Journal of Animal and Veterinary Advances 6 (10): 1219-1222, 2007
ISSN: 1680-5593

Cork Oak (*Quercus suber* L.) Acorn as a Substitute for Barley in the Diet of Rabbits: Effect on *In vivo* Digestibility, Growth and Carcass Characteristics

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Abstract: In this study 2 experiments were conducted to evaluate the feeding value of cork oak acorn as an energy source for rabbits. Experiment 1 was a digestibility trial using 20 adult rabbits (10 rabbits/group) and experiment 2 was a growth performance and carcass evaluation using 24 growing rabbits in a completely randomised design. Two diets were formulated to contain either 250 g Dry Matter (DM) barley (Barley diet) or 250 g DM oak Acorn (Acorn diet)/kg and included mainly, wheat bran, soybean meal, hay, molasses, calcium phosphate, Cu SO_4 and salt. Inclusion of acorn in the diet did not result in any change in odour and fungal contamination nor in the feed intake ($p>0.05$). However, acorn in the diet decreased the *in vivo* digestibility by 10.8, 11.5 and 17.5%, respectively, for DM, Organic Matter (OM) and Crude Protein (CP). Although the rabbits fed acorn diet retained less nitrogen than those fed barley diet, they were positive in the nitrogen balance. The final live weight and daily weight gain from weaning through slaughter did not show any significant difference between rabbits fed the control diet and those fed the experimental diet. Similar carcass yield and feed conversion ratio were observed for the 2 groups. Weight of full gastrointestinal, liver, kidney and caecum were not affected ($p>0.05$) by the presence of acorn in the experimental diet. A more careful evaluation of the real content and digestibility of nutrients from acorn is necessary to evaluate their nutritional value before considering them as a potential feed for rabbits.

Key words: Acorn, digestibility, growth, rabbit, tannin

INTRODUCTION

Today, food production depends not only on quantity but mainly on the nutritional quality of food products, allowing to maximise the food product, well being and health relationship. On the other hand, an important objective in livestock feeding is to promote the use of local feeds and by product in order to reduce feeding costs.

Acorns of *Quercus* sp. (Fagaceae) are not a novel feedstuffs but their usage in human and animal nutrition has a long history especially in the Mediterranean region. Several authors (Gonzalez-Martin *et al*., 2005) evaluated the effect of acorn on pork meat characteristics, while others (Al Jassim *et al*., 1998) studied acorn as an alternative energy source, partly replacing some grain in sheep ruminant concentrate diets. Studies on Mediterranean porcine show that feeding animals on acorn has a positive aspect regarding consumer's health preservation. Oak acorn diets compared to corn diet decreased the abdominal fat deposition and the total lipids in chickens (Bouderoua and Selselet-Attou, 2003). However, the inclusion of acorns in the diet of ruminants decreased digestibilities of organic constituents. This was attributed partly to the presence of tannins in acorn that are known to impair feed utilization, growth and animal health when diets contain more than tolerable limits.

The aim of the present work was to study the effect of acorn as a substitute for conventional barley on nutrient utilization, growth performance and carcass characteristics of growing rabbits.

MATERIALS AND METHODS

Diets: Two diets were formulated for growing rabbits to contain either barley (Control diet) or acorn (Experimental diet). In the experimental diet, 250 g kg^{-1} Dry Matter (DM) of acorn was substituted for barley. Acorn consisted the whole fruit (hull and kernel) collected in January 2006. To ensure safer and longer storage of experimental diet, acorn

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Table 1: Ingredients and composition of the experimental diets

	Acorn	Barley	Diets: Barley diet	Diets: Acorn diet
Ingredients (g kg^{-1} DM diet)				
Barley			250	0.0
Acorn			0	250.0
Wheat bran			280	280.0
Soybean meal			220	240.0
Hay			200	180.0
Molasses			34	34.0
Calcium phosphate			10	10.0
Salt			5	5.0
$CuSO_4$			1	1.0
Chemical composition (%DM)				
Dry matter (%)	71.5	86.8	89.2	89.6
Organic matter	97.1	96.6	92.8	95.9
Crude protein (N×6.25)	7.9	14.4	18	17.3
NDF	27.4	26.3	31.8	31.1
ADF	25.8	6.7	14.1	18.3
ADL	14.1	1.3	3.8	6.6
Starch	-	-	18.4	17.6
Condensed tannins	4.5	0	ND[1]	1.1

[1]ND: Not detected

was incorporated in diet after being air-dried in the shade for 2 weeks and ground using a local commercial grain mill fitted with 2 mm pore size sieve. Complete pelleted diets using ground ingredients were prepared. The weighed feed ingredients were mixed and moistened with water to achieve 25-30% moisture content. The feed mixtures were pelleted in a minipelleting machine and dried at 60°C for 48 h. Ingredients and chemical composition are shown in Table 1.

Experiment 1: Digestibility trial: A digestibility trial was carried out using 20 adult New Zealand White (NZW) rabbits (10 rabbits per group). Rabbits were housed in individual cages with facility for separate quantitative collection of urine and faeces and reared following standard protocols (EGRAN). The experimental period lasted 37 days, 30 for adaptation to the diets and cages and 7 to faeces and urine collect. Feed was offered *ad libitum* and daily records of feed offered, unconsumed feed, faeces and urine voided were maintained during the collection period. Total faeces voided was weighed and dried in an oven at 60°C until constant weight. The dried samples for each animal over the collection period were pooled and ground for analysis. Urine voided was measured, mixed and 1% aliquot was preserved in sulphuric acid for Nitrogen (N) estimation.

Experiment 2: Growth and carcass characteristics: Experiment 2 was a growth and carcass characteristics study using 24 weaning NZW rabbits (12 rabbits per group). All rabbits were randomly distributed and individually housed in individual cages located in a well-ventilated house. Rabbits were fed *ad libitum* from weaning at 28 days until 11 weeks of age. The diets were offered at 09:00 h daily with allowance of 10% above the previous day's consumption. The unconsumed feed was weighed and discarded before offering feed to determine the intake for the previous day. Rabbits had free access to clean drinking water. Daily records of feed intake and health status (diarrhoea, abnormal behaviour, etc.) were maintained throughout the experiment. The animals were weighed at weekly intervals to assess their growth performance. After 7 weeks of experimental feeding, rabbits were slaughtered and the weights of hot carcass, full digestive tract, full and empty caecum, liver and kidney and the pH of the caecal contents were recorded. The fresh caecal contents were freezed at -18°C, then freeze-dried for DM analyses.

Chemical analysis: All analysis were carried out on duplicate samples. Procedures described by AOAC (1990) were used to determine Dry Matter (DM), ash and Crude Protein (CP). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Lignin (ADL) according to Van Soest *et al.* (1991). Starch was determined, after grinding the samples through a 0.5 mm mesh screen, according to the method of Faisant *et al.* (1995) and Condensed Tannins (CT) were determined using the vanilline/HCl method (Porter *et al.*, 1986). Samples were extracted with 1% HCl in methanol. After the extraction, the samples were centrifuged in 1000 rpm for 20 min and CT were determined in the supernatant. Catechin was used as a source for CT standard. The pH of caecal contents was measured with a glass electrode pH meter.

Calculations and statistical analysis: Apparent nutrient digestibility was calculated as follows:

$$\text{Nutrient Digestibility}(\%) = \frac{\text{Nutrient Intake} - \text{Nutrient in feces)}}{\text{Nutrient Intake}} \times 100$$

Where, nutrient is DM, OM or CP content in g.

The effects of diets on digestibility, performance and carcass characteristics were analyzed using the GLM procedure of the SAS program (SAS, 1990). Means were compared with a Tukey test and the significance level was set at a level of 5 % (i.e., $p< 0.05$).

RESULTS

Inclusion of acorn in the diet did not result in any change in odour and fungal contamination. Table 1 shows that the 2 diets had the same level of NDF, but different levels of cell wall fractions. Acorn diet had more lignified

Table 2: Nutrient intake, digestibility and nitrogen balance in rabbits fed diets containing 250 g kg $^{-1}$ DM of barley (Barley diet) or acorn (Acorn diet)

	Barley diet	Acorn diet	Pooled SE	p-Value
Number of rabbits	10	10		
Intake (g day^{-1})				
Dry matter	88	74	18	NS[1]
Organic matter	81	69	17	NS
Digestibility (%)				
Dry matter	65.05	57.97	4.20	0.037
Organic matter	66.09	58.53	4.11	0.026
Crude protein	77.36	63.86	5.30	0.005
Nitrogen balance				
N-intake (g d^{-1})	2.53	2.05	0.47	NS
N-faeces (g d^{-1})	0.57	0.74	0.13	0.046
N-urine (g d^{-1})	1.18	1.04	0.17	NS
N-retention (g d^{-}1)	0.78	0.27	0.53	NS

[1]NS: not significant (p>0.05)

Table 3: Performance and carcass characteristics of growing rabbits fed a diet containing 250 g kg^{-1} DM of barley (Barley diet) or acorn (Acorn diet)

	Diets			
	Barley diet	Acorn diet	Pooled SE	p-Value
Number of rabbits	12	12		
Weight at 28 d (g)	592	566	44	NS[1]
Weight at 77 d (g)	1742	1868	342	NS
Average daily gain (g d^{-1})	23	26	3.5	NS
Feed intake (g d^{-1})	64	72	13	NS
Feed efficiency (g g^{-1})	2.78	2.76	0.30	NS
Mortality (%)	0.25	0		NE[2]
Slaughter weight (SW, g)	1742	1868	260	NS
Carcass weight (CW, g)	1029	1130	241	NS
Carcass yield (%)	59	60	4.1	NS
Liver (%CW)	5.2	5.1	0.7	NS
Kidney (%CW)	1.1	1.2	0.2	NS
Full gastointestinal tract (GIT,%SW)	22	20	4.8	NS
Full caecum (%GIT)	43	40	6.9	NS
Empty caecum (g)	30	28	5	NS
Fresh caecal content (g)	122	117	27	NS
Dry matter of caecal contents (%)	21	20	5	NS
Caecum pH	6.4	6.3	0.2	NS

[1]NS: not significant (p>0.05); [2]NE: Not estimable

fibre than barley diet (ADL: 6.6 versus 3.8%). Condensed tannin content was relatively high in acorn diet (1.1%) but not detected in barley diet.

No rabbit died in the digestibility trial. Nutrient intake (DM and OM) of rabbits from the 2 diets was similar but presented very high variability between animals (Table 2). Inclusion of acorn in the diet decreased by 10.8, 11.5 and 17.5%, respectively, for DM, OM and CP digestibility. Table 2 shows, the N-intake and its excretion in urine were similar in rabbits fed barley and acorn diets. However, the fecal-N excretion increased (p<0.05) in rabbits fed acorn diet, while apparent N-retention was similar for the 2 groups.

In the growing trial, 3 rabbits fed the control diet had diarrhoea disease and died. In contrast, no signs of diarrhoea or poor health were observed on the rabbits fed acorn diet. The final live weight and daily weight gain from weaning through slaughter did not show any significant difference between rabbits fed the control diet and those fed the experimental diet. Similar carcass yield and feed conversion ratio were observed for the 2 groups and weight of full gastrointestinal, liver, kidney and caecum were not affected (p>0.05) by the presence of acorn in the experimental diet (Table 3).

DISCUSSION

Since the starch and CP levels differ little between diets, the higher lignin and CT level of acorn diet might help to explain the lower digestibility of DM, OM and CP observed with the acorn diet compared to the barley diet. The intake of lignin involves a reduction of the feed digestibility, associated with a reduction of the digesta retention time in the wole tract (Gidenne, 2003). On the other hand, protein digestibility as well as the digestibility of other nutrients was reported to be depressed by the presence of tannins through inhibition of digestive enzymes. Recently, Al-Mamary *et al.* (2001) reported an inhibition of α-amylase activity by 37, trypsin by 22 and lipase by 6% in rabbits fed diet containing only 0.79 % CT. However, the 17.5% lower CP digestibility in rabbits fed the acorn diet than those fed barley diet does not explain the 23% higher N-fecal loss in rabbits fed the acorn diet, suggesting that additional factors may be involved. This could be due to an increase in endogenous nitrogen excretion in presence of tannins that strongly influence the excretion of endogenous material in monogastrics (Shahkhalili *et al.*, 1990). It can be also explained by the formation of indigestible tannic-proteic complexes which increase the fecal N-content, as well known in ruminants and in monogastrics.

In the growing trial, rabbits fed acorn diet could have counterbalanced the lower nutritive value by increasing the daily feed consumption, even if the differences did not seem significant. The results concerning average daily gain were comparatively lower than those reported by De Blas *et al.* (1996) but still within the normal range for countries with arid climates. This might be explained by a lower feed intake caused by the high temperatures (30±2°C) recorded in the region at the time of the test.

Regarding the presence of compounds with anti-nutritionnel properties, Al-Mamary *et al.* (2001) indicated that the addition of high-tannin sorghum grains to the rabbit diet (2.02% CT) significantly reduced their live body weight gain by 10%, feed conversion ratio by 13% and increased food consumption by 3% with respect to the control group, while a low-tannin sorghum diet (0.79% CT) gave productive parameters similar as those of free-tannin diet. They also reported an increase in the liver weight of rabbits fed high tannins but not those fed on low tannins. In monogastrics, Tebib and Rouanet (1996) have indicated that feeding of grape seed tannins to rats, at a dietary level of 71 mg kg^{-1} diet for 12 weeks resulted in a number of changes in cecal and colonic parameters, most notably a decrease in caecal pH and in bacterial enzyme activities. In this study, final live weight, ADG, feed conversion liver, kidney, caecum weight and caecal pH remained unaffected by the presence of acorn in the diet despite the fact that acorn contained 4.5% CT.

CONCLUSION

These results may indicate that CT content in acorn diet (1.1% DM) is still within a tolerable level in rabbits, which is supported by the lack of toxicity and incidence of mortality in experimental group. However, the mortality observed in the control group may be partly due to the relatively low ADF content in the diet (14.1%), consistent with Gidenne *et al.* (1998) who reported that the sanitary risk (mortality + morbidity) increased from 18-28% where the dietary ADF content decreased from 19-15%.

We suggest a more careful evaluation of the real content and digestibility of nutrients from acorn to evaluate their nutritional value before considering them as a potential feed for rabbits.

ACKNOWLEDGEMENT

The study was supported financially by the Ministry of Scientific Research, Technology and Capacity Building of Tunisia (Laboratoire des Ressources Animales et Alimentaires). The first author thanks the Director of ESA Mateur, for providing facilities.

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