Indian Journal of Animal Sciences **83** (8): 820–824, August 2013/Article

Effect of feeding oak leaves on nutrient utilization and growth performance of goats in Kumaon hills of temperate sub Himalayas

PIYUSHA S D MINZ[1], B SAHOO[2], A K GARG[3], M SHANKAR[4] and A K SHARMA[5]

Indian Veterinary Research Institute, Mukteshwar, Uttarakhand 263 138 India

Received: 2 August 2012; Accepted: 14 January 2013

ABSTRACT

A 120 days of growth study was conducted on goats to assess the effect of tanniniferous oak leaves (*Quercus semecarpifolia*) on nutrient utilization and growth performance. Growing kids (18) of 7–9 month-old (13.13±0.99 kg) were randomly divided into homogenous groups T_1, T_2 and T_3 of 6 in each. All the animals were fed same concentrate mixture but, the roughage source was different and the concentrate: roughage source was maintained at about 40: 60 ratio. Native grass hay (*Heteropogon contortus*) was fed in T_1 and T_3 which was replaced by oak tree leaves in T_2. Tannic acid was supplemented in T_3, at par with the hydrolysable tannin content in oak leaves fed to T_2. A metabolic trial of 6 days duration was conducted after 90 days of growth trial. DM intake through roughage (oak leaves) in T_2 was higher than T_1 and T_3. The total DM intake (g d^{-1} $kg^{-1}W^{0.75}$) was also higher in T_2 than T_1 and T_3. The nutrient digestibilities were similar except ether extract digestibility which was higher in T_2 than T_1 and T_3. N balance (g d^{-1}) was similar in all 3 groups. However, N retention as percent of absorbed nitrogen was higher in T_2 than T_3, but at par with T_1. Average daily gain (g d^{-1}) was higher in T_2 (60.36) than T_1 (38.12) and T_3 (26.46) which were at par. Feed gain ratio (DMI/unit body weight gain) was comparatively better in T_2 (12.93) than T_3 (23.24) but at par with T_1 (17.29). It was concluded that feeding of oak leaves (CT, 0.85% and HT, 4.4% in diet) improved nutrient utilization, growth performance and feed efficiency in kids compared to animals fed local grass hay with or without supplementation of tannic acid.

Key words: Goats, Growth, Oak leaves, Tannin

The animals in hilly regions of India usually remain undernourished for a significant period of the year due to scarcity of fodder. Oak (*Quercus semecarpifolia*) leaves are used as major substitute of fodder round the year in the Western Himalayas (Paswan and Sahoo 2012). However, poisoning from the consumption of immature oak leaves limits its use as a sole feed in cattle (Garg *et al*. 1992). Oak leaves contain plant secondary compounds i.e. tannin which is a known anti-nutritive factor and broadly classified into 2 subgroups, condensed tannins (CT) and hydrolysable tannins (HT). Hydrolysable tannins (HT) are potentially toxic and cause poisoning in animals if sufficiently large amounts of tannin-containing plant material are consumed (Garg *et al.* 1992). Condensed tannins (CT) at low-moderate level are not toxic to ruminants and it exhibits both beneficial and detrimental effects on ruminants based on its level and type (Min *et al.* 2003). Reports suggested that tannin (CT and HT) and tannic acid supplementation has interaction with various nutrients that influence the productive performance of animals (Waghorn 1996). Tannins also help to control certain internal parasites of animals (Singh and Gupta 2009). However, findings on effect of feeding tanniniferous oak leaves, supplementation of tannic acid similar to that of tannin in oak leaves in temperate hills along with their effect on internal parasites in animals is scanty. Since, goats are important domestic animals in hilly region because of their ability to adapt to harsh climatic conditions (Silanikove 2000), the present study is designed to assess the effect of tannin through feeding of oak leaves and tannic acid on nutrient utilization, growth performance and internal parasitic load of kids.

MATERIALS AND METHODS

Animals and feeding

Eighteen local male hill goats (13.13±0.99 kg) of 7–9 months of age were randomly divided into 3 homogenous groups of 6 animals in each. A growth trial of 120 days along with a metabolic trial of 6-day duration was conducted at IVRI campus, Mukteshwar after 90 days of post feeding. All

Present address: [1]M.V.Sc student (e mail: piyusha.dona @gmail.com), [2]Sr. scientist (email: sahoo biswanath11@gmail. Com), [4]Scientist (e mail: drsankar@gmail.com), [5]Sr. scientist and Head (e mail: sharmaak62@yahoo.co.in), T.A.H Division, I.V.R.I, Mukteshwar, [3]pr. Scientist, I.V.R.I, Izatnagar (email: akgivri@gmail.com

the animals were fed similar feeding regime with concentrate and roughage at about 40: 60 ratio satisfying the requirement as per Kearl (1982). All the animals were offered similar concentrate mixture and the roughage source was different in which hay was fed in T_1 and T_3 and oak tree leaves was fed to T_2. Tannic acid was provided in T_3 at a level similar to that in T_2 (6.72%). The animals were housed in well-ventilated shed with facilities for individual feeding under uniform hygienic and managemental conditions. Feed samples and residues were collected periodically and sampled for DM estimation to assess feed and DM intake in animals during the experimental feeding. The body weight was recorded at fortnight intervals before offering feed and water throughout the growth trial. Representative samples of feed offered, residues and faeces were collected during the metabolic trial and analysed for DM, OM, EE and CP as per AOAC (2000). The fibre components (NDF and ADF) were analysed as per Van Soest *et al*. (1991). A separate aliquot of faecal sample was preserved with sulphuric acid (25% w/v) for analysis of nitrogen (N).

The tannins (HT and CT) were estimated as per Makkar (2003). Faecal samples were collected directly from the rectum of each animal in polythene bags, labeled and processed immediately by qualitative and quantitative methods. The intensity of the infection was studied based on number of egg per gram of faeces (epg) by the McMaster egg counting technique (MAFF 1986).

Statistical analysis: The data generated were analysed through SPSS software (version 16.0) by applying one-way analysis of variance (Snedecor and Cochran 1994), and the difference between the means was analysed by Duncan's multiple range tests with a test of significance at P<0.05.

RESULTS AND DISCUSSION

Chemical composition of experimental diets: The chemical composition and fiber fraction of concentrate mixture, oak leaves and native hay (*Heteropogon contortus*) offered to goats were within the normal range (Ranjhan 1998, Table 1). Supplementation of tannic acid at par with HT content in oak leaves with concentrate mixture did not alter its chemical composition. The organic matter (OM) and ether extract (EE) content of oak leaves were comparatively more than concentrate mixture and grass hay. Fiber fraction (NDF and ADF) of oak leaves and hay was more than concentrate which was attributed to high cell wall constituents in roughage. The concentration (% on DM basis) of CT and HT in oak leaves was 1.5 and 6.72, respectively; which were comparatively lower in temperate than tropical climate (Makkar and Becker 1998). Climate, soil, availability of water, age of plant and maturity of leaves are known to influence tannins level (Morris and Robbins 1997).

Feed intake, digestibility of nutrients and plane of nutrition: The DM intake through concentrate among animals of all the 3 groups was similar (Table 2 and 3). However, DM intake through roughage (oak leaves) in T_2 was higher (P<0.05) than T_1 and T_3. The total DM intake (g d^{-1} $kg^{-1}W^{0.75}$) was also higher (P<0.05) in T_2 than T_1 and T_3 due to higher DM intake through oak leaves. Similarly, higher voluntary feed intake was reported in animals fed tree leaves containing moderate (1–4%) level of CT (Ramirez-Restrepo *et al.* 2004, Dey *et al.* 2008). The OM intake in T_2 was also higher (P<0.05) than T_1 and T_3 due to high OM content of oak leaves. The digestibility coefficients of DM, OM, CP, NDF, ADF and TCHO did not differ irrespective of dietary treatments except EE due to higher fat intake by the animals through green oak leaves.

Pathak (2010) reported that supplementation of CT at 1–2% of diets did not interfere with the microbial activity and total tract digestibility of nutrients. Tannins mainly exert their effects on proteins based on their ability to form hydrogen bonds that are stable between pH 3.5 and 8 (rumen pH). These stable complexes dissociate at abomasum (pH 2.5–3) or at duodenum (pH>8) resulting improvement in bioavailability of N components of high biological value. Although protein digestibility was lower in oak leaves fed group (T_2) than T_1 and T_3, but the difference was statistically non-significant (P>0.05) and tannic acid supplementation has no interaction with protein digestibility. In contrary to the present findings, Hervas *et al*. (2000) reported that treatment of soybean meal with different doses (0,1,4,7,9,13 and 20%) of tannic acid or

Table 1. Chemical compositions (% DM basis) of experimental feeds and fodders

Nutrients	Concentrate (C-I)	Concentrate (C-I) + tannic acid	Oak leaves	Hay
Organic matter	88.64	90.47	95.18	91.02
Crude protein	21.19	20.75	8.50	6.80
Ether extract	2.07	2.00	3.00	1.24
Total carbohydrate	65.38	66.72	83.68	83.38
Neutral detergent fiber	48.43	47.90	60.03	79.9
Acid detergent fiber	8.64	8.35	53.25	51.14
Hydrolysable tannin (HT)	-	6.72	6.72	-
Condensed tannin (CT)	-	-	1.5	-

Table 2. Digestibility coefficient (%) of nutrients in kids

Attributes	T_1	T_2	T_3	SEM	P value
Dry matter	56.13	55.26	54.48	0.74	0.68
Organic matter	56.15	56.07	55.34	0.76	0.90
Crude protein	48.76	44.85	48.83	1.75	0.59
Ether extract*	60.27[ab]	64.73[a]	57.93[b]	1.21	0.05
Neutral detergent fibre	49.59	46.21	47.10	1.18	0.71
Acid detergent fibre	30.84	33.21	30.09	1.18	0.64
Total carbohydrate	52.74	53.68	52.48	0.85	0.84

[a,b]Means with different superscripts in a row differ significantly *P<0.05.

commercial *quebracho* CT extract significantly reduced the CP degradation in the rumen even at the lowest dose in sheep. The formation of tannin-protein complex is not only affected by the composition and structure of proteins, but also by the size, length and flexibility of the tannin molecule. Thus, animals supplemented with oak leaves containing both HT and CT and tannic acid alone showed variable degree ($P>0.05$) of protein digestibility.

Tannins also interacts with carbohydrate especially fiber digestibility. The fiber degradation in rumen was drastically reduced in animals consumed tannin-rich feeds (McSweeny *et al.* 2001). The affinity of polysaccharides (fiber fractions) is strongly dependent on the molecular size, conformational mobility, and shape and water solubility of polyphenols. NDF digestibility in T_2 was comparatively lower than T_1 and T_3, but the difference was statistically non-significant which might be due to lower level of tannin in oak leaves and similar level of supplemental tannic acid.

Daily nutrient intake through DM, OM, CP and TDN (g $d^{-1}kg^{-1}W^{0.75}$) was significantly higher ($P<0.05$) in T_2 than T_1 and T_3 (Table 3). However, DCP intake in all the 3 groups of animals was similar. The nutrient density of composite diets in 3 dietary treatments in terms of CP, DCP and TDN was also comparable. In conformity with the present findings, palatability of diet, nutrient intake, utilization and plane of nutrition was not adversely affected with tannin supplementation at low-moderate level (Min *et al*. 2003, Dey *et al.* 2008).

Nitrogen balance: N intake and N balance (g d^{-1}) was similar among the different treatments (Table 4). However, N retention as percent of absorbed nitrogen was significantly

Table 3. Nutrient intake and plane of nutrition of kids

Attributes	T_1	T_2	T_3	SEM	P value
DM intake Concentrate (g d^{-1})	307	330	287	22.25	0.75
Roughage (g d^{-1})*	312^b	438^a	265^b	26.18	0.03
DM intake (g d^{-1})	619	768	552	45.10	0.13
DM intake (g $d^{-1}kg^{-1}W^{0.75}$)*	76.1^b	84.8^a	72.1^b	1.67	0.03
OM intake (g $d^{-1}kg^{-1}W^{0.75}$)*	68.3^b	78.3^a	65.0^b	1.68	0.03
CP intake (g $d^{-1}kg^{-1}W^{0.75}$)*	10.5^b	12.1^a	9.9^b	0.30	0.02
DCP intake (g $d^{-1}kg^{-1}W^{0.75}$)	5.1	5.4	4.9	0.24	0.67
TDN intake (g $d^{-1}kg^{-1}W^{0.75}$)*	37^b	43^a	35^b	1.16	0.03
Nutritive values (%)					
CP	13.8	14.2	13.7	0.15	0.27
DCP	6.7	6.4	6.7	0.28	0.87
TDN	48.2	50.9	48.2	0.8	0.32

a,bMeans bearing different superscripts in a row differ significantly *$P<0.05$.

Table 4. Nitrogen balance (g d^{-1}) in kids

Attributes	T_1	T_2	T_3	SEM	P value
Nitrogen					
Intake	13.62	17.51	12.24	1.08	0.12
Excretion					
Faeces*	6.99^b	9.52^a	5.88^b	0.05	0.02
Urine	2.84	2.42	2.92	0.28	0.76
Total	9.82	11.94	8.80	0.66	0.14
Excretion (% of intake)					
Faeces	51.24	54.51	48.18	1.75	0.60
Urine**	21.38^a	13.71^b	23.71^a	1.44	0.01
Balance	3.80	5.57	3.43	0.49	0.16
% of intake	27.90	31.88	28.25	1.86	0.55
% of absorbed*	57.10^{ab}	69.50^a	53.85^b	3.16	0.05

a,bMeans bearing different superscripts in a row differ significantly*$P<0.05$, **$P<0.01$.

($P<0.05$) higher in T_2 than T_3, but at par with T_1 which was correlated with higher feed intake and better quality of protein or amino acid constitution in oak leaves than local grasses (*Heteropogon contortus*). Feeding of tanniniferous feed lower the CP digestibility and enhance N retention in ruminants due to better protein flow from the rumen and absorption of amino acids from the intestine. Similarly, increased N retention was reported in sheep and goats given tanniniferous feeds (CT and HT) at moderate levels due to lower N excretion through urine (Dey *et al*. 2008).

Growth performance: Total body weight gain (kg) for whole experimental period of 120 days were significantly ($P<0.01$) higher in T_2 than in T_1 and T_3. Similarly, average daily gain (ADG, g d^{-1}) was also higher ($P<0.01$) in T_2 than T_1 and T_3 which were at par (Table 5). Feed gain ratio (DMI/unit body weight gain) was improved ($P<0.05$) in T_2 (12.93) than T_3 (23.24) but at par with T_1 (17.29) showing better feed efficiency. Higher growth rate of animals supplemented with oak leaves could be due to less adverse effects of tannin in oak leaves, variable nature of tannin, anti- nutritive activity

Table 5. Growth rate and voluntary feed intake by kids

Attributes	T_1	T_2	T_3	SEM	P value
Growth rate					
Body wt (kg)	13.20	13.30	13.13	0.99	0.99
Initial Final	17.78	20.54	16.30	1.29	0.41
Total gain (kg)**	4.58^b	7.24^a	3.18^b	0.53	0.01
Growth rate (g d^{-1})**	38.12^b	60.36^a	26.46^b	4.38	0.01
Voluntary feed intake					
Concentrate (g d^{-1})	277	306	266	20.62	0.75
Roughage (g d^{-1})	358	470	335	35.50	0.26
Total DMI (g d^{-1})	636	776	602	115.50	0.42
Feed gain ratio*	17.29^{ab}	12.93^b	23.24^a	1.69	0.03

a,bMeans with different superscripts in a row differ significantly * $P<0.05$, **$P<0.01$.

Table 6. Egg count (per gram of faeces) in different groups of kids

Attributes/	Days post experimental feeding			Treatment SEM	P values		
Treatments	Before start of experiment	60	120		T	P	TXP
T_1	1533	1233	2433	1733±260.9	0.40	0.01	0.61
T_2	1700	883	1783	1455±289.4			
T_3	1783	717	1416	1305±126.7			
Period SEM	1672^A±103.5	945^B±134.6	1878^A± 341.0				

^{A,B}Means bearing different superscripts in row differ significantly**P<0.01.

on feed digestibility and its better nutrients utilization efficiency *in vivo* (Aerts *et al*. 1999). Rubanza *et al*. (2007) reported that leaf meal supplementation of *Accacia nilotica* (CT, 52.8 g kg^{-1} DM) and *A. polyacantha* (CT, 98.3 g kg^{-1} DM) showed significant (P<0.05) increase in ADG (114.3 *vs* 42.9 g d^{-1}) in lower CT containing diet which might be due to protecting excessive protein digestion in the rumen and enhanced flow of amino acids to small intestine for absorption following their protein quality. Wang *et al*. (1996) observed increased live weight gain, carcass weight, dressing proportion in lambs grazing on *L. corniculatus* (34g CT kg^{-1} DM) compared with a group supplemented with polyethylene glycol (PEG) which binds tannins and inactivates them. However, consumption of small quantities of HT in soybean meal (20.8 g CT kg^{-1} DM) by Merino sheep showed that these compounds were neither toxic nor had any negative effect on animal performance (Frutos *et al*. 2004). The level of HT in oak leaves and similar amount of tannic acid supplementation in our study was comparatively higher than the above dose which showed some negative effects on growth performance of goats. Further, tannic acid supplementation in T_3 also reduced the DM intake due to its astringency nature. Improvement in growth rate in oak leaves supplemented group of animals might be attributed to higher fed intake and comparatively better nutrient profile of oak leaves than local grasses.

Gradual increase in faecal egg count (FEC) in T_1 throughout the experimental period as compared to oak leaves and tannic acid supplemented group indicates that their supplementation had negative effect on parasite development and establishment (Table 6). Present findings are in agreement with the previous reports that dietary supplementation of tannin may be used as an alternative parasite management strategy (Min *et al*. 2003). Moore *et al*. (2008) also reported that supplementation of tanniniferous hay can reduce FEC and increase performance of goats compared to no tannin hay.

Condensed tannins may have direct effects on internal parasites or may indirectly control the parasites by increasing the resistance and resilience of animals to gastrointestinal parasitism through improved nutrient utilization. Direct effects of CT on GI parasite may account for reduced FEC and nematode burden in lambs that grazed *Hedysarum coronarium* compared to *M. sativa* in New Zealand (Niezen *et al*. 1998). Indirect effects on resistance and resilience could be mediated by changes in the supply of digested protein.

Feeding of oak leaves (*Quercus semecarpifolia*; CT, 0.85% and HT, 4.4% of diet on DM basis) improved nutrient utilization, growth rate and feed efficiency in local hill goats compared to kids fed local grass (hay) with or without supplementation of tannic acid at par with tannin level in oak leaves.

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