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CHARACTERIZATION OF FIBRE DIGESTION OF GRAPE-SEED MEAL AND SUNFLOWER HULLS IN RABBITS. I. FIBRE DIGESTIBILITY AND RATE OF PASSAGE[1]

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ABSTRACT

Twenty New Zealand White x Californian rabbits were used to evaluate faecal apparent NDF, ADF and ADL digestibility and another twelve to determine rate of passage of defatted grape-seed meal (GSM) and sunflower hulls (SH). Two diets were formulated by supplementing these fibrous feeds with a concentrate containing starch, protein, fat and a min/vit mix. No differences between diets were found for NDF, ADF or ADL digestibility (7.2, 7.6 and 5.2%, on average), being the latter different from zero. Digestibility of NDF was lower than that obtained in previous difference trials, where lower levels of inclusion of the fibrous ingredients were tested. Total and caecal mean retention time were short and similar for both fibrous feeds (16.5 and 8.6 h, on average, respectively). As a consequence, feed intake was high and did not differ in animals fed both diets (164 g DM/d, on average). By comparing these results with previous literature, we conclude that GSM and SH might substitute partially alfalfa hay in rabbit diets with no impairment of rate of passage and intake, although a decrease of fibre digestion efficiency should be expected.

INTRODUCTION

Defatted grape-seed meal (GSM) and sunflower hulls (SH) are fibrous concentrated by-products (> 75% NDF on DM), highly available in Spain and other Mediterranean countries. A digestible energy concentration of about 5.5 MJ/kg DM for both feeds has been established by García et al. (1996, 1999_a), using the substitution method. This value has been validated in feeding trials using commercial diets (García et al., 1999_a) and represents around 75% of the energy value of an average lucerne meal (Villamide et al., 1998). Also, GSM and SH can contribute to meet the high fibre requirements in this species (about one third of NDF in the diet; De Blas and Mateos, 1998). However, a better knowledge of their fibre digestion is needed, as type of fibre greatly affects its physical characteristics, digestion efficiency, rate of passage and intake (García et al., 1999_b; De Blas et al., 1999).

The aim of this work was to study fibre digestion and rate of passage of GSM and SH using semisynthetic diets that contained these feeds as sole source of fibre.

MATERIAL AND METHODS

Diets

Two diets were formulated to contain GSM or SH as the sole source of fibre. To

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assure a minimum nutrient supply, fibre sources were supplemented with a concentrate to obtain diets containing at least 18% crude protein and 12% starch. Chemical composition of fibre sources is shown in Table 1. Ingredient and chemical composition and particle size distribution of diets are shown in Table 2.

Table 1. Chemical composition of the fibrous raw materials (% of DM)

	Grape seed meal (GSM)	Sunflower hulls (SH)
Dry matter	90.0	92.8
Ash	5.84	3.01
Ether extract	3.60	2.65
Crude protein	11.0	5.56
NDF	80.6	75.7
ADF	72.0	59.7
ADL	59.0	21.8
Acid detergent cutin (ADC)	46.0	10.4
GE, MJ/kg DM	20.5	20.3
Dry density, gDM/ml	0.345	0.170
Hydration capacity, %	192	506

Faecal Apparent Digestibility Trial

A group of 20 New Zealand White x Californian rabbits (ten per diet) 46 days old weighing 1324±36 (SE) g, were randomly allotted to the experimental diets without regard to gender. Animals were given ad libitum access to the feed. Following a 19-d period of adaptation to each diet animals weighed 1782±70 (SE) g. At that time feed intake was recorded and faeces collection was made on four consecutive days. The final weight of the animals was 1905±73 (SE) g. Faeces were stored at –20°C and dried at 80°C.

Rate of Passage Trial

Europium was selected as marker and was fixed to the residue obtained from the particle size determination of the sources of fibre (particles larger than 0.160 mm). Labelling of the fibre particles with europium was done as described by García et al. (1999_b). Twelve New Zealand White x Californian rabbits (six per diet) weighing 1595±22 (SE) g, were allotted randomly to the experimental diets. Animals were given ad libitum access to the experimental diets for a 14-d period of adaptation. At the end of this period they weighed 1989±50 (SE) g. Then, the experimental diets were removed from 16.00 to 16.30 h and animals were fed special pellets containing 2 g of fibre particles marked with europium, 1 g of wheat flour and 1 g of sugar beet molasses. At 16.30 h animals were given again ad libitum access to the experimental diets. Four hours after the europium containing pellets were consumed, faecal excretion was fractionated into 21 collections during 72 h. The intervals among collections were 1, 2, 4, 12, 6 and 12 h for the first 11, and the following 3, 2, 1, 2 and 2 samples, respectively. Faeces were dried at 80ºC and analysed for europium. Afterwards animals were slaughtered by cervical dislocation at 19.00 h. Final weight was 2320±75 (SE) g. Caeca were weighed separately with and without their contents.

Mean retention time (MRT) values were calculated by using the formula: $\sum Mi \cdot Ti / \sum Mi$, (Faichney, 1975) where *Ti* was the time elapsed between the supply of the single dose of marker (T_o) and the *i*th collection of faeces and *Mi* was the amount of marker excreted between *Ti-1* and *Ti.* Transit time (TT) is defined as the time elapsed between T_o and the first faecal collection containing detectable marker. Finally, the declining phase of the Europium excretion kinetics was modelled using the following function: $y(t) = A * e^{-k * t}$, where y(t) is europium concentration in the faeces collected at time t, A is a constant, k is the rate-constant and t is the interval between the marker dosage and the faeces collection. Caecal MRT was estimated as 1/k.

Table 2. Ingredient and chemical composition of experimental diets

	61.3% GSM	61.3% SH
Ingredient, % as fed		
Grape seed meal	61.3	0
Sunflower hulls	0	61.3
Pork lard	1.20	1.20
Wheat flour	18.0	18.0
Casein	15.3	15.3
Sepiolite	1.53	1.53
Calcium carbonate	0.50	0.50
Calcium phosphate	1.50	1.50
Sodium chloride	0.50	0.50
Vitamin/mineral premix[a]	0.17	0.17
Chemical analysis, % DM basis		
GE, MJ/kg DM	19.7	19.5
Ash	7.60	5.86
Crude protein	24.0	19.4
NDF	49.1	47.3
ADF	44.5	36.9
ADL	36.0	13.7
Acid detergent cutin	27.7	5.89
Particle size distribution, % DM		
< 0.160 mm	57.7	44.8
0.160 – 0.315 mm	13.6	11.1
0.315 – 0.630 mm	19.7	18.5
0.630 – 1.250 mm	7.9	20.1
> 1.250 mm	1.1	5.5

[a] Provided by Roche Vitaminas (Madrid, Spain). Mineral and vitamin composition (mg/kg of feed): Mn, 22.8 ($MnSO_4$); Zn, 68 ($ZnSO_4$); I, 1.14 (KI); Fe, 40.8 ($FeSO_4$); Cu, 13.6 ($CuSO_4$); Co, 0.59 ($CoSO_4$); Se, 0.14 (Na_2SeO_3); riboflavin, 3.6; calcium d-pantothenate, 12.4; nicotinic acid, 46.9; menadione sodium bisulfite, 1.4; vitamin E, 37.4; thiamine, 1.14; pyridoxine, 1.4; biotine, 0.08; folic acid, 0.8; vitamin B_{12}, 0.014; vitamin A, 11,390 IU/kg and vitamin D_3, 1,598 IU/kg.

Housing

Animals were housed in metabolism wired cages measuring 405 x 510 x 320 mm high that allowed separation of faeces and urine. A cycle of 12 h of light and 12 h of dark was used throughout the experiment. Light was switched on at 7.30 h. Heating and forced ventilation systems allowed the building temperature to be maintained between 18 and 23ºC throughout the experiment. Experimental procedures followed the principles for care of animals in experimentation (Spanish Royal Decree 223/88, 1988).

Analytical Methods.

Chemical analysis of diets and faeces was performed using the method of Van Soest et al. (1991) for NDF and Goering 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 AOAC (1995) were used for DM, ash, CP and ether extract. Proportions of fine and large particles (FP: < .315 mm, LP: > 1.25 mm, respectively) of diets were determined by wet sieving according to García et al. (1999_b). Dry density and hydration capacity were determined as described by Mir et al. (1990).

Statistical Analysis.

Data were analysed as a completely randomised design by using the GLM procedure of SAS (1990) with type of diet as main factor.

RESULTS AND DISCUSSION

Both GSM and SH had a high NDF concentration (Table 1), although its NDF composition showed wide differences. Hemicelullose (NDF-ADF) and celullose (ADF-ADL) proportions in NDF were 11 and 16% in GSM, and 21 and 50% in SH, respectively. Degree of lignification (ADL/NDF) of GSM was higher than that of SH (73 vs 29%, respectively), mainly due to differences in ADC proportion (57 vs 13% on NDF, respectively), as true lignin (ADL-ADC) concentrations in NDF were similar (16% on average). These high proportions of lignin and cutin explain the high gross energy content of both sources of fibre (around 20.4 MJ/kg DM). Proportion of fine particles (< 0.315 mm) of GSM was higher than for SH (71 vs 56%) whereas that of large particles (> 1.25 mm) was lower (1 vs 5%). Particle size in GSM was similar to that obtained previously for alfalfa hay (79 and 2% of fine and large particles, respectively; García et al., 1999_b). Dry density of GSM was double than that of SH, whereas its hydration capacity was a 40% from that of SH.

Type of fibre did not affect NDF, ADF or ADL digestibilities. Although GSM had a higher degree of lignification than SH, most of it was due to cutin, which might have a lower negative effect on fibre digestibility than true lignin (Van Soest, 1994). Acid detergent cutin digestibility of SH was positive and different from zero, whereas that of GSM did not differ from zero. Both GSM and SH had a lower NDF digestibility than that of alfalfa hay determined in high fibrous diets (around 18%, Gidenne et al., 1991; García et al., 1999_b). This can be explained by the higher degree of lignification of NDF in GSM and SH and the lower proportion of fine particles, especially in the case of SH, with respect to alfalfa hay. Thus, it could be expected that the inclusion of GSM or SH in rabbit diets in substitution of alfalfa hay would impair dietary fibre digestion.

Digestibility of NDF in GSM was lower than our own observed results (24.5%, unpublished), determined by substituting a basal diet with a 15% of GSM. However, the latter diet had a lower NDF content and degree of lignification of NDF (42.8 and 7.5%, respectively) than the semisynthetic diet used in the present study. As a consequence, fermentation time might have been shorter and microbial digestion efficiency lower in the present study. The highest value obtained in the difference trial fitted well with the DE content derived in that work (5.5 MJ/kg DM; García et al., 1999_a). A similar trend is observed when comparing NDF digestibility of SH (5.84%) with that obtained by difference (13.3%)

by García et al. (1996) using inclusion levels of SH up to 24%.

Table 3. Effect of type of fibre on dry matter intake and nutrient faecal apparent digestibility (%) of the experimental diets

	61.3% GSM	61.3% SH	SEM[a]	P
Dry matter intake, g/d	149	153	6.42	0.67
Faecal apparent digestibility, %				
Dry matter	44.2	44.3	0.78	0.91
Gross energy	43.7	44.8	0.81	0.33
Crude protein	76.3	80.0	0.48	0.001
NDF	8.57	5.84	1.32	0.15
ADF	8.11	7.19	1.49	0.66
ADL	6.13	4.38	1.72	0.47
ADC	-0.69	11.5	2.15	0.001

[a] n = 10

No differences were detected between total and caecal MRT between GSM and SH diets (16.5 and 8.6 h on average, respectively), although total TT tended to be shorter for SH than for GSM (P = 0.06; Table 4) and weight of caecal contents decreased a 23% from SH to GSM diet (P = 0.023). As a consequence, feed intake did not differ in rabbits fed these two diets (164 g DM/d, on average). These results do not follow the differences of particle size of these fibrous sources and might indicate that other variables, as shape of particles, hydration capacity or density, might also have an influence on rate of passage. Total MRT was relatively short and similar to that obtained for alfalfa hay by Gidenne et al. (1991). In this way, a previous work (García et al., 1999[a]) has shown that inclusion of 15% of GSM in a balanced basal diet, containing traditional sources of fibre and 10.6 MJ DE/kg DM), only decreased slightly (by 5.3%) feed efficiency in the fattening period. Part of this result was explained by a parallel increase of feed intake (by 9.6%) with GSM inclusion.

Table 4. Effect of inclusion of grape seed meal and sunflower hulls on total and caecal mean retention time (tMRT and cMRT, respectively) and total transit time (tTT).

	61.3% GSM	61.3% SH	SEM[a]	P
Dry matter intake, g/d	167	160	8.0	0.58
DM digestibility, %	49.4	48.6	0.48	0.31
tMRT, h	16.5	16.4	1.15	0.98
tTT, h	5.08	4.03	0.33	0.060
cMRT, h	7.61	9.62	1.38	0.35
Caecal content weight, % BW	3.61	4.71	0.27	0.024

[a] n = 6

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