Journal of Animal and Feed Sciences, 5, 1996, 281–288

Effect of dehulling white lupin (*Lupinus albus*) on protein utilization by rats*

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(Received 28 February 1996; accepted 9 July 1996)

ABSTRACT

The nutritive value of 8 semisynthetic and 2 natural diets containing whole or dehulled white lupin seeds from three low-alkaloid varieties was evaluated in two experiments. Substituting dehulled seeds for whole seeds lowered dietary fibre in the semisynthetic diets from 112.7-122.6 to 63.3-65.0 g/kg. However, this did not lead to increased intake. True protein digestibility coefficients of the diets were similar (85.2-87.7%), irrespective of the lupin variety and presence or lack of seed hulls. A slight increase in the protein efficiency ratio (PER) from 2.16-2.19 (diet with whole seeds) to 2.33-2.38 (diet with dehulled seeds) was noted. Dehulling white lupin seeds did not improve protein digestibility or PER of natural diets containing cereals.

KEY WORDS: white lupin, dehulling, nutritional value, rats, TD, PER

INTRODUCTION

Most of the carbohydrates in white lupin are non-starch polysaccharides and oligosaccharides that undergo digestion mainly in the large intestine of monogastric animals, where they are decomposed by bacterial enzymes (Brenes et al., 1993). Utilization of energy from the terminal part of the digestive tract is negligible thus the net energy in lupin seeds is low, and does not exceed 50% of

* The study was supported by the Committee for Scientific Research, Project 5 S 305 035 07

digestible energy (Taverner et al., 1983). Because of the high concentration of polysaccharides in the seed hull, dehulling seems to be a useful method of increasing the nutritive value of lupin seeds. The chemical composition and nutritive value of low-alkaloid varieties of white lupin was studied in our previous works (Zduńczyk et al., 1996 a,b).

The objective of this study was to examine the effect of dehulling seeds used as the only or supplementary protein source in rat diets.

MATERIAL AND METHODS

Material

The seeds of three low-alkaloid varieties of white lupin, Wat, Herman and Bardo, from the 1993 or 1994 harvests, were used in this study. Dehulling was performed on the laboratory scale using a disk mill with a wide slit and sieves facilitating manual separation of cotyledons and hulls. Both fractions were then ground using a beater mill with a 0.5 mm sieve.

Animals and diets

The experiments were conducted on 80 Wistar rats, individually housed in organic glass cages in rooms with controlled lighting (12 h), temperature (22-23^{0}C) and relative humidity (about 70%). The experiments were performed on animals 28-30 days of age and body weight of about 65 g, allotted to groups of 4 males and 4 females.

Semisynthetic diets were used in Experiment 1. Whole or dehulled seeds of different lupin varieties were the only source of protein (Table 1). The proportion of lupin seeds in the diets varied and corresponded to about 10% crude protein content. The diets were supplemented with DL-methionine (2.5 g/kg). Dietary fat content was adjusted to 80 g/kg with soyabean oil.

In Experiment 2, whole or dehulled Bardo seeds were the only source of protein in semisynthetic diets or the main source of protein in natural diets containing cereals (Table 2). The lysine and methionine contents in the semisynthetic and natural diets (expressed in relation to protein) were equalized by adding synthetic amino acids. The protein, lysine and methionine contents in the natural diets were in agreement with the requirements for growing pigs (Nutritional Requirements for Pigs, 1993).

The growth test lasted 4 weeks in each experiment, and feed intake and body weight gains of rats were used to calculate the protein efficiency ratio (PER). The true protein digestibility (TD) was determined using a 5-day faeces collection in

the last week of the growth test. The amount of metabolic nitrogen excreted in the faeces, 46.3 mg/animal/5 days, was adopted after Rakowska et al. (1978). The animals were sacrificed at the end of Experiment 1, and the liver, pancreas and small intestine were excised and weighed.

Statistical analysis

The results were subjected to single factor variance analysis, using the Duncan test to assess the significance of differences between experimental groups.

RESULTS AND DISCUSSION

The nutritive value of whole and dehulled seeds of various lupin varieties (Experiment 1)

Differences among varieties in the chemical composition of seeds, including alkaloid content (Table 1), had no effect on feed intake, protein digestibility or PER (Table 3). PER values were similar to those obtained by Prieto and Aguiler (1986), who used a similar methionine supplement (0.2%) to diets containing white lupin. Dehulling lupin seeds and decreasing dietary fibre from 112.7-122.6 to 63.3-65.9 g/kg was also found not to affect protein digestibility or efficiency (PER). True digestibility of lupin protein in all groups ranged from 85 to 88% and was in agreement with the results of Eggum et al. (1993). The tendency, but not significant, for the PER to increase from 2.16-2.19 (whole seeds) to 2.32-2.38 (dehulled seeds), i.e. a 6-10% rise, was found.

Lupin variety and dehulling had no effect on the weight of rat liver or pancreas. There was, however, a difference in the weight of the small intestine. In those groups receiving diets with higher fibre contents (whole seeds) the weight of the small intestine of rats was significantly higher.

The effect of dehulling on the nutritive value of semisynthetic and natural diets (Experiment 2)

Dehulling Bardo variety seeds did not affect the consumption of semisynthetic diets in which whole or dehulled seeds were the only source of protein, or of natural diets, in which they were a supplementary protein source (Table 4). Intake of natural diets was higher than of the semisynthetic ones, which may have been due to their higher fibre content, thus lower energy concentration. The dietary fibre content of semisynthetic diets with whole or dehulled seeds equaled

TABLE 1

Composition of the diets, g/kg (Experiment 1)

Specification	Experimental group					
	I	II	III	IV	V	VI
Whole seeds:						
var. Wat	310	–	–	–	–	–
var. Hetman	–	285	–	–	–	–
var. Bardo	–	–	285	–	–	–
Dehulled seeds:						
var. Wat	–	–	–	260	–	–
var. Hetman	–	–	–	–	240	–
var. Bardo	–	–	–	–	–	240
Soya oil	56	58	56	55	57	57
Mineral mixture[1]	30	30	30	30	30	30
Vitamin mixture[2]	10	10	10	10	10	10
DL-methionine	2.5	2.5	2.5	2.5	2.5	2.5
Maize starch	591.5	614.5	616.5	642.5	660.5	660.5
Diet composition:						
crude protein (analysed)	100.7	101.6	106.8	101 .6	106.8	101.6
dietary fibre (calculated)	122.6	114.6	112.7	65.9	63.8	63.3
total alkaloids (calculated)	0.27	0.13	0.17	x	x	x

[1] mineral mixture (NRC, 1976) containing in 100 g: 73.5 g $CaHPO_4$; 8.10 g K_2HPO_4; 6.80g K2SO4; 3.06 g NaCl; 2.10 g $CaCO_3$; 2.14 g $NaHPO_4$; 2.50 g MgO; 558 mg ferric citrate; 81 mg $ZnCO_3$; 421 mg $MnCO_3$; 33 mg $CuCO_3$; 0.7 mg KJ and 705 mg citric acid (40 g/kg of diet)

[2] vitamin mixture (AOAC, 1975) containing in 1 g: 2 000 IU vitamin A; 200 IU vitamin D_3; 10 IU vitamin E; 0.5 mg vitamin K; 200 mg choline; 10 mg paminobenzoic acid; 10 mg inositol; 4 mg niacin; 4 mg calcium pantothenate; 0.8 mg riboflavin; 0.5 mg thiamin; 0.5 mg pyridoxine; 0.2 mg folic acid; 0.04 mg biotin; 0.003 mg cobalamine; sucrose supplemented to 1 g. (10 g/kg of diet)

120 and 74 g/kg, respectively (Table 2), while in natural diets containing about 75% wheat and barley meal, the fibre content was considerably higher (about 200 and 170 g/kg). Studies by other authors (Lopez-Guisa et al., 1988) indicate that the intake of feeds with higher fibre contents, i.e. with lower energy concentrations, usually increases.

Although the natural diets were consumed in larger amounts, the body weight gains of rats were only insignificantly higher. Protein utilization of these diets was lower than in the semisynthetic ones (PER 1.52 and 1.59 vs. 2.19 and 2.35, respectively), mainly due to the higher (about 15%) level of protein in the natural diets and the concomitantly higher fibre content, which decreased the energy value of the diets. Substituting whole seeds in both types of diets with dehulled seeds led to insignificant increases in the body weight of rats, and in TD and PER. Similar small differences in the utilization of protein from whole or dehulled

TABLE 3

Effect of feeding whole and dehulled lupin seed as the only protein source in the diets (Experiment 1)*

Protein source in diet	Diet intake g/rat	Body weight gain g	TD	PER	Liver** g	Pancreas** g	Small intestine** g
Whole seeds							
Wat	297.3±34.7	66.5±13.2	85.1±1.99	2.19±0.25	3.81±0.46	0.29±0.04	3.48^{Aa} ±0.29
Hetman	300.5±34.0	71.3±15.4	86.1±3.16	2.19±0.21	3.44±0.49	0.28±0.03	3.18^{ABab} ±0.32
Bardo	295.6±38.9	69.3±15.3	85.2±2.46	2.16±0.24	3.75±0.64	0.27±0.05	3.31^{ABab} ±0.26
Dehulled seeds							
Wat	304.2±32.4	72.5±12.2	86.8±2.36	2.32±0.26	3.62±0.26	0.27±0.04	3.11^{ABbc} ±0.18
Hetman	292.2±24.6	70.1±14.0	87.7±2.25	2.34±0.21	3.52±0.41	0.28±0.03	3.00^{Bc} ±0.32
Bardo	304.8±33.1	74.4±14.6	87.0±2.85	2.38±0.25	3.09±0.24	0.27±0.02	3.07^{Bbc} ±0.19

* mean value and SEM during 4-weeks experiment

** per 100 g body weight of rat

means with different superscripts within a column are significantly diffrent by Duncan's multiple range test: a, b – $P \leqslant 0.05$; A, B – $P \leqslant 0.01$

TABLE 2

Composition of the diets, g/kg (Experiment 2)

Specification	Semisynthetic diet		Natural diet	
	I	II	III	IV
Whole seeds var. Bardo	304	–	225	–
Dehulled seeds var. Bardo	–	255	–	175
Soya oil	56	57	–	–
Mineral mixture[1]	30	30	30	30
Vitamin mixture[2]	10	10	10	10
DL-methionine	1.5	1.5	0.8	0.7
L-lysine HCl	0.9	1.0	3.0	3.1
Barley	–	–	361.2	391.2
Wheat	–	–	370.0	390.0
Maize starch	597.6	645.5	–	–
Chemical composition:				
crude protein (analysed)	100.7	101.6	150.6	148.8
lysine (calculated)	5.5	5.5	8.2	8.2
methionine (calculated)	1.7	1.7	2.5	2.5
dietary fibre (calculated)	120.1	73.5	199.4	170.6

[1, 2] as in note to table 1

TABLE 4

Intake and nutritive value of semisynthetic and natural diets containing whole and dehulled seeds of var. Bardo

Diet	Diet intake g/28 days	Liveweight gain g	TD	PER
Semisynthetic				
whole seeds	$350.4^{b} \pm 13.2$	80.8 ± 2.7	85.6 ± 1.5	$2.19^{A} \pm 0.18$
dehulled seeds	$345.4^{b} \pm 14.2$	85.3 ± 7.5	86.8 ± 1.5	$2.35^{A} \pm 0.21$
Natural				
whole seeds of lupin and cereal	$386.4^{a} \pm 34.5$	89.5 ± 14.0	81.1 ± 3.5	$1.52^{B} \pm 0.18$
dehulled seeds of lupin and cereal	$386.4^{a} \pm 52.0$	92.8 ± 17.0	82.9 ± 1.4	$1.59^{B} \pm 0.17$

seeds by rats were found by other authors (Hove, 1974). In an experiment carried out on young chickens by Brenes et al. (1993), the use of dehulled white lupin seeds caused a rise in metabolizable energy of the diet by 18%, while only a 7% rise in crude protein digestibility, as compared with a diet containing whole seeds.

CONCLUSIONS

The presented experiments showed that dehulling white lupin seeds did not increase protein digestibility or the protein efficiency ratio of diets in which whole or dehulled seeds were the only protein source, or when they were only a component of natural diets containing a large proportion of cereals. Differences in the chemical composition of the seeds from different varieties, including alkaloid content, also had no effect on true digestibility and protein efficiency ratio.

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STRESZCZENIE

Wpływ odłuszczenia nasion łubinu białego (*Lupinus albus*) na wykorzystanie białka przez szczury

W dwóch doświadczeniach na szczurach określono wartość odżywczą 8 półsyntetycznych i 2 naturalnych diet z udziałem całych lub odłuszczonych nasion trzech niskoalkaloidowych odmian łubinu białego. Zastąpienie całych nasion nasionami odłuszczonymi spowodowało zmniejszenie zawartości włókna pokarmowego w dietach półsyntetycznych z 112,7-122,6 do 63,3-65,0 g/kg. Nie zwiększyło to pobierania diet przez szczury. Współczynniki strawności rzeczywistej białka diet były podobne (85,2-87,7%), niezależnie od odmiany łubinu i obecności lub braku okrywy nasiennej w diecie. Wystąpiła tendencja niewielkiego wzrostu wskaźnika wydajności wzrostowej białka PER z 2,16-2,19 (diety z udziałem nasion całych) do 2,33-2,38 (diety z udziałem nasion odłuszczonych). Odłuszczenie nasion łubinu białego nie zwiększyło strawności i wydajności wzrostowej białka diet naturalnych z udziałem ziarna zbóż.