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PERFORMANCE RESPONSE OF GROWING RABBITS TO INCLUSION LEVEL OF SOYA BEAN HULLS AND GRAPE SEED MEAL[1]

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ABSTRACT

This study investigated the performance response of growing rabbits to dietary inclusion level of soya bean hulls (SBH) and grape-seed meal (GSM). Four isofibrous (42.6% NDF/DM, on average) and isolignified (7.1% ADL/DM, on average) diets (A-D), with similar particle size, were formulated by substitution of a mixture (35:35:30) of alfalfa hay, sunflower hulls and wheat straw with a mixture (81:19) of SBH and GSM. A fattening trial was carried out using 160 weaning rabbits, 30 days old, until they reached slaughter weight (2.02 ± 0.04 (SE) kg). Thirty-six rabbits of 52 d of age (on average), were selected at random from the growth trial to determine the digestibility of the diets while 40 other rabbits (2.02 ± 0.07 (SE) kg) at the end of the growth trial were used to determine caecotrophy traits. Average daily gain was lower for rabbits fed diet D relative to the other three diets, both in the first two weeks after weaning (28.4 *vs* 31.7 g/d; P = 0.03) and in the whole fattening period (35.8 *vs* 37.3 g/d; P = 0.03). A parallel effect was observed on feed intake, which decreased (P < 0.01) from 112 g/d (average of diets A, B and C) to 106 g/d for diet D in the whole fattening period. In this period, type of diet had no effect either on feed efficiency or on mortality. Crude protein digestibility decreased linearly (P < 0.001) when inclusion level of SBH and GSM increased, from 0.756 in diet A to 0.703 in diet D. Treatments had no effect on DM, energy and NDF digestibilities and on daily soft faeces excretion. From these results we can conclude that use of SBH in fattening rabbits combined with high lignified and cheap by-products, as GSM, could substitute a sizeable proportion of traditional sources of fibre with no impairment of performance.

INTRODUCTION

The inclusion of high amounts of SBH (40%) in the diet together with a low dietary levels of ADL (3.3% ADL/DM) reduced feed intake, growth rate and increased caecal contents weight of fattening rabbits (NICODEMUS *et al*., 1999). In the same way, GIDENNE and PEREZ (1994) detected an increase in the caecal mean retention time and a reduction of feed intake when dietary ADL concentration decreased. The inclusion of high levels of SBH could have the same effect, as it led to a higher caecal mean retention time (14.1 h; GARCIA *et al*., 1999_a) with respect to a diet containing alfalfa hay (6.9 h; GIDENNE *et al*., 1990). It also tended to increase caecal contents weight with respect to alfalfa hay (GARCIA *et al*., 2000_a). DE BLAS *et al*. (1999) established a positive correlationship between ileo-rectal mean retention time and caecal contents weight. To elucidate if the impairment of performance was related to low lignin content or to the high SBH inclusion of the diet, four isofibrous (42.6% NDF/DM, on average) and isolignified (7.1% ADL/DM, on average) diets, with similar particle size (around 35% of particles larger then 0.315 mm), were formulated combining SBH with GSM. Grape-seed meal is a by-product characterised by a high degree of lignification. As other grape by-products, its inclusion in the diet leads to high rate of passage and to a decrease of caecal contents weight (FRAGA *et al*., 1991; GARCIA *et al*., 1999_b and GARCIA *et al*., 2000_b). The mixture of SBH and GSM might allow a higher inclusion of SBH in the diet maintaining the dietary ADL concentration.

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MATERIAL AND METHODS

Diets

Four isofibrous (42.6% NDF/DM, on average) and isolignified (7.1% ADL/DM, on average) diets (A-D) were formulated by a gradual substitution of a mixture (35:35:30) of alfalfa hay, sunflower hulls and wheat straw with a mixture (81:19) of SBH and GSM. Diets had a similar particle size distribution (around 35% of particles larger than 0.315 mm). They were formulated to meet or exceed all the essential nutrient requirements of a mixed feed for growing rabbits (DE BLAS and MATEOS, 1998). The ingredient and chemical composition of the experimental diets is shown in Table 1.

Table 1. Ingredient and chemical composition of experimental diets.

	Diets			
	A	B	C	D
Ingredient, % as fed				
Grape-seed meal	0.00	2.50	5.00	7.5
Soya been hulls	0.00	10.8	21.7	32.5
Alfalfa hay	14.0	9.34	4.66	0.00
Wheat straw	12.0	8.10	4.10	0.00
Sunflower hulls	14.0	9.34	4.66	0.00
Basal diet[1]	60.0	60.0	60.0	60.0
Chemical analysis, %DM basis				
Ash	9.9	8.5	7.7	7.4
Crude protein	18.5	18.4	18.4	18.0
Neutral detergent fibre	42.1	42.5	42.8	43.0
Acid detergent fibre	27.2	27.4	27.7	28.1
Acid detergent lignin	6.8	6.9	7.3	7.5
Acid detergent cutin	2.2	2.9	3.9	4.7
Gross energy, MJ/kg DM	18.5	18.6	18.5	18.5
Particle size distribution, %DM				
< 0.160 mm	56.5	54.8	54.6	53.7
0.160 - 0.315 mm	11.3	10.0	10.1	9.4
0.315 – 0.630 mm	16.1	17.7	18.6	17.9
0.630 – 1.250 mm	13.6	15.0	14.9	16.4
> 1.250 mm	2.5	2.5	1.8	2.6
> 0.315 mm	32.2	35.2	35.3	36.9

[1] Basal diet (%): Barley grain: 13; Cane molasses: 1.50; Lard: 0.91; Sunflower seed meal: 10.0; Soya been meal: 11.7; Corn gluten feed: 2.0; Wheat bran: 19.4; Calcium carbonate: 0.63; Sodium chloride: 0.45; Choline chloride 75: 0.03; Alimet (supplied by Novus): 0.06; Robenidine premix (6.6% of active ingredient. Supplied by Impex Ibérica): 0.10; Vitamin/mineral premix: 0.17 (provided by Roche Vitaminas. Composition (%): Mn: 1.34; Zn: 4.0; I: 0.067; Fe: 2.4; Cu: 0.8; Co: 0.035; Se: 0.008; rivoflavin: 0.21; calcium pantothenate: 0.73; nicotininc acid: 2.76; menadione: 0.08; a-tocopherol: 2.2; thiamin: 0.067; pyridoxine: 0.08; biotin: 0.005; folic acid: 0.05; cyanocobalamin: 8 mg/kg; vitamin A: 6700.000 IU/kg; vitamin D_3: 940.000 IU/kg)

Growth Trial

One hundred and sixty New Zealand x Californian weaning mixed-sex rabbits (40 per diet), 30 days old, were blocked by litter and assigned to the treatments. They were individually caged in flat-deck cages and were given *ad libitum* access to the feed, until they reached the slaughter weight (2.02 ± 0.04 (SE) kg). Feed intake and weight of rabbits at day 14 after weaning and at the end of the experimental period were recorded per cage.

Faecal Apparent Digestibility Trial

A group of 36 New Zealand x Californian growing rabbits (9 per diet) from 50 to 55 days of age, weighing 1.72 ± 0.27 (SE) kg as average, were selected at random from the growth trial to determine faecal apparent digestibility of DM, energy, CP and NDF. No control of sex of litter was done. Following a three-day period of adaptation to metabolism cages, the feed intake (*ad libitum* access) and the total faecal output (caecotrophy was not prevented) were recorded for each rabbit over a four-day period. Faeces produced daily were pooled individually in plastic bags and stored at –20ºC for further analyses.

Caecotrophy Trial

A group of 40 New Zealand x Californian (10 per diet), weighing 2.02 ± 0.07 (SE) kg as average, were selected at random at the end of the growth trial without regard to their gender. Animals were given *ad libitum* access to the feed. A wooden collar (150 g and 25 cm diameter) was put on each animal to prevent the ingestion of soft faeces. The collar was put on at 8:00 h, half an hour after light was switched on, and was removed 24 h later. The soft faeces collected were stored at –20ºC. Feed intake was recorded for 3 d before the collar was placed, and the animals were weighed just before the collar was placed. Seven days later the same procedure was repeated to determine more precisely an average soft faeces excretion. Soft faeces were freeze-dried and analysed for CP.

Housing

A cycle of 12 h light and 12 h of dark was used throughout the experiments. Building cooling systems and forced ventilation allowed the temperature to be maintained between 20-27ºC. The light was switched on at 7:30 h. Animals were housed in flat-deck and metabolism cages, that allowed separation of faeces and urine, measuring 250 x 600 x 330 mm and 405 x 510 x 320 mm high, respectively. Animals were handled according to the principles for care of animals in experimentation (SPANISH ROYAL DECREE 223/88).

Analytical Methods

Chemical analysis of diets and faeces was made using the method of VAN SOEST *et al*. (1991) for NDF, and GOEHRING and VAN SOEST (1970) for ADF, ADL and acid detergent cutin (ADC). Neutral detergent fibre was determined directly, whereas ADF and ADL were extracted successively. Acid detergent cutin was determined after extracting ADF, ADL and permanganate lignin. Procedures of the AOAC (1995) were used for dry matter, ash and CP. Gross energy was determined by adiabatic bomb calorimetry. Distribution of particle size of diets was determined by wet sieving according to GARCIA *et al*. (1999_a).

Statistical Analysis

Data from growth trial were analysed as a completely randomised block design with litter as block effect and type of diet as the main source of variation. Weaning weight was used as linear covariate. Digestibility and caecotrophy trials were analysed as a completely randomised design with type of diet as the main source of variation. Data were analysed by using the GLM procedure of SAS (1990). Mean comparisons were made using orthogonal contrasts. Furthermore, treatment sums of squares were partitioned into linear and quadratic effects of SBH and GSM inclusion level in the diet. All data are presented as least-square means.

RESULTS

Growth Trial

The effect of diet on growth traits is shown in Table 2. Average daily gain was lower for rabbits fed with the diet D relative to the other three diets, both in the first two weeks after weaning (28.4 *vs* 31.7 g/d; P = 0.03) and in the whole fattening period (35.8 *vs* 37.3 g/d; P = 0.03). The same trend was found in the first two weeks after weaning, although in this case differences did not reach statistical significance. A parallel effect was observed on feed intake, which decreased (P < 0.001) from 112 g/d (average of diets A, B and C) to 106 g/d for diet D in the whole fattening period. Contrasts between diet C and the average of diets A and B or between diets A and B were not significant for average daily gain and feed intake. Type or diet had no effect either on feed efficiency (expressed as g of weight gain per g of feed intake) or on mortality in the whole fattening period.

Table 2. Effect of diet on fattening performance, faecal apparent nutrient digestibility and excretion and chemical composition of soft faeces.

	Diets				SEM	Contrast[1]		
	A	B	C	D		1	2	3
Inclusion level of SBH, %	0	10.8	21.7	32.5				
Fattening performance								
Two weeks after weaning period								
N	39	37	38	40				
Average daily gain, g	32.2	30.8	32.2	28.4	1.14	0.03	NS[2]	NS
Feed intake, g/d	66.3	66.3	68.9	64.2	1.77	NS	NS	NS
Feed efficiency, g gain/g intake	0.481	0.453	0.463	0.445	0.01	NS	NS	NS
Whole fattening period								
N	39	35	37	39				
Average daily gain, g	37.6	36.6	37.8	35.8	0.57	0.03	NS	NS
Feed intake, g/d	111	111	113	106	1.50	0.006	NS	NS
Feed efficiency, g gain/g intake	0.338	0.329	0.333	0.335	0.005	NS	NS	NS
Mortality[3], %	2.5	12.5	7.5	2.5	0.05	NS	NS	NS
Faecal apparent nutrient digestibility (n = 9)								
Feed intake, g DM/d	131	139	136	133	4.85	NS	NS	NS
Dry matter digestibility, %	55.4	53.9	54.1	55.5	0.80	NS	NS	NS
Gross energy digestibility, %	56.7	54.6	54.0	55.5	0.90	NS	NS	NS
Neutral detergent fibre digestibility, %	22.3	19.5	22.0	22.5	1.60	NS	NS	NS
Crude protein digestibility, %	75.6	73.7	72.4	70.3	1.00	0.005	0.08	NS
Digestible energy, MJ/kg DM	10.5	10.2	10.0	10.3	0.167	NS	NS	NS
Caecotrophy trial (n = 10)								
Feed intake 3 days before, g DM/d	133	139	141	135	5.03	NS	NS	NS
Soft faeces excretion, g DM/d	24.1	24.4	25.8	25.2	1.43	NS	NS	NS
Soft faeces excretion, % BW/d	1.19	1.22	1.27	1.27	0.07	NS	NS	NS
Crude protein soft faeces, % DM	23.7	24.6	23.4	23.8	0.53	NS	NS	NS
Soft faeces contribution to total protein intake, %	18.7	18.8	18.8	20.5	0.86	0.12	NS	NS

[1] 1 = Diet D *vs* others; 2 = Diet C *vs* B, A; 3 = Diet B *vs* A.
[2] NS: Non significant (P > 0.15).
[3] n = 40.

Faecal Apparent Digestibility Trial

The effect of dietary treatments on nutrient digestibility is shown in Table 2. Dry matter intake was not affected by treatments and was 135 g DM/d on average. Type of diet had not effect on DM, energy and NDF digestibilities being 0.547; 0.557 and 0.216 on average, respectively. Crude protein digestibility decreased linearly ($P < 0.001$) when inclusion level of SBH and GSM increased, from 0.756 in diet A to 0.703 in diet D.

Caecotrophy Trial

The results of this trial are shown in Table 2. No significant differences among diets were found on DM intake, measured the three days before putting the wooden collar, and daily soft faeces excretion (expresed as g DM/d and as % BW/d) being 137 g DM/d, 24.9 g DM/d and 1.24% BW/d, on average, respectively. The highest inclusion level of SBH and GSM (diet D) tended to increase ($P = 0.12$) the soft faeces contribution to total protein intake with respect to the average of the other three diets (20.5 *vs* 18.8%).

DISCUSSION AND CONCLUSIONS

The results of this study show that a 32.5% level of SBH inclusion impairs feed intake (around 5%) and average daily gain (around 4.3%) in the whole fattening period, even when maintaining dietary ADL concentration. NICODEMUS *et al*. (1999) also observed a reduction of growth performance in rabbits feed with high inclusion levels of SBH (40%). In this case, feed intake and growth rate decreased 11.5% and 5%, respectively. Part of this effect could be due also to the low dietary lignin concentration in this diet (3.3% ADL/DM). A parallel effect of type of diet on caecal contents weight was found, as it increased by 14% in the animals fed with this diet. In a previous work (GARCIA *et al*., 2000_a) an increase of caecal contents weight (around 20%) when high levels of SBH were included (62.2%) with respect to a diet with high levels of alfalfa hay (75.2%) has also been detected. This accumulation of digesta in the caecum might decrease rate of passage, and have a negative effect on feed intake capability, in a similar way as rumen fill has in ruminants (VAN SOEST, 1994). Although in this work caecal contents weight has not been measured, it could be expected an accumulation of digesta in the caecum in the animals fed with the diet containing 32.5% of SBH, which might decrease feed intake, even when maintaining a high dietary ADL concentration.

Diet D also had the higher inclusion level of GSM. Grape-seed meal, as other grape by-products, is characterised by a high degree of lignification. Its inclusion in the diet leads to a high rate of passage and to a decrease of caecal contents weight (FRAGA *et al*., 1991; GARCIA *et al*., 1999_b; GARCIA *et al*., 2000_b). This effect would explain the lack of differences found in growth performance between diets A and C, and also the lower impairment observed at high levels of SBH inclusion with respect to previous work (NICODEMUS *et al*., 1999). In the same way, an increase of feed intake and growth rate was observed by GARCIA *et al*. (1999_c) when substituting a 15% of a balanced basal diet with GSM.

There were no differences in faecal apparent digestibility due to the inclusion of SBH and GSM, except for CP digestibility. This effect would be explained by the lower digestion efficiency of SBH protein with respect to that alfalfa hay (GARCIA *et al*., 1995 and 1997).

From these results we can conclude that use of SBH in fattening rabbits combined with high lignified and cheap by-products, as GSM, could substitute a sizeable proportion of traditional sources of fibre with no impairment of performance.

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