THE FATTY ACID CONTENT OF OIL FROM SEEDS OF SOME LUPIN VARIETIES

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ABSTRACT

This work addresses the problem of the quality of oil from whole seeds and kernels of some lupin varieties (Amiga, LAL, Oležka, Boruta, Probor, Boregine, Bornal and Wodjil) registered in the Czech Republic. The quality of oil was assessed on the basis of the levels of individual fatty acids (FAs). A total of 37 fatty acids with a carbon chain length C4–C22 were determined using gas chromatography. The results showed that despite a relatively low content of oil ranging from 44.90 to 80.30 g/kg for whole seed (depending on a variety) and from 55.50 to 97.00 g/kg for kernel, the oil obtained is of high quality, particularly if one considers the ω-3:ω-6 ratio. Of all FAs determined, palmitic acid C16:0 belonging to saturated FAs was found at the highest levels in both whole seed and kernel (6.96% and 7.17%, respectively), followed by behenic acid C22:0 (3.20% and 3.08%, respectively). The highest levels of monounsaturated fatty acids (MUFAs) in lupin oil were detected for oleic acid and its isomer elaidic acid (Σ36.82% and 37.17%, respectively). Linoleic acid C18:2n6c and its isomer linolelaidic acid C18:2n6t were found at the highest levels (Σ35.81% and 35.55%, respectively) of all polyunsaturated fatty acids (PUFAs). The highest level of all ω-3 FAs was found for α-linolenic acid C18:3n3 (8.34% for whole seed and 8.13% for kernel). Seed dehulling resulted in a highly significant increase in saturated FAs in kernel ($P \leq 0.01$). In unsaturated FAs, the levels of PUFAs increased highly significantly ($P \leq 0.01$), primarily due to a significant ($P \leq 0.05$) increase in ω-6 FAs. However, these changes had no effect on the ratios of saturated/unsaturated FAs (1:5.8 and 1:5.7 for whole seed and kernel, respectively), MUFA/PUFA (1:1 for both whole seed and kernel) and ω-3 FA/ω-6 FA (1: 3.7 and 1:3.8 for whole seed and kernel, respectively).

KEYWORDS

Lupinus, seed, kernel, oil, fatty acids

INTRODUCTION

Lupin seeds are characterised by the high content of proteins. Therefore, the attention is particularly focused on protein quantity and quality (the amino acid profile) because of the potential use of lupins in human and farm animal nutrition. However, much less attention is focused on the content and quality of oil lupin. Unlike crude protein whose level varies in a wide range (30-50%) depending on a particular variety, the oil content is considerably lower (5–10%). For example, Roth-Maier and Kirchgessner (1993) reported the levels of crude fat in white lupin and yellow lupin varieties being 7.6% and 4.6%, respectively. Uzun *et al*. (2007) reported mean fat level of 10.75% in two white lupin varieties.

Oil is present particularly in the cotyledon, as reported by Smulikowska *et al*. (1995) who found 95-98% of total seed fat in the cotyledon. From a dietetic point of view, oil quality is more important than oil quantity in lupin seeds. Generally, the quality of fat depends on fatty acid (FA) profile and content, and the ratios between individual acids. Unsaturated fatty acids, particularly polyunsaturated fatty acids (PUFA), are essential nutrients and the ω-3/ω-6 ratio is considered as very important with respect to human and farm animal nutrition. Published data show that lupin oil has high dietetic quality from this point of view. Roth-Maier and Kirchgessner (1993) reported that the fat contained in lupin seeds was characterised by high content of unsaturated fatty acids (50% of linoleic acid in *Lupinus luteus*). Uzun *et al*. (2007) reported that oleic acid is a prevailing fatty acid in white lupin. Boschin *et al*. (2007, 2008) who analysed lupin meal found that the content of linoleic acid in six white lupin varieties varied from 1.76 to 4.76 mg/g (7.79–15.81% of a total FA content) and the level of α-linolenic acid ranged from 1.17 to 3.14 mg/g (5.40–10.36% of total FA). Consequently, the seeds of analysed lupins showed very favourable ω-3/ω-6 FA ratios ranged from 0.49 to 0.79.

This favourable content of essential fatty acids in lupin oil can be used in the feeding mixtures for farm animals to improve the nutritional quality of their products. Mieczkowska and Smulikowska (2005) published that the diet containing lupin increased the levels of oleic and α-linolenic acids in chicken fat tissue. The authors concluded that lupin seed can be used as a source of α-linolenic acid in balanced chicken diets and can favourably modify the fatty acid

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Table 1. Mean levels (g/kg) of fatty acids in whole seed and kernel in lupin varieties analysed.

Fatty acid	Seed			Kernel			P
	x	sn	sx	x	sn	sx	
C4:0	0.002	0.001	0.0005	0.000	0.000	0.0000	≤ 0.01
C6:0	0.001	0.002	0.0008	0.000	0.000	0.0001	NS
C8:0	0.000	0.000	0.0001	0.001	0.001	0.0002	NS
C10:0	0.000	0.000	0.0001	0.001	0.001	0.0003	≤ 0.05
C11:0	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C12:0	0.007	0.002	0.0007	0.009	0.003	0.0009	NS
C13:0	0.001	0.001	0.0004	0.001	0.001	0.0003	NS
C14:0	0.067	0.035	0.0124	0.202	0.252	0.0889	NS
C14:1	0.001	0.001	0.0002	0.001	0.001	0.0003	NS
C15:0	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C15:1	0.000	0.000	0.0000	0.000	0.001	0.0002	NS
C16:0	3.764	1.304	0.4609	4.825	1.800	0.6362	NS
C16:1	0.103	0.106	0.0376	0.128	0.131	0.0463	NS
C17:0	0.050	0.039	0.0138	0.043	0.015	0.0052	NS
C17:1	0.011	0.012	0.0043	0.015	0.017	0.0058	NS
C18:0	1.698	0.907	0.3207	2.165	1.310	0.4631	NS
C18:1n9t+ C18:1n9c	19.927	9.730	3.4402	25.015	10.911	3.8577	NS
C18:2n6c+C18:2n6t	19.381	3.843	1.3587	23.929	5.456	1.9289	NS
C18:3n6	0.000	0.000	0.0000	0.003	0.007	0.0026	NS
C18:3n3	4.515	2.537	0.8970	5.472	2.890	1.0218	NS
C20:0	0.640	0.443	0.1565	0.768	0.501	0.1772	NS
C20:1n9	1.127	1.257	0.4444	1.320	1.443	0.5103	NS
C20:2n6	0.101	0.085	0.0301	0.116	0.097	0.0342	NS
C20:3n6	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C21:0	0.041	0.050	0.0177	0.079	0.050	0.0178	NS
C20:4n6	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C20:3n3	0.014	0.024	0.0084	0.017	0.027	0.0094	NS
C20:5n3	0.003	0.007	0.0025	0.006	0.010	0.0035	NS
C22:0	1.731	0.962	0.3399	2.075	1.052	0.3721	NS
C22:1n9	0.403	0.493	0.1744	0.477	0.578	0.2045	NS
C22:2n6	0.038	0.036	0.0128	0.044	0.043	0.0152	NS
C23:0	0.085	0.053	0.0187	0.134	0.034	0.0121	≤ 0.05
C24:0	0.387	0.215	0.0762	0.437	0.212	0.0750	NS
C22:6n3	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C24:1	0.017	0.021	0.0074	0.020	0.025	0.0088	NS
C22:4n6	0.000	0.000	0.0000	0.000	0.000	0.0000	NS
C22:5n3	0.000	0.000	0.0000	0.003	0.009	0.0033	NS

x – arithmetic mean of eight lupin varieties, sn – standard deviation, sx – standard error of arithmetic mean.

Table 2. Mean levels (g/kg) of individual groups of fatty acids (FA) in whole seed and kernel of lupin varieties analysed.

Fatty acid group	Seed			Kernel			P	%
	x	sn	sx	x	sn	sx		
SFA	8.520	1.051	0.372	10.665	1.665	0.589	≤ 0.01	25.18
UFA	49.418	15.421	5.452	60.762	15.942	5.636	NS	22.96
MUFA	24.570	13.576	4.800	30.330	15.217	5.380	NS	23.44
PUFA	24.848	3.661	1.295	30.432	3.946	1.395	≤ 0.01	22.47
ω-3 FA	5.273	3.152	1.114	6.330	3.578	1.265	NS	20.04
ω-6 FA	19.575	3.503	1.238	24.103	4.954	1.752	≤ 0.05	23.13

SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, x – arithmetic mean of eight lupin varieties, sn – standard deviation, sx –standard error of arithmetic mean.

composition of carcass lipids, thus influencing the quality of broiler meat. The supplementation of feeding mixtures for monogastric animals with lupin may improve the quality as well as the safety of raw materials and foodstuffs of animal origin.

The main aim of this work was to study the levels of fatty acids in oil obtained from whole seeds and kernels of lupin (*L. albus*, *L. angustifolius* and *L. luteus*) varieties registered in the Czech Republic.

MATERIALS AND METHODS

In the study, *L. albus* varieties (Amiga, LAL and Oležka), *L. angustifolius* (Boruta and Probor) and *L. luteus* (Boregine, Bornal and Wodjil) were used. The samples of seeds were obtained from the Central Institute for Supervising and Testing in Agriculture (Czech Republic). Whole seeds and kernels obtained by hand dehulling were analysed for the levels of oil and individual fatty acids. Attention was focused on the contents of saturated (SFAs) and unsaturated (UFAs) fatty acids. The levels of monounsaturated (MUFAs) and polyunsaturated acids (PUFAs) and the levels of ω-3 and ω-6 fatty acids were also assessed. The relative distribution of individual fatty acids in lupin oil was calculated.

The oil content was determined using ANKOM^{XT10} Fat Analyser (O.K. SERVIS BioPro, Czech Republic). The levels of individual fatty acids were determined by gas chromatography using GC 2010 Gas Chromatograph (Shimadzu, Japan). Samples were prepared using a fat extraction procedure based on the Soxhlet method followed by the transesterification of the sample under a cooler and the injection of a sample to the analyser. The values are related to 100% dry matter of seed or kernel. Data were analysed using the UNISTAT CZ statistical program.

RESULTS AND DISCUSSION

It follows from the results in Table 1 that the content of crude oil in whole seed and kernel (cotyledon) ranged from 44.90 to 80.30 g/kg and from 55.50 to 97.00 g/kg, respectively. The values published by Roth-Maier and Kirchgessner (1993) also fall into this range. The mean oil level in analysed varieties was 56.28 g/kg in whole seed and 69.13 g/kg in kernel. Dehulling resulted in a significant ($P \leq 0.05$) increase (by up to 22.83%) in the content of kernel oil. These results agrees with the findings made by Smulikowska *et al*. (1995), who reported that the lupin seed oil is concentrated mainly in the cotyledon (kernel).

As mentioned in the introduction of this paper, the oil quality depends on the presence of individual fatty acids rather than on the oil quantity. The mean levels of individual fatty acids in whole seed and kernel of the lupin varieties analysed are presented in Table 1. The quality of oil in the final product (kernel) did not change (no change in the FA profile occurred) after the dehulling of lupin seeds. Of all FAs determined, palmitic acid C16:0 belonging to saturated fatty acids was found at highest levels in both whole seed and grain (6.96% and 7.17%, respectively) followed by behenic acid C22:0 (3.20% and 3.08%, respectively). The highest levels of MUFAs in lupin oil were detected for oleic acid and its isomer elaidic acid (36.82% and 37.17%, respectively). This was also confirmed by Uzun *et al*. (2007).

The highest levels of PUFAs were found for linoleic acid C18:2n6c and its isomer linolelaidic acid C18:2n6t (35.81% and 35.55%, respectively) belonging to ω-6 FAs, and for α-linolenic acid C18:3n3 (8.34% and 8.13%), which belong to ω-3 FAs. Our analyses of seed revealed a considerably higher content of linoleic acid as compared to Boschin *et al*. (2007, 2008).

The levels of individual groups of FAs increased after seed dehulling in a range of 20.04–25.18% (Table 2). Dehulling resulted in a highly significant ($P \leq 0.01$) increase in the levels of fatty acids in kernel. The levels of unsaturated FAs, namely polyunsaturated acids (PUFAs), increased highly significantly ($P \leq 0.01$) in kernel; a significant increase ($P \leq 0.05$) was detected for kernel ω-6 FA (Table 1). However, these changes did not influence ratios of SFA/UFA (1:5.8 and 1:5.7 for whole seed and kernel, respectively), MUFA/PUFA (1:1 for both whole seed and kernel) and ω-3 FA/ω-6 FA (1:3.7 and 1:3.8 for whole seed and kernel, respectively). The favourable ω-3 FA/ω-6 FA ratio was reported by Boschin *et al*. (2007, 2008).

In conclusion, the analyses of lupin seeds and the product (kernel) obtained after seed dehulling confirmed the high quality of lupin oil with regard to human and farm animal nutrition. The ω-3 FA/ω-6 FA ratio of 1:3.7 for whole seed and 1:3.8 for kernel is favourable from a nutritional point of view, as it makes the lupin seed a potentially useful source of both protein and high-quality oil.

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