic C16:0 palmitynowy	5.60±0.76	12.47±1.20	8.57±0.91
4	palmitoleic C16:1 palmitooleinowy	0.08±0.01	0.06±0.02	0.37±0.04
5	margaric C17:0 margarynowy	0.09±0.01	0.08±0.01	0.03±0.01
6	stearic C18:0 stearynowy	2.70±0.78	6.40±1.01	1.57±0.48
7	oleic C18:1n9 oleinowy	24.09±2.11	34.94±4.63	54.29±4.38
8	linoleic C18:2n6 linolowy	47.74±3.54	37.64±5.50	14.92±2.24
9	α-linolenic C18:3n3 α-linolenowy	6.86±1.04	4.53±0.64	7.22±0.59
10	arachidic C20:0 arachidowy	2.58±0.51	0.76±0.17	0.81±0.33
11	gadoleic C20:1n9 gadoleinowy	1.55±0.21	0.23±0.03	4.14±0.21
12	eicosadienoic C20:2 eikozadienowy	0.18±0.02	0.05±0.02	0.05±0.04
13	eicosatrienoic C20:3n6 eikozatrienowy	0.21±0.04	0.03±0.01	0.15±0.13
14	behenic C22:0 behenowy	5.61±0.44	1.40±0.40	2.73±1.28
15	erucic C22:1n9 erukowy	0.70±0.13	0.03±0.01	1.59±0.52
16	docosadienoic C22:2 dokozadienowy	0.26±0.04	0.09±0.04	0.07±0.08
17	lignoceric C24:0 ligocerynowy	0.75±0.09	0.31±0.12	0.60±0.25
18	unidentified niezidentyfikowany	0.77±0.14	0.67±0.06	2,73±0,31
∑SFA (saturated fatty acids)		17.58±2.05	21.78±1.39	16.14±1.94
∑MUFA (monounsaturated fatty acids)		26.42±1.98	35.26±4.64	58.79±4.14
∑PUFA (polyunsaturated fatty acids)		55.24±3.64	42.30±6.02	14.98±2.32
Total n-6		47.95±3.57	37.67±5.51	15.06±2.38
Total n-3		6.86±1.04	4.53±0.64	7.22±0.59
n-6/n-3		7.12±1.02	8.34±0.84	2.11±0.50

Table 3. Comparison of lines and cultivars of yellow lupine in respect of the contents of main fatty acids, %
Tabela 3. Porównanie rodów i odmian łubinu żółtego pod względem zawartości podstawowych kwasów tłuszczowych, %

Fatty acid Kwas tłuszczowy	Dukat	Baryt	Perkoz	Mister	Talar	WTD 2911	WTD 2811	Taper	Lord	C.V.*
C16:0	5.8	5.9	5.7	5.0	6.06	5.1	4.7	7.2	5.0	0.14
C18:1n9	22.3	24.9	28.6	22.7	21.7	24.3	22.9	25.4	24.0	0.09
C18:2n6	47.6	47.2	41.6	50.7	50.0	49.3	51.5	42.4	49.3	0.07
C18:3n3	7.1	6.1	5.4	6.7	7.6	6.7	7.0	9.0	6.1	0.15
∑SFA	19.2	18.2	21.0	15.8	17.1	15.9	14.9	19.6	16.5	0.12
∑MUFA	25.0	27.2	30.7	25.5	23.7	26.7	25.2	27.3	26.6	0.08
∑PUFA	55.3	54.0	47.6	58.0	58.3	56.7	59.1	52.0	56.2	0.07
Total n-6	47.8	47.4	41.8	51.0	50.2	49.5	51.7	42.5	49.6	0.07
Total n-3	7.1	6.1	5.4	6.7	7.6	6.7	7.0	9.0	6.1	0.15
n-6/n-3	6.75	7.73	7.78	7.64	6.58	7.35	7.44	4.72	8.09	0.14

* coefficient of variation – współczynnik zmienności

Table 4. Comparison of lines and cultivars of blue lupine and white lupine in respect of the contents of main fatty acids, %
Tabela 4. Porównanie rodów i odmian łubinu wąskolistnego oraz odmian łubinu białego pod względem zawartości podstawowych kwasów tłuszczowych, %

Fatty acid Kwas tłuszczowy	Blue lupine – Łubin wąskolistny									White lupine – Łubin biały		
	Regent	Kadryl	WTD 811	WTD 1710	Zeus	Tango	Sonet	Karo	C.V.*	Boros	Butan	C.V.*
C16:0	13.03	12.9	12.3	14.0	10.8	13.2	12.7	10.58	0.10	7.9	9.2	0.11
C18:1n9	45.3	31.7	35.8	36.8	31.3	33.1	31.8	33.73	0.13	51.2	57.4	0.08
C18:2n6	25.7	42.2	36.9	34.8	42.3	40.6	40.8	37.77	0.15	16.5	13.3	0.15
C18:3n3	3.2	4.7	4.7	4.6	4.8	4.1	5.2	4.93	0.14	6.8	7.6	0.08
∑SFA	24.5	20.4	21.6	22.8	20.3	21.2	21.2	22.2	0.06	15.6	13.6	0.10
∑MUFA	45.7	32.0	36.1	37.0	31.7	33.4	32.1	34.9	0.13	57.8	62.9	0.06
∑PUFA	29.0	47.0	41.7	39.5	47.3	44.7	46.1	43.02	0.14	23.7	21.0	0.09
Total n-6	25.8	42.3	36.9	34.8	42.3	40.6	40.9	37.82	0.15	16.7	13.4	0.16
Total n-3	3.2	4.7	4.7	4.7	4.8	4.1	5.2	4.93	0.14	6.80	7.6	0.08
n-6/n-3	8.18	8.93	7.84	7.48	8.73	10.00	7.92	7.67	0.10	2.46	1.75	0.11

* coefficient of variation – współczynnik zmienności

The fatty acid profile of the two assessed white lupine cultivars was very similar, and the largest differences were noted between the contents of linoleic acid (6.2 p.p.), and between the totals of monounsaturated acids (5.12 p.p.), (Table 4).

In the seeds of the faba bean cultivars the oil content was only higher by about 0.5 p.p. than in the seeds of both vetch species (Table 5).

Table 5. Oil content in the seeds of faba bean, hairy vetch and common vetch cultivars (% ± standard deviation)
Tabela 5. Zawartość oleju w nasionach odmian bobiku, wyki kosmatej i wyki siewnej (% ± odchylenie standardowe)

No. Lp.	Faba bean – Bobik		Hairy vetch – Wyka kosmata		Common vetch – Wyka jara	
	cultivar odmiana	oil – olej %±SD	cultivar odmiana	oil – olej %±SD	cultivar odmiana	oil – olej %±SD
1	Martin(M)	1.67±0.35	Rea(M)	1.22±0.12	Jaga(M)	1.10±0.03
2	Ashleigh(M)	1.77±0.51	–	–	–	–
Mean – Średnia		1.72±0.07	–	1.22		1.10
Coefficient of variation Współczynnik zmienności		0.04	–	–	–	–

Oils from the faba bean and both vetch species belong to the PUFA type, as a result of the approximately 50% proportion of linoleic acid in the fatty acid profile (Table 6). The highest difference between the fatty acid compositions referred to the amount of α-linolenic acid. There was less of it in the oil from both faba bean cultivars (5.85 and 3.20%) than in the oil from hairy vetch and common vetch (8.79 and 8.35%). As a result, the oil from faba bean had on average about twice as wide a n-6/n-3 acid ratio than the oil from both vetch species.

Table 6. Fatty acid profiles of oil from the seeds of faba bean, hairy vetch and common vetch, %
Tabela 6. Profile kwasów tłuszczowych oleju z nasion bobiku, wyki kosmatej i wyki siewnej, %

No. Lp.	Fatty acid Kwas tłuszczowy	Faba bean Bobik		Hairy vetch Wyka kosmata	Common vetch Wyka siewna
		cultivar – odmiana			
		Martin	Ashleigh	Rea	Jaga
1	2	3	4	5	6
1	myristic C14:0 mirystynowy	0.32	0.41	0.26	0.31
2	pentadecanonic C15:0 pentadekanowy	0.19	0.27	0.17	0.21
3	palmitic C16:0 palmitynowy	12.73	16.69	14.88	14.89
4	palmitoleic C16:1 palmitooleinowy	0.05	0.05	0.11	0.06
5	margaric C17:0 margarynowy	0.17	0.15	0.16	0.18
6	stearic C18:0 stearynowy	2.77	1.88	2.56	3.54
7	oleic C18:1n9 oleinowy	21.85	24.99	24.32	18.24

Table 6 continue – cd. tabeli 6

1	2	3	4	5	6
8	linoleic C18:2n6 linolowy	52.72	49.49	45.12	51.08
9	α-linolenic C18:3n3 α-linolenowy	5.84	3.2	8.79	8.35
10	arachidic C20:0 arachidowy	1.05	0.93	0.69	0.97
11	gadoleic C20:1n9 gadoleinowy	0.55	0.6	0.64	0.34
12	eicosadienoic C20:2 eikozadienowy	0.12	0.05	0.11	0.03
13	eicosatrienoic C20:3n6 eikozatrienowy	0.11	0.04	0.07	0.04
14	behenic C22:0 behenowy	0.46	0.39	0.52	0.3
15	erucic C22:1n9 erukowy	0.07	0.11	0.45	0.09
16	docosadienoic C22:2 dokozadienowy	0.27	0.12	0.10	0.22
17	dignoceric C24:0 digocerynowy	0.33	0.2	0.28	0.54
18	unidentified niezidentyfikowany	0.39	0.44	0.76	0.60
∑SFA (saturated fatty acids)		18.02	20.92	19.52	20.94
∑MUFA (monosaturated fatty acids)		22.45	25.64	25.07	18.64
∑PUFA (polysaturated fatty acids)		58.79	52.78	54.09	59.50
Total n-6		52.83	49.53	45.19	51.12
Total n-3		5.84	3.2	8.79	8.35
n-6/n-3		9.05	15.48	5.14	6.12

DISCUSSION

The oil content in the tested Polish lupine cultivars is similar to the content in lupine cultivars reported by other authors [Erbaş *et al.* 2005, Boschin *et al.* 2008, Yoshida *et al.* 2009, Chiofalo *et al.* 2012, Barczak *et al.* 2013, Rybiński *et al.* 2013, Calabrò *et al.* 2015]. Most authors determined the oil content and composition in a small number of cultivars of a given species (mostly from 1 to 4). Nevertheless, a larger number of cultivars was analysed by Rybiński *et al.* [2013] and in that experiment, similar to the present study, larger differences among cultivars occurred within the yellow lupine species than the blue lupine one. In both of these experiments the oil content was analysed in cultivars of yellow lupine (Lord, Perkoz and Talar), blue lupine (Regent and Zeus) and white lupine (Boros and Butan). In these two sets of experiments differences in oil composition in the seeds of yellow lupine cultivars did not exceed 0.5 p.p., while the differences in composition of the oil from blue lupine cultivars and the white lupine cultivar Butan did not exceed 1.0 p.p. Only in the case of the white lupine cultivar Boros was the difference as high as 1.5 p.p. However, in both experiments the seeds of this cultivar contained the most oil of all the studied cultivars of the genus *Lupinus.*

Polish yellow lupine cultivars Dukat, Mister and Taper and one blue lupine cultivar Sonet have also been grown and assessed in Sicily [Chiofalo *et al.* 2012], which is subject to a Mediterranean climate. In those conditions the oil content was on average higher by 1 p.p. than in the Polish environment. Fatty acid proportions were very similar to those described in this study. The content of n-3 PUFA acids in both the Sicilian and present cases was the highest in the oil from the cultivar Taper – 9.46% [Chiofalo *et al*. 2012] and 9.01% according to the present study. In other studies it has also been shown that the seed yield potential and oil accumulation in seeds were higher from the cultivar Mister than from the cultivar Taper [Jarecki and Bobrecka-Jamro 2014].

In the oil from yellow lupine, similar to the oil from pea [Andrzejewska *et al.* 2015] α-linolenic acid was subject to the highest variability and this had a strong effect on the value of n-6/n-3 acid ratio. The genotypes of blue lupine had lower differentiation, both in respect of the oil content in seeds and of the n-6/n-3 fatty acid ratio. Moreover, the present study indicates that the oil from yellow lupine contains behenic (5.61%) and arachidic (2.58%) acids from the group of saturated acids. The oil from white lupine also contained behenic acid and monounsaturated gadoleic acid in the amount of more than 4%.

Oil content in the two tested faba bean cultivars was low (1.74%), but a similar level (1.68%) was reported for the Polish cultivar Nadwiślański by Grela and Günter [1995]. According to Yoshida *et al.* [2009], in Japanese cultivars of faba bean there was on average 1.0 p.p. more oil than in the Polish cultivars. The lowest fat content was determined in the seeds of both vetch species. The fatty acid profiles of faba bean and both vetch species are very similar, and they differ only in the content of α-linolenic acid. Of the analysed species of legumes, the oil from faba bean contained the least α-linolenic acid.

Regarding the content of unsaturated fatty acids and the value of the n-6/n-3 acid ratio of annual legumes from the temperate climate zone, the oil that is the most desired, both for food and fodder, is obtained from white lupine, followed by genotypes of field pea with white flowers and colourful flowers [Andrzejewska *et al.* 2015], hairy vetch and spring vetch, yellow lupine, blue lupine, and faba bean.

CONCLUSIONS

1. The raw oil content and fatty acid composition in the seeds of Polish lines and cultivars of yellow lupine, blue lupine, white lupine, faba bean, hairy vetch and common vetch is very similar to other European, Asian or African genotypes.
2. There is a higher differentiation regarding both oil and α-linolenic acid content among the lines and cultivars of yellow lupine than among the cultivars of blue lupine.
3. In regard to their food and fodder oil quality, the annual species grown in Poland can be arranged according to the follow sequence (from the highest to the lowest): white lupine, field pea, hairy vetch, spring vetch, yellow lupine, blue lupine, faba bean.

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ZAWARTOŚĆ OLEJU I PROFIL KWASÓW TŁUSZCZOWYCH W NASIONACH POLSKICH RODÓW I ODMIAN ROŚLIN STRĄCZKOWYCH

Streszczenie. Obecnie w badaniach ukierunkowanych na zastąpienie śruty sojowej przez inne rośliny strączkowe powinno się uwzględniać nie tylko zawartość i jakość białka, ale także zawartość i jakość tłuszczu (oleju). Celem pracy była ocena zróżnicowania pod względem zawartości oleju (tłuszczu surowego) i profilu kwasów tłuszczowych polskich rodów i odmian łubinów – żółtego, wąskolistnego i białego, bobiku oraz wyki kosmatej i jarej. W badaniach uwzględniono 9 rodów i odmian łubinu żółtego i 8 łubinu wąskolistnego, 2 odmiany łubinu białego, 2 odmiany bobiku, 1 odmianę wyki kosmatej i 1 odmianę wyki siewnej. Zawartość oleju w nasionach rodów i odmian łubinu żółtego mieściła się w zakresie 5.1-6.6%, łubinu wąskolistnego 6.2-6.9%, łubinu białego 9.3-10.6%, bobiku 1.7-1.8%, wyki kosmatej 1.2% i wyki siewnej 1.1%. Kwas linolowy przeważał w oleju z bobiku, wyki kosmatej i siewnej oraz w większości genotypów łubinu żółtego. Kwas oleinowy dominował w oleju z łubinu białego, a w oleju z łubinu wąskolistnego kwasy linolowy i oleinowy występowały często z podobnych ilościach. Najwięcej kwasu α-linolenowego zawierał olej z obu gatunków wyk (8.4-8.5%), a następnie z łubinu białego (6.8-7.6%) i łubinu żółtego (5.4-9.0%), a najmniej z bobiku (3.2-5.8%) i łubinu wąskolistnego (3.2-5.2%). Odmiany łubinu żółtego były bardziej zróżnicowane pod względem zawartości oleju, kwasu α-linolenowego oraz wartości stosunku kwasów n-6/n-3 niż odmiany łubinu wąskolistnego.

Słowa kluczowe: kwas α-linolenowy, kwas linolowy, *Lupinus*, tłuszcz surowy, *Vicia*

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