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Dietary Fibre Content in Lupine (*Lupinus albus* L.) and Soya (*Glycine max* L.) Seeds

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Abstract

The objective of this study was to determine the concentrations of total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) in the samples of whole or dehulled seeds of *Lupinus albus* (L.) and *Glycine max* (L.), and to assess the effect of dehulling on the concentrations obtained. The results showed a higher content of TDF and IDF and a lower content of SDF in lupine seeds compared to soybeans. Lupine seed dehulling resulted in a lower content of TDF ($P < 0.05$) and IDF ($P < 0.05$), and a higher content of SDF. Following soybean dehulling, the increase of SDF ($P < 0.05$) and decrease of IDF but no effect on TDF was reported. The proportion of IDF (90.4 vs. 96.0%) and SDF (9.6 vs. 4.0%) in TDF changed only slightly following lupine seed dehulling, whereas in soybeans, the proportion of IDF markedly decreased (91.8 vs. 73.0%), and SDF increased (8.2 vs. 27.0%). The effectiveness of dehulling with regard to soluble fibre was higher in soybeans compared to lupine seeds. In lupine, dehulling did not show any significant increase of nutritional value concerning the proportion of insoluble fibre in cotyledon. Due to the content of insoluble fibre in lupine seeds, their proportion in the ration of animals should be considered.

Dehulling, total dietary fibre, insoluble dietary fibre, soluble dietary fibre

Dietary fibre is an essential part of vegetable feeds. Fibre is not digested with the enzymes of the mammalian digestive tract but is to various degrees digested by the enzymes of intestinal microflora. A specific, physiological activity connected with the ability to bind different organic and mineral substances can be seen in individual components of fibre (Trowell 1974; Stratil 1993).

At present, the definition of dietary fibre defined by the American Association of Cereal Chemists (AACC) is preferred: "Dietary fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the small intestine with complete or partial fermentation in the large intestine"(AACC Report 2001). Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances. The pro-kinetic effect of dietary fibre promotes positively a number of physiological functions, including lower blood cholesterol levels and control of blood glucose level (Tichá et al. 2003).

Hemicelluloses and pectin substances that can bind water and swell are termed soluble fibre. Other hemicelluloses, celluloses and lignin bind only little water and are termed insoluble fibre (Stratil 1993; Trowell 1974; Kalač and Míka 1997). Insoluble fibre makes the volume of the digested food larger, improves bowel function and reduces the intestinal transit time. Soluble dietary fibre with its ability of water absorption has a laxative effect which leads to the prevention of constipation and diverticular disease. Reduction of the intestinal transit time by insoluble fibre results in shorter contact of toxic substances with the intestinal mucosa; absorption of toxic substances into the molecules of soluble fibre limits their contact with mucosa. The above beneficial effects are determined by the proportion of soluble and insoluble fibre in the diets received (Zadák 2000).

In most leguminous plants the content of crude fibre ranges from 8% to 27.5%, and that of soluble fibre from 3.3% to 13.8% (Guillon and Champ 2002). Compared to

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other legumes, lupine seeds contain more dietetically beneficial crude fibre (Johnson and Gray 1993). The composition of dietary fibre fractions depends to a large degree on their localisations in the seed coat or cotyledons. Generally, the content of crude dietary fibre is lower in a leguminous cotyledon compared to the seed coat, where the proportion of dietary fibre in dry matter reaches about 90% (Guillon and Champ 2002). Of the selected leguminous plants, lupine showed the highest content (25 – 40%) of dietary fibre (Gross et al. 1988; Bagger et al.1998; Petterson 2000). Lupin seeds had about twice as much non-starch polysaccharides than the other legumes and higher insoluble dietary fibre. Soluble dietary fibre represented over one third of total dietary fibre in all legumes (Donangelo et al. 1995).

The objective of our study was to determine the concentrations of total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) in the samples of whole or dehulled seeds of lupine and soybeans, and to assess the effect of dehulling on the concentrations obtained.

Materials and Methods

The content of total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) was determined in the samples of whole or dehulled seeds of *Lupinus albus* (L.) and *Glycine max* (L.) using enzymatic and gravimetric methods based on the AOAC (1997) procedure with TDF-100A (Sigma) kit. A total of 12 samples were analysed, of which six were samples of whole and dehulled lupine seeds (cultural variety Amiga, Butan and Dieta, harvested in 2008), and six were samples of whole and dehulled soybeans (variety Korada and Vision, harvested in 2008, and one sample bought in a supermarket). Seeds were dehulled manually.

Dried and ground samples were defatted and gelatinised using a heat-stable α-amylase and digested enzymatically by protease and amyloglukosidase to remove protein and starch. Ethanol was used for precipitation of soluble fibre. The rest in the filter was washed with ethanol and acetone, dried and weighted. The whole procedure of TDF and IDF determination was in individual seed samples carried out six times including blank samples. Half of the seed samples and half of the blank samples were analysed for the content of proteins, and the remaining samples were burnt. The following formula for calculation of dietary fibre was used: dietary fibre (expressed as g/100 g dry matter) = 100 (weight of residue – weight of protein – weight of ash - blank)/wt. sample. SDF concentration was determined by subtraction of IDF from TDF. The AOAC (2001) methods were used to measure dry matter, protein according to Kjeldahl, and ash.

The results were processed by statistical methods using analysis of variance and Tukey test (STAT Plus software VRI, Brno, Czech Republic).

Results and Discussion

Analyses showed a higher content of TDF and IDF and a lower content of SDF in lupine seeds compared to soybeans. Dehulling of lupine seeds resulted in a lower content of TDF (50.4 ± 2.4 vs. 42.9 ± 3.6 g/100 g; $P < 0.05$) and IDF (48.4 ± 3.1 vs. 38.8 ± 2.1 g/100 g; $P < 0.05$) and a higher content of SDF (4.1 ± 5.1 vs. 2.0 ± 4.9 g/100 g). In soybeans, dehulling had no effect on concentration of TDF (35.9 ± 4.6 vs. 35.5 ± 1.9 g/100 g) but decreased IDF (32.6 ± 5.5 vs. 26.2 ± 1.9 g/100 g) and increased SDF (2.9 ± 1.4 vs. 9.7 ± 3.3 g/100 g; $P < 0.05$) (Table 1, Figs 1 to 3).

Table 1. Concentrations of TDF, IDF and SDF (g/100 g in dry matter) in seeds of lupine (*Lupinus albus*) and soya (*Glycine max*)

Indicator	*Lupinus albus*		*Glycine max*	
	WS[4] n = 3	DS[5] n = 3	WS[4] n = 3	DS[5] n = 3
TDF[1]	50.4 ± 2.4[a]	42.9 ± 3.6[b]	35.5 ± 1,9	35.9 ± 4.6
IDF[2]	48.4 ± 3.1[a]	38.8 ± 2.1[b]	32.6 ± 5.5	26.2 ± 1. 9
SDF[3]	2.0 ± 4.9	4.1 ± 5.1	2.9 ± 1.4[c]	9.7 ± 3.3[d]

[1] Total dietary fibre, [2] insoluble dietary fibre, [3] soluble dietary fibre, [4] whole seeds, [5] dehulled seeds
[a:b] ($P < 0.05$), [c:d] ($P < 0.05$)

A major difference between insoluble and soluble dietary fibre lies in the relative content of cellulose and non-cellulose polysaccharides. Cell walls of cotyledons contain a wide range of polysaccharides including pectin substances, cellulose and non-starch non-cellulose glucans, while the seed coat contains more fibre in the form of cellulose, a lower amount of

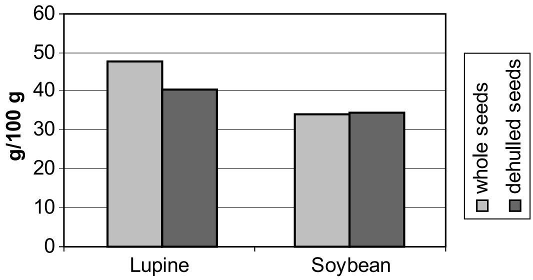

Fig. 1. TDF concentration.

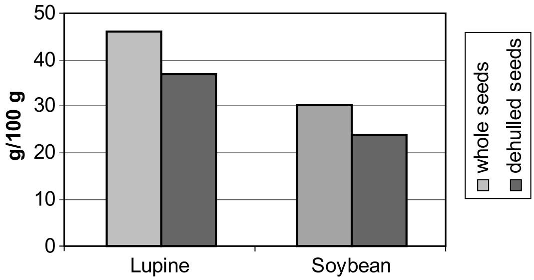

Fig. 2. IDF concentration.

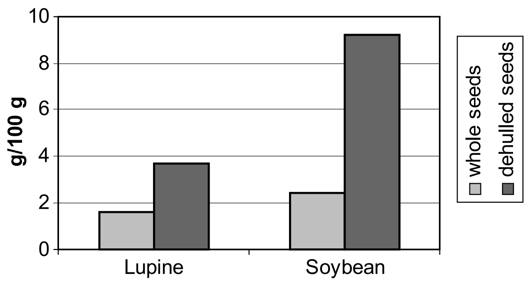

Fig. 3. SDF concentration.

hemicellulose and pectin. Cell walls of cotyledons are not lignified, while the hulls of various lupine species contain lignin (Brillouet and Riochet 1983; Weightman et al. 1994; Donangelo et al. 1995; Petterson 1998; van Laar et al. 1999).

In lupine seeds, the proportion of insoluble (90.4 vs. 96.0%) and soluble fibre (9.6 vs. 4.0%) did not significantly change after dehulling, whereas in soybeans the content of insoluble fibre decreased (91.8 vs.73.0%) and soluble fibre increased (8.2 vs. 27.0%)

Table 2. Proportion of insoluble and soluble fibre (%) of TDF in whole and dehulled seeds of lupine (*Lupinus albus*) and soya (*Glycine max*)

	Lupinus albus		*Glycine max*	
Indicator	WS[4]	DS[5]	WS[4]	DS[5]
IDF[2]	96.0	90.4	91.8	73.0
SDF[3]	4.0	9.6	8.2	27.0

[2] insoluble dietary fibre, [3] soluble dietary fibre, [4] whole seeds, [5] dehulled seeds

(Table 2). The results showed a similar content of insoluble dietary fibre in lupine seeds after dehulling in comparison to whole lupine seeds. The effect of dehulling was more distinctly manifested in soybeans by the decrease of insoluble fibre and increase of soluble fibre.

Data from available literature show certain variability in the composition of TDF, IDF and SDF in lupines and soybeans, which can be based on genetic and environmental impacts (Hill 1986). Pak et al. (1990) found in the lupine variety Multolupa 36.6% TDF and 5.6% SDF; Azizah and Zainon (1997) reported 22.3% TDF, 12.1% IDF and 4.6% SDF in soybean. Andersen et al. (1999) found the concentrations of total dietary fibre in whole and dehulled seeds of white lupine to be 41.2% and 32.6%, respectively. The corresponding figures found by Yokosawa and Takenaka (2000) in soybeans were 32.3% and 33.3%.

Based on soybean dry matter analysis, Guillon and Champ (2002) found the proportion of TDF in cotyledon 80% vs. 75% in the hull, while in lupine the percentage was the same: 80% vs. 80%. The proportion of SDF was 21% vs. 10% and 8% vs. 8% in soybean and lupine, respectively. The same authors reported twice as big galactose content in lupine cotyledon compared to soybean (62.4% and 34.4%). Bellaver et al. (2004) found in soybean meal containing 46% and 48% crude protein, TDF concentrations of 23.5% and 20.8%, and a variation coefficient of 10.8% and 25.9%, respectively.

Polysaccharide composition of *Lupinus albus* L. 2043N was investigated by Mohamed and Rayas-Duarte (1995a) who found the contents of IDF and SDF in lupine cotyledons 21.5% and 2.2%, and in hulls 86.1% and 1%, respectively. According to Evans and Cheung (1991), the composition of dietary fibre extracted from hulls and cotyledons of *L. angustifolius* differs predominantly in the content of galactose which is the major component of cotyledons, whilst glucose dominates in the hull.

Dehulling showed only a mild effect on the proportion of insoluble and soluble fibre in lupine seeds. Lupine species have a special position within the family *Leguminosae* in the way that they contain a great deal of cell wall material in cotyledons (7.5%–32.1%) in the form of thicker cell walls (Brillouet and Riochet 1983). It is ascribed to a large amount of galactans that are stored in cell walls (Guillon and Champ 2002). This hypothesis was confirmed by the study of Mohamed and Rayas-Duarte (1995b) who analysed non-starch polysaccharides (NSP) in *Lupinus albus* L. 2043N and found 88.3% soluble NSP fraction in cotyledons that contained a higher proportion of galactose compared to mannose and arabinose. This is suggestive of the presence of galactomannans that indicate a high proportion of cell wall materials in lupine cotyledons.

In conclusion, the effectiveness of dehulling with respect to soluble fibre was higher in soybeans compared to lupine. Dehulling did not show a significant increase of the nutritional value of lupine regarding the proportion of insoluble fibre in cotyledon. Further studies are needed that would require extended analyses (especially the composition of neutral sugars in the soluble and insoluble fractions of dietary fibre) and focus on the factors that may have an effect on the characteristics under study.

Obsah dietní vlákniny v semenech lupiny (*Lupinus albus* L.) a sóji (*Glycine max* L.)

Cílem práce bylo zjistit ve vzorcích celých nebo odslupkovaných semen lupiny (*Lupinus albus* L.) a sóji (*Glycine max* L.) koncentrace celkové dietní vlákniny (TDF), nerozpustné dietní vlákniny (IDF) a rozpustné dietní vlákniny (SDF) a posoudit vliv odslupkování. Výsledky neodslupkovaných i odslupkovaných lupinových semen prokázaly vyšší obsah

TDF a IDF vůči sojovým bobům. Vliv odslupkování se u lupiny projevil nižším obsahem TDF (P < 0,05) a IDF (P < 0,05) a vyšším obsahem SDF. U sóji nebyla odslupkováním ovlivněna koncentrace TDF, došlo ke snížení IDF a zvýšení SDF (P < 0,05). U lupinových semen se procentický podíl IDF a SDF z koncentrace TDF odslupkováním příliš neměnil (90,4 vs. 96,0 %) a (9,6 vs. 4,0 %), u sóji se významně snížil podíl IDF (91,8 vs. 73,0 %) a významně zvýšil podíl SDF (8,2 vs. 27,0 %).

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