

# NUTRITIVE COMPOSITION OF SEEDS OF THE LUPIN VARIETIES REGISTERED IN THE CZECH REPUBLIC

Vladimír Večerek, Pavel Suchý, Eva Straková and Miroslav Macháček

Department of Nutrition, Animal Husbandry and Animal Hygiene, Faculty of Veterinary Hygiene and Ecology, University of Veterinary and Pharmaceutical Sciences, Palackého 1-3, 612 42 Brno, Czech Republic

Corresponding author's email: vecerekv@vfu.cz

## ABSTRACT

The results of nutrient analyses of nine lupin varieties registered in the Czech Republic (Amiga, LAL, Oležka, APR 82, Boruta, Probor, Boregine, Bernal and Wodjil) are presented in this study. The contents of crude protein, fat, crude fibre, acid detergent fibre (ADF), neutral detergent fibre (NDF), nitrogen-free extracts (NFE), starch, non-starch polysaccharides (NSP), ash, macro minerals (Ca, P and Mg) and gross energy (GE) were determined in the whole seeds of lupin varieties. The changes in nutrient composition of the kernel as the product of seed dehulling were also studied. The hull and the kernel comprised on average 22.16% and 76.85% of the seed, respectively. The mean nutrient composition in the final product (kernel) changed considerably after dehulling of lupin seeds. These changes were characterised by a significant ( $P \leq 0.01$ ) increase in the contents of crude protein and gross energy. The oil content also increased significantly ( $P \leq 0.05$ ). In contrast, the contents of crude fibre, ADF, NDF and Ca decreased significantly ( $P \leq 0.01$ ) after seed dehulling. Although the contents of NFE, starch, NSP, ash, P and Mg were increased after dehulling of seeds, the differences in their mean values between the whole seed and kernel were not statistically significant. Valuable protein feed suitable for monogastric animal nutrition can be obtained by the dehulling of lupin seeds.

## KEYWORDS

*Lupinus*, seed, chemical composition, dehulling

## INTRODUCTION

The growing of individual varieties of the genus *Lupinus* in the Czech Republic has not yet been developed to any large extent. This is due to intense competitive pressure from soya and soya products. With regard to its potential use as a component of feedstuffs for farm animals, lupin seed is still only at the experimental stage, and lupin and lupin products are practically impossible to find in human nutrition in the Czech Republic. This is also due to the lack of relevant information on the excellent nutritive value of seeds of this crop. The knowledge of chemical composition of lupin seeds is a basis for practical usage

of lupin seeds and their products in animal and human nutrition. Many authors have dealt with the chemical composition of lupin seeds, particularly in relation to the contents of saccharides (Gdala, 1998; Perez-Maldonado *et al.* 1999; Van Barneveld, 1999) and proteins (Pettersson, 2000; Hauksdottir *et al.* 2004; Rodriguez-Macias *et al.* 2006). The majority of authors reported that lupin seed is an excellent protein feed. However, from a dietary point of view, lupin seed contains both low starch content and high content of non-starch polysaccharides. This can be solved through the addition of suitable enzymes (Steenfeldt *et al.* 2003). The nutritive value of lupin seeds can be successfully increased (primarily for monogastric animals) by dehulling (Rubio *et al.* 2003; Mieczkowska *et al.* 2005).

The aim of this study was to determine the nutrient composition of seeds of nine lupin varieties registered in the Czech Republic and changes in the nutrient composition of the product (kernel) obtained by seed dehulling.

## MATERIALS AND METHODS

In the study, the varieties of three lupin species were used: white lupin (*Lupinus albus*) varieties Amiga, LAL and Oležka, narrow-leafed lupin (*L. angustifolius*) varieties APR 82, Boruta and Probor, and yellow lupin (*L. luteus*) varieties Boregine, Bernal and Wodjil. Whole seeds and kernels obtained by hand dehulling of seeds were analysed in each variety. Crude protein was determined such as nitrogen ( $N \times 6.25$ ). The nitrogen content was determined by the Kjeldahl method using Buchi analyser (Centec automatika, Czech Republic). Fat was determined by extraction with petrol ether using the ANKOMXT<sup>10</sup> Fat Analyser (O.K. SERVIS BioPro, Czech Republic). Crude fibre, acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined using ANKOM<sup>220</sup> Fibre Analyser (O.K. SERVIS BioPro, Czech Republic). Starch was determined using Automatic digital polarimeter P 3002 RS (Krüss, Germany). The ash content was determined gravimetrically after sample ashing at 550°C under prescribed conditions. Calcium (Ca), phosphorus (P) and magnesium (Mg) were determined after sample ashing, followed by extractions and subsequent titration. Gross energy (GE) was determined calorimetrically as

the gross heating value of a sample using AC 500 Calorimeter (LECO, USA). Calculation was used to determine nitrogen-free extracts (NFE) = dry matter of the sample – (protein + fat + crude fibre + ash). Non-starch polysaccharides (NSP) were calculated as NSP = NFE – starch. The values are expressed as 100% of dry matter of the whole seed or kernel. The program UNISTAT CZ was used for statistical analysis.

## RESULTS AND DISCUSSION

Analyses were carried out on the whole seeds and kernels of the studied lupin varieties. Before the analyses, thousand seed weight was determined for each variety as an indicator of seed weight (Table 1). The results showed that there is a marked variability in seed weight among varieties. This agrees with the results of Hauksdottir *et al.* (2004). After dehulling of seeds, the proportion of the hull and kernel to whole seed weight was determined. In the varieties studied, the hull and kernel (cotyledon) comprised in average 22.16% and 76.85% of whole seeds, respectively.

After dehulling of the lupin seeds, the average nutrient composition of the final product (kernel) changed significantly (Table 2). These changes were characterised by a highly significant ( $P \leq 0.01$ ) increase in crude protein and gross energy (GE). A significant ( $P \leq 0.05$ ) increase in the oil content was also found, which is connected with the increased GE content. In contrast, there was a highly significant ( $P \leq 0.01$ ) reduction in the crude fibre, ADF, NDF and calcium contents after dehulling. Although the contents of NFE, starch, NSP, ash, P and Mg increased after dehulling, the differences between whole seed and kernel were not statistically significant ( $P \geq 0.05$ ).

It is possible to conclude from the results that crude protein is located primarily in the kernel (cotyledon), whereas crude fibre and fibre fractions are found in the hull.

Table 3 shows the changes in the individual nutrients of nine lupin varieties registered in the Czech Republic. There was an unambiguous increase in crude protein after the seed dehulling in all lupin varieties (Table 3). For the majority of varieties, it is possible to create by seed dehulling a highly concentrated protein product comparable with soyabean meal. The values that we determined for crude protein agree with the results published by Hauksdottir *et al.* (2004) and Rodriguez-Macias *et al.* (2006).

As was the case with crude protein, the contents of lupin oil similarly increased after dehulling of seed in all analysed varieties (Table 3).

After dehulling of lupin seeds, there was a marked reduction in crude fibre (Table 3). This results in a considerable concentration of the aforementioned nutrients and an increase in nutritive value of the final product. The dehulling of lupin seeds simultaneously

caused a marked reduction in ADF and NDF (Table 3), which leads to a product suitable as a component to feed mixtures for monogastric animals.

Lupin seeds are characterised by unique composition of saccharides, primarily by non-starch polysaccharides. This fact is highlighted in the studies by Gdala (1998), Perez-Maldonado *et al.* (1999), Van Barneveld (1999) and Petterson (2000). Of the total saccharide content, characterised by NFE, the level of starch was relatively low at the expense of non-starch polysaccharides (Table 3). Seed dehulling had no effect on their content in the final product (kernel). The increased level of starch was at the threshold of statistical significance. However, the starch content is a very low in comparison to cereals and does not represent a dominant portion of the total saccharides.

As a consequence of dehulling of lupin seeds, a change in the mineral contents occurred. These changes were primarily characterised by a marked reduction in Ca in the kernel and an increase ( $P \geq 0.05$ ) in P and Mg (Table 3). The results indicate that Ca is deposited mainly in the hull, while P and Mg are found in the kernel (cotyledon).

As is evident from the results, the dehulling of lupin seeds can significantly increase the nutritive value of the final product. Many authors pointed out this fact in their publications (Gdala, 1998; Rubio *et al.* 2003; Mieczkowska 2005). In conclusion, from the perspective of animal feeds, lupin seeds and products are an important source primarily of proteins. In the manufacture of feed mixtures, it is always necessary (due to large variability among varieties) to precisely and nutritionally define the variety of lupin used.

## ACKNOWLEDGEMENT

This work was realised as a part of the Research Plan No. MSM6215712402 'Veterinary aspects of food quality and safety' from the Ministry of Education, Youth and Sports of the Czech Republic.

## LITERATURE CITED

- Gdala, J. 1998. Composition, properties, and nutritive value of dietary fibre of legume seeds. A review. *Journal of Animal and Feed Sciences* 7: 131-150.
- Hauksdottir H., N. Kuptsov and B. Joernsgaard. 2004. Variation in seed size, seed coat proportion, and protein content in narrow-leaved lupin. pp. 46-48. *IN* E. van Santen and G.D. Hill (eds). Wild and cultivated lupins from the Tropics to the Poles. Proceedings of the 10<sup>th</sup> International Lupin Conference, Laugarvatn, Iceland, 19-24 June 2002.
- Mieczkowska, A., A.J.M. Jansman, R.P. Kwakkel and S. Smulikowska. 2005. Effect of dehulling and alpha-galactosidase supplement on the ileal digestibility of yellow lupin based diets in broiler chickens and adult roosters. *Journal of Animal and Feed Sciences* 14: 297-304.

- Perez-Maldonado, R.A., P.F. Mannion and D.J. Farrell. 1999. Optimum inclusion of field peas, faba beans, chick peas and sweet lupins in poultry diets. I. Chemical composition and layer experiments. *British Poultry Science* 40: 667-673.
- Pettersson, D.S. 2000. The use of lupins in feeding systems – review. *Asian-Australasian Journal of Animal Sciences* 13: 861-882.
- Rodriguez-Macias R., M.A. Ruiz-Lopez, P.M. Garcia-Lopez, F. Zamora-Natera and J. Ruiz-Moreno. 2006. Nutritional potential of *Lupinus exaltatus* Zucc. for use as an alternative crop of high protein content. pp. 219-220. *IN E. van Santen, and G.D. Hill (eds.). Mexico, where old and new world lupins meet. Proceedings of the 11<sup>th</sup> International Lupin Conference, Guadalajara, Jalisco, Mexico, 4-9 May, 2005.*
- Rubio, L.A., A. Brenes and C. Centeno. 2003. Effects of feeding growing broiler chickens with practical diets containing sweet lupin (*Lupinus angustifolius*) seed meal. *British Poultry Science* 44: 391-397.
- Steenfeldt, S., E. Gonzalez and K.E. Bach Knudsen. 2003. Effects of inclusion with blue lupins (*Lupinus angustifolius*) in broiler diets and enzyme supplementation on production performance, digestibility and dietary AME content. *Animal Feed Science and Technology* 110: 185-200.
- Van Barneveld, R.J. 1999. Understanding the nutritional chemistry of lupin (*Lupinus* spp.) seed to improve livestock production efficiency. *Nutrition Research Reviews* 12: 203-230.

**Table 1.** Average seed weight (g) of nine varieties of lupin analysed.

Parameter	Variety								
	Amiga	APR82	Boregine	Bornal	Boruta	LAL	Oležka	Probor	Wodjil
Weight	0.286	0.124	0.145	0.104	0.120	0.223	0.224	0.089	0.076

**Table 2.** Nutrient composition of whole seeds and kernels – average from nine lupin varieties.

Nutrient	Study part	Max	Min	x	sn	sx	v	P
Protein (g/kg)	Seed	437.00	332.30	376.13	39.29	13.10	10.44	≤ 0.01
	Kernel	548.10	411.10	466.97	48.66	16.22	10.42	
Fat (g/kg)	Seed	80.30	44.90	56.32	11.16	3.72	19.81	≤ 0.05
	Kernel	97.00	55.50	69.24	13.10	4.37	18.92	
Fibre (g/kg)	Seed	168.90	127.70	148.51	13.82	4.61	9.31	≤ 0.01
	Kernel	51.40	19.80	28.72	9.79	3.26	34.08	
NFE (g/kg)	Seed	431.40	301.00	376.08	48.16	16.05	12.81	NS
	Kernel	460.40	296.80	386.79	59.75	19.92	15.45	
Starch (g/kg)	Seed	100.30	64.60	83.27	12.49	4.16	15.00	NS
	Kernel	124.00	66.40	91.40	16.88	5.63	18.47	
NSP (g/kg)	Seed	331.10	230.90	292.81	37.43	12.48	12.78	NS
	Kernel	351.90	230.40	295.39	44.78	14.93	15.16	
Ash (g/kg)	Seed	52.00	37.70	42.94	5.10	1.70	11.87	NS
	Kernel	62.00	41.60	48.24	7.02	2.34	14.56	
Ca (g/kg)	Seed	4.80	2.67	3.50	0.71	0.24	20.23	≤ 0.01
	Kernel	3.10	1.79	2.18	0.43	0.14	19.58	
P (g/kg)	Seed	9.18	5.45	6.61	1.32	0.44	19.98	NS
	Kernel	11.26	6.70	8.09	1.69	0.56	20.87	
Mg (g/kg)	Seed	3.62	1.80	2.35	0.69	0.23	29.37	NS
	Kernel	4.10	2.10	2.70	0.75	0.25	27.83	
GE (MJ/kg)	Seed	20.80	19.70	20.07	0.39	0.13	1.93	≤ 0.01
	Kernel	21.50	20.20	20.71	0.41	0.14	1.95	
ADF (g/kg)	Seed	211.10	178.00	195.32	11.86	3.95	6.07	≤ 0.01
	Kernel	72.70	38.40	60.89	12.82	4.27	21.06	
NDF (g/kg)	Seed	248.20	198.30	226.18	20.82	6.94	9.21	≤ 0.01
	Kernel	106.30	45.30	72.03	18.13	6.04	25.17	

MAX – maximum value; MIN – minimum value; x – arithmetic mean from nine lupin varieties; sn - standard deviation; sx - standard error of arithmetic mean; v – variation coefficient).

NFE – nitrogen-free extracts; NSP – non-starch polysaccharides, GE – gross energy; ADF – acid detergent fibre; NDF – neutral detergent fibre.

**Table 3.** Nutrient composition (g/kg) of whole seed a kernel of lupin varieties.

Nutrient	Variety																	
	Amiga		APR 82		Boregin		Bornal		Boruta		LAL		Oleška		Probor		Wodjil	
	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.	Seed	Ker.
CP	380.1	473.4	341.1	419.8	332.3	411.1	437.0	537.8	334.2	423.3	384.9	464.5	384.2	462.9	358.2	461.9	433.2	548.1
Oil	80.3	97.0	56.7	70.2	50.6	62.5	46.5	55.5	48.8	61.9	61.1	73.6	64.8	79.4	53.2	67.6	44.9	55.5
Fibre	127.7	27.4	148.6	23.0	146.0	22.0	163.5	51.4	153.9	19.8	148.0	35.8	128.3	23.4	151.7	25.3	168.9	30.4
ADF	179.5	66.8	209.2	49.4	192.0	58.0	196.5	71.8	205.5	72.7	191.3	71.2	178.0	71.4	194.8	38.4	211.1	48.3
NDF	198.4	65.4	248.2	74.7	246.0	89.5	233.9	77.2	232.4	72.1	203.9	61.4	198.3	56.4	247.3	106.3	227.2	45.3
NFE	370.9	358.5	415.9	445.4	431.4	460.4	301.9	296.8	421.9	447.9	363.2	379.6	381.1	388.5	397.4	400.0	301.0	304.1
Starch	86.5	87.7	98.6	103.5	100.3	124.0	64.6	66.4	91.5	96.0	80.5	92.3	72.6	90.8	84.7	90.7	70.1	71.2
NSP	284.4	270.8	317.3	341.9	331.1	336.4	237.3	230.4	330.4	351.9	282.7	287.3	308.5	297.7	312.7	309.3	230.9	232.9
Ca	3.8	2.2	3.9	2.2	4.8	3.1	2.7	1.9	3.7	2.6	3.1	1.8	2.8	1.9	3.9	2.1	2.7	1.9
P	5.6	6.7	5.5	6.7	6.2	7.8	9.2	11.3	6.0	7.9	5.9	7.0	6.7	7.2	6.0	7.6	8.5	10.7
Mg	1.8	2.4	2.0	2.6	1.9	2.1	3.6	4.1	2.0	2.1	2.1	2.3	2.3	2.5	2.1	2.3	3.4	3.9

CP – crude protein; ADF – acid detergent fibre; NDF – neutral detergent fibre; NFE – nitrogen-free extracts; NSP – non-starch polysaccharides.