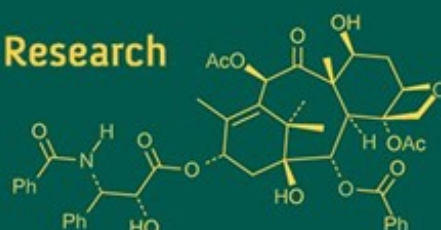
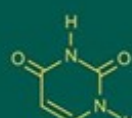


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Effect of dietary inclusion of babul pods (*Acacia nilotica*) in concentrate mixture on haemato-biochemical, rumen fermentation parameters and faecal egg count in growing Osmanabadi goats

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ABSTRACT

The study was conducted to evaluate the effect of dietary inclusion of babul pods (*Acacia nilotica*) at 15 and 25% in the concentrate mixture on haemato-biochemical parameters, rumen fermentation profile, and faecal egg count in growing Osmanabadi goats. Eighteen growing Osmanabadi goats aged 4–5 months with mean body weight of 12.95 ± 0.36 kg were assigned to three groups of six each: T_0 (control), T_1 (15% babul pods in concentrate), and T_2 (25% babul pods in concentrate), each receiving a total mixed ration of 50% jowar kadbi, 20% Hybrid Napier, and 30% concentrate for 90 days. Blood was collected monthly for haematological and serum biochemical analysis. Rumen liquor was collected 2 hours post-feeding at trial end, and faecal samples were processed by the McMaster technique for egg per gram count. Haemoglobin and packed cell volume remained within normal physiological range with non-significant differences across all groups. Serum total protein was significantly higher in T_2 than T_0 , while albumin, globulin, albumin-to-globulin ratio, blood urea nitrogen, and liver enzymes were non-significant and within normal limits. Total volatile fatty acids, titratable acidity, and total nitrogen in rumen liquor were significantly reduced in T_2 , while rumen pH remained unaffected. Faecal egg count was significantly and progressively reduced with increasing babul pod inclusion, with the 25% group recording the lowest count. Babul pods can be safely incorporated up to 25% in the concentrate mixture of growing Osmanabadi goats without adverse effects on blood health or liver function, while beneficially modulating rumen fermentation and reducing gastrointestinal parasitic load.

Keywords: *Acacia nilotica*, Babul pods, Faecal egg count, Haemato-biochemical parameters, Osmanabadi goats, Rumen fermentation

Introduction

Goat farming constitutes an integral component of smallholder livestock production in India, providing livelihood, meat, and milk to millions of farmers. Osmanabadi goats (*Capra hircus* Linnaeus), indigenous to the Marathwada region of Maharashtra, are a hardy, dual-purpose breed well-suited to agro-pastoral systems. Escalating costs of conventional feed ingredients and the increasing problem of gastrointestinal parasitism in small ruminants have collectively necessitated exploration of locally available, cost-effective, and bio-functionally beneficial alternative feed resources (Chaudhari *et al.*, 2022) [1]. Babul pods (*Acacia nilotica* Willd. ex Delile), a leguminous tree resource of arid and semi-arid India, contain moderate levels of condensed and hydrolysable tannins, which exhibit anthelmintic, antimicrobial, and protein-protection properties relevant to small ruminant health (Makkar, 2003) [2].

The haemato-biochemical status of ruminants is a critical indicator of metabolic health and nutritional adequacy. Tannin-containing diets can influence haemoglobin synthesis and serum protein levels through the protein protection effect of condensed tannins, which form stable protein-tannin complexes in the rumen, increasing the supply of ruminally undegraded protein to the small intestine (Parthasarathi *et al.*, 2018) [3]. Rumen fermentation is sensitive to dietary tannin levels; condensed tannins at moderate concentrations reduce total volatile fatty acid and ammonia nitrogen production and modify microbial community structure (Bhatta *et al.*, 2009; Rira *et al.*, 2019) [4, 5]. The anthelmintic properties of condensed tannins against gastrointestinal nematodes are well documented, with significant reductions in faecal egg count reported following supplementation with tannin-rich forages (Nguyen *et al.*, 2005; Max, 2010; Paswan *et al.*, 2016) [6, 7, 8]. However, data on the haemato-biochemical, rumen fermentation, and faecal egg count responses of the indigenous Osmanabadi breed to dietary babul pods are lacking. The present study was therefore undertaken to evaluate the effect of dietary inclusion of *Acacia nilotica* pods at 15 and 25% in the concentrate mixture on

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haemato-biochemical parameters, rumen fermentation profile, and faecal egg count in growing Osmanabadi goats.

Materials and methods

Experimental animals, site, and design

The experiment was conducted at the Department of Animal Nutrition, College of Veterinary and Animal Sciences (COVAS), Maharashtra Animal and Fishery Sciences University (MAFSU), Parbhani, Maharashtra, India during 2023–24 for 90 days following a 15-day acclimatization period. Eighteen growing Osmanabadi goats (9 males and 9 females, aged 4–5 months, mean initial body weight 12.95 ± 0.36 kg) were randomly allocated to three equal groups ($n = 6$ each; 3 males + 3 females) in a completely randomized design after anthelmintic treatment with albendazole (10 mg/kg body weight): T₀ – control total mixed ration without babul pods; T₁ – total mixed ration with 15% babul pods in concentrate; T₂ – total mixed ration with 25% babul pods in concentrate. Animals were individually housed. Ethical approval was obtained from the Institutional Animal Ethics Committee, COVAS, MAFSU, Parbhani.

Experimental diets and feeding management

Mature fallen pods of *Acacia nilotica* were shade-dried, ground with seeds using a Willey mill, and stored in airtight bags. Three isonitrogenous concentrate mixtures (Table 1) were formulated and supplied at 30% of the total mixed ration on an as-fed basis along with 50% jowar kadbi and 20% Hybrid Napier as per (ICAR) [9] norms. Crude protein of all concentrate mixtures was uniformly 21.60% on dry matter basis. Total mixed ration was offered twice daily with quantities adjusted fortnightly. Proximate composition was determined as per (AOAC) [10].

Haematological parameters

Blood samples (4 ml each) were collected by jugular venepuncture at monthly intervals (days 0, 30, 60, and 90). One ml was transferred into ethylene diamine tetraacetate vacuum tubes and the remaining 3 ml into clot activator tubes; serum was stored at -20°C . Haemoglobin was determined by the acid-hematin technique and packed cell volume by the Wintrobe microhaematocrit technique (Jain, 1986) [11].

Serum biochemical parameters

Serum total protein was estimated by the Biuret method (Kaneko, 1980) [12] at 578 nm. Albumin was measured by the bromocresol green endpoint method (Dumas *et al.*, 1971) [13] at 630 nm. Globulin was calculated by subtraction. Blood urea nitrogen was analysed by the Berthelot method (Kaneko *et al.*, 2008) [14]. Aspartate aminotransferase and alanine aminotransferase were estimated using a semi-automatic biochemical analyser and expressed as IU/l.

Rumen fermentation parameters

Approximately 75 ml of rumen liquor was collected 2 h post-feeding at trial end using a hand suction pump and Ryle's stomach tube. Rumen pH was measured immediately with a digital pH meter. Total volatile fatty acids were estimated by Markham's steam distillation (Barnett *et al.*, 1957) [15] and expressed as mEq/100 ml. Titratable acidity was estimated as per (Rosenberger) [16]. Total nitrogen was estimated by micro-Kjeldahl method (AOAC, 2023) [10] and expressed as mg/100 ml.

Faecal egg count

Fresh faecal samples were collected directly from the rectum at monthly intervals and processed by the McMaster floatation technique. Eggs counted under one chamber were multiplied by 100, or two chambers by 50, to obtain the egg per gram value.

Statistical analysis

Data were analysed by one-way analysis of variance in a completely randomized design as per (Snedecor and Cochran) [17]. Significance was considered at $p < 0.05$.

Results and discussion

Proximate composition of feedstuffs and total mixed rations

The proximate composition of babul pods (*Acacia nilotica*) on dry matter basis was: dry matter 93.16%, organic matter 95.64%, crude protein 16.60%, ether extract 4.21%, crude fibre 15.10%, nitrogen-free extract 59.73%, and total ash 4.36% (Table 2). All three concentrate mixtures were isonitrogenous (crude protein 21.60% dry matter) and the three total mixed rations showed comparable composition (crude protein uniformly 11.30% dry matter), confirming that observed treatment differences were attributable to babul pod inclusion and associated tannins rather than differential nutrient supply.

Haematological parameters

The haemoglobin and packed cell volume values of growing Osmanabadi goats are presented in Table 3. The overall mean haemoglobin for T₀, T₁, and T₂ were 10.51 ± 0.22 , 10.59 ± 0.21 , and 10.73 ± 0.20 g/dl, respectively, with non-significant ($p > 0.05$) differences. At all monthly intervals, haemoglobin values remained within the normal physiological range of 8–14 g/dl for goats. Similarly, the overall mean packed cell volume for T₀, T₁, and T₂ were 30.37 ± 0.27 , 30.47 ± 0.27 , and $30.70 \pm 0.32\%$, respectively, with non-significant ($p > 0.05$) differences, all within the normal range of 22–38%.

Maintenance of haemoglobin and packed cell volume within normal limits indicates that dietary tannins at these levels did not adversely affect erythropoiesis or iron utilization. (Mousa) [18] reported similar findings in Awassi lambs fed *Acacia* at up to 40%. (Paswan *et al.*) [19] found only slight, non-significant effects on haemoglobin in Black Bengal kids fed babul pod meal. (Dey *et al.*) [20] similarly reported that haemoglobin and packed cell volume remained similar across dietary groups in lambs supplemented with condensed tannins from *Ficus infectoria* (Roxb.) leaves. The numerically higher haemoglobin and packed cell volume in T₂ may reflect greater erythrocyte stability due to the antioxidant properties of polyphenolic compounds in babul pods (Olafadehan, 2011) [21].

Serum biochemical parameters

The monthly serum biochemical values are presented in Table 4. Serum total protein showed a significant ($p < 0.05$) increase in T₂ at all monthly intervals and in the overall mean (T₀: 6.31 ± 0.06 ; T₁: 6.70 ± 0.06 ; T₂: 6.89 ± 0.05 g/dl), with T₂ significantly higher than T₀ and T₁ intermediate. This elevation is consistent with the protein-protection mechanism of condensed tannins, which form stable protein-tannin complexes in the rumen, reducing microbial degradation of dietary protein and increasing the supply of ruminally undegraded protein to the small intestine (Makkar, 2003) [2]. (Parthasarathi *et al.*) [3] reported significantly ($p < 0.05$) higher serum total protein in Deccani ram lambs fed tanniferous diets, and (Uguru *et al.*) [22] noted significant ($p < 0.05$) differences in serum total protein in Red Sokoto goats fed *Acacia nilotica* pods.

Serum albumin levels were 3.52 ± 0.07 , 3.52 ± 0.06 , and 3.61 ± 0.04 g/dl for T₀, T₁, and T₂, respectively, with non-significant ($p > 0.05$) differences, all within the normal range of 2.4–3.8 g/dl. Globulin values (T₀: 2.80 ± 0.07 ; T₁: 3.18 ± 0.09 ; T₂: 3.27 ± 0.05 g/dl) showed non-significant ($p > 0.05$) differences. The albumin:globulin ratio values were 1.28 ± 0.05 , 1.13 ± 0.04 , and 1.11 ± 0.02 for T₀, T₁, and T₂, respectively ($p > 0.05$), within normal limits. Blood urea nitrogen values (T₀: 16.53 ± 0.32 ; T₁: 16.39 ± 0.39 ; T₂: 16.20 ± 0.35 mg/dl; $p > 0.05$) showed a declining trend, indicating that condensed tannins facilitated greater tissue-level nitrogen utilization and reduced ruminal ammonia absorption (Olafadehan, 2011) [21]. Serum glutamic oxaloacetic transaminase (T₀: 41.38 ± 0.57 ; T₁: 42.01 ± 0.47 ; T₂: 42.27

± 0.63 IU/l) and serum glutamic pyruvate transaminase (T_0 : 20.60 ± 0.56 ; T_1 : 21.18 ± 0.61 ; T_2 : 21.62 ± 0.46 IU/l) were non-significant ($p > 0.05$) and within normal limits, confirming the absence of hepatotoxic effects at these dietary levels (Mousa, 2011; Paswan *et al.*, 2017) [18, 19].

Rumen fermentation parameters

The rumen fermentation data are presented in Table 5. Total volatile fatty acid concentrations for T_0 , T_1 , and T_2 were 16.23 ± 0.41 , 15.27 ± 0.67 , and 13.79 ± 0.69 mEq/100 ml, respectively, with T_2 significantly ($p < 0.05$) lower than T_0 . Titratable acidity (T_0 : 19.36 ± 0.61 ; T_1 : 18.36 ± 0.63 ; T_2 : 16.12 ± 0.53) was significantly ($p < 0.05$) reduced in T_2 compared to both T_0 and T_1 . Total nitrogen was significantly ($p < 0.05$) lower in T_2 (74.04 ± 1.37 mg/100 ml) than in T_0 (80.74 ± 1.01). Rumen pH (T_0 : 6.16 ± 0.05 ; T_1 : 6.26 ± 0.07 ; T_2 : 6.40 ± 0.10) showed a consistent increasing trend but non-significant ($p > 0.05$) differences, all values within the normal range of 5.5–7.5 for ruminants.

The significant reductions in total volatile fatty acids and titratable acidity in T_2 are consistent with the inhibitory effect of condensed tannins on rumen microbial fermentation (Bhatta *et al.*, 2009) [4]. (Rira *et al.*) [5] reported that hydrolysable tannins from *Acacia nilotica* pods significantly ($p < 0.05$) reduced total volatile fatty acid production. The significant reduction in total nitrogen reflects condensed tannin-mediated inhibition of rumen proteolysis and deamination, reducing ammonia nitrogen production (Yang *et al.*, 2016; Ebong, 1995) [23, 24]. The maintenance of normal rumen pH across all groups confirms that tannin content at these inclusion levels did not disrupt rumen buffering capacity, in agreement with (Santra and Karim) [25].

Faecal egg count

The faecal egg per gram values are presented in Table 6. The overall mean egg per gram values for T_0 , T_1 , and T_2 were 383.33 ± 52.70 , 266.67 ± 27.89 , and 141.67 ± 23.86 , respectively. A significant ($p < 0.05$) and progressive reduction was observed with increasing babul pod inclusion, with all three groups differing significantly ($T_0 > T_1 > T_2$), and T_2 achieving a 63.04% reduction compared to the control.

The significant reduction in faecal egg per gram is attributed to the anthelmintic properties of condensed tannins, which precipitate infective larvae of gastrointestinal nematodes, inhibit larval development and exsheathment, impair establishment of adult worms, and reduce worm fecundity (Nguyen *et al.*, 2005) [6]. (Paswan *et al.*) [8] reported significant ($p < 0.01$) reduction in egg per gram in goats fed *Acacia nilotica* pod meal. (Max) [7] observed significant ($p < 0.01$) reductions in faecal egg counts in sheep and goats supplemented with tannin-containing plants. The anthelmintic effect is particularly valuable

given increasing anthelmintic drug resistance among *Haemonchus contortus* in small ruminants in India (Paswan *et al.*, 2017) [19]. In contrast, (Kahiya *et al.*) [26] found non-significant reductions in goats fed 40% *Acacia nilotica* leaves, likely due to differences in tannin form and nematode species involved.

Conclusion

The dietary inclusion of babul pods at 15 and 25% in the concentrate mixture of growing Osmanabadi goats did not adversely affect haematological parameters or hepatic safety markers, all of which remained within normal physiological limits throughout the trial. Serum total protein was significantly improved in the 25% inclusion group, indicating enhanced bypass protein utilization mediated by the protein-protection properties of condensed tannins. Rumen fermentation was modulated in a dose-dependent manner, with significant reductions in total volatile fatty acid production, titratable acidity, and total nitrogen without disruption of rumen pH, while a significant, progressive reduction in faecal egg count demonstrated meaningful anthelmintic activity. These findings collectively support the safe and beneficial incorporation of babul pods up to 25% in the concentrate mixture of growing Osmanabadi goats, with particular implications for sustainable parasite management and improvement of protein nutrition in smallholder goat production systems.

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Conflict of interest

The authors declare that they have no conflict of interest related to this work.

Authorship contribution statement

S. D. Nagre: conceptualization, experimental design, field work, data collection, laboratory analysis, data interpretation, and preparation of manuscript. S. M. Wankhede: supervision, guidance, and critical review. V. K. Munde: supervision and advisory support. T. K. Rathod: assistance in field work and data collection. A. B. Patil: statistical analysis, data interpretation, and manuscript revision.

Tables

Table 1. Percent ingredient composition of concentrate mixtures

Sr. No.	Ingredients	Conc. I (T_0)	Conc. II (T_1)	Conc. III (T_2)
1	Maize	30	30	35
2	Soybean meal	27	30	30
3	Babul pod meal	—	15	25
4	Gram remnant	35	18	4
5	Jowar remnant	5	4	3
6	Mineral mixture	2	2	2
7	Common salt	1	1	1
	Total	100	100	100

Table 2. Proximate composition of babul pods (*Acacia nilotica*) and total mixed rations (% dry matter basis)

Nutrient parameter	Babul pods	TMR T_0	TMR T_1	TMR T_2
Dry matter	93.16	58.64	58.68	58.76
Organic matter	95.64	91.16	91.12	91.13

(continued on next page)

Nutrient parameter	Babul pods	TMR T ₀	TMR T ₁	TMR T ₂
Crude protein	16.60	11.30	11.30	11.30
Ether extract	4.21	3.26	3.28	3.32
Crude fibre	15.10	24.15	24.18	24.22
Nitrogen-free extract	59.73	52.03	52.09	52.12
Total ash	4.36	9.26	9.15	9.04

TMR = total mixed ration

Table 3. Effect of dietary inclusion of babul pods (*Acacia nilotica*) on haematological parameters in growing Osmanabadi goats (Mean $\pm$ SE)

Parameter	Day	T ₀	T ₁	T ₂	p-value
Haemoglobin (g/dl)	0	10.54 $\pm$ 0.52	10.61 $\pm$ 0.54	10.69 $\pm$ 0.43	0.979
	30	10.50 $\pm$ 0.47	10.58 $\pm$ 0.46	10.71 $\pm$ 0.45	0.950
	60	10.52 $\pm$ 0.48	10.59 $\pm$ 0.48	10.66 $\pm$ 0.48	0.979
	90	10.49 $\pm$ 0.52	10.58 $\pm$ 0.46	10.87 $\pm$ 0.48	0.850
	Overall mean	10.51 $\pm$ 0.22	10.59 $\pm$ 0.21	10.73 $\pm$ 0.20	–
Packed cell volume (%)	0	30.29 $\pm$ 0.74	30.38 $\pm$ 0.57	30.69 $\pm$ 0.66	0.902
	30	30.25 $\pm$ 0.52	30.34 $\pm$ 0.60	30.47 $\pm$ 0.71	0.967
	60	30.46 $\pm$ 0.48	30.57 $\pm$ 0.63	30.92 $\pm$ 0.76	0.873
	90	30.50 $\pm$ 0.62	30.61 $\pm$ 0.66	30.73 $\pm$ 0.64	0.968
	Overall mean	30.37 $\pm$ 0.27	30.47 $\pm$ 0.27	30.70 $\pm$ 0.32	–

Table 4. Effect of dietary inclusion of babul pods (*Acacia nilotica*) on serum biochemical parameters in growing Osmanabadi goats (Mean $\pm$ SE)

Parameter	Day	T ₀	T ₁	T ₂	p-value
Total protein (g/dl)	0	6.30 $\pm$ 0.14 ^a	6.70 $\pm$ 0.18 ^{ab}	6.91 $\pm$ 0.14 ^b	0.044
	30	6.36 $\pm$ 0.11 ^a	6.73 $\pm$ 0.14 ^{ab}	6.89 $\pm$ 0.12 ^b	0.027
	60	6.32 $\pm$ 0.14 ^a	6.70 $\pm$ 0.14 ^{ab}	6.89 $\pm$ 0.09 ^b	0.020
	90	6.29 $\pm$ 0.12 ^a	6.69 $\pm$ 0.15 ^{ab}	6.88 $\pm$ 0.13 ^b	0.022
	Overall mean	6.31 $\pm$ 0.06 ^a	6.70 $\pm$ 0.06 ^{ab}	6.89 $\pm$ 0.05 ^b	–
Albumin (g/dl)	Overall mean	3.52 $\pm$ 0.07	3.52 $\pm$ 0.06	3.61 $\pm$ 0.04	–
Globulin (g/dl)	Overall mean	2.80 $\pm$ 0.07	3.18 $\pm$ 0.09	3.27 $\pm$ 0.05	–
AG ratio	Overall mean	1.28 $\pm$ 0.05	1.13 $\pm$ 0.04	1.11 $\pm$ 0.02	–
BUN (mg/dl)	Overall mean	16.53 $\pm$ 0.32	16.39 $\pm$ 0.39	16.20 $\pm$ 0.35	–
SGOT (IU/l)	Overall mean	41.38 $\pm$ 0.57	42.01 $\pm$ 0.47	42.27 $\pm$ 0.63	–
SGPT (IU/l)	Overall mean	20.60 $\pm$ 0.56	21.18 $\pm$ 0.61	21.62 $\pm$ 0.46	–

Means with different superscripts (a, ab, b) in a row differ significantly ($p < 0.05$). AG = albumin:globulin; BUN = blood urea nitro-

gen; SGOT = serum glutamic oxaloacetic transaminase; SGPT = serum glutamic pyruvate transaminase

Table 5. Effect of dietary inclusion of babul pods (*Acacia nilotica*) on rumen fermentation parameters in growing Osmanabadi goats (Mean $\pm$ SE)

Parameter	T ₀	T ₁	T ₂	p-value
TVFA (mEq/100 ml)	16.23 $\pm$ 0.41 ^a	15.27 $\pm$ 0.67 ^{ab}	13.79 $\pm$ 0.69 ^b	0.037
Titrate acidity	19.36 $\pm$ 0.61 ^a	18.36 $\pm$ 0.63 ^a	16.12 $\pm$ 0.53 ^b	0.005
pH	6.16 $\pm$ 0.05	6.26 $\pm$ 0.07	6.40 $\pm$ 0.10	0.055
Total nitrogen (mg/100 ml)	80.74 $\pm$ 1.01 ^a	79.03 $\pm$ 0.98 ^a	74.04 $\pm$ 1.37 ^b	0.002

Means with different superscripts (a, ab, b) in a row differ significantly ($p < 0.05$). TVFA = total volatile fatty acids

Table 6. Effect of dietary inclusion of babul pods (*Acacia nilotica*) on faecal egg count (eggs per gram) in growing Osmanabadi goats (Mean $\pm$ SE)

Parameter	T ₀	T ₁	T ₂	p-value
EPG (overall mean)	383.33 $\pm$ 52.70 ^a	266.67 $\pm$ 27.89 ^b	141.67 $\pm$ 23.86 ^c	0.001

Means with different superscripts (a, b, c) differ significantly ($p < 0.05$). EPG = eggs per gram of faeces

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