

Nutritional Composition of Seeds of the Genus *Lupinus*

E. STRAKOVÁ¹, P. SUCHÝ¹, V. VEČEREK¹, V. ŠERMAN², N. MAS², M. JŮZL³

¹University of Veterinary and Pharmaceutical Sciences Brno, Czech Republic

²Veterinary Faculty of the University of Zagreb, Croatia

³Mendel University of Agriculture and Forestry in Brno, Czech Republic

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Abstract

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The aim of this study was to determine and evaluate the chemical composition of the seeds of the genus *Lupinus* and soybeans. The chemical analyses were carried out in frequently grown lupin varieties in Europe (AMIGA, ANDA, ATU, BORUTA, BUTAN, DIETA, JUNO, KARO, PRIMA, ROSE, SONET and WATT) and two locally grown varieties of soybeans (KORADA and VISION). The contents of individual substances in analysed lupin seeds showed large differences in chemical composition of individual lupin varieties (crude protein: 317.06 - 458.86 g·kg⁻¹; lipids: 52.15 - 125.76 g·kg⁻¹; fibre: 101.21 - 154.23 g·kg⁻¹; non-nitrogenous extractive substances: 285.94 - 436.47 g·kg⁻¹; starch: 41.31 - 102.65 g·kg⁻¹; organic matter: 951.75 - 966.24 g·kg⁻¹; ash: 33.76 - 48.25 g·kg⁻¹; calcium: 2.29 - 5.10 g·kg⁻¹; phosphorus: 4.62 - 8.04 g·kg⁻¹; magnesium: 1.36 - 2.51 g·kg⁻¹; acid detergent fibre: 133.13 - 209.25 g·kg⁻¹). Lupin seeds were characterized by high contents of crude protein; in some varieties they significantly exceeded the content of crude protein in soybeans. In contrast to lupine seeds, soybeans contained a significantly higher content of lipids and lower content of fibre including acid detergent fibre. In lupin seeds, a negative correlation coefficient was found between the crude protein and BNLV content ($r = -0.93$) and between crude protein and starch content ($r = -0.79$). A positive correlation ($r = 0.76$) was found between the starch and BNLV content in lupin seeds. The results of the study provide information not only for growers regarding the choice of individual lupin varieties, but also for breeders who intend to use lupin seeds as suitable components for feed rations and mixtures.

Lupins, varieties, chemical composition, seed

At present suitable protein components for feed rations and mixtures for farm animal feeding are searched for. With meat and bone meal being prohibited in farm animal feeding in connection with Bovine Spongiform Encephalopathy (BSE), suitable protein sources for the preparation of vegetable diets are searched for with the objective to secure animal provenance food safety. Apart from soya and soya products, seeds of some varieties of the genus *Lupinus* appear to be a very perspective source of vegetable protein. In practise we encounter a wide range of diverse varieties mostly derived from the white lupin (*Lupinus albus*), yellow lupin (*L. luteus*) and narrow-leaved lupin (*L. angustifolius*). Experimental studies of Koreleski et al. (1987) or Castanon and Perezlancac (1990) prove the possibility of a partial replacement of extracted soymeal in diets with a suitable variety of lupin seeds (*L. angustifolius*, *L. albus*). RothMaier and Kirchgessner (1993); Lettner and Zollitsch (1995); Ravindran et al. (2002) and other authors recommend lupin seeds as a suitable source of vegetable proteins in diets even for monogastric animals. Lupin seeds have a unique saccharide composition characterized by a low content of starch and high content of non-starch polysaccharides, as stated by VanBarneveld (1999). From this point of view the nutritional value of lupin seeds and their inclusion to farm animal diet is often discussed, as mentioned by Petterson (2000). The seed nutritional value may be significantly increased by hulling,

Address for correspondence:

Doc. Ing. Eva Straková, Ph.D.,
Department of Animal Nutrition
University of Veterinary and Pharmaceutical Sciences Brno
Palackého -3, 612 42 Brno Czech Republic

Phone: +420 541 562 672
Fax: +420 541 562 675
e-mail: strakovae@vfu.cz
<http://www.vfu.cz/acta-vet/actavet.htm>

as confirmed by Smulikowska et al. (1995). A high content of lupin seeds (*L. angustifolius*) in diets may worsen production efficiency of feed mixtures due to the absence of some amino acids (methionine), as it was found in hens by Hammershoj and Steinfeldt (2005). It is clear from literary sources that a reasonable use of *Lupinus* seeds in diets for farm animal feeding requires knowledge and definition of the nutrition composition of the used lupin variety.

The objective of our study was to draw attention to high variability of basic substances in seeds between individual varieties of the genus *Lupinus* and to compare their contents with those of soybeans.

Materials and Methods

The analyses were carried out in the laboratory of the Department of Nutrition, Animal Husbandry and Animal Hygiene at the Faculty of Veterinary Hygiene and Ecology of the University of Veterinary and Pharmaceutical Sciences Brno. We have chosen 12 varieties from more than 20 analyzed individual seed varieties of the genus *Lupinus* (AMIGA, ANDA, ATU, BORUTA, BUTAN, DIETA, JUNO, KARO, PRIMA, ROSE, SONET and WATT). Because these varieties represent the best known and most often grown varieties of lupins in Europe, our sample therefore comprises values of nutrients typical for most lupin varieties. By comparing nutritional values of analysed lupin seeds we used the results of analyses of two varieties of soybeans (KORADA and VISION). Before the analysis itself samples were homogenized and dry matter was determined at 105 °C to constant weight. Crude protein was calculated from the content $N \times 6.25$; N was determined according to Kjeldahl on Buchi analyser. The lipid content was determined by a device Fat Analyser ANKOM^{XT10}, crude fibre including acid detergent fibre by a device Fibre Analyser ANKOM²²⁰. Ash was determined gravimetrically as a residuum after a sample being incinerated at the temperature of 550 °C to constant weight under prescribed conditions. Ca, P and Mg elements were determined using chelatometric titration procedure from the extract of an incinerated sample. Organic matter values (OH = crude protein + lipid + fibre) and non-nitrogenous extractive substances (BNLV = dry matter - crude protein - lipid - fibre - ash) were established by calculation. For an objective comparison of the obtained results the content of individual content substances was recalculated for 100% of dry matter. The results of analyses in observed content substances were subject to correlation analysis (STAT PLUS). Significant correlation relations characterized by a correlation coefficient are stated in the results of the study.

Results and Discussion

It can be seen from the results presented in Table 1 that considerable differences exist in seeds of individual varieties of lupins in the content of individual observed substances.

To make an objective comparison of analysed varieties among them and in relation to soybeans, the values of individual content substances were expressed in 100% of dry matter because different water content in the seeds of analysed varieties stated in Table 1 would affect their comparison. The contents of individual substances expressed in 100% of dry matter are in Table 2.

Table 2 shows that lupin seeds contain a large portion of crude protein. The crude protein content of studied varieties ranged rather widely, from 317.06 g·kg⁻¹ (BORUTA) to 458.86 g·kg⁻¹ (JUNO). In some varieties of lupin seeds the crude protein content is comparable (AMIGA, KARO) or even higher (DIETA, BUTAN, ANDA, JUNO) than in analysed soybeans. The obtained results are also in accordance with literary sources that similarly point out the large range in the contents of crude protein within the studied varieties, such as RothMaier and Kirchgessner (1993); Lettner and Zollitsch (1995) or Ravindran et al. (2002).

Compared to soybeans, lupin seeds have a significantly lower content of lipids. Their content in the seeds of studied varieties ranged from 52.15 g·kg⁻¹ (ATU) to 125.76 g·kg⁻¹ (ANDA). Literary sources unambiguously confirm a lower content of lipids in lupin seeds in comparison with soybeans. The results of lipid analyses differ among individual authors even within the same variety. For instance, in AMIGA variety Lettner and Zollitsch (1995) state the lipid content of 11.3% (113 g·kg⁻¹), whereas RothMaier and

Table 1. Chemical composition of analysed varieties of lupin seeds and varieties of soybeans (KORADA, VISION)

(g/kg)	AMIGA	ANDA	ATU	BORUTA	BUTAN	DIETA	JUNO
water	71.50	67.30	87.20	86.30	85.60	117.80	104.30
dry matter	928.50	932.70	912.80	913.70	914.40	882.20	895.70
crude protein	329.60	409.30	320.10	289.70	347.30	320.90	411.00
lipid	80.30	117.30	47.60	53.80	93.50	84.90	49.20
fibre	110.20	94.40	133.90	136.60	103.80	114.90	127.80
BNLV	372.80	266.70	373.70	398.80	336.90	324.60	265.40
starch	85.70	56.14	71.20	83.95	81.50	78.80	37.00
OH	892.90	887.70	875.30	878.90	881.50	845.30	853.40
ash	35.60	45.00	37.50	34.80	32.90	36.90	42.30
Ca	3.61	4.57	3.60	3.41	4.66	3.00	3.80
P	4.29	6.58	6.01	5.54	4.33	4.80	7.20
Mg	1.94	2.18	1.33	2.18	1.58	1.20	2.25
ADF	154.30	124.17	191.00	182.30	132.40	128.30	168.11
(g/kg)	KARO	PRIMA	ROSE	SONET	WATT	KORADA	VISION
water	81.80	79.30	78.40	82.40	101.70	93.20	59.80
dry matter	918.20	920.70	921.60	917.60	898.30	906.80	940.20
crude protein	326.30	305.70	302.50	311.60	289.80	321.10	333.90
lipid	56.20	53.70	49.10	55.70	87.10	197.20	201.60
fibre	110.40	142.00	136.90	128.50	133.70	63.80	70.70
BNLV	394.30	382.50	400.00	386.30	350.00	274.30	278.70
starch	83.00	92.90	94.60	62.00	73.68	62.00	67.70
OH	887.20	883.90	888.50	882.10	860.60	856.40	884.90
ash	31.00	36.80	33.10	35.50	37.70	50.40	55.30
Ca	2.10	4.00	4.01	4.50	3.20	3.19	3.60
P	4.80	5.23	4.62	5.47	5.55	7.30	8.57
Mg	1.88	1.94	1.46	1.34	1.94	2.18	1.94
ADF	145.22	192.20	177.70	169.40	175.87	96.70	82.60

Kirchgessner (1993) state the value of 7.6% (76 g·kg⁻¹) in the same variety, which corresponds more to our results.

Unlike soybeans lupin seeds contain a relatively high amount of crude fibre, including acid detergent fibre. The crude fibre content in the analysed varieties ranged from 101.21 g·kg⁻¹ (ANDA) to 154.23 g·kg⁻¹ (PRIMA), acid detergent fibre from 133.13 g·kg⁻¹ (ANDA) to 209.25 g·kg⁻¹ (ATU).

Non-nitrogenous extractive substances (BNLV) represent especially various kinds of saccharides up to non-structural polysaccharides. Their content in seeds of individual lupin varieties ranged from 285.94 g·kg⁻¹ (ANDA) to 436.47 g·kg⁻¹ (BORUTA). Table 2 shows that the majority of seeds of analysed lupin varieties have a higher content of BNLV, and therefore also saccharides, than soybeans. The amount of starch in lupin seeds ranged from 41.31 g·kg⁻¹ (JUNO) to 102.65 g·kg⁻¹ (ROSE), which is a rather low quantity and presents approximately 20% of BNLV in average, whereas in cereals starch represents 70% and more. This fact shows a relatively high presence of non-starch saccharides in lupin seeds. The stated conclusions correspond with Van Barneveld (1999); Ravindran et al. (2002) or Hammershoj and Steinfeldt (2005), who found high contents of non-starch polysaccharides in lupin seeds.

The quantity of organic compounds in the seed is characterized by the content of organic matter. The organic matter content in lupin seeds ranged in a rather narrow range, from

Table 2. Chemical composition of analysed varieties of lupin seeds and varieties of soybeans (KORADA, VISION) expressed in 100% of dry matter

100%	AMIGA	ANDA	ATU	BORUTA	BUTAN	DIETA	JUNO
crude protein	354.98	438.83	350.68	317.06	379.81	363.75	458.86
lipid	86.48	125.76	52.15	58.88	102.25	96.24	54.93
fibre	118.69	101.21	146.69	149.50	113.52	130.24	142.68
BNLV	401.51	285.94	409.40	436.47	368.44	367.94	296.30
starch	92.30	60.19	78.00	91.88	89.13	89.32	41.31
OH	961.66	951.75	958.92	961.66	964.02	958.17	952.77
ash	38.34	48.25	41.08	38.09	35.98	41.83	47.23
Ca	3.89	4.90	3.94	3.73	5.10	3.40	4.24
P	4.62	7.05	6.58	6.06	4.74	5.44	8.04
Mg	2.09	2.34	1.46	2.39	1.73	1.36	2.51
ADF	166.18	133.13	209.25	199.52	144.79	145.43	187.69
100%	KARO	PRIMA	ROSE	SONET	WATT	KORADA	VISION
crude protein	355.37	332.03	328.23	339.58	322.61	354.10	355.10
lipid	61.21	58.33	53.28	60.70	96.96	217.50	214.40
fibre	120.24	154.23	148.55	140.04	148.84	70.40	75.20
BNLV	429.43	415.44	434.03	420.99	389.62	302.50	296.40
starch	90.39	100.90	102.65	67.57	82.02	68.40	72.00
OH	966.24	960.03	964.08	961.31	958.03	944.40	941.20
ash	33.76	39.97	35.92	38.69	41.97	55.60	58.80
Ca	2.29	4.34	4.35	4.90	3.56	3.52	3.83
P	5.23	5.68	5.01	5.96	6.18	8.05	9.12
Mg	2.05	2.11	1.58	1.46	2.16	2.40	2.06
ADF	158.16	208.75	192.82	184.61	195.78	96.70	87.90

951.75 g·kg⁻¹ (ANDA) to 966.24 g·kg⁻¹ (KARO). In lupin seeds organic matter content was slightly higher than in compared soybeans.

The mineral content is characterized by the ash content. In the analysed lupin seeds the ash content ranged from 33.76 g·kg⁻¹ (KARO) to 48.25 g·kg⁻¹ (ANDA). The contents of analysed elements in lupin seeds ranged from 2.29 g·kg⁻¹ (KARO) to 5.10 g·kg⁻¹ (BUTAN) in calcium, from 4.62 g·kg⁻¹ (AMIGA) to 8.04 g·kg⁻¹ (JUNO) in phosphorus and from 1.36 g·kg⁻¹ (DIETA) to 2.51 g·kg⁻¹ (JUNO) in magnesium. When comparing the chemical composition of lupin seeds with soybeans, a higher content of ash, and therefore also minerals, was proved in soybeans. In individual analysed elements certain differences were noticed that may be characterized in the majority of analysed lupin varieties by a higher content of calcium and on the contrary a lower content of phosphorus.

Also some relations between contents of substances of lupin seeds may be regarded as interesting. It was established by correlation analysis that the content of BNLV (saccharides) declines with increasing content of crude protein in lupin seeds ($r = -0.93$). Similarly a high negative correlation ($r = -0.79$) was established between the crude protein and starch content. Despite a relatively small amount of starch in lupin seeds, its content was in a positive correlation with the content of BNLV ($r = 0.76$).

In conclusion, our results indicate that lupin seeds of some varieties are very perspective with regard to animal nutrition, especially for their protein feed component. Hence, it is necessary to know the exact relation of lupin variety characteristics with their nutritional composition before their inclusion to feed rations or mixtures.

Nutriční složení semen rodu *Lupinus*

Cílem práce bylo stanovit a ohodnotit chemické složení semen rodu *Lupinus* a sójových bobů. Chemická analýza byla provedena u nejčastěji v Evropě pěstovaných odrůd rodu *Lupinus* (AMIGA, ANDA, ATU, BORUTA, BUTAN, DIETA, JUNO, KARO, PRIMA, ROSE, SONET a WATT) a dvou tuzemsky pěstovaných odrůd (KORADA a VISION). Obsahy jednotlivých látek analyzovaných odrůd semen lupin poukazují na velkou rozdílnost v chemickém složení jednotlivých lupinových odrůd (dusíkaté látky: 317,06 - 458,86 g·kg⁻¹; tuk: 52,15 - 125,76 g·kg⁻¹; vláknina: 101,21 - 154,23 g·kg⁻¹; bezdusíkaté látky výtažkové: 285,94 - 436,47 g·kg⁻¹; škrob: 41,31 - 102,65 g·kg⁻¹; organická hmota: 951,75 - 966,24 g·kg⁻¹; popel: 33,76 - 48,25 g·kg⁻¹; vápník: 2,29 - 5,10 g·kg⁻¹; fosfor: 4,62 - 8,04 g·kg⁻¹; hořčík: 1,36 - 2,51 g·kg⁻¹; acidodetergentní vláknina: 133,13 - 209,25 g·kg⁻¹). Lupinová semena byla charakterizována vysokým obsahem dusíkatých látek, u některých odrůd výrazně převyšující obsah dusíkatých látek v sojových bobech. Na rozdíl od lupinových semen obsahovaly sojové boby výrazně vyšší obsah tuku a nižší obsah vlákniny včetně vlákniny acidodetergentní. U lupinových semen byl zjištěn záporný korelační koeficient mezi obsahem dusíkatých látek a obsahem BNLV ($r = -0,93$) a mezi obsahem dusíkatých látek a škrobu ($r = -0,79$). Kladná korelace ($r = 0,76$) byla zjištěna mezi obsahem škrobu a BNLV v lupinových semenech. Výsledky práce přinášejí podklady nejen pro pěstitele z hlediska atraktivnosti pěstování jednotlivých odrůd lupin, ale i pro chovatele, při využití lupinových semen jako vhodné komponenty do krmných dávek a krmných směsí.

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