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EFFECT OF A DIET CONTAINING WHITE LUPIN HULLS (*LUPINUS ALBUS* cv. AMIGA) ON TOTAL TRACT APPARENT DIGESTIBILITY OF NUTRIENTS AND GROWTH PERFORMANCE OF RABBITS

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Abstract: The objective of this study was to evaluate the effect of the inclusion of white lupin hulls in a rabbit diet on the digestibility of nutrients and growth performance. Two experimental diets were formulated: C [control: 168 g crude protein (CP) and 409 g neutral detergent fibre (NDF)/kg) and WLH diet (substituting 100 g wheat bran by 50 g barley and 50 g white lupin hulls/kg: 162 g CP and 391 g NDF/kg). A total of 24 weaned rabbits were individually housed, randomly allocated to 2 groups and fed one of the 2 experimental diets from 31 to 73 d of age. The coefficients of total tract apparent digestibility (CTTAD) of dry matter, gross energy, CP and NDF of the experimental diets were determined in rabbits between 45 and 49 d of age. The diets had a similar digestible protein/digestible energy ratio (11.2 and 10.7 g/MJ for the C and WLH diet, respectively). Rabbits showed normal figures for growth rate (on av. 52.4 g/d), feed intake (on av. 155.1 g/d) and feed conversion ratio (on av. 2.97). There were no significant differences between treatments in the CTTAD of dry matter (0.656 and 0.666 for the C and WLH diet, respectively), gross energy (0.667 and 0.677 for the C and WLH diet, respectively), CP (0.770 and 0.777 for the C and WLH diet, respectively) or NDF (0.451 and 0.428 for the C and WLH diet, respectively). It may be concluded that white lupin hulls can serve as a suitable by-product for rabbit feed and do not significantly reduce the nutritive value of the diet.

Key Words: rabbit, diet, lupin hulls, digestibility, growth performance.

INTRODUCTION

Research has shown that whole white lupin seeds (*Lupinus albus* cv. Amiga) are a suitable dietary crude protein (CP) source for growing-fattening rabbits that can fully replace traditionally used protein sources (soybean meal and sunflower meal) without adverse effects on the digestibility of nutrients, caecal traits, performance or carcass parameters (Volek and Marounek, 2009). Furthermore, Volek and Marounek (2011) reported that feeding rabbits a diet based on whole white lupin seeds (*Lupinus albus* cv. Amiga) affected the fatty acid profile of hind leg meat and perirenal fat in a favourable manner.

Thus, the dehulling of lupin seeds is not important for the growing-fattening rabbits in terms of the nutritive value of the diet. However, in other species such as broiler chickens or pigs, the dehulling of lupin seeds is an effective means of reducing the level of some anti-nutritional factors (e.g., the high level of non-starch polysaccharides) and improving the feeding value of lupin seeds (Smulikowska *et al.*, 1995; Mieczkowska *et al.*, 2005; Písaříková and Zralý, 2009; Nalle *et al.*, 2010).

Indeed, Brillouet and Riochet (1983) showed that lupin hulls were mainly constituted of cellulose associated with hemicellulosic and pectic polymers. Similarly, Dandanell Daveby and Åman (1993) reported that lupin hulls contained 952 g/kg dietary fibre, with glucose, uronic acids and xylose as the three main monosaccharide units of non-starch polysaccharides. According to Evans *et al.* (1993), lupin hulls consisted predominantly of non-starch polysaccharides, with values ranging from 856 to 891 g/kg dry matter (DM). Glucose, xylose, uronic acids and arabinose are the

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principal sugar residues present, reflecting the composition of the major constituent polysaccharides, cellulose, hemicelluloses and pectins.

Because the favourable effect of a high dietary fibre intake on rabbit digestive health is known (Gidenne *et al.*, 2010), removed hulls might represent an agro-industrial by-product suitable for use in rabbit feed. To our knowledge, however, the available literature includes no information about the nutritive value of a diet containing lupin hulls.

Accordingly, the aim of this study was to evaluate the effect of the inclusion of lupin hulls in a rabbit diet on the digestibility of nutrients and growth performance.

MATERIALS AND METHODS

Experimental diets

Two experimental diets were formulated. The C diet (control) contained common feed components, whereas the WLH diet contained 50 g of white lupin hulls/kg and 50 g of barley/kg instead of 100 g wheat bran/kg (Table 1). This rather low dietary inclusion of hulls was intended as the first step to evaluate lupin hulls as a feed ingredient of rabbit diet. The hulls were obtained by the manual dehulling of seeds. The C diet had more wheat bran and less barley (230 and 80 g/kg, respectively) than the WLH diet (130 and 130 g/kg, respectively). The diets were offered as 3 mm pellets with a length of 5-10 mm. Apart from salinomycin, an ionophore used to control coccidiosis, no other medication was included in the feed or in the drinking water.

Table 1: Ingredient and chemical composition (g/kg as-fed basis unless otherwise stated) of the experimental diets and white lupin hulls (WLH).

		Diets	
	White lupin hulls	Control	WLH
Ingredients			
Wheat bran	-	230	130
White lupin hulls	-	0	50
Barley	-	80	130
Other ingredients[1]	-	690	690
Determined values			
Dry matter	899	900	907
Crude protein (CP)	40	168	162
Neutral detergent fibre	781	409	391
Acid detergent fibre	639	196	213
Acid detergent lignin	65	59	72
Ether extract	8	39	42
Starch	9	153	172
Ash	25	76	71
Nutritive value[2]			
Digestible protein (DP)	-	129.4	125.9
Digestible energy (DE, MJ/kg)	-	11.6	11.8
DP/DE ratio (g/MJ)	-	11.2	10.7

[1]Other common ingredients for the 2 diets: Alfalfa meal 300, sunflower meal (280 g CP/kg) 170, sugar beet pulp 40, oats 130, rapeseed oil 20, dicalcium phosphate 5, sodium chloride 5, limestone 10, vitamin and mineral premix 10 (Included per kg of feed: vitamin A, 12000 IU; vitamin D_3, 2000 IU; vitamin E, 50 mg; vitamin K_3, 2 mg; vitamin B_1, 3 mg; vitamin B_2, 7 mg; vitamin B_6, 4 mg; niacinamide, 50 mg; Ca-pantothenate, 20 mg; folic acid, 1.7 mg; biotin, 0.2 mg; vitamin B_{12}, 0.02 mg; choline chloride, 600 mg; Co, 1 mg; Cu, 20 mg; Fe, 50 mg; I, 1.2 mg; Mn, 47 mg; Zn, 50 mg; Se, 0.15 mg; L-lysine, 150 mg in WLH diet; salinomycin, 22.5 mg).

[2]Nutritive value of experimental diets was calculated from digestibility coefficients (Table 2).

Rabbit husbandry and experimental design

This study was approved by the Ethics Committee of the Institute of Animal Science and was conducted according to guidelines for applied nutrition experiments in rabbits (Fernández-Carmona *et al.*, 2005).

A total of 24 Hyplus weaned rabbits (PS 19×PS 39), 31 d old at the beginning of the trial, were randomly allocated to 2 groups and fed one of the experimental diets for 42 d, at which time the rabbits were 73 d old. The animals were kept under controlled environmental conditions (at room temperature between 16 and 17 °C, a relative humidity of 60% and 12 h of light per day) and individually housed in digestibility cages (50×40×42.5 cm). The diets were offered for *ad libitum* consumption. The rabbits were weighed every 7 d and the feed intake was measured every day. The coefficients of total tract apparent digestibility (CTTAD) of DM, CP, gross energy and neutral detergent fibre (NDF) of the experimental diets were determined when the rabbits were between 45 and 49 d old, in accordance with the European reference method (Perez *et al.*, 1995).

Chemical analyses

DM was determined by drying samples of feed and faeces at 105 °C to a constant weight. AOAC International (2005) procedures were used to determine the CP (954.01), starch (920.40) and ash (942.05) content. Ether extract was determined by AOAC procedure 920.39 (1995). The NDF content, excluding residual ash, was determined using the method of Mertens (2002), whereas the analyses of acid detergent fibre (ADF) and acid detergent lignin (ADL) were conducted according to AOAC International procedure 973.18 (2000) and expressed exclusive of residual ash. Gross energy was measured using an adiabatic calorimeter (C5000 control, IKA-Werke, Germany).

Statistical analyses

The data on the performance and the CTTAD of the diets were examined by one-way analysis of variance using the GLM procedure of SAS (SAS version 8.2. SAS Inst. Inc., Cary, NC). The individual rabbit was used as the experimental unit.

RESULTS AND DISCUSSION

In accordance with the purpose of the experiment, the 2 experimental diets had similar CP, ether extract, NDF and ADF content (Table 1). Because the C diet had more wheat bran and less barley, the WLH diet contained slightly less hemicelluloses and more starch.

Cellulose was the predominant constituent (57.4%) of the structural polysaccharides of lupin hulls (estimated as ADF-ADL, Table 1), consistent with the findings of other authors (Brillouet and Riochet, 1983; Dandanell Daveby and Åman, 1993; Gdala, 1998). When compared with the literature data regarding the other legumes hulls, lupin hulls contained more NDF, ADF and cellulose than soybean hulls (García *et al.*, 1997, 1999; de Blas *et al.*, 1999). Lupin hulls do not differ greatly in this respect (as for the dietary fibre content) from sunflower hulls (García *et al.*, 1996; Nicodemus *et al.*, 2002). However, sunflower hulls contain more ADL (García *et al.*, 1996; Nicodemus *et al.*, 2002) when compared to the lupin hulls ADL content observed in the present study. Furthermore, lupin hulls contain approximately 50 g/kg of non-starch polysaccharides soluble in water (Evans *et al.*, 1993). However, non-starch polysaccharides soluble in water were not determined in this study. CP, ether extract, and starch concentrations in lupin hulls were negligible, consistent with the results of previous work (Bailey *et al.*, 1974).

The data on the CTTAD of the experimental diets are presented in Table 2. There were no significant differences between treatments in the CTTAD of DM (on average 0.661), gross energy (on average 0.672) or CP (on average 0.774), a finding indicating the possibility of application of white lupin hulls as a source of dietary fibre for growing-fattening rabbits. Similarly, the CTTAD of NDF (on average 0.440) was not affected by dietary treatments.

Data describing the growth performance are presented in Table 2. Rabbits showed normal figures for growth rate (on av. 52.4 g/d), feed intake (on av. 155.1 g/d) and feed conversion ratio (on av. 2.97). No mortality or morbidity occurred during the experiment.

Table 2: Coefficients of total tract apparent digestibility (CTTAD) between days 45 and 49 of age and growth performance between 31 and 73 d of age of rabbit fed with the control and WLH diets.

	Control	WLH	RMSE[1]	*P*-value
CTTAD				
Dry matter	0.656	0.666	0.028	0.382
Crude protein	0.770	0.777	0.030	0.586
Gross energy	0.667	0.677	0.026	0.339
Neutral detergent fibre	0.451	0.428	0.048	0.254
Growth performance				
Live weight (g)				
At 31 d	940	947	105	0.877
At 52 d	2155	2207	159	0.433
At 73 d	3124	3166	285	0.718
Average daily weight gain (g/d)	52.0	52.8	5.6	0.711
Average daily feed intake (g/d)	152.6	157.5	14.1	0.400
Feed conversion	2.95	2.99	0.17	0.546

[1]RMSE=root mean square error (n=12 rabbits per treatment).

CONCLUSIONS

White lupin hulls can serve as a suitable by-product for rabbit feed and produce no significant reduction in the nutritive value of the diet. Further research should focus on determining the maximal dietary level for lupin hulls.

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