Indian Journal of Animal Sciences **83** (12): 1306–1312, December 2013/Article

Strategic use of condensed tannins through a tree leaves mixture on nutrient utilization and performance of kids

MANISH DUBEY[1], NARAYAN DUTTA[2], K SHARMA[3], P S BANERJEE[4], A K PATTANAIK[5] and M SINGH[6]

Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh 243 122 India

Received: 9 June 2012; Accepted: 28 August 2013

ABSTRACT

The study was designed to ascertain the effect of strategic use of condensed tannins (CT) through tanniferous tree leaves on nutrient utilization and growth in kids. Indigenous kids (18) were randomly divided into 3 groups of 6 each in a completely randomized design and fed 3 iso-nitrogenous diets to contain 0, 1.0 and 2.0% CT through a dried and ground leaf meal mixture of *Ficus infectoria, Psidium guajava* and *Ficus bengalensis*. The diets were designated as CT-0, CT-1, and CT-2, respectively, and fed to kids on a basal diet of wheat straw to meet requirements for maintenance and growth. Blood-biochemical profile was monitored in all the kids at 0, 40, 80 and 120 days of feeding. The average daily growth rate and feed conversion ratio for 120 days showed a significant linear increase by supplementation of CT up to 2.0% of diet through leaf meal mixture. Though supplementation of CT up to 1.0% of diet did not interfere with the nutrient intake or digestibility, a depressing effect on DM and OM digestibility at 2.0% CT level was apparent without any detrimental effect on intake. DCP and TDN values of the composite diets were decreased significantly (linear, $P<0.046$ or 0.016) in CT-2 than control (CT-0), however, intake of DCP, DOM and TDN did not differ significantly irrespective of dietary treatments. Feeding of CT containing diets up to 2.0% level significantly influenced N utilization and enhanced its retention. Similarly, microbial nitrogen synthesis as estimated by urinary excretion of purine derivatives was increased significantly with CT inclusion. Haematological (haemoglobin and PCV) and biochemical parameters (serum glucose, total protein, albumin, globulin, A:G ratio and LDH, were similar among the dietary treatments except for significant reduction in serum urea concentration of kids fed diets containing 1-2% CT. It may be concluded that CT from a mixture of *F. infectoria, P. guajava* and *F. bengalensis* leaves from 1 to 2% of diet improved overall performance of kids.

Key words: Condensed tannins, Growth**,** Kids, Nutrient utilization, Organic protectant, Tree leaves

Protection of proteins is essential for productive animals, where the protein requirement of these animals cannot be met from microbial protein synthesis (Dey *et al.* 2008). Studies indicated that feeding proteins, which are resistant to microbial breakdown in the rumen but available in the post-ruminally, significantly increased growth rate (Wang *et al.* 1996a, Dey *et al.* 2008). In this context, there is a growing interest in the possible use of condensed tannins (CT) to protect the protein in the ration of animals. CT present in tropical tree leaves are organic in nature and facilitate the by-pass of protein that might otherwise be lost through microbial deamination in the rumen. They form complexes with feed proteins and render them unavailable to rumen microbes, which become available at lower digestive tract (Dey *et al.* 2008). Studies indicated that the rumen protective effect of CT was much higher for essential amino acids than non-essential amino acids, which is likely to account for at least part of higher growth rates and N retention in sheep given diets containing CT (Min *et al.* 2001, Dey *et al.* 2008). The present study was designed to study the effect of CT from a leaf meal mixture of *F. infectoria* (*pakar*)*, P. guajava* (*amrud*) and *F. bengalensis* (*bargad*) on the nutrient utilization and performance of growing kids.

Present address: [1]Ph D Scholar, Veterinary College, Jabalpur (manish.dubey81@gmail.com). [2,5]Principal Scientist (dutta65@gmail.com, akpattanaik1@gmail.com), [4]Head of Division (banerjeepartho62@gmail.com). [3]Assiatant Director General, HRD, ICAR, New Delhi (ksharma52@gmail.com). [6]Subject Matter Specialist, KVK, Dhamora, Rampur (singhmanoj_21@rediffmail.com).

MATERIALS AND METHODS

The experiment was conducted at the Animal Nutrition Research Sheds of the Indian Veterinary Research Institute (IVRI), Izatnagar in Uttar Pradesh Province of India.

Animals and diets: Eighteen 6-month-old indigenous kids (11.33±1.52 kg), were randomly allocated to 3 dietary treatments, 6 each in a completely randomized design and

assigned to 3 dietary treatments CT-0, CT-1, and CT-2 containing 0, 1.0, and 2.0% CT of diet, respectively. Prior to start of the trial the lambs were treated with broad-spectrum anthelmintic at the onset of the study. The kids were treated for ectoparasites. The kids were penned individually with free access to freshwater in ventilated sheds and allowed exercise out-doors in an adjacent dry paddock daily between 08:30 and 09:30 h. All the experimental kids were offered a basal diet of wheat straw (*ad lib.*) along with required amount of concentrate mixture. A required quantity of dried and ground leaf meal mixture was added in the concentrate mixture of kids in group CT-1 and CT-2 in the morning to bring CT content to 1.0 and 2.0% of total diet. The leaf meal mixture was prepared by mixing *Ficus infectoria* (*pakar*), *Psidium guajava* (*amrud*) and *Ficus bengalensis* (*bargad*) in the ratio of 70:20:10. The leaves harvested in one lot in July from the IVRI campus were dried and ground in an electric grinder before mixing in the supplement. The same lot was used for the entire study. The daily allowance of the supplements was offered in single meals (at 09:30 h) in the morning; green berseem (100 g) and wheat straw was then offered *ad lib.*, when all the kids had consumed the concentrate. All goats were fed so as to meet their requirements (Kearl 1982) for maintenance and a growth of 50 g/day. The ingredients and chemical analysis of the supplement and wheat straw are given in Table 1. The amount of supplement offered to individual kids was adjusted fortnightly as per the body weight changes of each animal to meet the nutrient requirement (Kearl 1982).

Experimental procedures: Leftover straw residues were weighed 24 h post-feeding to ascertain daily feed consumption. The feeding trial was carried out for 141 days duration including the first 21 days for adaptation and subsequent 120 days for measurement. Daily DM intake and fortnightly BW of all the kids were recorded before feeding in the morning throughout the study. A digestion and N balance trial was conducted after 70 days of experimental feeding. During the metabolism trial, the kids were housed in individual metabolism cages (90 cm×75 cm×90 cm) fitted with removable feeders and arrangements for quantitative collection of faeces and urine separately. The trial lasted for 9 days with a 3-day adaptation period to accustom the kids to cages prior to 6-day collection and measurement period. Samples of feed offered and refused were collected daily. Total daily (24 h) faecal and urine outputs were recorded. A sub-sample of the faeces (20%) collected and dried at 80±2 °C for 24 h in a forced-draft oven for DM estimation. Pooled samples (6 days for each animal) were ground and stored for chemical analysis. For N determination, the faeces samples (1/100th of the daily voids) were preserved in 25% sulphuric acid to make pooled samples for individual lamb. Daily urine output was collected quantitatively in plastic bottles containing known quantity of sulphuric acid (10%) to bring down pH around 3.0 and a sub-sample was collected into kjeldahl flasks containing known quantity of sulphuric acid for N estimation. Another aliquot was taken in properly marked plastic bottle and stored at –20°C for purine derivatives (PD) estimation.

Blood collection: Blood samples were collected via jugular vein puncture in the morning before feeding at 0, 40, 80, and 120 days post feeding. Serum was separated and preserved at –20°C for serum glucose, serum proteins, serum enzymes and serum urea analysis. Another 2 ml blood sample was collected in vials containing ethylene diamine tetra-acetate, 1 mg/ml blood, for haemoglobin (Hb) and packed cell volume (PCV).

Chemical and statistical analyses: Samples of feeds, residues and faeces were milled to pass through a 1mm sieve and analyzed as per AOAC (1995) to determine DM by the oven drying method (934.01), organic matter by muffle furnace incineration (967.05), crude protein by kjeldahl method (984.13; N×6.25), ether extract (920.39), ash (942.05). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined accroding to Van Soest *et al.* (1991). NDF was assayed with sodium sulphite in the NDF reagent without alpha-amylase and the results were expressed with residual ash. The CT content in leaf meal mixture was estimated by Butanol-HCl method (Makkar 2000). Urinary purine derivatives (allantoin, uric acid, xanthine, and hypoxanthine) and creatinine were determined by high performance liquid chromatography (HPLC; Resines *et al.* 1992). Microbial N yield (g/day) was calculated according to Chen and Gomes (1995). Haemoglobin and packed cell volume (PCV) were estimated in whole blood (Benjamin 1985) and Wintrobe's tube, respectively. Serum glucose concentration was determined as per Hultmann (1959). The serum protein and albumin content were measured as per Wotton (1964) and Doumas *et al*. (1971), respectively. Serum urea was estimated by improved diacetyl monoxime method (Rahmatulla and Boyde 1980). Activity of serum LDH was estimated as per Howell (1979).

The results were subjected to analysis of variance and treatment means were ranked using Duncan's multiple range test (DMRT) using SPSS 11.0. The data were analyzed for polynomial contrasts to outline linear and quadratic trends associated with increasing levels of CT supplementation. The periodic alterations in body weight and blood biochemical parameters were analyzed using repeated measures design. Significance of treatments with respect to different characters was declared at $P < 0.05$ unless otherwise stated. All the statistical analysis procedures were done as per Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Chemical composition of feeds: The chemical composition of concentrate and major feed components is given in Table 1. The chemical composition of concentrate mixture and wheat straw offered as basal feed was within normal range

and comparable to values reported by many workers for Indian feeds and fodders (Patra *et al.* 2003, Dey *et al*. 2008). The concentration of NDF and ADF was higher in leaf meal mixture as compared to concentrate this could be attributed to the high cell-wall constituents usually present in leaf meal (Anbarasu *et al.* 2004, Dey *et al*. 2008). The condensed tannins content of leaf meal mixture was 13.3%.

Dry matter intake: Intake of DM and OM (g/ kg $W^{0.75}$) during metabolism trial was significantly (linear, P= 0.011 or P= 0.016) lower in CT-0 as compared to comparable intake between CT-1 and CT-2 treatments. Concentrate intake (g/ kg $W^{0.75}$) was significantly higher in CT-2 than CT-0, while CT-1 has an intermediate position between CT-0 and CT-2 treatments. Intake of wheat straw moiety was comparable irrespective of dietary treatments. The intake of DM by kids was within the normal range (Kearl 1982) and this clearly indicated that all the experimental diets were palatable. Similar to the present study, higher voluntary intake at moderate (1–4%) CT containing diets was reported by previous workers (Ramirez-Restrepo *et al.* 2004, Dey *et al.* 2008).

Nutrient utilization: Digestibilities of DM and OM were comparable between CT supplemented groups, except for CT-2 which had significantly (linear, P<0.05) lower DM and OM digestibility than CT-0 (control). Digestibility coefficient of CP, EE, ADF and NDF were comparable irrespective diets by treatments. Our results are in consistency with the earlier reports (Dey *et al.* 2008, 2009); who observed no adverse effect on nutrients digestibility, except depressive effect on DM and OM digestibility at 2% dietary CT in lambs and crossbred cows. In the present study the supplementation of CT at 1-2% of diet did not seem to interfere with the microbial activity or total tract digestibility of nutrients. However, a depressing effect on DM and OM digestibility at 2% CT level was apparent without detrimentally affecting dietary intake, which may be attributed to associative effects of CT and higher percentage of structural carbohydrates contributed by leaf meal mixture. Our results are in concurrence with the earlier report (Dey *et al.* 2008) in growing lambs given diet containing *F. infectoria* as CT source.

Table 1. Ingredients and chemical composition of concentrate, wheat straw and leaf meal mixture

Attributes	Concentrate mixture	Wheat straw	Leaf meal mixture	Berseem
Ingredients (%)				
Maize (grain)	30.0	-	-	-
Deoiled groundnut cake	37.0	-	-	-
Wheat bran	30.0	-	-	-
Mineral mixture	2.0	-	-	-
Common salt	1.0	-	-	-
Chemical composition (%)				
Organic matter	92.5 ±0.08	92.1 ±0.14	87.4 ±0.12	89.56 ±0.08
Crude protein	22.7 ±0.08	3.7 ±0.06	11.6 ±0.07	16.51 ±0.05
Total ash	7.5 ±0.04	7.9 ±0.06	13.1 ±0.11	10.44 ±0.07
Ether extract	2.18 ±0.08	0.79 ±0.02	3.44 ±0.06	2.05 ±0.03
NDF	35.5 ±0.14	80.7 ±0.2	54.2 ±0.08	55.21 ±0.12
ADF	13.4 ±0.11	53.3 ±0.11	33.5 ±0.07	39.10 ±0.10
GE (kcal/kg DM)	4327±7	3966.5±9	4050±8	-
Condensed tannins*	-	-	13.3	-

* It was assumed that only leaf meal mixture of *F. Infectoria, P. guajava* and *F. bengalensis* contains CT, and CT content of diets was calculated accordingly.

Daily intake (g/day) of N by kids was significantly (linear, P<0.023) lower in CT-0 as compared to CT-2. The faecal excretion of N (g/day) was significantly (linear, P<0.023) higher in CT-2 as compared to CT-0, however, faecal-N excretion in CT-1 did not differ significantly from either CT-0 or CT-2 treatments. Urinary and total N excretion (g/day) was comparable among the treatments. However, supplementation of CT from 1–2% (CT-1, CT-2) of diets linearly (P<0.004) reduced the urinary N excretion (% intake). All the kids had positive N-balance, irrespective of dietary treatments, however, N-retention was significantly (linear, P<0.012) higher at CT-1 and CT-2 as compared to control.

Comparable faecal N-excretion (g/day) in CT supplemented groups and control, except for CT-2 which had higher faecal-N excretion is suggestive of the tannin bound dietary substrate undergoing digestion in the post ruminal digestive tract before reaching the hindgut. Another feature of N utilization as evident by significantly higher (linear, P=0.024 or 0.018) N retention as percentage of intake or absorbed N (an indicator of availability of amino acid-N at tissue level) in animals given CT protected diets was apparently due to better amino acid availability and higher biological value of CT protected diets (Barry and McNabb 1999). This observation is further substantiated by the fact that kids given CT supplemented diets excreted significantly lower N in urine as per cent intake (linear, P=0.004) relative to control animals. Similar to the present study, increased N retention in sheep given tanniferous feeds at moderate levels (1–4% CT) due to lowered nitrogen excretion through urine was reported earlier (Waghorn *et al.* 1994 b, Ngwa *et al.* 2002, Dey *et al.* 2008).

Nutritive value: The nutrient density in terms of per cent content of DCP and TDN of the composite diets decreased significantly (linear, P=0.046 or 0.016) in CT-2 than control (CT-0) group. McNeill *et al.* (1999) indicated that dietary protein complex with tannins was made available in abomasum and digested in intestine, but tannins released from the protein-

Table 2. Intake and utilization of nutrients at graded levels of CT by kids

Attributes	Treatments*				P values**		
	CT-0	CT-1	CT-2	SEM	C	L	Q
Body weight (kg)	11.68	12.20	12.36	0.80	0.945	0.752	0.920
Metabolic size ($kgW^{0.75}$)	6.27	6.48	6.53	0.33	0.950	0.765	0.910
Intake (g/ $kgW^{0.75}$)							
Dry matter	45.20^{a}	53.12^{b}	55.67^{b}	1.76	0.029	0.011	0.406
Organic matter	42.45^{a}	49.32^{b}	51.51^{b}	1.58	0.041	0.016	0.481
Concentrate	28.82^{a}	31.98^{ab}	35.32^{b}	1.11	0.048	0.015	0.965
Wheat straw	16.37	21.14	20.34	1.36	0.350	0.048	0.349
Nutrient digestibility (%)							
Dry matter	61.79^{b}	58.3^{8ab}	56.65^{a}	0.99	0.096	0.036	0.670
Organic matter	65.55^{b}	61.29^{ab}	59.77^{a}	1.08	0.07	0.028	0.51
Crude protein	61.94	60.29	58.61	0.76	0.214	0.084	0.989
Ether extract	69.44	68.00	67.76	1.14	0.828	0.575	0.818
NDF	45.27	43.14	41.66	0.71	0.114	0.041	0.819
ADF	40.26	39.58	38.19	0.82	0.610	0.337	0.846
N- balance (g per day)							
Intake	7.28^{a}	8.06^{ab}	8.69^{b}	0.25	0.069	0.023	0.866
Faeces	2.76^{b}	3.0^{a}	3.32^{b}	0.10	0.069	0.023	0.851
Urine	2.77	2.51	2.38	0.10	0.348	0.159	0.790
Balance	1.73^{a}	2.54^{b}	2.98^{b}	0.18	0.012	0.004	0.567
Nitrogen excretion (% intake)							
Faecal	37.40	38.19	40.12	0.73	0.317	0.146	0.716
Urinary	38.68^{b}	30.99^{a}	27.46^{a}	1.71	0.013	0.004	0.481
Retention (%)							
N intake	23.25^{a}	31.7^{b}	34.14^{b}	1.80	0.024	0.010	0.359
N absorbed	37.54^{a}	50.41^{b}	55.34^{b}	2.82	0.018	0.007	0.430

Means values with different superscripts (a and b) with in a row differ significantly.*CT-0: 0% CT of diet; CT-1: 1% CT of diet; CT-2: 2% CT of diet. **C: combined; L: linear; Q: quadratic.

tannin complex may react with non-dietary protein (including digestive enzymes) as it passes along the intestines, thus counteracting the benefits of by-pass dietary protein. The decrease in TDN content was apparently as a consequence of decreased OM digestibility when the level of CT increased to 2.0% of diet. The decreased DCP content in CT-2 may not be attributed to any biological consequences rather it was due to increased (P<0.05) DM intake by kids in this group. Present results are in agreement with the finding of Dey *et al.* (2008), who reported decreased DCP and TDN content of diet in lambs when the level of CT was 2% of supplement.

Daily nutrient intake in terms of DCP, DOM and TDN remained same (P<0.05) among of dietary treatments. The absence of any detectable adverse effect on the health of experimental animals suggests that kids were on balanced diets with no apparent deleterious consequences. Except for TDN, which fell short of requirements (Kearl 1982) by 10–29%, all the kids had enough nutrient intakes irrespective of dietary treatments to meet the requirements for maintenance and growth (50 g/d). The findings suggested that plane of nutrition was not affected adversely with CT supplementation and the findings are in conformity with the earlier reports (Waghorn *et al.* 1994 a, b, Dey *et al.* 2008).

Urinary excretion of purine derivatives and microbial nitrogen synthesis: Daily excretion (mmol) of PD (allantoin, hypoxanthine and total PD) in urine of kids increased significantly with CT supplementation as compared to control (CT-0). However, CT supplementation did not exert any effect on excretion of uric acid, xanthine, creatinine (C) and PD: C ratio. PD absorption (mmol/ day) and microbial nitrogen (MN) synthesis (g/day) was increased linearly (P=0.006) with CT supplementation (1–2%) relative to control group. Similarly, efficiency of MN synthesis (g/kg DOMI) was increased linearly (P=0.07) in CT supplemented groups as compared to control. The results are in conformity with the earlier reports that the presence of CT has a potentially beneficial effect on protein nutrition of the host animal by altering partitioning of nutrients towards higher microbial yield rather than short chain fatty acids (Baba *et al.* 2002). No depressing effect of CT supplementation on rumen microbial protein synthesis observed in present study agrees with the observations recorded earlier in sheep fed tannin containing *Acacia* pods and *F. infectoria* (Ngwa *et al.* 2002, Dey *et al.* 2008).

Voluntary feed intake, growth and feed conversion ratio: The overall DMI (g/day) by kids was significantly (linear,

Table 3. Urinary excretion of PD and microbial-N supply to kids fed graded levels of CT

Attributes	Treatments*				P values**		
	CT-0	CT-1	CT-2	SEM	C	L	Q
Urinary excretion of PD (mmol/ day)							
Allantoin	3.59[a]	4.82[b]	5.31[b]	0.23	0.003	0.001	0.324
Uric acid	0.18	0.29	0.21	0.05	0.591	0.811	0.326
Xanthine	0.26	0.23	0.25	0.04	0.933	0.861	0.746
Hypoxanthine	0.41[a]	0.53[b]	0.55[b]	0.03	0.014	0.301	0.006
Total	4.45[a]	5.88[b]	6.32[b]	0.27	0.015	0.007	0.219
Creatinine	1.52	1.56	1.6	0.08	0.928	0.705	0.985
PD: C	2.99	3.92	3.95	0.26	0.231	0.124	0.457
PD absorption	5.04[a]	6.82[b]	7.23[b]	0.33	0.013	0.006	0.218
Microbial N supply (g/day)	3.66[a]	4.96[b]	5.36[b]	0.24	0.013	0.006	0.217
Efficiency of microbial N synthesis (g/ kg DOMI)	21.52	26.42	27.40	1.17	0.126	0.072	0.332

[ab]Means values with different superscripts with in a row differ significantly
* CT-0: 0% CT of diet; CT-1: 1% CT of diet; CT-2: 2% CT of diet.**C, combined; L, linear; Q, quadratic.

Table 4. Effect of graded levels of CT on growth rate and plane of nutrition by kids under experimental feeding for 120 days

Attributes	Treatments*				P values**		
	CT-0	CT-1	CT-2	SEM	C	L	Q
Body weight changes(kg)							
Initial	11.33	11.38	11.35	0.81	1.00	0.994	0.982
Final	13.15	14.41	14.67	0.82	0.821	0.560	0.838
Total gain	1.82[a]	3.02[b]	3.31[b]	0.14	0.000	0.000	0.031
Average daily gain (g)	15.16[a]	25.23[b]	27.62[b]	1.20	0.000	0.000	0.031
DMI (g/day)	319.38[a]	385.59[b]	374.26[b]	10.42	0.18	0.046	0.29
FCR (kg DM/kg gain)	21.05[c]	15.38[b]	13.39[a]	0.57	0.000	0.000	0.281
Nutrient intake (g/kg$W^{0.75}$)							
DCP	4.57	4.76	4.80	0.11	0.659	0.397	0.760
TDN	29.05	31.59	36.67	0.86	0.268	0.126	0.623
Nutrient density (%)							
DCP	10.27[b]	9.05[ab]	8.64a	0.33	0.111	0.046	0.542
TDN	64.72[b]	59.79[ab]	58.0[a]	1.17	0.042	0.016	0.474

TDN calculated from DOM (1kg DOM= 1.05 kg TDN; NRC 1981). Means values with different superscripts (a-b) with in a row differ significantly. * CT-0, 0% CT of diet; CT-1., 1% CT of diet; CT-2., 2% CT of diet. **C, combined; L, linear; Q, quadratic.

P<0.05) lower in control group (CT-0) as compared to comparable intake between CT-1 and CT-2 treatments. The higher DMI in CT supplemented groups may be due to difference in body growth as its amount had to be adjusted fortnightly to meet the maintenance and growth requirement of protein. Similar to the present study, higher voluntary feed intake at moderate CT containing diets was reported by many workers (Ramirez-Restrepo *et al.* 2004, Dey *et al.* 2008). The fortnightly BW changes are depicted in Fig. 1. Initial and final live weights (kg) were comparable among the kids irrespective of dietary treatments. However, BW gain (kg) and ADG (g) for the period of 120 days were significantly (linear, P=0.001) higher in CT supplemented groups (CT-1 and CT-2) than control (CT-0) group. FCR was significantly (linear, P=0.001) higher in treatment CT-2 followed by CT-1 and CT-0, respectively. The encouraging results of ADG and FCR at 1-2% level of CT in the diets gave an indication that the binding effect of tannins was pronounced only at this level by supplying protein to the lower gut and subsequently its more efficient use for tissue growth (Ngwa *et al.* 2002, Dey *et al.* 2008). At appropriate concentration, the CT reduced the degradation of sulphur amino acids (SAA) in the rumen, increase the irreversible loss of cystine from plasma and increased the flow of cystine to body synthetic reaction (McNabb *et al.* 1993, Wang *et al.* 1994).

Blood biochemical profile: The Hb, PCV, serum levels of glucose, proteins and enzyme during entire growth trial are shown in Table 5. Treatment period interaction was not evident in any blood parameters of the blood biochemical profile. The levels of Hb and PCV were within normal range

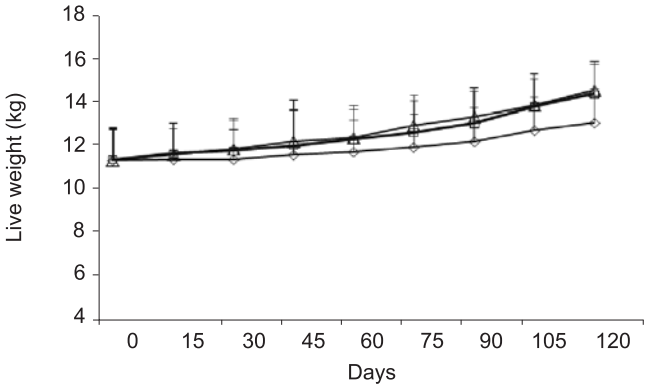

Fig. 1. Effect of diets containing 0 (CT-0; –◊–), 1 (CT-1; –□–) and 2 (CT-2; –Δ–)% condensed tannins (CT) on fortnightly live weight changes by kids.

Table 5. Effect of graded levels of CT on Hb (g/dl), PCV (%), glucose (mg/dl), serum proteins (g/dl), serum urea (mg/dl), LDH (IU) by kids

Attributes	Treatments*			
	CT-0	CT-1	CT-2	SEM
Hb	10.69	11.14	11.12	0.19
PCV	39.08	40.33	39.87	0.87
Glucose	57.68	57.78	56.60	1.41
Total protein	6.46	6.62	6.52	0.08
Albumin	3.78	3.76	3.68	0.06
globulins	3.00	2.85	2.88	0.05
A:G ratio	1.26	1.34	1.29	0.04
Serum urea	40.98[b]	36.43[a]	34.19[a]	1.12
LDH	329.20	319.56	319.71	8.78

Means values with different superscripts (a-b) with in a row differ significantly (P<0.05). * CT-0, 0% CT of diet; CT-1, 1% CT of diet; CT-2, 2% CT of diet.

(Hb10.5–11.8 g/ dl and PCV 37.3–41.8%) in goats (Kaneko 1997, Patra *et al.* 2003). The serum glucose level remained similar (53–90 mg/dl) across treatments and within the normal ranges (Kaneko 1997). An increased or decreased level of serum glucose level is an indicator of stress to the animals. However, in the present study, similar glucose level indicated normal physiological condition of all the experimental animals. Total serum protein, albumin, globulin and A:G ratio remained similar for all the treatments, which clearly indicated that low levels of CT did not have any adverse effect on serum proteins. The comparable serum LDH levels (300–359 IU/ l) observed in this study were within the normal range (Kaneko 1997) and reflected no adverse effect of CT up to 2% of diet on target organs like liver and heart. However, significantly (P<0.01) lower concentration of serum urea was observed in kids fed 1.0 and 2.0% CT in the diets, which may be attributed to the reduced rumen protein breakdown and increased EAA absorption (Waghorn *et al.* 1987, Dey *et al.* 2008). Similarly, lower plasma/serum urea concentration was reported in sheep grazed on Lotus pasture (Waghorn *et al.* 1994b, Wang *et al.* 1996a, Min *et al.* 2001) and in lambs fed supplement containing 1.5–2.0% CT through *F. infectoria* leaves (Dey *et al.* 2008).

On the basis of present results, it could be concluded that a mixture of *F. infectoria, P. guajava* and *F. bengalensis* leaves, used as a prospective source of CT, may prove successful as a protectant of proteins. A discernible encouraging impact was evident on nutrient utilization, growth performance and FCR in kids given diet containing CT from 1 to 2%.

ACKNOWLEDGEMENT

This study was financially supported by funds provided by Indian Council of Agricultural Research (ICAR), New Delhi, India.

REFERENCES

Anbarasu C, Dutta N, Sharma K and Rawat M. 2004. Response of goats to partial replacement of dietary protein by a leaf meal mixture containing Leucaena leucocephala, *Morus alba* and *Tectona grandis*. *Small Ruminant Research* **51**: 47–56.

AOAC. 1995. *Official Methods of Analysis.* 16th edn. Association of Official Analytical Chemists,Washington D C.

Ashes J R, Mangan J L and Sidhu G S. 1984. Nutritional availability of amino acids from protein cross-linked to protect against degradation in the rumen. *British Journal of Nutrition* **52**: 239–47.

Baba A S H, Castro F B and Orskov E R. 2002. Partitioning of energy and degradability of browse plants *in vitro* and the implications of blocking effects of tannin by the addition of polyethylene glycol. *Animal Feed Science and Technology* **76**: 77–88.

Barry T N and McNabb W C. 1999. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. 2. Quantitative digestion of carbohydrates and proteins. *British Journal of Nutrition* **81**: 263–72.

Benjamin M M. 1985. *Outline of Veterinary Clinical Pathology.* 3rd edn. Pp. 233–54. Kalyani Publishers, New Delhi, India.

Chen X B and Gomes M J. 1995. Estimation of Microbial Protein Supply to Sheep and Cattle Based on Urinary Excretion of Purine Derivatives—an Overview of the Technical Details. *Occasional Publication 1992*. Internal Feed Resources Unit. Rowett Research Institute, Aberdeen, UK.

Dey A, Dutta N, Sharma K and Pattanaik A K. 2008. Effect of dietary inclusion of *Ficus infectoria* leaves as a protectant of proteins on the performance of lambs. *Small Ruminant Research* **75**: 105–14.

Dey A, Dutta N, Sharma K and Pattanaik A K. 2009. Response of dairy cows to dietary supplementation of condensed tannins through *Ficus infectoria* leaves. *Indian Journal of Animal Sciences* **79** (1): 56–60.

Doumas V T, Watson W A and Biggs H G. 1971. Albumin standards and the measurement of serum albumin with bromocresol green. *Clinica Chimica Acta* **31**: 87–96.

Dutta N and Agrawal I S. 2000. Effect of formaldehyde and heat

treatment on protein degradability. *Indian Veterinary Journal* 77: 36–39.

Howell F B, McCune S and Schaffer R. 1979. Lactate-to-pyruvate or pyruvate-to-lactate assay for lactate dehydrogenase: a reexamination. *Clinical Chemistry* **25**: 269–72.

Hultmann E. 1959. Rapid specific method for determination aldohexoses (Aldorac chandes) in body fluid. *Nature* **103**: 108–09.

IFOM. 2006. *Proceedings of the First International Conference of Animal in Organic Production*. Minnesota University, St. Paul, Minnesota, USA, August 23–25.

Kaneko J J. 1997. *Clinical Biochemistry of Domestic Animals.* 5th edn. Pp. 885–905. Academic Press, New York, USA.

Kearl L C. 1982. Nutrient requirements of ruminants in developing countries. Pp. 45–81. *International Feed Stuffs Institute.* Utah Agricultural Experiment Station, Utah State University, Logan, Utah, USA.

Makkar H P S. 2000. Quantification of Tannins in Tree Foliage. *A Laboratory Manual for the FAO/IAEA Co-ordinated Research Project on "Use of Nuclear and Related Techniques to Develop Simple Tannin Assays for Predicting and Improving the Safety and Efficiency of Feeding Ruminants on Tanniniferous Tree Foliage*". Pp. 1–26. Joint FAO/IAEA working document, IAEA, Viena.

McNabb W C, Waghorn G C, Barry T N, and Shelton I D. 1993. The effect of condensed tannins in *Lotus pedunculatus* on the digestion and metabolism of methionine, cystine and inorganic sulphur in sheep. *British Journal of Nutrition* **70**: 647–61.

McNeill D M, Osborne N, Komolong M and Nankervis D. 1999. Condensed tannins in the Leucaena genus and their nutritional significance for ruminant. *ACIAR Proceedings* **86**. Pp. 205–14. (Eds.) Shelton H M, Gutteridge R C, Mullin B F, Bray R A. Leucaena-Adaptation, Quality and Farming Systems.

Min B R, Fernandez J M, Barry T N, McNabb W C and Kemp P D. 2001. The effect of condensed tannins in Lotus corniculatus upon reproductive efficiency and wool production in ewes during autumn. *Animal Feed Science and Technology* **92**: 185–202.

Ngwa A T, Nsahlai I V and Iji P A. 2002. Effect of supplementing veld hay with a dry meal or silage from pods of Acacia sieberiana with or without wheat bran on voluntary intake, digestibility, excretion of purine derivetives, nitrogen utilization and weight gain in South African Merino sheep. *Livestock Production Science* 77: 253–64.

Pathak A K and Pal S. 2008. Seasonal prevalence of gastrointestinal parasites in goats from Durg District of Chhattisgarh. *Veterinary World* 1: 136–37.

Patra A K, Sharma K, Dutta N and Pattanaik A K. 2003. Effect of partial replacement of dietary protein by a leaf meal mixture on nutrient utilization by goats in pre and late gestation. *Small Ruminant Research* **63**: 66–74.

Rahmatulla M and Boyde T R C. 1980. An improvement in determination of urea using diacetylmonoxime method with and without deproteinization. *Clinica Chimica Acta* **107**: 3–7.

Ramirez-Restrepo C A, Barry T N, Lopez-Villalobos N, Kemp P D and McNabb W C. 2004. Use of *Lotus Corniculatus* containing condensed tannins to increase lamb and wool production under commercial dryland and farming conditions without the use of anthelmintics. *Animal Feed Science and Technology* **117**: 85–105.

Resines J A, Arin M J and Diez M T. 1992. Determination of creatinine and purine derivatives in ruminants urine by reversed-phase high performance liquid chromatography. *Journal of Chromatography* **607**: 199–202.

Schonhusen U, Voigt J and Piatkowski B. 1986. Effect of the pH value when treating concentrate protein with formaldehyde on protein protection in the rumen. *Archives of Animal Nutrition* **36**: 741–47.

Snedecor G W and Cochran W C. 1994. *Statistical Methods.* 8th edn. East West Press Private Limited, New Delhi, India

Stutts J A, Nipper W A, Adkinson R W, Chandler J E and Achacoso A S. 1988. Protein solubility, in vitro ammonia concentration and *in situ* disappearance of extruded whole cottonseed and other protein sources. *Journal of Dairy Science* 7**1**: 3223–333.

Van Soest P J, Robertson J B and Lewis B A. 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* **74**: 3583–97.

Waghorn G C, John A, Jones W T and Shelton I D. 1987. Nutritive value of *Lotus corniculatus L.* containing low and medium concentrations of condensed tannins for sheep, *Proceedings New Zealand Society of Animal Production* **47**: 25–30.

Waghorn G C, Shelton I D and McNabb W C. 1994a. Effects of condensed tannins in Lotus pedunculatus on its nutritive value for sheep. 1. Non-nitrogenous aspects. *The Journal of Agricultural Science (Cambridge)* **123**: 99–107.

Waghorn G C, Shelton I D, McNabb WC and McCutcheon S N. 1994b. Effects of condensed tannins in *Lotus pedunculatus* on its nutritive value for sheep. 2. Nitrogenous aspects. *The Journal of Agricultural Science (Cambridge)* **123**: 109–19.

Wang Y, Waghorn G C, Barry T N and Sheltons I D. 1994. The effect of condensed tannins in *Lotus corniculatus* on plasma metabolism of methionine, cystine and inorganic sulphate by sheep. *British Journal of Nutrition* **72**: 923–35.

Wang Y, Douglas G B, Waghorn G C, Barry T N, Foote A G and Purchas R W. 1996a. Effect of condensed tannins upon the performance on lambs grazing *Lotus corniculatus* and lucerne (*Medicago sativa*). *The Journal of Agricultural Science (Cambridge)* **126**: 87–98.

Wotton I D P. 1964. *Microanalysis in Medical Biochemistry.* 4th edn. Pp. 138–40. G and A Churchill Limited, London, WI.