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A note on the chemical composition of the cotyledons and seed coat of three species of sweet lupin

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ABSTRACT

Nine varieties of sweet lupins, harvested in Poland during 1993 (yellow: Juno, Popiel and Amulet; white: Wat, Bardo and Hetman; narrow-leaved: Sur, Emir and Saturn), differing in the size of seeds, were dehulled by hand. The chemical composition of whole seeds, hulls and dehulled seeds were determined.

The size of seeds (expressed as the weight of 1000 seeds) of white and narrow-leaved lupins was positively correlated with the cotyledons and protein and fat contents in the seeds. In all varieties about 97% of total protein and 95 to 98% of total fat contained in the seeds were found in the cotyledons, 74 to 86% of total crude fibre in the hulls. Dehulling of lupin seeds may increase their metabolizable energy content for poultry by 20 to 35%.

KEY WORDS: *L. luteus, L. albus, L. angustifolius,* hull, cotyledon, chemical composition

INTRODUCTION

Sweet lupin seeds are a potentially important source of protein for monogastric animals. Their nutritional value also depends on fat content, which is not only a source of energy, but also a rich source of essential unsaturated fatty acids. According to Matyka and Przegalińska (1986) they can constitute up to 56.5% of total fatty acids in yellow lupins, about 60% in white and 30-40% in narrow-leaved lupins. However, the content of dietary fibre is also high in lupin seeds. It is poorly digested in the small intestine of pigs (Gdala et al., 1994) and digested only to a very small extent by chicks (Alloui et al., 1994).

Most of the dietary fibre is concentrated in hulls which, according to Brillouet and Riochet (1983), make up from 16 to 28% of the whole seed in different species of lupin. Systematic observations made in our laboratory (Wasilewko, unpublished) indicated that different varieties representing three species of lupin recently cultivated in Poland *(L. luteus, L. albus* and *L. angustifolius)* may differ greatly in the size of the seeds. However, there is little evidence on the relative proportion of hulls in lupin seeds of different genetic origin.

The aim of the study was to recognize if there is a relationship between the size of the seed, proportion of hulls in it, and partitioning of the main nutrients (protein and fat) and fibre, between the cotyledon and hull fractions in seeds of different genetic origin.

MATERIAL AND METHODS

Nine varieties of sweet lupins representing 3 species harvested in Poland during 1993 and differing in seed size (measured as the weight of 1000 seeds) were investigated. They were: Juno, Popiel and Amulet *(L. luteus)*; Wat, Bardo and Hetman *(L. albus)* and Sur, Emir and Saturn *(L. angustifolius)*.

One kg samples of seeds were soaked in distilled water at 6^0C overnight and dehulled by hand. The hulls and cotyledons were collected quantitatively and germs were included with the cotyledons. The hulls and cotyledons were dried in 90^0C, weighed and finely ground on a Cyclotec 1090 Sample Mill (Tecator).

The dry matter (DM) content was determined by oven-drying at 105^0C and all further analyses were reported on DM basis. Crude protein (Nx6.25), ash, fat and fibre content in seeds, hulls and cotyledons were determined according to standard methods (AOAC, 1990) and the nitrogen-free extractives (NFE) content calculated from the difference. Neutral detergent (NDF) and acid detergent (ADF) fibre and acid detergent lignin (ADL) were determined according to Van Soest and Wine (1967) on a Fibertec M (Tecator) apparatus.

RESULTS AND DISCUSSION

Significant differences in the size of seeds (expressed as the weight of 1000 seeds) were found among the three investigated lupin species (Table 1). The weights of 1000 seeds ranged between 115 and 274 g in *L. luteus*, between 274 and 454 g in *L. albus* and between 137 and 196 g in *L. angustifolius*. In *L. luteus* no correlation between the size of the seed and the hull content in the seed was found, the average content of the hull was 24.5%. A lower (22.55%) proportion

TABLE 1

Size of lupin seeds and proportion of hulls and cotyledons

Lupin	Weight, g/1000 seeds	Dry matter, % of whole seed	Hull, % of whole seed DM	Cotyledons, % of whole seed DM
L. luteus				
Juno	132	89.22	25.42	74.58
Popiel	274	88.06	24.58	75.42
Amulet	115	89.97	24.52	75.48
L. albus				
Wat	274	92.46	24.08	75.92
Bardo	326	88.16	19.60	80.40
Hetman	454	92.01	17.59	82.41
L. angustifolius				
Sur	137	90.46	24.68	75.32
Emir	196	90.58	20.02	79.98
Saturn	172	90.46	23.53	76.47

of hulls was reported for the Juno variety by Zduńczyk et al. (1994), but much higher (27.2%) by Brillouet and Riochet (1983) for LL29 cv. There was a significant negative correlation between the size of the seed and the hull content in *L. albus* ($r = -0.898$) as well as in *L. angustifolius* P ($r = -0.924$). Also Brillouet and Riochet (1983) reported that the hull proportion in 5 cultivars of *L. albus* depended on the size of the seed ($r = -0.89$), but the proportion of hulls in 10 other species of lupin evaluated by them was not correlated with the weight of 1000 seeds.

Whole seeds of *L. luteus* contained on average (DM %) 42.44 ± 1.1; *L. albus* 31.31 ± 3.5 and *L. angustifolius* 32.19 ± 2.78 of crude protein (Table 2). The protein content was lower than that reported for the same varieties but harvested in 1991 (Alloui et al., 1994), probably due to unfavourable weather conditions during vegetation in 1993. The differences in respective fat contents (Table 2) and that reported by Alloui et al., (1994) were smaller, only *L. albus* contained more fat than reported in the earlier work.

As is shown on Figure 1, in all species over 97% of total crude protein (CP) was present in the cotyledon fraction and only about 2.5% in the hull fraction. The distribution of total fat was similar, from 95.5 to 98.1% was present in the cotyledon fraction, and only from 1.9 to 4.5% in the hull fraction. In many reports it has been proved that both protein and fat of lupin seeds are well digested by chickens (Alloui et al., 1994), in the small intestine of pigs (Gdala et al., 1994), by pigs and sheep (Tae Hong Kang et al., 1989), and by rats (Zduńczyk et al., 1994).

TABLE 2

Chemical composition of whole lupin seeds, % of DM

Lupin	Crude protein	Crude fat	Crude ash	NFE	Crude fibre	NDF	ADF	ADL	AME_N* MJ/kg
L. luteus									
Juno	41.06	5.31	5.67	29.48	18.48	27.39	24.01	2.19	9.02
Popiel	40.25	5.54	6.10	30.38	17.73	27.82	23.26	2.17	8.98
Amulet	42.75	3.70	5.35	31.34	16.86	25.58	22.20	1.97	8.80
L. albus									
Wat	28.81	10.37	5.10	39.66	16.06	23.90	21.44	3.37	8.82
Bardo	31.06	12.79	3.90	39.36	12.89	21.63	18.34	2.51	9.99
Hetman	34.56	11.24	4.04	38.60	11.56	19.31	16.86	1.73	10.04
L. angustifolius									
Sur	28.94	6.12	4.46	43.10	17.38	27.30	22.97	2.50	7.49
Emir	32.75	6.88	4.07	42.14	14.16	23.66	19.95	1.66	8.36
Saturn	33.31	4.70	4.46	40.15	17.38	27.30	22.97	2.50	7.70

* calculated according to equations given in European Table of Energy Value for Poultry Feedstuffs (1989)

TABLE 3

Chemical composition of cotyledons, % of DM

Lupin	Crude protein	Crude fat	Crude ash	NFE	Crude fibre	NDF	ADF	ADL	AME_N* MJ/kg
L. luteus									
Juno	54.56	7.81	2.42	31.41	3.80	19.10	6.09	2.24	12.12
Popiel	53.49	8.50	6.76	27.37	3.88	14.21	6.53	1.43	12.11
Amulet	56.46	6.08	5.99	27.81	3.66	13.15	4.67	2.11	11.81
L. albus									
Wat	35.78	13.60	5.13	40.13	5.36	16.91	9.74	1.41	11.05
Bardo	37.51	15.56	4.32	37.65	4.96	11.70	6.80	1.67	11.94
Hetman	41.59	13.82	4.78	35.68	4.13	9.14	8.13	1.20	12.02
L. angustifolius									
Sur	37.62	8.97	4.63	45.10	3.68	13.05	5.31	1.88	9.90
Emir	39.72	9.42	2.87	44.84	3.14	11.15	4.84	1.37	10.40
Saturn	44.51	7.42	4.40	40.54	3.13	9.71	5.42	2.10	10.46

* as in Table 2

TABLE 4

Chemical composition of hulls, % of DM

Lupin	Crude protein	Crude fat	Crude ash	NFE	Crude fibre	NDF	ADF	ADL	AME_N* MJ/kg
L. luteus									
Juno	5.22	0.96	6.28	24.45	63.09	85.73	76.48	2.74	1.56
Popiel	5.18	1.06	2.66	32.23	58.87	82.52	73.15	3.75	1.71
Amulet	4.40	1.09	2.48	30.24	61.79	87.66	74.77	3.35	1.56
L. albus									
Wat	3.73	0.98	2.99	29.41	62.89	85.22	76.97	4.23	1.40
Bardo	3.56	1.07	2.66	32.31	60.40	88.04	76.76	7.45	1.45
Hetman	4.33	1.25	2.57	34.19	57.66	82.31	72.56	5.47	1.66
L. angustifolius									
Sur	4.02	1.11	3.39	32.26	59.22	81.84	70.51	3.35	1.54
Emir	2.91	0.97	4.20	33.10	58.82	83.51	71.69	3.52	1.32
Saturn	3.58	0.89	2.82	31.35	61.36	83.59	74.93	3.80	1.38

* as in Table 2

However, the cotyledon fraction also contains about 30% of cell walls and alpha-galactosides (Brenes et al., 1989, Zduńczyk et al., 1994), which are of low nutritional value for non-ruminants, but rather have no detrimental effect on the digestibility of other components of a diet.

Hulls are composed mainly of dietary fibre; in 9 investigated varieties of lupin hulls contained from 82 to 88% of the NDF and from 70 to 76% of the ADF (Table 4). In the hull fraction from 76 to 84% of total crude fibre (CF), from 70 to 81% of total ADF and from 63 to 68% of total NDF of the seed could be found (Figure 1).

As reported by many authors (Brillouet and Riochet, 1983; Dandanell Daveby and Äman, 1993) hulls of lupin are composed mainly of cellulose, galactomannans, pectic acids and arabinogalactans, the proportion of lignin being very low (1.3-2.1% of DM). According to Brillouet and Riochet (1983) among hull polysaccharides, the following sugars predominate, glucose (35-56%), xylose (7.4-18.5%) and arabinose (3.8-9.7%). Tae Hong Kang et al. (1989) reported that hulls of white lupin were better digested by sheep than pigs (DE 3278 vs. 2669 kcal/kg) and their true metabolizable energy for poultry was very low: hulls 1930, whole seed 2890 and dehulled seed 3550 kcal/kg.

Metabolizable energy (AME_N) of the whole seeds, calculated according to equations given in the European Tables (1989), ranged from 7.70 to 10.04 MJ/kg (Table 2), dehulled seeds from 9.90 to 12.12 (Table 3), but the hulls only from 1.32 to 1.66 MJ/kg (Table 4). It seems that the difference in the utilization of lupin hulls between ruminants and poultry is so big that it may justify the cost of dehulling.

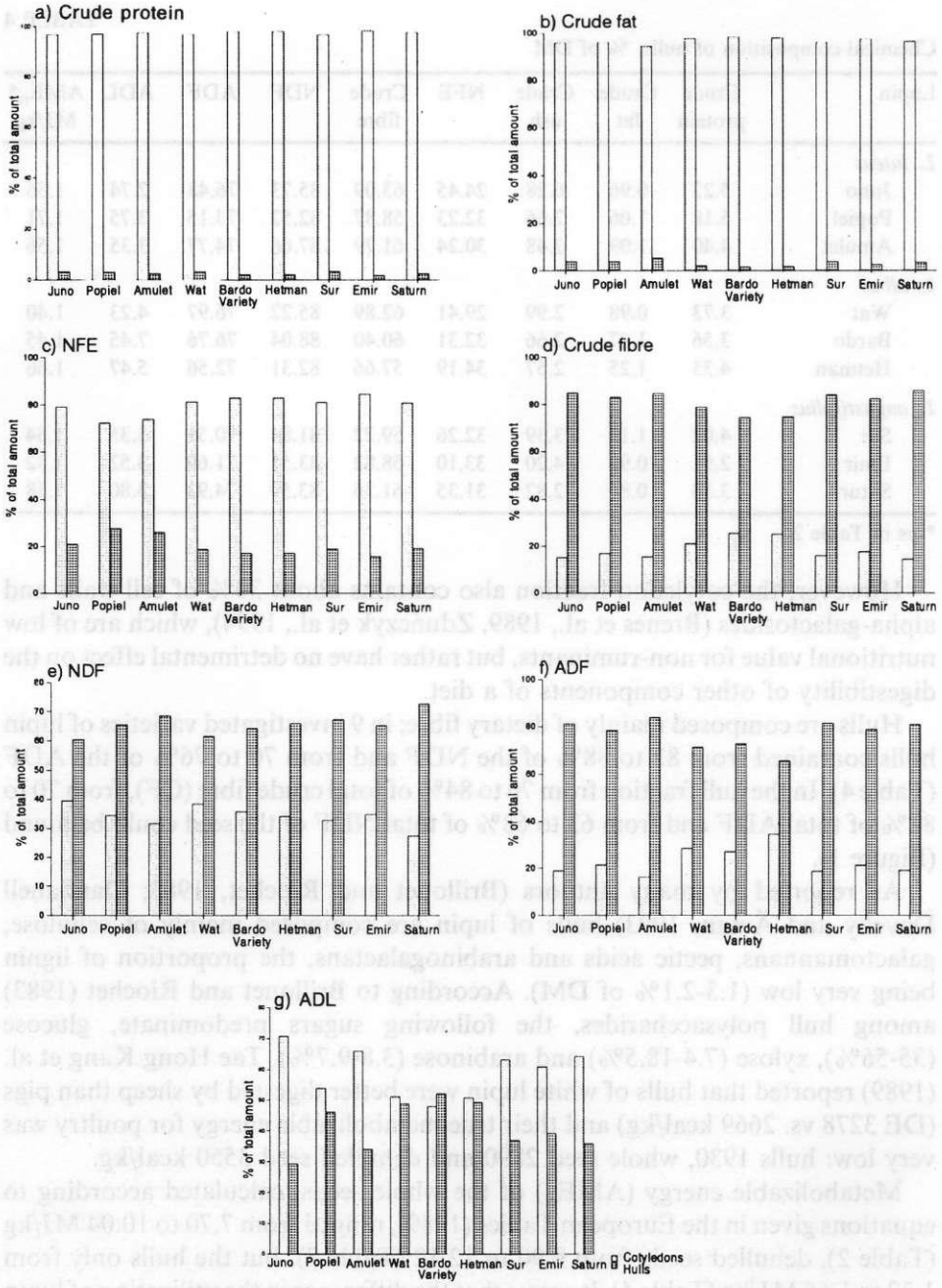

Figure 1. Distribution of components of the whole lupin seeds between cotyledon and hull fractions (total amount in the whole seeds as 100)

CONCLUSIONS

The size of the seed (expressed as the weight of 1000 seeds) in *L. albus* and *L. angustifolius* is positively correlated with the proportion of cotyledons in it, as well as with the content of main nutrients (protein + fat). Dehulling of lupin seeds may increase their metabolizable energy for poultry by 20-35%. The remaining hull fraction may be utilized as a valuable source of energy for ruminants.

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STRESZCZENIE

Skład chemiczny bielma i łuski trzech gatunków łubinu słodkiego

Dziewięć odmian łubinów słodkich ze zbiorów 1993 roku (żółte: Juno, Popiel i Amulet; białe: Wat, Bardo i Hetman; wąskolistne: Sur, Emir i Saturn) różniących się wielkością nasion obłuszczono ręcznie. Oznaczono skład chemiczny całych nasion, łuski i nasion obłuskanych.

Stwierdzono, że wielkość nasion, mierzona jako ciężar 1000 nasion, jest w łubinach białych i wąskolistnych dodatnio skorelowana z udziałem w nich frakcji bielma oraz z zawartością głównych składników odżywczych (białka i tłuszczu). Niezależnie od odmiany około 97% białka i od 95 do 98% tłuszczu zawartego w nasionach znajdowało się we frakcji bielma, natomiast od 74 do 86% włókna surowego znajdowało się we frakcji łuski. Obłuszczenie łubinu może więc zwiększyć jego energię metaboliczną dla drobiu o 20 do 35%.