Journal of Animal and Veterinary Advances, 6 (11): 1269-1272, 2007
ISSN: 1680-5593

First Attempt to Study Carob Pulp Utilization in Rabbits Feeding

[1]Aziza Gasmi-Boubaker, [1]R. Bergaoui, [2]A. Khaldi, [3]M.R. Mosquera-Losada and [1]A. Ketata
[1]Institute National Agronomique, Tunis, Tunisia
[2]Institute National des Recherches en Géne Rural, Eaux et Forêts, Tunis, Tunisia
[3]Escuela Polytecnica Superior, Universidade de Santiago de Compostela, Lugo, Spain

Abstract: Twenty four New Zealand x Californian rabbits (2413±147 g initial weight) were allotted to three dietary treatments in a completely randomised design, to investigate the effect of inclusion of carob pulp in commercial concentrate on nutrient digestibility and nitrogen balance. Carob pulp was added at 3 different levels: 0, 10 and 20% to the commercial concentrate and 3 dietary treatments designated as D1 (0% carob pulp), D2 (10% carob pulp) and D3 (20% carob pulp) were fed to the rabbits. Digestibility was determined by total faecal collection (caecotrophy was not prevented). Dry matter and OM digestibilities have been significantly increased in rabbits fed the diets incorporating carob pulp ($p<0.05$) but no significant differences ($p>0.05$) can be found for CP and CF digestibilities among the different diets. The apparent absorption rates of phosphorus, magnesium and potassium showed weak changes among diets and averaged 36, 73 and 86%, respectively. Apparent nitrogen retention (as g day^{-1} or proportion of N intake) was similar in the 3 group of rabbits. Based on the above, assessment of conditions for using higher levels of carob pulp for rabbits requires more research.

Key words: Carob pulp, rabbit, digestibility, nitrogen balance, mineral absorption

INTRODUCTION

Conventional by-products and unconventional materials from the food processing industry have been frequently included in livestock diets. Carob pulp is by-product widely available in the Mediterranean area. Spain is the main producer and exporter country of carob pods with more than 40% of the world's production (average production of 150.000 Tons $year^{-1}$; Petit and Pinilla, 1995). The 2 principal components of the fruit are the seeds and the pulp. The latter component represents about 90% of the weight of the fruit. It is especially rich in total sugars and in gross energy making carob pulp a high-energy food for animal nutrition However, its incorporation in the diet should be limited due to its relatively high tannin (3-4%) and low protein (<50g kg^{-1} DM) content (Albanell *et al*., 1991). There are no specific studies about the maximum level of inclusion for carob pulp in rabbit diets, but levels of 7-10% have been utilised without negative effects in commercial diets (Gonzalez and Rial, 1989).

As part of a program to develop under-utilized resources the following study was initiated to obtain information on nutrient digestibility, nitrogen balance and mineral absorption in rabbits fed diets containing different levels of carob pulp.

MATERIALS AND METHODS

Diets: The carob pulp used in this study was obtained from INGREF (Tunisia). Three diets were prepared in a pelleted form using an electric meat mincer. Diets were formulated to contain an increasing proportion of carob pulp: 0, 10 and 20% DM for diets D1, D2 and D3, respectively, by the substitution of a decreasing proportion (20, 10 and 0%) of a typical commercial rabbit concentrate. The weighed feed ingredients were mixed with water to achieve 25-30% moisture content, pelleted then oven dried at 40°C for 2 days. The diets did not contain any drug supplementation (antibiotic or coccidiostatic). The ingredients and chemical composition of the experimental diets are given in Table 1.

Animals: Twenty four adult rabbits weighing 2413±147 g, were used. The rabbits divided into 3 groups and were allocated randomly to the experimental diets shown in Table 1. Animals were placed in individual cages with facility for separate quantitative collection of urine and faeces. The diets were offered at 10:00 h daily with allowance of 10% above the previous day's consumption and water was available *ad libitum*.

Corresponding Author: Aziza Gasmi-Boubaker, Institut National Agronomique, Tunis, Tunisia

Digestibility trial: *In vivo* apparent digestibility of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fibre (CF), Phosphorus (P), Potassium (K) and Magnesium (Mg) were determined by total faecal collection. The *in vivo* trial lasted 15 days, with 10 days for adaptation to the diets, 5 days for collection of urine, feces (caecotrophy was not prevented), feed supplied and refusals. Every morning, before supplying the diet, the feed refusals of each animal were removed and weighed. The refusals were sampled after the weighing and recording. Total feces voided was weighed and stored in a freezer. Urine voided was measured, mixed and 5% aliquot was preserved in sulphuric acid for Nitrogen (N) estimation. At the end of the experiment, the feces from each animal was removed from the freezer, thawed at room temperature and blended manually, making a composite sample per animal over the 5-day collection period. The same method was used to obtain a composite sample per urine. The samples of supplied feed, refusals and feces were pre-dried in a forced air oven over 60°C, ground in a Wiley mill (1-mm sieve) and analyzed in duplicate. Daily intake was determined by the difference between the weight of supplied feed and the refusals.

Analytical methods: Samples of feed, refusals and faeces were analyzed for DM, OM and N according to AOAC (1990). Urinary N was also measured in the same way. Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were determined according to Van Soest *et al*. (1991). Hemicellulose fraction was estimated by difference between NDF and ADF. Phosphorus, K and Mg were measured by ashing samples at 550°C and dissolving the residue in hydrochloric acid (1:3 v v^{-1}). The resultant extracts were analysed for K and Mg using an atomic spectrophotometer and P using a Technicon autoanalyser.

Table 1: Ingredients and chemical composition of experimental diets

	Diets		
	D1 (0% carob p.)	D2 (10% carob p.)	D3 (20% carob p.)
Ingredients (%)			
Commercial concentrate	100	90	80
Carob pulp	0	10	20
Total	100	100	100
Chemical composition (g kg^{-1} DM)			
Dry matter	881.7	881.3	891.1
Organic matter	906.6	908.5	911.8
Crude protein (N×6.25)	168.9	164	158.3
Neutral-detergent fibre	451.1	437.2	423.4
Acid-detergent fibre	218.1	222.5	227
Crude Fibre	210	202	198
Hemicellulose (NDF-ADF)	233	214.7	196.4
Phosphorus	4.9	4.9	4.9
Magnesium	5.21	5.10	4.75
Potassium	12.2	11.08	10.98

Statistical analysis: Data of nutrient digestibilities and N balance were subjected to analysis of variance using the GLM procedure of SAS (1989). Tukey's test for multiple comparisons (Steel and Torrie, 1980) was used and significant differences were declared if $p<0.05$.

RESULTS

Table 2 presents the proximate chemical composition of carob pulp used in this study. Reference values of carob pulp from other regions are included in the Table, for comparison. Carob pulp, used in this study, had low CP content but had relatively high CF.

Intake, *in vivo* digestibility of DM, OM, CP and CF of the whole diets, N utilization and mineral absorption are shown in Table 3. There was no significant difference ($p>0.05$) in intake of the diet among the rabbits on the three tested diets. The inclusion of carob pulp in the diet produced significant ($p<0.05$) increases in the apparent digestibility of both DM and OM while the digestibilities of CP and CF improved numerically but not at a significant

Table 2: Chemical composition (g kg^{-1}) of carob pulp

	References			
	(1)	(2)	(3)	(4)
Dry matter	888	873.1	833	940
Organic matter	959.4	967.3	969	963
Crude protein	46.8	43.2	38	46.3
Crude fibre	210	80.1	64	-
Neutral Detergent Fibre (NDF)	312.8	346.7	-	2915
Acid Detergent Fibre (ADF)	262.8	338.0	-	260.5
Potassium	9.9	-	8.02	-
Magnesium	1.4859	-	0.668	-
Phosphorus	0.700	-	0.315	-

1: Carob pulp examined in our study; 2: Albanell *et al.*(1991); 3:Petit and Pinilla (1995); 4: Williams *et al.*(2005)

Table 3: Intake, digestibility, nitrogen utilization and mineral absorption.

	D1 (0% carob p.)	D2 (10% carob p.)	D3 (20% carob p.)	p-value
Intake (g day^{-1})				
DM	163±5	159±22	168±31	0.250
CP	27.5±0.8	26.5±4.1	26.6±1.2	0.157
Digestibility (%)				
DM	57.3±1.6b	61.3±1.2a	60.6±1.9a	0.002
OM	58.5±1.7b	623±1.2a	62.2±2.3a	0.003
CF	27.7±6.1	32.8±4.7	31.8±4.2	0.238
CP	67.1±4.1	71.7±3.5	68.3±5.7	0.128
N balance (g day^{-1})				
N intake	4.40±0.12	4.24±0.65	4.27±0.19	0.057
Fecal N output	1.543±0.220a	1.166±0.266b	1.37±0.29b	0.017
Urinary N output	0.504±0.303	0.583±0.175	0.421±0.19	0.122
Retained N	2.353±0.311	2.38±0.52	2.47±0.39	0.714
Retained N (% N-intake)	53.47±5.4	58.0±4.3	57.8±8.1	0.123
Mineral absorption (%)				
Phosphorus	36.1±11.6	35.9±10.6	35.7±11.8	0.611
Magnesium	73.4±9.3	71.3±9.2	75±8.8	0.375
Potassium	83.2±5.9	88.9±6.1	86.3±11.4	0.448

a, b: means not sharing a common letter in the same row are significantly different ($p<0.05$), Values are means±SEM for 8 rabbits level ($p > 0.05$). Data in Table 3 indicate that N intake and urinary N excretion were similar in the 3 group of rabbits. However, the fecal -N excretion decreased ($p < 0.05$) in rabbits fed on D2 and D3, but without effect on N balance that remained positive for all diets. Apparent nitrogen retention (as g day^{-1} or proportion of N intake) was similar in the 3 group of rabbits. The apparent absorption rates of phosphorus, magnesium and potassium showed weak changes among diets (Table 3) and averaged 36, 73 and 86%, respectively.

DISCUSSION

There were differences in the chemical composition of the carob pulp with that previously reported. Overall, the biggest variation between substrates seemed to occur in the fibre and mineral contents, while values for CP are not very different and generally low. Thomson (1971) found in 40 cultivars of carob pods the following percentage ranges: total sugars (37-62%), crude protein (2.2-6.6%), crude fibre (4.2-9.6%) and ash (1.5-2.4%). Most bibliographic references highlight the variation of carob composition with cultivar, climate and growing techniques (Tous, 1990; Owen *et al*., 2003).

The enhancement in DM and OM diet digestibility through the addition of carob pulp could be attributed to the fact that carob pulp is rich in non nitrogen cellular content, which is readily degraded by gut micro-organisms. These constituents accounted for 60% of the total DM content of the carob pulp used in this study, similar to the 62% reported by Williams *et al.* (2005). In another study, Guessous *et al.* (1988) reported a high content of soluble carbohydrates (47%) and pectins (8%). Nevertheless, reported values (3.8-5.3%) for condensed tannins in carob pulp (Priolo *et al*., 1998) would normally have a negative effect on nitrogen utilization. It is well established that tannins inhibit digestive enzymes and increase endogenous and fecal nitrogen excretion that strongly depress protein digestibility as well as the digestibility of other nutrients in ruminants and in monogastrics. In the present study, tannins were not determined, but the lack of negative effect of carob pulp on nutrient digestibility and nitrogen retention might be partly related to the low proportion of carob pulp in the diet. Consequently, a negligible amounts of these compounds might be ingested by rabbits and/or could still within a tolerable level for rabbits.

Digestibility of CF observed with the 3 diets is relatively poor but in concordance with results of Gidenne (1990). In a previous work (Uden and Van Soest, 1982; Paul-Murphy *et al.*, 1982), it was reported that fibrous digesta is rapidly propelled through the colon and excreted as hard faeces making rabbits less efficient in the digestion of fibre than cattle and sheep. To our knowledge, no data are presently available on the effect of carob pulp inclusion on apparent absorption of essential minerals in the rabbit. However, the values obtained in this study are similar to those reported by Tortuero *et al.* (1994) for diets incorporating olive pulp meal or grape pulp meal.

CONCLUSION

Results show that substitution of part of a commercial concentrate for rabbit with carob pulp improved nutrient digestibility of the diet suggesting that carob pulp has a potential as an unconventional feed resource for rabbits. However, the experiment needs repeating to determine the optimum level of carob pulp that is able to increase digestibility and growth performance.

ACKNOWLEDGEMENT

This study was partially funded by the Ministry of Scientific Research, Technology and Capacity Building of Tunisia (Laboratoire de Recherche en Economie Agro-Alimentaire, INAT).

REFERENCES

Albanell, E., G. Caja and J. Plaixats, 1991. Characteristics of Spanish carob pods and nutritive value of carob kibbles. Options Méditerranéennes-Séries séminaires- n°, 16: 135-136.

AOAC., 1990. Association of Official Analytical Chemists, Official Methods of Analysis. 15th Edn., AOAC, Arlington, VI, USA.

Gidenne, T., 1990. Digestion des constituants pariétaux et activité fermentaire caecale chez le lapin en croissance: Incidence du taux d'incorporation et de la granulométrie de la source de fibre. Ann. Zootech., 41: 33-34.

Gonzalez, G. and E. Rial, 1989. Technologia de la fabricati'on de piensos compuestos para conejos. In:'Alimentacion del conejo'. Ed. Mundiprensa, Madrid.

Guessous, F., A. El Hilali and W.L. Johnson, 1988. Influence du taux d'incorporation de la pulpe de caroube sur la digestibilité et l'utilisation des rations par les ovins à l'engraissement. Reprod. Nutr. Dev., 28: 93.

Owen, R., R. Haubner, W. Hull, G. Erben, B. Spiegelhalder, H. Bartsch and B. Haber, 2003. Isolation and structure elucidation of the major individual polyphenols in carob fibre. Food and Chemical Toxicology, 41: 1727-1738.

Petit, M. and M. Pinilla, 1995. Production and purification of a sugar syrup from carob pods. Lebensm. Wiss. u. Technol., 28: 145-152.

Paul-Murphy, J., C. Murphy, H. Hintz, P. Meyrs and H. Schryver, 1982. comparison of transit time of digesta and digestive efficiency of the rock hyrax, the barabados sheep and the domestic rabbit. Comparative Biochem. Physiol., 72A: 611-613.

Priolo, A., M. Lanza, I. Biondi, P. Pappalardo and O. Young, 1998. Effect of partially replacing dietary barley with 20% carob pulp on post-weaning growth and carcass and meat characteristics of Comisana lambs. Meat Sci., 50: 355-363.

SAS/STAT, 1989. Statistical Software and User's Guide. Version 6. 4th Edn. Vol. 2. SAS Institute Inc., Cary, NC, USA.

Steel, R. and J. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edn., McGraw-Hill, Singapore.

Thomson, P., 1971. The carob in California. California Rare Fruit Growers. Year Book, III: 61-102.

Tortuero F., J. Rioperez, C. Cosin, J. Barrera and M.L. Rodriguez, 1994. Effects of dietary fiber sources on volatile fatty acid production, intestinal microflora and mineral balance in rabbits. Anim. Food Sci. Tech., 48: 1-14.

Tous, J., 1990. El Algarrobo. Ed. Mundiprensa, Madrid, pp: 27-43.

Uden, P. and P.J. Van Soest, 1982. comparative digestion of timothy (*Phleum pratense*) fibre by ruminants, equines and rabbits. Br. J. Nutr., 47: 267-272.

Van Soest, P., J. Robertson and B.A. Lewis, 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

Williams, B., M. Bosh, H. Boer, M. Verstegen and S. Tamminga, 2005. An *in vitro* bath culture method to assess potential fermentability of feed ingredients for monogastric diets. Anim. Feed Sci. Technol., pp: 123-124, 445-462.