Haematobiochemical parameters of goats fed tannin rich *Psidium guajava* and *Carissa spinarum* against *Haemonchus contortus* infection in India

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Abstract The antihelminthic properties of tannin-rich plants are being explored as an alternative to chemical drugs to minimise the effects of gastro intestinal nematodes (GIN). The present study was, therefore, conducted to investigate the effect of condensed tannins (CT), obtained from regional tanniferous tree leaves, in the *Haemonchus contortus* infected goats on the haematobiochemical parameters to assess the goat health. Twelve adult male goats were randomly divided into three equal groups, namely negative control, infected control and treatment. *H. contortus* infected goats were allocated into infected control and treatment groups and their feeds contained 0 and 1.96 % of CT, respectively. Feeding trial was conducted for the duration of 90 days during which haematological and serum biochemical parameters were monitored on fortnightly basis. The animals ingesting the CT-rich leaf meal mixture had increased levels of haemoglobin, packed cell volume, total protein, globulin, glucose and calcium, and decreased levels of blood urea; indicating a beneficial effect of CT supplementation at the selected level. However, the phosphorus balance, serum albumin levels and serum enzyme activity were not affected significantly. The study revealed that inclusion of CT in the diets of the adult

male goats did not pose any threat to the health of the goats. Further, the CT based diet had beneficial impact on the haematological parameters and could therefore be included in small ruminant diets to minimize the impact of GIN.

Keywords Condensed tannins ·
Gastrointestinal nematodes · *Haemonchus contortus*

Introduction

The gastrointestinal nematode (GIN) parasites, especially *Haemonchus contortus* are important pathogens of sheep and goats. These parasites are considered to be a major health and welfare problem for sheep and goats (Hoste et al. 2005). Parasitism with gastrointestinal nematodes impairs animal health, welfare and productivity since the presence of nematodes results in increased mortality rate, poor growth and reproduction (Hoste et al. 2005). Goat constitutes an important species of livestock in Asia and contributes greatly to food, rural employment, and the gross domestic product (GDP). Parasitism is thought to be one of the major factors hindering rural goat production in the country (Chowdhury et al. 2003). Haemonchosis caused by *Haemonchus contortus* in goats, for example, is associated with causing anemia, hypoproteinemia, and parasitic gastroenteritis (Albers et al. 1990), which ultimately reduce the production potential of goats. Parasitic infection in goats also has an adverse effect on hematological parameters and serum enzyme levels, which in turn suppresses goat production in different biological ways. Parasitic infections causes significant economic loss due to significant mortality, stunted growth, underweight animals, poor skin quality, and decreased milk and meat production (Ahmed and Ansari 1989). Parasitic nematodes of the digestive tract remain one

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of the main constraints to goat production both in temperate and tropical countries. The usual mode of control of these gastrointestinal nematodes (GIN) remains based on the repeated use of anthelmintics (AHs), either for prevention of infection or to cure the animals. However, the development of anthelmintic resistance in worm populations is now a worldwide phenomenon, in constant expansion, and is particularly prevalent in goats (Jackson and Coop 2000). This constant increase in AH resistance has stimulated the search for alternative solutions and has inherent challenges to the poor farmers of developing countries (Marley et al. 2003) and presence of residues in meat and milk with associated high environmental impact (Echevaria et al. 2007). Anthelmintic resistance and other associated shortcomings of conventional drugs has necessitated search for alternative herbal remedies. Numerous studies from various parts of the World have shown that certain plant species effectively reduce the degree of parasite infestation in ruminants and are promising alternatives to conventional anthelmintics (Oliveira et al. 2009). Many of these plant species owe their anthelmintic effects to plant secondary metabolites such as saponins, tannins and essential oils (Yadav et al. 2010; Mehmood et al. 2011; Maphosa and Masika 2012). Among these alternative methods, manipulation of host nutrition in order to improve the host resistance and resilience to parasitic infections seems to represent one promising options. Studies on these aspects of interactions between host nutrition and nematode infections are abundant in sheep but still remain scanty in goats. An improvement in host nutrition can enhance the host resistance i.e. its aptitude to regulate the worm populations as well as the host resilience, i.e. its ability to withstand the negative effects of nematode infections. This research concerns the manipulation of nutrition in order to reduce the dependence on conventional chemotherapy and to favour the sustainable control of gastrointestinal nematode infections in goats both in temperate and tropical conditions. Therefore, supplementation of potential source and optimum level of leaf meal mixture containing CT may be a possible alternative approach to control GIN infection in goats. Keeping this in view, the present study was undertaken to evaluate the effect of leaf meal mixture supplementation on haemato-biochemical profile in *Haemonchus contortus* infected goats.

Materials and methods

Animals

Twelve local adult male goats aged 2–2.5 years with an average live weight of 21.33 kg were used for this study and randomly allotted as per completely randomized block design to three equal groups of four animals each. The animals were

housed intensively in well-ventilated individual pens ($1.2 \times 1.0 \text{ m}^2$), in an open-sided type of house with corrugated aluminium roofing sheet and a wooden floor, which had been disinfected before the arrival of the animals. All goats were dewormed by a combination of Tab. Distodine (Oxyclozanide) at 15 mg/kg body weight orally and Tab. Panacur (Fenbendazole) at 5 mg/kg body weight orally and repeated after 2 weeks. The elimination of parasitic infection was confirmed by skin scrapings and faecal examination.

Experimental feed

On the basis of CT content of the eight regional tree leaves, a tannin-rich leaf meal mixture (*Psidium guajava*:*Carissa spinarum*; 65:35) was prepared for in vivo study. The plant leaves of Amrod (*Psidium guajava*) and Garna (*Carissa spinarum*) used for this study were collected from samba region of Jammu province. The foliage was harvested fresh and sun-dried for 3 days until the leaves and petiole were brittle and thoroughly dried.

Experimental infection of animals

The gastrointestinal tracts of two slaughtered goats naturally infected with *H. contortus* were collected. The abomasal contents were drained through sieves; thereafter it was strained with the running tap water. The abomasal walls were washed with normal saline to recover the parasites adhered in the abomasal fold. Subsequently the parasites were identified on the basis of their morphological characteristics. The parasites identified as adult female *H. contortus* worms were washed by normal saline and shifted to a large petri-dish containing normal saline. The adult female *H. contortus* parasites were picked up one by one with the help of forceps. Both ends of each parasite were cut by a sharp B.P. blade on a slide and put on the large petri-dish containing normal saline. The eggs were retrieved and collected from gravid uterus by application of gentle pressure. The collected eggs were cultured at 27 °C for 8 days. The larvae were extracted by Baermann Funnel method (using saturated NaCl solution). After recovering, the infective 3rd larvae (L3) of *H. contortus* collected were administered orally at 2,000 larvae per goat of infected control (IC) and treatment (T) groups (Blackburn et al. 1991).

In vivo experiment (feeding trial)

An in vivo experiment (feeding trial) of 90 days duration was carried out to assess the effect of leaf meal mixture containing condensed tannins on fortnightly changes in haemato-biochemical parameters. *Ad libitum* wheat straw was the basal diet for all the experimental goats. Negative

control (NC) and infected control were supplemented with conventional concentrate mixture (Table 1). However, treatment group was supplemented with concentrate mixture containing leaf meal. Nutrient requirement for maintenance of all the experimental goats were met as per NRC (2007). All the experimental goats were fed iso-nitrogenous and iso-energetic diets.

Blood parameters

Blood samples (approximately 10 ml) were collected from each goat via jugular vein puncture using hypodermic syringes before feeding. Blood collection was made at the start of the experiment and thereafter repeated at fortnightly intervals till the end of the feeding trial. Blood, 5 ml, was drawn into a heparinized tube to prevent coagulation while the remaining 5 ml was left in the syringe to coagulate, to separate the serum. Blood samples were then analysed for packed cell volume (PCV) and Haemoglobin (Hb). Sera samples were separated from the blood and stored at -10°C until required for the analysis of Biochemical parameters. Biochemical parameters of interest included: serum protein, serum Albumin, Albumin:Globulin ratio, serum glucose, serum urea, calcium and phosphorus.

Hb was quantified in whole blood samples by Drabkin method. PCV was estimated by Wintrobe (1974) method. The estimation of total serum protein, albumin and blood urea nitrogen, were carried out using commercially available diagnostic kits (Agappe Diagnostic Kits) and read spectrophotometrically at the determined wavelength. Minerals elements (Ca and P) were estimated using atomic absorption spectrophotometry.

Statistical analysis

Sigma stat software (SPSS) was used to conduct a one-way analysis of variance (ANOVA). Results were expressed as mean $\pm$ standard error at $P = 0.05$.

Results

In the present study the hematological parameters were analysed and estimated on days 0, 15, 30, 45, 60, 75 and 90

during the experimental trial. A statistically significant ($P < 0.05$) difference in Hemoglobin (g/dl) and PCV (%) values was observed among all the three groups with NC having the highest values and IC the lowest (Table 2). There was a significant difference ($P < 0.05$) between all the three groups with NC having the highest values and IC the lowest.

Total protein (g/dl), Glucose (mg/dl) and Calcium (mg/dl) were significantly ($P < 0.05$) lower in IC compared to the rest two groups which differed non-significantly with respect to each other, while the Albumin (g/dl) levels were significantly ($P < 0.05$) higher in NC compared to the rest two groups which differed non-significantly with respect to each other (Table 3). Globulin (g/dl) values showed a significant difference ($P < 0.05$) between all the three groups with T having the highest values and IC the lowest. A:G ratio and Urea (mg/dl) levels were significantly ($P < 0.05$) lower in T compared to the rest two groups which differed non-significantly with respect to each other. No significant variation ($P > 0.05$) was observed in Phosphorus (mg/dl) levels within the 3 groups.

Ca intake (g/day) and Ca retention (g/day) was significantly higher ($P < 0.05$) in T compared to NC and IC which differed non-significantly with each other (Table 3). Lastly, Ca retention (as % intake) was significantly lower ($P < 0.05$) in IC compared to NC and T which differed non-significantly with each other. P retention (g/day) was significantly different ($P < 0.05$) between NC and T but there was no significant difference ($P > 0.05$) between IC and rest of the two groups. Hence, the feeding of CT did not affect the P balance significantly.

Discussion and conclusion

The haematological parameters like haemoglobin and PCV are indicators of erythrocytic normalcy and general well being of animals. The mean haemoglobin level of NC was within the normal range (8–12 g/dl) for goats as per Kaneko et al. (1997). The mean PCV of NC was within the normal range (24–48 %) for goats as per Banerjee (2004). There was a significant difference ($P < 0.05$) between all the three groups with NC having the highest values and IC the lowest. The *H. contortus* infected male goats had lower Hb and PCV values than uninfected controls as documented by previous workers (Sharma et al. 2000; Misra

Table 1 Feeding schedule in the experimental animals during the feeding trial

Group	Infection status	Feed given
Negative control	No infection	Wheat straw + conventional concentrate mixture
Infected control	<i>H. contortus</i> infected	Wheat straw + conventional concentrate mixture
Treatment	<i>H. contortus</i> infected	Wheat straw + conventional concentrate mixture + leaf meal

Table 2 Evaluated blood Haematology from the samples of trial goats

Attribute	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90	Group mean $\pm$ pooled SE	P value
Haemoglobin (g/dl)									
NC	9.84 $\pm$ 0.05	9.92 $\pm$ 0.10	10.20 $\pm$ 0.19	10.12 $\pm$ 0.16	10.02 $\pm$ 0.13	10.22 $\pm$ 0.17	9.98 $\pm$ 0.10	10.04 $\pm$ 0.05 ^c	
IC	10.12 $\pm$ 0.06	9.59 $\pm$ 0.16	8.84 $\pm$ 0.10	8.56 $\pm$ 0.17	8.12 $\pm$ 0.16	7.75 $\pm$ 0.29	7.17 $\pm$ 0.23	8.59 $\pm$ 0.19 ^a	
T	9.78 $\pm$ 0.22	9.64 $\pm$ 0.15	9.42 $\pm$ 0.21	9.10 $\pm$ 0.20	8.90 $\pm$ 0.13	8.87 $\pm$ 0.31	8.65 $\pm$ 0.27	9.19 $\pm$ 0.11 ^b	
Period mean $\pm$ SEM	9.91 $\pm$ 0.08 ^b	9.71 $\pm$ 0.08 ^b	9.49 $\pm$ 0.19 ^{ab}	9.26 $\pm$ 0.22 ^{ab}	9.01 $\pm$ 0.25 ^{ab}	8.94 $\pm$ 0.33 ^{ab}	8.60 $\pm$ 0.36 ^a	9.28 $\pm$ 0.10	<0.05
P value								<0.05	
PCV (%)									
NC	35.24 $\pm$ 1.00	35.72 $\pm$ 1.10	36.84 $\pm$ 1.29	36.58 $\pm$ 0.22	36.12 $\pm$ 0.70	36.77 $\pm$ 0.79	35.28 $\pm$ 0.38	36.08 $\pm$ 0.31 ^c	
IC	36.22 $\pm$ 0.89	34.58 $\pm$ 0.53	31.56 $\pm$ 0.38	29.88 $\pm$ 0.13	27.24 $\pm$ 0.81	23.54 $\pm$ 0.6	20.25 $\pm$ 0.56	29.09 $\pm$ 1.05 ^a	
T	34.78 $\pm$ 0.92	33.43 $\pm$ 0.37	32.39 $\pm$ 0.87	31.14 $\pm$ 0.99	30.53 $\pm$ 0.40	29.84 $\pm$ 0.29	29.33 $\pm$ 0.35	31.63 $\pm$ 0.42 ^b	
Period mean $\pm$ SEM	35.41 $\pm$ 0.52 ^c	34.58 $\pm$ 0.48 ^{bc}	33.59 $\pm$ 0.85 ^{bc}	32.57 $\pm$ 0.92 ^{abc}	31.30 $\pm$ 1.16 ^{abc}	30.05 $\pm$ 1.66 ^{ab}	28.29 $\pm$ 1.88 ^a	32.25 $\pm$ 0.50	<0.05
P value								<0.05	

Means bearing different superscripts within a row differ significantly ($P < 0.05$)Means bearing different superscripts within a column differ significantly ($P < 0.05$)

and Ruprah 1970). Except infected control group, mean Hb and PCV values were within the normal range, Kaneko et al. (1997). This suggests infected goats (T) given dietary CT exhibited better health than the infected control (IC). Similar to the present findings, Shaik et al. (2006) reported that the feeding of CT-rich *Sericea lespedeza* (SL) hay to GI nematode infected goats improved PCV as compared to bermuda grass (BG) fed goats.

The mean total protein value (g/dl) of NC was within the normal range (6.4–7.0 g/dl) for goats as reported by Kaneko et al. (1997). Total protein (g/dl) was significantly ($P < 0.05$) lower in IC compared to NC. Similar result was obtained by Sharma et al. (2001) in Barbari goats and Abakar et al. (1999–2000) in lambs. Total proteins and globulin were significantly higher in treatment group as compared to infected control. The reduction in TP in infected control (IC) might be attributed to the increased endogenous losses of protein through urinary and faecal excretion (MacRae 1993). The increase in globulin levels in CT fed groups probably reflect an increased rate of immunoglobulin synthesis associated with the development of immunity (Kyriazakis et al. 1994).

The mean albumin and globulin values (g/dl) of NC were within the normal range (2.7–3.9 and 2.7–4.1 g/dl, respectively) for goats as reported by Kaneko et al. (1997). The serum albumin of *H. contortus* infected lambs was significantly ($P < 0.05$) decreased when compared with non-infected controls. The present findings concurred with the findings of Abakar et al. (1999–2000) in lambs. The albumin was comparable between treatment and infected control. The main effect of GI parasites is the elevated enteric loss of protein, especially albumin, at the site of infection. The leakage of protein into the gut increases the rate at which albumin is synthesized and compensated for the losses in blood plasma (Symons and Steel 1978). The A:G ratio was lower in treatment group as compared to infected control as globulin levels in the former were higher while the albumin levels in the two groups were comparable.

The mean calcium level (mg/dl) of NC was within the normal range (8.9–11.7 mg/dl) for goats as reported by Kaneko et al. (1997). The levels of Ca in NC were significantly higher compared with IC. The levels of Ca in IC and T groups differed significantly which may be attributed to high levels of Ca in LMM. The mean phosphorus level (mg/dl) of NC was within the normal range (4.2–9.1 mg/dl) for goats as reported by Kaneko et al. (1997). The P levels were found to differ non-significantly in the three groups. Abakar et al. (1999–2000) reported that in lambs, the mean serum phosphorus level of *H. contortus* infected lambs failed to show any consistent pattern of changes throughout the observation period. Similar to the present study, comparable Ca and P levels were observed in GI nematode-

Table 3 Evaluated blood Biochemical's from the samples of trial goats

Attribute	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90	Group mean ± pooled SE	P value
Total protein (g/dl)									
NC	6.62 ± 0.16	6.58 ± 0.18	6.57 ± 0.26	6.60 ± 0.15	6.65 ± 0.10	6.69 ± 0.11	6.57 ± 0.10	6.61 ± 0.05 ^b	
IC	6.38 ± 0.21	6.09 ± 0.04	5.65 ± 0.20	5.48 ± 0.10	5.21 ± 0.26	4.58 ± 0.17	4.80 ± 0.09	5.46 ± 0.13 ^a	
T	6.46 ± 0.15	6.44 ± 0.11	6.25 ± 0.27	6.46 ± 0.25	6.32 ± 0.04	6.45 ± 0.14	6.26 ± 0.10	6.37 ± 0.06 ^b	
Period mean ± SEM	6.49 ± 0.10	6.37 ± 0.09	6.16 ± 0.17	6.18 ± 0.18	6.06 ± 0.20	5.91 ± 0.29	5.88 ± 0.24	6.15 ± 0.07	>0.05
P value								<0.05	
Albumin (g/dl)									
NC	3.42 ± 0.28	3.48 ± 0.12	3.67 ± 0.18	3.68 ± 0.16	3.72 ± 0.66	3.71 ± 0.16	3.83 ± 0.11	3.64 ± 0.06 ^b	
IC	3.47 ± 0.18	3.33 ± 0.21	2.93 ± 0.16	2.60 ± 0.18	2.43 ± 0.15	2.29 ± 0.17	2.13 ± 0.14	2.74 ± 0.11 ^a	
T	3.52 ± 0.12	3.42 ± 0.13	3.31 ± 0.10	2.74 ± 0.33	2.57 ± 0.14	2.50 ± 0.12	2.54 ± 0.08	2.94 ± 0.10 ^a	
Period mean ± SEM	3.47 ± 0.11	3.41 ± 0.08	3.30 ± 0.12	3.01 ± 0.19	2.90 ± 0.19	2.83 ± 0.21	2.83 ± 0.23	3.11 ± 0.07	>0.05
P value								<0.05	
Globulin (g/dl)									
NC	3.20 ± 0.35	3.11 ± 0.20	2.90 ± 0.25	2.92 ± 0.18	2.93 ± 0.14	2.98 ± 0.08	2.74 ± 0.05	2.97 ± 0.07 ^b	
IC	2.66 ± 0.39	2.76 ± 0.23	2.72 ± 0.16	2.89 ± 0.26	2.79 ± 0.27	2.28 ± 0.28	2.34 ± 0.29	2.63 ± 0.10 ^a	
T	2.95 ± 0.11	3.03 ± 0.17	2.94 ± 0.25	3.71 ± 0.55	3.76 ± 0.18	3.95 ± 0.21	3.76 ± 0.09	3.44 ± 0.12 ^c	
Period mean ± SEM	2.94 ± 0.17	2.96 ± 0.11	2.85 ± 0.12	3.17 ± 0.22	3.16 ± 0.17	3.07 ± 0.23	2.95 ± 0.20	3.01 ± 0.07	>0.05
P value								<0.05	
A:G ratio									
NC	1.13 ± 0.20	1.13 ± 0.10	1.29 ± 0.15	1.28 ± 0.13	1.28 ± 0.08	1.25 ± 0.08	1.40 ± 0.06	1.25 ± 0.04 ^b	
IC	1.45 ± 0.33	1.24 ± 0.16	1.09 ± 0.10	0.93 ± 0.13	0.90 ± 0.12	1.07 ± 0.19	0.97 ± 0.15	1.09 ± 0.07 ^b	
T	1.20 ± 0.06	1.15 ± 0.11	1.14 ± 0.10	0.83 ± 0.22	0.69 ± 0.07	0.64 ± 0.06	0.68 ± 0.03	0.90 ± 0.06 ^a	
Period mean ± SEM	1.26 ± 0.13	1.17 ± 0.07	1.17 ± 0.07	1.01 ± 0.10	0.96 ± 0.09	0.99 ± 0.10	1.01 ± 0.10	1.08 ± 0.04	>0.05
P value								<0.05	
Calcium (mg/dl)									
NC	10.12 ± 0.04	10.17 ± 0.08	10.04 ± 0.16	9.82 ± 0.10	10.08 ± 0.09	9.78 ± 0.17	10.06 ± 0.11	10.01 ± 0.05 ^b	
IC	10.32 ± 0.22	10.04 ± 0.10	9.82 ± 0.07	8.98 ± 0.05	8.81 ± 0.07	8.74 ± 0.09	8.70 ± 0.08	9.34 ± 0.13 ^a	
T	10.24 ± 0.24	10.18 ± 0.23	10.02 ± 0.13	9.98 ± 0.10	9.95 ± 0.15	9.62 ± 0.22	9.33 ± 0.42	9.90 ± 0.10 ^b	
Period mean ± SEM	10.23 ± 0.10 ^c	10.13 ± 0.08 ^{bc}	9.96 ± 0.07 ^{abc}	9.59 ± 0.14 ^{abc}	9.61 ± 0.18 ^{abc}	9.38 ± 0.16 ^a	9.36 ± 0.21 ^a	9.75 ± 0.06	<0.05
P value								<0.05	

Table 3 continued

Attribute	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90	Group mean ± pooled SE	P value
Phosphorus (mg/dl)									
NC	6.32 ± 0.25	6.48 ± 0.28	6.23 ± 0.23	6.14 ± 0.22	5.98 ± 0.14	5.86 ± 0.11	6.12 ± 0.29	6.16 ± 0.08	
IC	6.38 ± 0.19	6.27 ± 0.10	6.20 ± 0.12	6.12 ± 0.10	6.02 ± 0.08	5.88 ± 0.05	5.93 ± 0.04	6.11 ± 0.05	
T	6.41 ± 0.13	6.37 ± 0.11	6.34 ± 0.11	6.06 ± 0.18	5.80 ± 0.13	5.86 ± 0.12	5.92 ± 0.07	6.11 ± 0.06	
Period mean ± SEM	6.37 ± 0.10 ^c	6.37 ± 0.10 ^c	6.26 ± 0.09 ^{bc}	6.11 ± 0.09 ^{abc}	5.93 ± 0.07 ^{ab}	5.87 ± 0.05 ^a	5.99 ± 0.10 ^{ab}	6.13 ± 0.04	<0.05
P value								>0.05	
Glucose (g/dl)									
NC	51.38 ± 0.36	52.23 ± 0.53	53.84 ± 1.41	55.46 ± 1.95	52.38 ± 1.77	53.98 ± 1.76	54.18 ± 0.85	53.35 ± 0.52 ^b	
IC	52.08 ± 1.58	50.97 ± 1.60	52.41 ± 0.50	50.57 ± 0.22	49.21 ± 0.59	46.78 ± 1.29	43.93 ± 1.36	49.42 ± 0.67 ^a	
T	51.94 ± 2.00	52.54 ± 1.08	52.38 ± 0.75	53.47 ± 0.72	53.32 ± 0.40	52.78 ± 0.67	52.56 ± 0.93	52.71 ± 0.36 ^b	
Period mean ± SEM	51.80 ± 0.78	51.91 ± 0.64	52.88 ± 0.55	53.17 ± 0.87	51.64 ± 0.78	51.18 ± 1.17	50.22 ± 1.47	51.83 ± 0.36	>0.05
P value								<0.05	
Urea (mg/dl)									
NC	43.41 ± 0.51	43.08 ± 1.15	43.25 ± 0.86	41.90 ± 0.26	41.62 ± 1.50	41.27 ± 0.44	41.02 ± 0.70	42.22 ± 0.34 ^b	
IC	42.92 ± 2.52	44.13 ± 1.34	41.42 ± 1.54	42.37 ± 1.64	47.72 ± 0.21	44.60 ± 0.60	47.85 ± 0.57	43.86 ± 0.60 ^b	
T	43.21 ± 1.42	38.56 ± 0.49	35.76 ± 1.58	33.28 ± 1.06	31.47 ± 0.94	30.78 ± 1.13	29.84 ± 1.09	34.70 ± 0.94 ^a	
Period mean ± SEM	43.18 ± 0.89	41.92 ± 0.91	40.14 ± 1.20	39.18 ± 1.39	38.94 ± 1.70	38.88 ± 1.82	39.57 ± 2.28	40.26 ± 0.58	>0.05
P value								<0.05	

Means bearing different superscripts within a row differ significantly ($P < 0.05$)Means bearing different superscripts within a column differ significantly ($P < 0.05$)

infected lambs fed on diet with and without CT from *Acacia mearnsii* (Cenci et al. 2007).

Serum glucose levels differed significantly in IC and T groups while as there was no significant difference between NC and T. However, contrary to our observations, Cenci et al. (2007) reported no difference in blood glucose levels in GI nematode infected sheep with and without CT supplementation from *A. mearnsii*. Serum urea level is an indicator of protein degradation in rumen. The mean blood urea value (mg/dl) of NC was within the normal range (3.57–7.14 mmol/l or 21.44–42.88 mg/dl) for goats as reported by Kaneko et al. (1997). The lower level of serum urea in treatment group of goats may be attributed to the decreased rumen protein breakdown and increased essential amino acid absorption (Waghorn et al. 1987; Waghorn 1990). Lower serum urea concentration was reported in lambs given diets containing CT supplied through *Ficus infectoria* leaves at 1.5–2 % (Dey et al. 2006) and in kids fed leaves of *Prosopis cineraria* (Bhatta et al. 2000). The elevated level of urea in infected control indicated the poor utilization of absorbed N.

In conclusion, the present study revealed that the animals ingesting the CT-rich leaf meal mixture had increased levels of haemoglobin, packed cell volume, total protein, globulin, glucose and calcium, and decreased levels of blood urea; indicating a beneficial effect of CT supplementation at the selected level. However, the phosphorus balance, serum albumin levels and serum enzyme activity were not affected significantly. The study revealed that inclusion of CT in the diets of the adult male goats did not pose any threat to the health of the goats. Further, the CT based diet had beneficial impact on the haematological parameters and could therefore be included in small ruminant diets to minimize the impact of GIN.

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