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Nutritional evaluation of cowpea, mung bean and cluster bean fodders in Barbari male adult goats

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ABSTRACT

This study evaluated the nutritive value of cowpea (*Vigna unguiculata*), mung bean (*Vigna radiata*) and cluster bean (*Cyamopsis tetragonoloba*) fodders in goats, fed during monsoon season in semi-arid tropics of India. Crops were grown as rain-fed on sandy loam soil fields and green biomass was harvested daily from flowering to pod formation stage. Barbari male (n=18) adult goats were divided into three equal groups with 5 animals in each and fed daily with one of the three crop fodders *ad lib.* followed by nutrient balance trial after 25 days of initiation feeding. Crude protein content of the three fodders varied from 12.90 to 18.80% during the experiment. Dry matter intake and digestibility of dry matter, acid detergent fibre and total carbohydrates were similar among three fodders; whereas, digestibility of organic matter, crude protein, neutral detergent fibre and hemicellulose were significantly different and found to be higher in cowpea fodder compared to other fodders. The total digestible nutrients (TDN) content was similar, but digestible crude protein (DCP) content was greater in cowpea (*Vigna unguiculata*), followed by cluster bean (*Cyamopsis tetragonoloba)* and mung bean (*Vigna radiata)*. Intake of TDN and DCP followed the trend of TDN and DCP content of the fodders. The nitrogen balance (g/kg $W^{0.75}$) increased marginally in cowpea fodder fed goats than other treatments. Rumen fluid *p*H and ammonia nitrogen (mg/dl) were enhanced in cluster bean (6.8 and 30.5 mg) followed by cowpea and mung bean; whereas total-nitrogen, tricarboxylic acid precipitable nitrogen (TCA-ppt-N) and total volatile fatty acids (TVFA) were similar among three fodders. Blood haemato-biochemical attributes were not affected by the three fodders, except plasma urea concentration (mg/dl) which was greater in cowpea fed goats compared to other treatments. From this study, it was found that TDN (%), DCP (%) and ME (Mcal/kg feed DM) contents of tested fodders can form a baseline data for goat ration formulation.

Keywords: Cluster bean, Cowpea, Fodder, Goat, Mung bean, Nutritive value

Goats contribute significantly to the agrarian economy and play a vital role in the livelihood and nutritional security of small and marginal farming communities in several countries (Devendra 2013) and were recommended for rearing in the arid and semi-arid regions (Aboul-Naga *et al.* 2014). The shortage of cultivated green forage and a decline in free rangeland resources decreased the availability of essential nutrients to the animals in India (Singh *et al*. 2022). However, the higher human population growth in developing countries has increased pressure on the community pasturelands.

Several investigators have recommended for cultivation of drought tolerant fodders/ grasses and legumes (Sorghum, Pearl Millet, Sudan grass, Alfalfa, and Sainfoin) for meeting the gap of feed production in arid and semi-arid areas of the World (Hanafy *et al*. 2007, Fahmy *et al.* 2010, Tripathi *et al.* 2014). The increasing consumer demands for healthier foods of animal origin have created further requirements of grass and fodders-based animal feeding strategies as the concentrate feeds increased the levels of saturated fatty acids with the decrease in conjugated linoleic acid contents (Lee *et al*. 2008, Tripathi *et al.* 2014). At present, consumers are demanding animal products containing healthier attributes and the feeding system based on fodder and grass for goat production. Furthermore, Kanani *et al.* (2006) recommended that forage legumes could be a valuable source of supplementary protein to poorer quality grass-based diets fed to goats. This is particularly important in most developing countries of the tropics where concentrate feeds are cost-prohibitive. Generally, cowpea plants and their by-products are important for cheaper protein-based human and animal diets for developing countries' livelihoods (Abebe and Alemayehu 2022). Cowpea (*Vigna unguiculata*) can thrive in arid environments with soil that contains up to 85% sand (Obatolu 2003) and this crop can also be used as livestock feed. Cluster bean (Guar)

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is a deep-rooted summer annual legume that needs a hot climate and has a high tolerance to drought (Garg and Burman 2002), salinity (Francois *et al*. 1990, Ashraf *et al*. 2005) and a good capability to fix atmospheric nitrogen. Mung bean (*Vigna radiata*), an important short-duration legume crop grown in India, is quite a versatile crop that can be grown for seeds, green manure and forage crop (Singh *et al*. 2021). Mung bean forage could supply an adequate amount of nutrients to support adult maintenance in sheep (Garg *et al.* 2004). Dutta *et al.* (2022) observed that three legume straw-based (cowpea or cluster bean or lablab) diets behaved almost similarly on rumen fermentation pattern and on intakes of DM, DCP, TDN, N-balance and growth performance in weaned Barbari kids.

The use of forage legumes could constitute a sustainable practice that can improve goat performance, enhance food security and increase income for the sustenance of farm families. The information on the nutritive value of fodder variety cowpea (*Vigna unguiculata*), mung bean (*Vigna radiata*) and cluster bean (*Cyamopsis tetragonoloba*) are very marginal for formulation of rations for goat feeding purposes. Therefore, the present study aimed to evaluate the effect of feeding three legume fodders (cowpea, mung bean and cluster bean) on nutritional value, rumen fermentation, haematology and blood parameters in Indian goat.

MATERIALS AND METHODS

Animals and feeding: Three legume fodder crops (cowpea-*Vigna unguiculata*, mung bean-*Vigna radiata* and cluster bean-*Cyamopsis tetragonoloba*) were cultivated on loamy sand soil during monsoon season and harvested as green fodder from flowering to pod formation stage. Agronomical practices were identical for the three crops. Eighteen healthy Barbari male adult goats (weight 31.70±0.89 kg) were divided into three equal groups (T_1, T_2 and T_3). The animals were dewormed at the beginning of the experiment. The experimental goats were vaccinated against *Peste des petits* (PPR), goat pox, enterotoxaemia, foot and mouth disease (FMD) and haemorrhagic septicaemia (HS) as per the standard Institute's schedule. Above cultivated green fodder was offered *ad lib.* daily at 10:00 AM and 4.00 PM to the goats of respective groups (T_1-cowpea, T_2-mung bean, T_3-cluster bean). Animals were penned in well-ventilated individual metallic enclosures and clean drinking water was made available to all goats during the experimental period. The amount of feed that the adult goat ate was measured daily using a double pan balance (Avery, India).

Metabolism study: A metabolism trial of 10 days (3 days adaptation in metabolism crates followed by 7 days of sample collection) duration was carried out on 26th day of feeding on all animals. Daily intake of fodder was recorded; and faeces and urine output of 24 h were collected. Samples of feeds, residues, faeces and urine were collected every morning. The DM of fodders, faeces and orts was determined by drying to a constant weight in a hot air oven at 70°C. Dried samples for each day of the 7 days collection were pooled, ground to pass a 1 mm screen and preserved for chemical analysis. For nitrogen estimation, samples of faeces (1/1000 of fresh faeces voided/day) and urine (1/100 of fresh urine excreted/day) from individual animals were collected every morning in a 500 ml flask containing 25 ml of concentrated sulphuric acid.

Rumen fermentation: Samples of rumen fluid (50 ml) were withdrawn from all intact animals at 4 h post-feeding using a stomach tube at the end of experiment as described by Prakash *et al*. (2006). Each sample was placed in a 100 mL glass jar and the *p*H was determined using a portable electronic *p*H meter within 4 to 5 min of sampling. Thereafter, rumen fluid was strained with four layers of muslin cloth, a few drops of saturated mercuric chloride were added to arrest microbial activity and stored at -20°C for further analysis. The total N in strained rumen liquor (SRL) was determined using Kjeldahl technique (AOAC 1990), total volatile fatty acids (TVFA) was determined according to Barnett and Reid (1957) procedure, ammonia nitrogen by Conway (1962) method, while TCA-precipitable-N was determined by following the procedure of Tagari *et al*. (1964).

Haemato-biochemical study: Blood samples were collected once at the end of the feeding experiment. Samples were drawn by puncture of jugular vein in EDTA-impregnated tubes for haematology and biochemical study. Haematological observations namely, haemoglobin (Hb), hematocrit, red blood cells, white blood cells, platelets, lymphocytes, monocytes and mean corpuscular haemoglobin concentration were determined in whole blood immediately after blood collection using automated blood analyzer (Nihon Kohden, Japan) dedicated for goat haematology. Plasma was separated from the same anticoagulant containing blood samples which were centrifuged for 10 min at 1,000-2,000 ×g using a refrigerated centrifuge and separated plasma was stored at -20°C until analyses. Plasma protein, albumin and urea were determined using commercial diagnostic kits (Span Diagnostics Ltd. Surat, India).

Chemical analysis: Feed, refusals and faecal samples were analyzed for DM by drying at 70°C until constant weight. Organic matter was determined by ashing at 550°C for 4 h (AOAC 1990) and crude protein was estimated by Kjeldahl technique (N×6.25, AOAC 1990). Total carbohydrate (TCHO) was calculated using the formula:

$$TCHO\% = OM\% - CP\% - EE\%$$

The procedure of Van Soest *et al.* (1991) was used for neutral detergent fibre (NDF) determination; whereas, acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to the method of Robertson and Van Soest (1981). Hemicellulose was calculated by the difference method (NDF-ADF). Total crude fat was estimated by solvent extraction procedure (AOAC 1990) with petroleum ether by a Soxhlet's apparatus. The digestible energy (DE) value (Mcal/kg DM) of fodder was evaluated according to NRC (2001):

DE (Mcal/kg of feed) = 0.04409 × TDN (%)

The metabolizable energy (ME) value (Mcal/kg DM) of test fodders was calculated using the formula (Ibidhi *et al*. 2021):

ME (Mcal/kg of feed) = 0.9215 × DE - 0.1434

Statistical analysis: Results of intake, nutrient utilization, rumen fermentation and blood biochemical parameters were subjected to statistical significance tests using a general linear model for one-way analysis of variance (ANOVA) (Snedecor and Cochron 1994). The ANOVA was performed using the computerized IBM SPSS 20.0 package.

The mathematical model used was:

$$Y_{ijk} = \mu + T_i + e_{ij}$$

where, Y_{ijk}, Observation mean; μ, General mean, T_i, Effect of i^{th} fodder (i = 1, 2, 3); e_{ij}, Random error.

The observations were declared significant by applying Tukey's HSD test when P-values were P<0.05 or P<0.01or P<0.001 and the tendency at 0.05<P<0.10.

RESULTS AND DISCUSSION

Chemical composition: Mung bean (*Vigna radiata*) fodder contained relatively lower CP (12.88%) than in cowpea (*Vigna unguiculata*) (18.80%) and cluster bean (*Cyamopsis tetragonoloba*) (17.13%). However, mean NDF, ADF and hemicellulose were almost similar among the three leguminous fodders (Table 1). Crude fat content was greater in cluster bean fodder followed by mung bean and cowpea fodders. However, total carbohydrate was highest in mung bean fodder and lowest in cowpea fodder.

Table 1. Chemical composition (g/100 g) of cowpea, mung bean and cluster bean green fodders

	Leguminous fodder crops		
	V. unguiculata (T_1)	*V. radiata* (T_2)	*C. tetragonoloba* (T_3)
Dry matter	20.60	29.60	25.84
Organic matter	86.87	90.18	91.21
Crude protein	18.80	12.88	17.13
Crude fat	2.29	2.41	2.52
TCHO[1]	66.49	74.89	71.55
NDF[2]	44.86	43.66	46.95
ADF[3]	33.41	32.34	35.49
Hemicellulose	11.44	11.39	11.46

[1], Total carbohydrates; [2], Neutral detergent fibre; [3], Acid detergent fibre.

Differences in chemical composition and proteolytic potential of fodders affect the content of fermentation products and products of protein degradation (McDonald *et al*. 1991) and that in turn, influences the mechanism of intake regulation and consequently leads to enhanced ruminant performance. Each tested fodder had sufficient quantity of CP (averaged 16%), which may support the protein requirements as recommended by Kearl (1982) and 2.4% mean crude fat and lower concentrations of NDF and ADF could support the energy requirement of such goats. Cowpea leaves (fresh and dry) and green pods provide greater levels of protein, carbohydrates, lipids, vitamins, dietary fibres, minerals, polyunsaturated fatty acids and other nutrients (Abebe and Alemayehu 2022). Earlier, El-Salam *et al.* (2013) also reported that mung bean varieties generally produce fodder with greater CP, ash and TDN; but, lower in content of CF and nitrogen free extract compared with fodder maize. Guar, in general, is high-quality leguminous forage crop, that could supply relatively higher protein and low fibre feed to the ruminants, especially when harvested at an early stage (Salama and Nawar 2016). Differences in chemical constituents of fodders could be due to the genotypic variations of plants; therefore, observed variations in the present study were attributed to the different species of legume fodders.

Intake, digestibility and nutritive value: Dry matter

Table 2. Voluntary intake and digestibility of different nutrients in goats fed various leguminous fodders

Parameter	T_1	T_2	T_3	P-value
Body weight (kg)	30.99±1.34	31.87±1.69	32.13±1.85	0.879
Dry matter intake				
g/day	873.34±41.02	926.70±61.97	794.62±39.04	0.182
kg/100 kg BW	2.82±0.10	2.94±0.22	2.49±0.10	0.118
g/kg $BW^{0.75}$	66.55±2.22	69.49±4.65	59.04±1.91	0.087
Apparent digestibility coefficient (%)				
DM	61.86±1.34	52.9±2.36	51.24±2.34	0.061
OM	65.37^{b}±1.12	56.59^{a}±2.13	60.91^{ab}±2.93	0.040
CP	68.88^{b}±1.65	55.03^{a}±2.48	62.21^{ab}±3.33	0.006
EE	71.56±3.78	66.54±2.68	71.03±4.22	0.572
TCHO	64.20±0.96	56.54±2.19	59.14±3.07	0.080
NDF	55.24^{b}±1.54	43.05^{a}±3.42	48.78^{ab}±3.97	0.048
ADF	48.99±2.66	38.96±3.17	45.54±4.24	0.143
Hemicellulose	73.52^{b}±3.61	54.73^{a}±4.90	58.83^{ab}±4.24	0.018

*Values with different superscripts along row differ significantly (P<0.05, P<0.01). T_1: *V. unguiculata,* T_2: *V. radiata*, T_3: *C. tetragonoloba*. DM, Dry matter; OM, Organic matter; CP, Crude protein; EE, Ether extract; TCHO, Total carbohydrate; NDF, Neutral detergent fibre; ADF, Acid detergent fibre.

intake (g/d/goat, kg/100 kg BW and g/kg $W^{0.75}$) was estimated to be similar (Table 2) among the three fodders and mean dry matter intake was estimated 2.74% of live weight. Digestibility of DM, crude fat, ADF and total carbohydrate were also similar among the three treatments; whereas, OM, NDF and hemicelluloses digestibility were greater ($P<0.05$) in T_1 compared to T_2, but was comparable to T_3. The CP digestibility also followed a similar trend ($P<0.01$). Total digestible nutrients (TDN) content and intakes were similar among the three legume forages, whereas digestible crude protein (DCP) content and intake (g/kg $W^{0.75}$) were greater ($p<0.001$) in *Vigna unguiculata* (12.45% and 8.28 g) followed by *Cyamopsis tetragonoloba* (10.34% and 6.25 g) and *Vigna radiata* (7.08% and 4.99 g) (Table 3). However, N balance (g/d/goat and g/kg $W^{0.75}$) was statistically non-significant (P=0.072 and P=0.073) among three treatments. Digestible NDF intake was observed with no difference among tested legume fodders. Similarly, the sole feeding of three legume fodders to adult goats did not differ intakes of digestible energy (DE) and metabolizable energy (ME); and DE and ME values of such fodders (Table 3).

Mean DMI of 2.74% of the live weight of goats in this study indicated that the fodders were of adequate quality in meeting the nutrients requirement of goats at maintenance and even can support partially the nutrient needs of growing goats. The tested fodders had CP levels more than 12.80%, which was enough to meet protein requirements (Kearl 1982) and was above the critical CP levels of 8% reported for ruminant feeds, being adequate to maintain the rumen microbial activity. Similarly, CP intake in all treatments met the requirement as recommended by NRC (2007). Although protein content and proteolytic potential of feeds influence the mechanism of intake regulation through protein degradation products (McDonald *et al*. 1991), fodders fed to goats had CP levels above the critical levels, hence intake was not affected and was similar among the three fodders. Therefore, apart from nitrogen, ruminants can obtain sufficient amount of energy from these fodders. The greater amount of DCP in cowpea was influenced by relatively higher crude protein content and resulted in enhanced N balance in T_1. However, similar TDN levels of test fodders were due to low levels of cell wall contents and similar digestibility of DM, crude fat and total carbohydrates. Cowpea fodder is rich in protein and easily digestible by ruminants (Anele *et al*. 2011). Three forages had NDF content lower than 600 g/kg DM, beyond which DM intake is known to be limited due to rumen fill (Mertens 1994). However, the NDF values for the test fodders ranged between 43.66-46.95%. Feeding of cowpea hay to lambs supplemented with barley grain resulted in positive growth rate (Singh *et al*. 2010). In Zimbabwe,

Table 3. Availability of different nutrients and N-balance in goats fed various leguminous fodders

Parameter	T_1	T_2	T_3	P-value
Total Digestible Nutrients intake (TDNI)				
TDNI (g)/d/kid	513.47±24.66	495.11±45.30	449.84±20.06	0.374
TDNI (g/kg $W^{0.75}$)	39.15±1.50	37.17±3.59	33.50±1.30	0.263
Digestible Crude Protein intake (DCPI)				
DCPI (g)/d/kid	108.55^b±4.90	66.28^a±6.59	83.90^a±2.98	<0.001
DCPI (g/kg $W^{0.75}$)	8.28^b±0.33	4.99^a±0.55	6.25^a±0.18	<0.001
Digestible NDF intake (DNDFI)				
DNDFI (g)/d/kid	483.18±28.88	404.70±51.03	383.95±26.04	0.170
DNDFI (g/kg $W^{0.75}$)	36.82±1.81	30.44±4.15	28.55±1.69	0.123
Digestible Energy (DE) intake				
DE intake, (Mcal/d/kid)	2.26±0.11	2.18±0.20	1.98±0.09	0.374
DE intake (Mcal/kg $W^{0.75}$)	0.17±0.01	0.16±0.02	0.15±0.01	0.263
Metabolizable Energy (ME) intake				
ME intake, (Mcal/d/kid)	1.94±0.10	1.87±0.18	1.68±0.08	0.261
ME intake (Mcal/kg $W^{0.75}$)	0.15±0.01	0.14±0.01	0.13±0.01	0.188
Nutritive value of feed				
TDN%	58.82±1.04	53.03±1.96	54.88±1.21	0.162
DCP%	12.45^c±0.29	7.08^a±0.31	10.34^b±0.26	<0.001
DE (Mcal/kg feed DM)	2.59±0.05	2.34±0.09	2.51±0.12	0.162
ME (Mcal/kg feed DM)	2.22±0.04	2.00±0.07	2.13±0.11	0.188
Nitrogen (N) balance				
N balance (g/d/goat)	6.91±1.12	3.24 ± 0.81	5.27 ± 1.07	0.072
N balance (g/kg $W^{0.75}$)	0.52±0.08	0.25±0.07	0.41±0.08	0.073

cowpea hay was used as a supplement (30% of the diet) to increase ME intake and microbial protein supply in lambs offered maize stover (Chakeredza *et al*. 2002). In goats, cluster bean hay (prepared at pod formation) gave similar intake and digestibility of nutrients to the mixture of guar hay and crushed oats (Pachauri and Upadhyay 1986). Cluster bean fodder had high relative feed value (RFV) and relative forage quality (RFQ) which makes it suitable for the high-producing dairy cows and young calves (Salama and Nawar 2016). Partial replacement of concentrate feed with cluster bean silage or hay had positive impacts on improving some metabolic profile and reproductive performance in Zaraibi does (Mohamed *et al*. 2020). Increasing the proportion of alfalfa in hay and silage mixtures quadratically enhanced *in vitro* OM disappearance (Xue *et al*. 2020). Cluster bean straw incorporated up to 70% in the ration provided maintenance to adult sheep (Singh *et al*. 2008). Earlier workers (Boe *et al*. 1991, Hediat-Ullah *et al*. 2012) observed that mung bean is highly palatable legume fodder consumed by the livestock and even more nutritious in nature. Promising multi-cut mung bean varieties containing high nutritive value could effectively be employed to narrow down the summer green fodder gap in Egypt (El-Salam *et al*. 2013). Das *et al.* (2005) also observed that small ruminants (goats and sheep) fed with legume masoor (*Lense exulenta*) straw *ad lib.* supplemented with 100 g concentrate mixture showed similar N balance in both species. Cowpea hay fodder (var.58/74) appeared to be a high-quality fodder for goat rearing purposes (Sow *et al*. 2020). Feeding of three legume straws (cowpea, cluster bean and lablab bean) resulted in similar intakes of DCP, TDN and N-balance in weaned kids (Dutta *et al*. 2022). TDN intakes in all three groups were recorded less than the requirements as recommended by NRC (2007) for goats with ADG of about 50 g. Digestible CP values of cowpea and cluster bean were sufficient for meeting the requirement of growing animals, as diets with DCP 10.6 to 11.54 have been reported to support daily gains of 25 to 56 g in goats (Aregheore 2005).

Rumen fermentation: Rumen fluid *p*H and ammonia nitrogen (NH_3-N mg/dl) levels were different (P<0.05) among three treatment groups fed on test fodders (Table 4), whereas concentrations of total-Nitrogen (mg/dl), tricarboxylic acid precipitable nitrogen (TCA-ppt-N mg/dl), non-protein nitrogen (NPN mg/dl) and total volatile fatty acids (TVFA mmol/dl) were similar. Tested fodders had identical crude fat and fibre contents; whereas, different CP levels and varying digestibility of nutrients reflected in different *p*H of rumen fluid.

Rumen fluid *p*H, NH_3-N and TVFA levels of the present study were within the reported range of variations for small ruminants (Tripathi *et al*. 2007, Chaudhary *et al*. 2013). The ruminal fluid *p*H in the goats fed test fodders was above 6.50, which was recommended for optimum fermentation of fibrous feed in the rumen (Stewart 1977). Low crude protein content with numerical higher DM intake and low digestibility of crude protein were the reasons of lower rumen *p*H and NH_3-N in goats fed mung bean (T_2). The rumen NH_3-N concentration between 15 to 18 mg/dl was reported adequate for optimum rumen fermentation (Satter and Slyter 1974). The rumen NH_3-N in the present experiment, ranging from 26.3 to 30.6 mg/dl, was greater than adequate to support better rumen fermentation and microbial growth. Similarly, TCA-ppt-N and TVFA in rumen fluid have demonstrated adequate microbial protein synthesis due to synchrony between available N and energy required for microbial cell growth in the rumen. It is known that a synchronized supply of ruminal fermentable carbohydrates with ruminal degradable protein could promote the production of microbial protein (Richardson *et al*. 2003). Since the intake of DM, TDN and rumen total-N levels were similar among goats fed test fodders, microbial protein synthesis did not change. Earlier Xue *et al*. (2020) reported that increasing the proportion of legume alfalfa (*Medicago sativa*) accelerated the rumen fermentation process and remarkably increased the growth of rumen anaerobic microbes. Similarly, three legume straws (cowpea, cluster bean and lablab bean) resulted in similar *in vivo* rumen fermentation pattern in weaner kids (Dutta *et al*. 2022).

Hence, the nutritive values of three seasonal fodders (cowpea: TDN-58.82%, DCP-12.45%, ME-2.22 Mcal/kg feed DM; Mung bean: TDN-53.03%, DCP-7.08%, ME-2.00 Mcal/kg feed DM; cluster bean: TDN-54.88%, DCP-10.34%, ME-2.13 Mcal/kg feed DM) evaluated in the study will be helpful for formulation of ration schedule for Indian goats.

Haematology and blood chemistry: Haematological attributes (RBC, WBC, platelets, Hb, hematocrit, lymphocytes, monocytes and MCHC) were not different among the treatments fed with different legume fodders (Table 5). Plasma protein and albumin levels were also

Table 4. Rumen fermentation pattern as affected by different leguminous fodders in Barbari goats

Parameter	T_1	T_2	T_3	P-value
*p*H	6.68^{ab}±0.03	6.59^{a}±0.07	6.81^{b}±0.03	0.013
TVFA (mmol/dl SRL)	11.10±0.43	11.42±0.42	10.12±0.28	0.074
Total-N (mg/dl SRL)	65.10±2.65	65.33±2.95	69.53±2.13	0.419
TCA-ppt-N (mg/dl SRL)	18.43±2.62	16.80±2.50	17.83±1.30	0.872
NPN (mg/dl SRL)	46.67±2.24	48.53±2.25	51.80±1.58	0.233
NH_3-N (mg/dl SRL)	29.28^{ab}±1.43	26.25^{a}±1.08	30.57^{b}±0.78	0.044

T_1, *V. unguiculata;* T_2, *V. radiata*; T_3, *C. tetragonoloba*; *p*H, Potential hydrogen; TVFA, Total volatile fatty acids; Total-N, Total nitrogen; TCA-ppt-N, Tricarboxylic acid precipitable nitrogen; NPN, Non protein nitrogen; NH_3-N, Ammonia nitrogen.

Table 5. Haematology and biochemical attributes of goats fed various leguminous fodder.

Parameter	T_1	T_2	T_3	P-value
Haematological profile				
RBC ($10^6/\mu L$)	13.24±0.51	14.20±0.59	13.70±0.22	0.383
WBC ($10^3/\mu L$)	16.05±2.41	17.65±1.74	17.15 ±2.16	0.863
Platelets ($10^2/\mu L$)	815.17±145.31	864.00±97.84	818.50±159.34	0.961
Haemoglobin (g/dl)	6.76±0.28	7.13±0.27	7.25 ±0.13	0.349
Haematocrit (%)	21.87±0.96	22.45±0.78	23.15 ±0.36	0.490
MCHC (g/dL)	31.77±0.12	31.73±0.23	31.30 ±0.22	0.201
Lymphocytes (%)	56.83±7.04	65.56±5.34	61.75 ±8.05	0.667
Monocytes (%)	3.00±0.61	2.23±0.22	2.10±0.41	0.378
Blood chemistry				
Total protein (g/dl)	6.24 ±0.27	5.69 ±0.77	6.16±0.28	0.713
Albumin(g/dl)	3.01±0.12	2.89±0.17	2.94±0.09	0.816
Blood urea (mg/dl)	50.28^{b}±1.40	30.27^{a}±1.56	41.60^{ab}±2.54	<0.001

T_1, *V. unguiculata*; T_2, *V. radiata*; T_3, *C. tetragonoloba*; RBC, Red Blood Corpuscles; WBC, White Blood Corpuscles; MCHC, Mean Corpuscular Haemoglobin concentration.

similar; whereas, plasma urea level was greater (P<0.001) in cowpea fed goats (50.28 mg) followed by Cluster bean (41.60 mg) and mung bean (30.27 mg) fed goats.

Except haemoglobin (Hb), all other haematological parameters were within the normal range in goats under all treatments. Hb concentration in all groups was slightly lower than the reference value (8.0-12.0 g/dl) reported by Radostits *et al*. (2000) for goats. Almost similar types of haematological observations were reported by earlier researchers (Pailan and Singhal 2007, Sahoo and Walli 2008, Chaudhary *et al*. 2013, Durge *et al*. 2014) in Indian goats. Plasma total protein and albumin levels of goats fed test fodders have corroborated favourably with the findings of earlier reports (Speijers *et al*. 2005, Mahore and Mahanta 2013, Durge *et al*. 2014), although plasma urea levels in the present study were higher than the reported value by Mahore and Mahanta (2013) due to higher protein content in the tested legume fodders.

The energy intake by the adult goats under all treatments was lower than the standard requirement (NRC 2007), since sole feeding of legume fodders was practiced in this experiment. Low CP content and digestibility of OM, CP and NDF attributed to the relatively low feed quality of mung bean (*Vigna radiata*); however, this did not negatively affect voluntary fodder intake in goats. It is concluded that the fodders of cowpea (*Vigna unguiculata*), mung bean (*Vigna radiata*) and cluster bean (*Cyamopsis tetragonoloba*) can provide sufficient crude protein and may be a good feed resource for small ruminants. The nutritive values of these tested seasonal legume fodders will be helpful to formulate balanced ration schedule for Indian goats.

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