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CHEMICAL COMPOSITION OF LINSEED WITH DIFFERENT COLOUR OF BRAN LAYER*

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Yield and chemical composition of two linseed cultivars of various colour was checked in the years 1998–2000. Dry matter, organic matter, total protein, ether extract, crude fibre, N-free extractives, acid detergent fiber (ADF), neutral detergent fiber (NDF), gross energy, sum of saturated and unsaturated acids were taken into account. Brown linseed – Opal and yellow – Hungarian Gold did not reveal significant differences in chemical composition and gave satisfactory and stable yield. On the basis of the results it was concluded that linseed can be regarded as reliable and efficient source of α-linolenic acid for human and animal nutrition.

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is nowadays an industrially important crop, that is used as a raw material for the production of oil for mainly technical purposes. The major producer and the largest exporter of linseed is Canada, while its import and consumption is dominated by the European Union [Oomah *et al.*, 1992]. In recent years there has been observed a growing interest in nutritional utilisation of flax, and such use is supposed to increase owing to the unique chemical composition of linseed [Cunnane *et al.*, 1995; Oomah, 2001].

It is a general agreement that there is a need to extend linseed cultivation area in countries of moderate climate, such as Poland. The trials to obtain higher crops resulted in registration of two new cultivars: Opal and Szafir, which are very similar in their morphology and productivity [Heimann, 1996]. Their productivity was compared with yellow linseed Hungarian Gold in field experiments [Borowiec *et al.*, 2001], which proved that these commercial cultivars differ in the amount of nutritional compounds, especially in the case of fibre and its fractions. There are few studies on chemical composition of local linseed cultivars varying in seed colour in different cultivation seasons, and they focus mainly on their yield and structure.

The aim of the study was to compare the yield and chemical composition of two linseed cultivars varying in seed colour in four successive vegetation seasons.

MATERIAL AND METHODS

Two linseed cultivars; native brown Opal and Hungarian yellow Hungarian Gold were obtained from experimental plot in Prusy (Cracow district) in the years 1998–2001. The randomised one factorial, block experiment with 4 replications was established and plot size was 10 m^2. Agrotechnical treatment was conducted according to the rules of proper cultivation, formulated by Wałkowski *et al.* [1998]. The chemical composition of linseed was determined according to AOAC [1995]. NDF was assessed by means of NAKOM 220 Fiber Analyser, according to modified method of Goering and Van Soest [1970]. Gross energy was measured by a calorimetric bomb (KL-10, Precyzja, Bydgoszcz, Poland) [Skulmowski, 1974]. Fat content and fatty acid profile were determined by gas chomatography using a Varian 3400 CX (Varian Associates, Palo Alto, USA) GC with FID detector (argon, DB-23 column of 30 m × 0.53 mm i.d.; column and detector temperature was 100–205°C and 240°C, respectively) according to Borowiec *et al.* [2001].

The results of chemical analyses were calculated using Excel for Windows (Microsoft) and statistical procedures of SAS program (SAS 1995). Statistical analysis was based on two-factorial analysis of variance for mixed model (years were taken as randomising factor) and significance of differences was checked with t-Student's test, $\alpha<0.05$ was regarded as significant.

RESULTS AND DISCUSSION

Analysis of yield (reported at 8% moisture content) revealed differences associated with year and cultivar (Table 1). In the whole period of the experiment a higher yield of 2 t/ha was obtained for yellow linseed Hungarian Gold. Native brown Opal cv. produced signicantly lower amount of seeds, that was caused mainly by low yield in 2001. Such a pattern was due to excessive development of Opal plants, which in consequence gave early and strong lodging. It should be emphasised, that the obtained yield of both cultivars was higher than those reported by Heimann [1996].

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TABLE 1. Total yield of linseed cultivars in 1998–2001 [t·ha^{-1}] and the contribution of fat and protein [kg·ha^{-1}].

Variety	Total yield in cultivation season				Mean yield		
	1998	1999	2000	2001	Seed	Fat	Protein
Opal	1.97^{*a}	2.30^{a}	1.75^{a}	1.31^{b}	1.83^{b}	739^{b}	386^{a}
Hungarian Gold	1.94^{a}	1.96^{b}	2.22^{a}	1.86^{a}	2.00^{a}	841^{a}	389^{a}
Mean	1.95^{a}	2.13^{a}	1.98^{a}	1.59^{b}	1.91^{a}	790^{a}	388^{a}

*) Values of the given trait denoted by the same lettter do not differ significantly.

The compared cultivars did not differ significantly regarding yield of protein per hectare, while the yield of fat was much higher in the case of Hungarian Gold cv. This makes it a competitive crop to winter rapeseed – dominating oil-bearing plant in Poland, that under average conditions produces 1000 kg of fat per hectare [Budzyński & Ojczyk, 1996].

The amount of selected components of linseed is presented in Table 2. Statistical analysis did not reveal significant variability between cultivars in any of the examined compounds, during 4 years of the experiment. However an interesting tendency regarding total protein and raw fat in yellow and brown linseeds was found. Brown-coloured Opal cultivar usually contained more protein and less fat in comparison to yellow Hungarian Gold. It denotes a negative correlation between these components, which is determined by cultivar's genotype.

Second tendency relating to chemical composition of linseed appeared in the amount of raw fibre and its fractions, which were regularly lower in yellow-coloured seeds.

Fatty acid profile of raw fat present in linseeds, shown in Table 3, exhibited only minor differences between cultivars. It should be stressed that the amount of unsaturated fatty acids, especially α-linolenic ($C_{18:3,\ n-3}$), was very high and in both cases exceeded 52%. This, however was signicantly changing between years, what suggests that its synthesis in seeds is strongly affected by temperature and water supply.

TABLE 2. Chemical composition of dry matter of two linseed cultivars and gross energy in the subsequent cultivation seasons.

Cultivar	Season	Dry matter	Organic matter	Total protein	Ether extract	Crude fibre	N-free extractives	Acid development fibre	Gross energy
		[g·kg^{-1}]							[kcal·kg^{-1}]
Opal	1998	950	962	211	463	204	146	240	6860
	1999	919	957	271	438	164	84	247	6817
	2000	972	958	237	440	204	90	152	6412
	2001	971	963	198	416	258	117	319	6380
Hungarian Gold	1998	952	961	193	478	207	174	232	6932
	1999	925	958	242	468	154	71	203	6990
	2000	977	961	204	475	184	78	164	6620
	2001	953	961	206	408	236	97	268	6320
Mean	Opal*	953	961	229	439	208	109	239	6617
	H.G.*	952	960	211	457	195	105	217	6716
SD		21	2	27	27	35	36	55	217
SEM		8	1	10	10	12	13	19	89

*) All the examined traits did not differ significantly

TABLE 3. Fatty acids profiles of two linseed cultivars in the subsequent cultivation seasons.

Cultivar	Season	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	Other	Saturated	Unsaturated	U/S
Opal	1998	6.3	3.3	22.6	16	51.5	0.4	9.6	90.0	9.4
	1999	6.4	3.3	18.5	14.3	57.3	0.3	9.7	90.0	9.3
	2000	6.2	4.6	27.9	14.5	46.1	0.8	10.8	88.4	8.2
	2001	6.5	4.6	20.6	12.3	55.8	0.2	11.1	88.8	8.0
Hungarian Gold	1998	5.9	4.3	20.1	14.0	54.7	0.9	10.2	88.9	8.7
	1999	9.2	5.2	24.7	15.3	44.6	1.0	14.4	84.6	5.9
	2000	5.8	2.9	18.5	12.3	59.7	0.7	8.8	90.5	10.3
	2001	6.3	3.6	27.7	12.8	49.0	0.6	9.9	89.5	9.0
Mean	Opal*	6.4	4.0	22.4	14.3	52.7	0.4	10.3	89.3	8.7
	H.G.*	6.8	4.0	22.7	13.6	52.0	0.8	10.8	88.4	8.5
SD		1.1	0.8	3.8	1.4	5.5	0.3	1.7	1.9	1.3
SEM		0.4	0.3	1.4	0.5	1.9	0.2	0.6	0.7	0.6

*) All the examined traits did not differ significantly.

The extremely high content of α-linolenic acid in flax oil correlates with opinions of other authors [Ratnayake *et al.*, 1992; Cunnane *et al.*, 1993], who regard linseed as the richest source of this valuable unsaturated acid. Omega-3 fatty acids are considered as hypocholesterolaemic agents, which strongly reduce "bad" cholesterol fraction – LDL [Bierenbaum *et al.*, 1993; Kolanowski & Świderski, 1997; Gambuś *et al.*, 2001; Oomah, 2001]. The importance of α-linolenic acid is even higher, as it is a precursor in synthesis of eicosanpentaenic acid ($C_{20:5,\ n-3}$) – EPA and dokozahexaenic acid ($C_{20:5,\ n-3}$) – DHA [Oomah, 2001]. The EPA and DHA play a role in synthesis of hormones: prostaglandins with prostacyclins, tromboxans and leucotriens, they also take part in metabolism of triglycerides and cholesterol, showing high antycholesterolic activity. They inhibit hydroxy--methylo-glutarylo-coenzymeA reductase (HMg-CoA) in liver, which is responsible for cholesterol synthesis, contrary to saturated fatty acids which activate it [Drevon, 1992; Horrobin, 1990].

As it can be concluded from many studies, contemporary diet is deficient in unsaturated omega-3 fatty acids, so in many countries, *e.g*. Japan, South Korea, European Union, USA, Canada and Australia, some food products are supplemented with these acids obtained from rafinated fish oil [Kolanowski & Świderski, 1997].

On the basis of the results of a four-year research, satisfactory and mostly stable yield of both linseed cultivars makes this species a reliable and efficient source of α-linolenic acid for human and animal nutrition. Low changes in the fatty acid profile of two linseed cultivars during 4 years of study resulted in similar variation of a derived feature – unsaturated to saturated acids ratio. However, some changes are visible when we compare selected years of Hungarian Gold cultivation. Higher stability of this feature was found for native Opal cultivar.

CONCLUSIONS

1. Higher amount of fat produced by Hungarian Gold cultivar was affected both by higher yield and fat content in seeds, as compared to Opal.

2. During four years of experiments, the compared linseed cultivars did not differ signicantly in the analysed chemical composition.

3. Both cultivars revealed comparable and high amount of α-linolenic acid $C_{18:3,n-3}$, in total fatty acids present in the seeds (approx. 52%).

4. Due to satisfactory and mostly stable yield of both cultivars, linseed can be regarded as reliable and efficient source of α-linolenic acid for human and animal nutrition.

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SKŁAD CHEMICZNY NASION LNU OLEISTEGO O RÓŻNEJ BARWIE OKRYWY NASIENNEJ

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Porównano wielkość plonu i skład chemiczny nasion lnu oleistego pochodzących ze ścisłego doświadczenia polowego przeprowadzonego w latach 1998–2001, w typowych dla tego gatunku warunkach siedliska i agrotechniki. Dobór odmiany uwzględniał typowe zabarwienie nasion: żółtonasienną, węgierską odmianę Hungarian Gold i polską brązowonasienną odmianę Opal. W okresie 4 lat badań nieznacznie lepszą pod względem wielkości plonu nasion i zawartości tłuszczu surowego okazała się odmiana o żółtych nasionach (tab. 1). Natomiast ze względu na zawartość suchej substancji, materii organicznej, białka ogółem, substancji bezazotowych wyciągowych, włókna surowego oraz jego frakcji ADF i NDF a także energii brutto porównywane odmiany nie wykazały istotnego zróżnicowania (tab. 2).

Obydwie odmiany charakteryzowały się podobnym i wysokim stosunkiem kwasów nienasyconych do nasyconych (tab. 3). Zarówno ze względu na satysfakcjonujący i na ogół stabilny poziom plonowania obu odmian lnu oleistego, można ten gatunek w warunkach Polski uznać za pewne i wydajne źródło kwasu α-linolenowego w żywieniu ludzi i zwierząt.