WHITE LUPIN (CV. AMIGA) SEEDS AS A PROTEIN SOURCE IN DIET FOR GROWING RABBITS: EFFECT ON GROWTH PERFORMANCE, DIGESTIBILITY OF NUTRIENTS AND CARCASS TRAITS

Volek Z.*, Marounek M.

Institute of Animal Science, Přátelství 815, CZ – 104 01, Prague, Czech Republic
*Corresponding author: volek.zdenek@vuzv.cz

ABSTRACT

This study aimed to evaluate whole white lupin (cv. Amiga) seeds as an alternative dietary crude protein source to soybean and sunflower meal. Diets contained soybean meal (10%, SBM diet), sunflower meal (17%, SFM diet) or white lupin seeds (15%, WL diet) as the main protein source. The experimental diets were similar in the level of crude protein (16.2%), starch (15.0%), fat (4.6%) and in the limiting amino acids. In comparison with the SBM diet, the diet based on sunflower meal contained slightly more cellulose and lignin, and less hemicelluloses and digestible energy. Diet based on white lupin seeds contained a higher level of raffinose-series oligosaccharides than other diets. Ninety Hyplus® rabbits (30 rabbits per group; 1058±72 g), weaned at 37 d of age, were used for growth performance evaluation (from 37 to 79 days of age). At the end of the growth trial, 18 rabbits of average body weight were slaughtered without fasting in each group, and used for the evaluation of carcass traits. Other 39 Hyplus® rabbits (13 rabbits per group; 950±92 g), weaned at 33 d of age, was used in a digestibility trial to determine digestibility coefficient of diets. No significant effects was detected on the weight gain (38.4, 40.1, and 40.0 g/d in rabbits fed the SBM, SFM and WL diet, respectively; P>0.05). The feed intake was higher in rabbits fed the sunflower meal-based diet than in other rabbits (135.0, 122.9 and 128.7 g/d in rabbits fed the SFM, SBM and WL diet, respectively; P=0.02). Similarly, feed conversion tended to be higher in rabbits fed the diet based on sunflower meal (3.40, 3.22 and 3.24 kg/kg in rabbits fed the SFM, SBM and WL diet, respectively; P=0.12). Dressing out percentage was significantly higher in rabbits fed the lupin-diet (58.7, 57.4 and 57.3% in rabbits fed the WL, SFM and SBM diet, respectively; P=0.01). There were no significant differences in digestibility of organic matter, crude protein, starch or fat. Digestibility of energy tended to be lower in rabbits fed the diet based on sunflower meal (66.5, 69.5 and 68.2% in rabbits fed the SFM, SBM and WL diet, respectively; P=0.06). Digestibility of NDF (35.7, 41.1 and 40.9% in rabbits fed the SFM, SBM and WL diet, respectively; P=0.03) and ADF was lower in rabbits fed the sunflower meal-based diet (26.8, 31.9 and 31.9%; P=0.09). In conclusion, white lupin seeds (cv. Amiga) are suitable dietary protein source for growing rabbits which can fully replace the traditionally used sources of protein, without adverse effect on the parameters evaluated in this study.

Key words: White lupin, Sunflower meal, Soybean meal, growth, Digestibility, Slaughter rate.

INTRODUCTION

Soybean meal is frequently used as protein source in rabbit feed. However, recent works (Gutiérrez *et al*., 2003; García-Ruiz *et al*., 2006), comparing different sources of protein, showed that animals fed a diet based on soybean meal had a higher mortality than those fed the sunflower meal-based diet. Authors above mentioned studies concluded that sunflower meal should be preferred to soybean meal in starter diets for rabbits in order to minimize digestive disorders.

An alternative dietary crude protein source may be whole white lupin seeds (*Lupinus albus* L.). In the past, several authors reported promising results regarding the possible use of lupin seeds in rabbit feed

(Seroux, 1984; Kelly *et al*., 1990; Maitre *et al*., 1990). Generally, it is obvious that lupins have significant potential as a protein and energy source for livestock. In addition to protein, lupin seeds contain negligible levels of starch, high levels of soluble and insoluble non-starch polysaccharides, high levels of raffinose-series oligosaccharides, and variable levels of lipids (Martínez-Villaluenga *et al*., 2006). White lupin seeds are known as sweet lupin due to their very low levels of toxic alkaloids (Ballester *et al.*, 1980). Furthermore, also levels of protease inhibitor and other components with anti-nutritional effects are low (Martínez-Villaluenga *et al*., 2006).

Thus, the aim of this study was to evaluate whole white lupin seeds (cv. Amiga) as an alternative crude protein source to soybean and sunflower meal in terms of growth performance, carcass traits, and digestibility of nutrients in growing rabbits.

MATERIALS AND METHODS

Protein sources, experimental diets, animals and experimental design

Three experimental diets were formulated. Diets contained soybean meal (SBM diet), sunflower meal (SFM diet), or white lupin seeds (WL diet) as the main protein source (Table 1). Diets were supplemented with the most limiting amino acids (L-lysine, DL-methionine) to meet their recommended levels for growing rabbits. Diets were given as pellets. The chemical composition of three dietary protein sources and the experimental diets is shown in Table 2. As white lupin seeds (cv. Amiga) contain a very low level of alkaloids (Zraly *et al*., 2007), determination of these compounds were not done in this study.

Table 1: Ingredients (%) of soybean meal (SBM), sunflower meal (SFM) and white lupin (WL) diets

	SBM	SFM	WL
Alfalfa meal	30	30	30
Soybean meal	10	0	0
Sunflower meal	0	17	0
White lupin	0	0	15
Wheat bran	30	23	31
Sugar beet pulp	7	4	2
Oats	13	13	12
Barley	5	8	6
Rapeseed oil	2	2	1
Vitamin supplement[1]	1	1	1
Dicalcium phosphate	0.5	0.5	0.5
Limestone	1	1	1
Salt	0.5	0.5	0.5

[1]Per kg supplement: vitamin A-1 200 000 IU; vitamin D_3-200 000 IU; vitamin E-5 g; Vitamin K_3-0.2 g; vitamin B_1-0.3 g; vitamin B_2-0.7 g; vitamin B_6-0.4 g; niacinamide-5 g; Ca-pantothenate-2 g; folic acid-0.17 g; biotin-20 mg; vitamin B_{12}-2 mg; choline-60 g; salinomycin 2.25 g.; L-lysine- 0, 150 and 50 g in the SBM, SFM and WL diet, respectively; DL-methionine-60, 0 and 100 g in the SBM, SFM and WL diet, respectively

A total of 90 Hyplus® rabbits (1058 ± 72 g), weaned at 37 days of age, were used for the growth performance evaluation. Rabbits were randomly allocated into three groups (30 per diet), and fed either of the experimental diets (SBM, SFM or WL diet). No control of sex was performed. Rabbits were housed in all-wire cages (0.16 m^2). Heating and forced ventilation system allowed the environmental temperature to be maintained at 16 ± 2°C. During the duration of the experiment (from 37 to 79 days of age), the diets and water were offered *ad libitum* to all rabbits. Consumption of feed was measured daily. Animals were individually weighed every week. Health status was evaluated according to European Group on Rabbit Nutrition (Fernández-Carmona *et al*., 2005). However, statistical evaluation of the health status was not done in this study due to a low number of rabbits in groups. At the end of the experiment, 18 rabbits of average body weight were slaughtered without fasting in each group, and used for the carcass evaluation according to the methodology of Blasco and Ouhayoun (1996).

Another group of 39 Hyplus® rabbits (950 ± 92 g), weaned at 33 days of age, was used in a digestibility trial to determine digestibility coefficient of diets following European reference method (Perez *et al*., 1995). Rabbits were assigned at random to the three experimental diets (13 rabbits per group), and individually housed in digestibility cages (50 x 40 x 42.5 cm). Diets were offered *ad libitum* and after an adaptation period of 15 days, a 4-day balance period started. Except three rabbits, which were excluded from the evaluation due to diarrhoea, all animals were healthy, during the duration of the experiment.

Table 2: Chemical composition (g/kg) of protein sources, and chemical composition (g/kg) and nutritive value of soybean meal (SBM), sunflower meal (SFM) and white lupin diet (WL)

	Soybean meal	Sunflower meal	White lupin	SBM	SFM	WL
Dry matter	868	887	883	896	898	896
Crude protein	438	275	297	164	160	161
NDF	108	386	330	330	350	351
Lignocellulose (ADF)	67	280	230	171	199	189
Lignins (ADL)	25	95	59	39	51	45
RSO[1]	8.7	1.9	11.2	1.5	0.8	2.4
Water-insoluble pectin[2]	82	71	104	55	49	52
Fat	23	28	114	44	45	46
Starch	-	-	-	148	151	153
Lysine[2]	26.2	9.9	15.8	7.5	7.6	7.5
Methionine + Cystine[2]	12.1	11.8	7.3	5.8	5.7	5.9
Threonine[2]	16.2	10.2	11.5	5.8	5.7	5.9
Digestible Protein[3] (g/kg)	-	-	-	123.7	121.0	119.8
Digestible Energy[3] (MJ/kg)	-	-	-	12.0	11.4	11.8

[1]ROS = Raffinose-series oligosaccharides (raffinose + verbascose + stachyose) expressed as mmol/100g; [2]Calculated from tables (Maertens *et al*., 2002); [3]Calculated from digestibility coefficients obtained in the digestibility trial (see Table 3)

Chemical Analyses

Crude protein, fat and starch content were determined by the Association of Official Analytical Chemists (AOAC) procedure (1980). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to the sequential procedure of Van Soest *et al.* (1991). Dry matter of samples was determined by drying at 105^{o}C to constant weight. Water-insoluble pectin, as well as amino acids content was calculated from tables (Maertens *et al*., 2002). Gross energy of diets and faeces was measured by adiabatic calorimeter. Raffinose-series oligosaccharides (RSO) content was determined according to RSO Assay Procedure (Megazyme, Ireland).

Statistical Analyses

Data on effect of the diets on growth performance, carcass traits, and digestibility coefficient were examined by one-way analysis of variance using the GLM procedure of Statistical Analysis Systems Institute (2001). Sheffe's test was used for mean comparison where appropriate. The statistical significance was considered as $P<0.05$.

RESULTS AND DISCUSSION

The sources of protein used in our study did not affect digestibility of the crude protein of the experimental diets, which is in agreement with results of other authors (Fekete and Gippert, 1986; Table 3). Also digestibility of organic matter, starch and of fat were not affected by the treatments. Digestibility of energy tended to be lower ($P=0.06$) in rabbits fed the diet based on sunflower meal than in other rabbits. It is caused by the higher level of ADF in this diet (Table 2). The relationship between energy digestibility and dietary ADF concentration is well known (De Blas *et al*., 1984). Also digestibility of NDF ($P=0.03$) and ADF ($P=0.09$) was lower in rabbits fed sunflower meal-based diet. This is apparently associated with the higher ADL level in this diet (Nicodemus *et al*., 1999; Table 2).

Table 3: Total tract apparent digestibility (TTAD) and nutritional value of soybean meal (SBM), sunflower meal (SFM) and white lupin diet (WL)

	SBM	SFM	WL	RMSE[1]	P-level
Number of rabbits	11	13	12		
Live weight (g)[2]	1874	1938	1870	187	NS
Feed intake (g)[2]	150.4	169.4	156.0	23.5	0.14
TTAD coefficients (%):					
Organic matter	69.0	69.0	70.2	2.46	NS
Crude protein	75.4	75.6	74.4	3.9	NS
Gross energy	69.5	66.5	68.2	2.7	0.06
Fat	91.3	93.1	91.6	2.9	NS
Starch	96.5	96.9	96.4	0.5	NS
NDF	41.1[a]	35.7[b]	40.9[a]	5.2	0.03
ADF	31.9	26.8	31.9	5.9	0.09

[1]RMSE: root mean square error; [2]mean live weight, and feed intake during digestibility measurements (from 48 to 52 d old); means with different letters on the same row differ significantly (P <0.05, Sheffe's test); NS: not significant

Table 4: Growth performance of rabbits fed soybean meal (SBM), sunflower meal (SFM) or white lupin diet (WL): whole fattening period (37–79 day of age)

	SBM	SFM	WL	RMSE[1]	P-level
Rabbits, no.	30	30	30		
Live weight (g):					
at 37 days	1055	1052	1057	72	NS
at 58 days	1976	2007	1974	140	NS
at 79 days	2630	2699	2683	218	NS
Daily Weight Gain (g/d)	38.4	40.1	40.0	4.8	NS
Daily Feed intake (g/d)	122.9[b]	135.0[a]	128.7[ba]	11.5	0.02
Feed conversion (g/g)	3.22	3.40	3.24	0.27	0.12
Morbidity, no.	8	4	2	-	-
Mortality, no.	0	0	0	-	-

[1]RMSE: Root mean square error; means with different letters on the same row differ significantly (P<0.05, Sheffe's test); NS: not significant

No significant effect of the experimental diets was detected on the weight gain (Table 4). The feed intake (P=0.02) and feed conversion were higher in rabbits fed the sunflower meal-based diet. This diet contained lower level of digestible energy, and higher ADL level (Table 2), which has been proven to increase feed intake in fattening rabbits (Partridge *et al*., 1989; Nicodemus *et al*., 1999). Morbidity was the highest in rabbits fed the diet with soybean meal. The adverse effect of soybean meal on intestinal health of growing rabbits was previously reported (Gutiérrez *et al*., 2003; García-Ruiz *et al*., 2006). Most of the slaughter results were not affected by the treatments (data not reported). Dressing out percentage was slightly, however significantly, higher in rabbits fed the lupin-diet (57.3, 57.4 and 58.7% in rabbits fed the SBM, SFM and WL diet, respectively; P=0.01).

Based on the results of this study, it can be concluded that white lupin seeds (cv. Amiga) are suitable dietary protein source for growing rabbits which can fully replace the traditionally used sources of protein, without adverse effect on parameters evaluated in this study.

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