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Nutritional Value of Cork Oak Acorn (*Quercus suber* L.) as an Energy Source for Growing Goats

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Abstract: The objective of this study was to evaluate the effect of the replacement of barley grain with cork oak acorn (*Quercus suber* L.) on performance, nutrients intakes, apparent digestibility coefficient and nitrogen balance with growing goats. Ten Boer kids (26.5±2 kg) were individually housed in metabolism cages and were randomly divided into a control (n = 5) and an experimental (n = 5) group. Kids in both groups received (on the basis of crude matter) 500 g/day per head of chopped oat hay and 600 g of concentrate containing barley grain (control group) or oak acorn (experimental group). Digestibility coefficients of dietary components were reduced as a result of acorn substitution for barley. Nitrogen retention (g/day) was positive for experimental group (6.18) but lower than for control group (8.72). The average consumption of digestible components, expressed in g kg^{-1} $LW^{0.75}$ for the control and experimental groups was, respectively, 51.5 and 41.5 (OM) and 7.9 and 6.0 (CP), resulting in weight gains of 80 and 43 g/day.

Key words: Acorn, digestibility, nitrogen balance, growth, kids

Introduction

The tree of oak is an important component of silvopastoral systems in Mediterranean areas, constituting the plant roof of the system and carrying out various functions; (1) to produce wood, (2) to provide food for livestock (browse, fruit, etc.). Extensive production of meat goats in the hill areas of northern Tunisia is mainly based on tree and shrubs. The small holders recognize the fodder potential of leaves and fruits. Recently, Gasmi-Boubaker *et al*. (2005) evaluated the nutritive value of various tree and shrub leaves browsed by goats. However, few studies have been performed on acorns (Kayouli and Buldgen, 2001). Proximate analyses have revealed the chemical composition of acorns to be similar to that of cereals. Starch is the main component of acorns, amounting to over 55% of the kernel (Saffarzadeh *et al*., 1999). No study involving the impact of oak acorn supplementation on diet utilisation by kids is available in the published literature. Such research would be useful in the Tunisian mountainous areas because of the use of acorn in the smallholder farming system goats and their availability in bulk (October-January) when the nutritive value of shrub vegetation is reduced. The aim of this study was to evaluate the performance and the apparent digestibility of goat diets which contain cork oak acorn in replacement of barley grain.

Materials and Methods

Animals and Diets

Ten male Boer kids with an average weight of 26.5 kg (SD = 2) and approximately of 8 months of age, previously treated against parasites, were randomly divided into a control (n = 5) and

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an experimental (n = 5) group. They were alloted to individual cages. Kids in both groups were fed 500 g/day per head of chopped oat hay and 600 g of concentrate containing barley grain (Control group) or oak acorn (Experimental group). Hay was offered twice daily (08.00 and 16.00 h), concentrate was offered three times per day at 08.30, 13.00 and 17.00 h and water was available at all times.

Concentrate Formulation

Two concentrates were formulated to contain either barley (conventional concentrate) or oak acorn (tested concentrate) and included mainly, soybean meal, salt, mineral and vitamin supplement (Table 1). Acorn from *Quercus suber* was chosen to carry out the experiment as it is the main *Quercus* species in the West-North of Tunisia. Acorn samples consisted in whole fruit (hull and kernel) collected in January 2005. To ensure safer and longer storage of experimental concentrate, the acorn samples were incorporated in the concentrate after being air-dried in the shade for 2 weeks. Ideally the acorn should have been offered not ground to resemble the situation in field conditions, but it was difficult to allow homogenous mixing with the others ingredients of the concentrate, so, it was decided to ground the whole acorn. The formulation of concentrate mixtures and their chemical compositions are shown in Table 1.

Experimental Design

The digestibility trial was carried out and lasted 21 days, using the technique of total collection of feces and urine. The 14 first ones were destined to the adaptation of the animals to the diets. After this adaptation, Faeces samples were collected daily, weighed and a sub-sample was taken each day for individual animals. They were frozen to await determination of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP) and Crude Fibre (CF). Amount of urine collected was measured daily for individual animals and acidified (pH = 3.0) with 100 mL L^{-1} of H_2SO_4 (approximately 5-10 mL) to prevent ammonia volatilisation. Urine samples were stored at -20°C until analysed. After this first experimental phase, the growth trial was carried out and lasted 73 days. Animals were weighed weekly in the morning before feeding.

Chemical Analyses and Measurements

The samples, composed of the ingredients, rations and feces, were carried to the laboratory to run the chemicals analysis. All analysis were carried out on duplicate samples. Procedures described by AOAC (1999) were used to determine DM, ash and Kjeldahl nitrogen (N). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and lignin (ADL) were analysed according to Van Soest *et al.* (1991). Condensed tannins (CT) were measured by the vanilline/HCl method (Porter *et al.*, 1986). Catechin was used as a source for CT standard. The CT were measured separately in acorn, hay and barley samples extracted with 1% HCl in methanol. After the extraction, the samples were centrifuged in 1000xg for 20 min and CT were determined in the supernatant. Coefficient of apparent digestibility of nutrients were determined by the following equation: Digestibility = [(nutrient in feed-nutrient in feces)/nutrient in feed] * 100. Nitrogen retention was calculated as the difference between the average N intake and N excretion (in feces and urine) during the 7 days collection period.

Statistical Analyses

A complete randomized design was used, with 2 treatments and five replicates to the growth, digestibility and nitrogen balance trial. All data were analysed with the software SAS (1989) and submitted to an analyses of variance.

Results

Animal Health

One animal fed the control diet was replaced at 3-week after the start for failing to eat, while the kids fed the experimental diet remained in apparent good health throughout the trials.

Chemical Composition of Feeds

The acorn-based concentrate had 7.9, 14.4, 9.7 and 3.8% units higher CF, ADF, ADL and CT content, respectively, than the barley based concentrate (Table 1). The acorn-based concentrate was kept well throughout the feeding trial with no change of odour or fungal contamination.

Apparent Digestibility of Diets and Nitrogen Balance in Kids

Inclusion of acorn in the concentrate did not result in any change in intake of the diet, but there were significant decrease in apparent digestibility coefficients for DM, OM and CP. There were, however, no significant differences in the digestibility of CF between animals fed barley diet or acorn diet. Nitrogen balance was positive in two groups, but the highest N excretion in feces was recorded in the group fed acorn concentrate, that resulted in low retention of N by the experimental group (Table 2).

Table 1: Ingredients and chemical composition of the experimental foods

				Concentrates	
Chemical composition	Hay	Barley	Acorn	Barley	Acorn
Dry matter (g kg^{-1})	822	868	715	877	839
Organic matter (g kg^{-1} DM)	894	966	971	919	933
Crude protein (g kg^{-1} DM)	93	144	79	192	186
Crude Fibre (g kg^{-1} DM)	386	62	118	66	145
NDF (g kg^{-1} DM)	578	263	274	233	234
ADF (g kg^{-1} DM)	342	67	258	69	213
ADL (g kg^{-1} DM)	86	13	141	15	112
Condensed Tannins (g kg^{-1} DM)	<1	0	45	<1	38
Ingredients (g kg^{-1} DM)					
Barley grain				799	0
Acorn				0	753
Soya bean meal				174	209
Urea				0	12
Salt				05	05
Calcium phosphate				10	10
Vitamin and mineral				10	10

Table 2: Intake, diet digestibility and N balance in barley and acorn diet

Chemical composition	Barley diet	Acorn diet	SE	Significance level
Intake (g/day)				
DM	891±82	868±60	22.00	NS
OM	830±42	778±58	20.00	NS
CP	129±2	133±2	4.00	NS
Intake digestible component (g kg^{-1} $LW^{0.75}$)				
OM	51.5±2.5	41.5±1.4	3.20	*
CP	7.9±0.9	6.0±0.8	0.80	*
Digestibility (%)				
DM	68.07±2.26	56.73±3.28	2.82	*
OM	70.71±1.98	57.97±3.23	2.68	*
CP	66.77±1.73	53.24±2.69	2.26	*
CF	45.00±7.14	50.54±4.17	5.85	NS
N balance (g/day)				
N intake	20.67±0.26	21.37±0.37	0.32	NS
Fecal N output	5.66±0.24	9.06±0.51	0.40	*
Urinary N output	6.26±0.86	6.12±1.77	1.39	NS
Retained N	8.72±0.85	6.18±1.05	0.96	*

*: $p<0.05$; NS: $p>0.05$

Table 3: Live weight changes in barley and acorn diets

Chemical composition	Barley diet	Acorn diet	Significance level
Initial weight (kg)	27.00±0.80	26.55±0.72	NS
Final weight (kg)	32.87±1.65	29.75±1.70	*
Average daily gain (g)			
1-23 days	33±12	-42±29	*
23-48 days	75±32	82±29	NS
48-73 days	130±50	85±41	*
1-73 days	80±26	43±21	*

*: $p<0.05$, NS: $p>0.05$

Growth Trial

Kids initial live-weights were similar ($p>0.05$) among groups (Table 3). Animals fed the barley diet gained 80 g/day, whereas kids fed the acorn diet gained 43 g/day. Nevertheless, data indicated that kids fed the acorn diet lost 42 g/day during the first 3 weeks of the experimental period. After that, control and experimental groups presented a continuous increase in weight gain.

Discussion

Some variation in the chemical composition of acorn can be expected because of variation in production site, *Quercus* species and stage of maturity. Compared to other oak species, the CP content of acorn used in this experiment was comparable to the value (80.5 g kg^{-1} DM) reported by Ventanas *et al.* (2006), higher than 62.5 reported by Nieto *et al.* (2002) for *Quercus suber* but lower than 11-12% suggested by NRC (1985) as adequate to meet requirements of growing kids. CF content was similar to 111 g kg^{-1} DM (Nowar *et al.*, 1994), but lower than 253 g kg^{-1} DM Al Jassim *et al.* (1998) reported for *Quercus coccifera*. Condensed tannin content (45 g kg^{-1} DM) was higher than (39.1 g kg^{-1} DM) reported by Nieto *et al.* (2002).

All kids have been offered 600 g of concentrate, they consumed all of it within a very short period of time and had similar DM and N intakes. The organic matter digestibility of the control diet was high due to the high proportion of concentrate mixture in the total diet, improving the activity of the cellulolytic bacteria in the rumen and promoting an increase in the nutrients digestibility.

The lower digestibility of DM, OM and CP with the experimental diet compared to the control diet supports the results reported by Al Jassim *et al.* (1998) where decreased digestibility of organic constituents was found with inclusion of acorns in the diet of growing lambs. These results could be due to the substrate being protected by tannins from hydrolysis and by the direct inhibition of digestive enzymes by tannins. Lignin incrustation of cell wall is also an important factor which can potentially limited feed digestibility. The chemical composition confirmed that the acorn concentrate contained higher condensed tannin and lignin contents compared to the barley concentrate. Nevertheless, the replacement of barley grain for oak acorn resulted in a similar utilization of crude fibre. This result apparently contradicts what is to be expected, knowing that tannins are cellulolytic inhibitors which have been reported in many Mediterranean shrubs (Gasmi-Boubaker *et al.*, 2005). The reason for the similar digestibility of CF may be related to the fact that feeding grains high in starch to the control group can be associated with adverse effects on the digestibility of crude fibre. The total digestible CP intake observed with the two diets were much higher than the values recommended for maintenance of growing kids (NRC, 1985). Consequently, the N retention was positive in the control and experimental groups.

The maximum growth rate in this study of 80 g/day in the barley diet is slightly lower than that recorded for Omani goats fed conventional diets (Mahgoub, 1997). This could be due to effects of feeding regimes, but may also result from different breeds.

Feeding acorn to kids did not visibly affect their health, as there was no clinical signs of constipation, diarrhoea or loss of appetite. This is in agreement with Silanikove *et al*. (1996) who reported no ill effects of CT when present at concentration close to 60 g/day. Nevertheless, the pattern of body weight gain of kids fed acorn diet indicates that kids may need time to adapt to acorn feeding before gaining body weight.

The lower growth performance of kids fed acorn diet has been shown previously with growing lambs (Al Jassim *et al*., 1998). This may be explained by the lower provision of available nutrients to these animals, as reflected by the amounts of digestible OM and CP intakes.

These results suggest that the inclusion of acorns in the concentrate mixture of goats can be economically advantageous particularly in autumn and winter when scarcity of feedstuffs occurs. Nevertheless, we need further investigations in order to improve utilisation of acorn.

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