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Research Article

In-vivo supplementation effects of *Sesbania aculeata* and *Pennisetum purpureum* with basal diet on feed intake, digestibility and growth performance of Black Bengal goat

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ABSTRACT

Eight weeks (56 days) long experiment was conducted to quantify the chemical composition, feed intake, digestibility, and growth performance of Black Bengal goat supplied with Sesbania (*Sesbania aculeata*) leaves and Napier (*Pennisetum purpureum)* grass with a basal diet. The experiment employed on fifteen Black Bengal goats with average weight around 9.62±0.54 kg and divided into three groups having five goats in each: group T_3 (control) offered only basal diet (concentrated mixture and straw) and allowed for native grass, whereas the group T_1 and group T_2 offered same basal diet but additionally supplemented with Sesbania leaves and Napier grass, respectively. In this experiment, both feed intake and nutrient digestibility of DM, CP, OM, ADF, and NDF were found to be higher in T_1 and T_2 over T_3 in the said order. The total dry matter intake (DMI) was 784.5, 601.5, and 619.2 g/d for goats fed with Sesbania, Napier and Native grass respectively, where Sesbania group (T_1) showed significantly higher ($p<0.05$) values compared with other treated groups (T_2 and T_3). Moreover, the total metabolic energy intake in Sesbania and Napier groups were 7.8 and 6.2 MJ/d that was comparatively higher over the control group (5.3MJ/d). Although, the total BW gain and average daily weight gain with feeding of Sesbania leaves were 5.46 kg and 97.50 g/day respectively, which were significantly higher ($p<0.01$) compared to Napier and control group. Thus, it can be concluded that Sesbania could be an alternative substitute fodder with basal diet in goat production than the other foliage.

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Introduction

Most of the developing countries like Bangladesh always face an issue of scarcity and unstable year-round availability and supply of conventional feed which has been a significant barrier to increase livestock productivity (IAEA 2006). Due to the food-feed competition between humans and animals, the cost of concentrates for livestock rearing is rising daily. On the other hand, grass production or the availability of natural pastures is another constraint in small ruminant production due to the extreme shortage of land or land topography in Bangladesh. Feed alone contributes about 60 to 75% of the total cost for any livestock production

(Becker 2008; Kırkpınar and Açıkgöz 2018). Therefore, scientists and farmers are trying to find relatively affordable alternative feed sources to reduce feed cost and environmental pollution. Among alternative feed sources, cultivation of multipurpose trees (MPTs) is an appealing option to adopt because they do not compete with agricultural crops and land, and also not with human food (Makkar 2002). Thus, in many developing countries like Bangladesh (tropical and subtropicals), the use of plant parts as alternative feed resources for ruminant livestock is becoming increasingly popular (Melesse et al. 2009).

There is a need to improve the feed resource base by identifying alternative and more nutritious feeds to overcome the existing nutritional problems of livestock. This can be achieved by cultivating high quality forages with high yield potential, like Napier grass (*Pennisetum purpureum*) and Sesbania (*Sesbania aculeata*), which are being widely promoted in Bangladesh (Shahjalal and Topps 2000; Kabir et al. 2018; Islam et al. 2021). As a result, supplementation of these MPTs to ruminants with low-quality basal diets improves feed intake, digestibility, blood metabolites, carcass parameters, and animal growth performance (Biruh 2008; Mekoya et al. 2009; Manaye et al. 2009; Bekele et al. 2013; Gholve et al. 2021; Islam et al. 2021). As one of these MPTs, Sesbania species is a widely cultivated multipurpose tropical legume which produces green foliage with a high crude protein and low fiber content that can be utilized as a high quality fodder for ruminants (Panda et al. 1988; Akbar et al. 1993). These plants are able to fix atmospheric nitrogen and can grow in a wide range of soils such as water-logged, saline, alkaline, high land, and highly cultivated land (Singh et al. 1980; Barroga 1989). Sesbania leaves or even the entire aerial parts of this plant are highly palatable and nutritious fodder for growth, fattening, and production of ruminants (Panda et al. 1988; Ash and Petala 1992; Zarkawi et al. 2003).

In addition, Sesbania species have also been considered as high potential forage due to their high concentration of nutrients, including protein (15-36% DM), minerals (11-19%), saponins (8-16%), lignin (2.4-8.4%), tannins, and essential amino acids which are not only present in their foliage but also in their stems, petioles, flowers, fruit, and seeds (Brown et al. 1987; Mekoya et al. 2009; Feedipedia 2016). However, previous studies indicated that the sesban plant contains a high level of crude protein (17 to 36% of DM), organic matter (86.8 to 91.5% of DM), neutral detergent fiber (23 to 43%) and acid detergent fiber (13.4 to 29.1%) (Shahjalal and Topps 2000; Mekoya et al. 2009; Fernandes and Kamble 2011; Bekele et al. 2013). On the other hand, Napier (*Pennisetum purpueum*) is considered an inferior quality feedstuff (Ishii et al. 2005), but the inclusion of Napier grass may increase the nutritive value of basal diet (Pachauri 1989; Taye 2009; Rahman et al. 2015; Rahman et al. 2020).

Based on the literature, there is very little information on the comparative effect of Sesbania leaves and Napier grass along with basal diet on the feeding value of goats (Panda et al. 1988; Sahu et al. 1988; Pachauri 1989; Akbar et al. 1993). Therefore, the present study was undertaken to investigate the feeding effect of Sesbania leaves and Napier grass supplemented with concentrate and straw on feed intake, digestibility and growth performance of goats.

Materials and Methods

Experiment place and duration

The study was conducted for a total of 56 days in the field and laboratory of Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka.

Cultivation and harvesting

Sesbania and Napier were cultivated at BLRI. Land was prepared using compost and when the plant was in growing stage, urea was spread by broadcasting method. The seeding rate was 5kg for 0.33 acre and applied in the field by hand broadcasting method. Approximately 2.5 to 3 months after sowing, it was harvested and given to the goats on fresh basis by cut and carry method.

Collection and preparation of leaf and grasses

Freshly flushed Sesbania leaves and Napier grasses were collected from the particular cultivated plot. After mixing thoroughly, all the samples were sub-sampled and the representative samples were dried in an oven at 60°C and kept in the polythene bag for further analysis. Dried samples were ground by grinding machine at a size of 2mm sieve for proximate nutrient analysis and 1mm sieve for neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Experimental animals, management and diet

The experiment was conducted on 15 castrated male Black Bengal goats aged about 7 to 8 months with an average body weight (BW) of 9.62±0.54 kg, which were randomly divided into three groups having five goats in each group. The control group (T_3) was fed only basal diet and allowed natural grazing on BLRI pasture land *ad-libitum*, whereas the treated groups (T_1 and T_2) were fed the same basal diet but additionally, group T_1 was supplied with Sesbania (*Sesbania aculeata*) and group T_2 was supplied with hybrid Napier (*Pennisetum purpueum*) grass *ad-libitum* for 56 days. The basal diet consisted of paddy straw and locally available concentrate ingredients such as wheat bran, rice polish, kheshari bran, broken maize, soybean meal, vitamin-mineral premix, DCP (Di-calcium Phosphate), and salt. Feeding was restricted to only 250gm per day for each animal throughout the trial.

Prior to the commencement of the study, the animals were separated for 15 days to check for any incidence of disease and allotted identification numbers. Animals were reared in captivity under stall feeding system where deworming and vaccination were performed properly. Each animal had its own separate mangers and water troughs to avoid the mixing of feeds with the water, urine and feces. A good hygienic practice was maintained, and the physical condition of the animal was closely monitored throughout the experimental period. Sesbania and Napier grass were chopped individually every morning and divided into three halves to feed the animals at 8:00am, 1:00pm and 5:00pm. Animals were fed twice a day in equal amounts of the recommended concentration diet and fresh drinking water was provided *ad-libitum*.

Feed intake, digestibility, body weight and proximate chemical analysis

All animals were fed the experimental diet daily and the leftover was weighed the following morning. The feed intake of each animal was recorded by subtracting residue from the supplied feed and values were represented on dry matter basis. The animals consumed all the concentrate and grasses daily during the trial but refused a little amount that was recorded properly.

The concept of digestibility is used to determine the amount of nutrients actually digested and absorbed from a measured amount of feed consumed by an animal. Generally, digestion trials measure apparent digestibility. The initial step is to determine the total intake, digestion, and metabolism of specific nutrients in the feedstuff. To find out the digestibility of proximate components, a conventional digestion trial was conducted for five days towards the end of the experiment. The daily feed supply, feed residues, and voided feces from each animal were collected manually throughout the day and night and carefully measured and recorded. About 5% of the daily well mixed feces of each animal were collected, sun dried, and stored in polythene bags. At the end of the collection period, the dried feces was composite together and then ground in 2mm sieve which was used for proximate components analysis except for two components DM and CP. For dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), and ash, the chemical composition of shade-dried samples was assessed using AOAC (2004) techniques. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were estimated by the methods of Faichney and White (1983).

Measurement of body growth

At the beginning of the experiment, the animals were weighed separately on three consecutive days and the average weight was taken as the initial body weight and subsequent weights were taken every 14 consecutive days. A digital weighing balance was used to measure the weight and the average increased production for each animal was calculated by deducing the initial body weight from the final body weight. Average daily weight gain was calculated by dividing the total body weight gain by total number of experimental days.

Statistical analysis

In this study the survey was externally observable on various parameters. Therefore, data were compiled, tabulated and analyzed using general statistical methods to fulfill the objectives of the study. Simple statistical tools like average, percentages, and other formulas were employed in tabular technique for data analysis. Standard Deviation, Standard Error and ANOVA: Two factors without replication were calculated using "Microsoft Excel 2010".

Results and Discussion

Chemical composition of feeds

Table 1 details the chemical composition of Sesbania, hybrid Napier, native grasses and concentrate feed used in the feeding of goats. Fresh Sesbania leaves had greater percentage of DM, CP, EE, and Ash than hybrid Napier (18.6, 10.47, 1.02, and 5.61%) and natural grass (14.87, 11.63, 1.46, and 4.91%), respectively. These values were 21.71, 25.25, 3.69, and 6.81%, respectively. However, the OM, ADF, and NDF contents of Napier grass were 94.39, 67.92, and 41.98%, respectively, higher than those of Sesbania leaves (93.29, 41.21, and 29.76%), and natural grass (90.61, 31.23, and 36.90%).

At 60 days of age, the chemical composition of *S. aculeanta* was almost identical to our findings as previously described by Sahu et al. (1988); Shahjalal and Topps (2000); Femandes and Kamble (2011); Manaye et al. (2009). NDF and ADF contents, however, were consistent with our findings while the DM, CP, EE, and ash levels did not match the findings of the study by Gholve et al. (2021). The ADF and NDF contents (g/100g DM) of Sesbania leaves in this experiment were higher as compared to Bekele et al. (2013) and Islam et al. (2021), who reported values of 15.5 and 19.3, and 20.54 and 26.97, respectively. However, our findings that Sesbania leaves had higher ADF and NDF concentration were in agreement with those of Fernandes and Kamble (2011); Zarkawi et al. (2003) and Gholve et al. (2021).

On the other hand, in contrast to our findings, the DM, CP, OM, and ash of the Napier grass did not agree with the findings of Manaye et al. (2009), with the exception of ADF and NDF (40.6 and 71.5 g/100g DM), which were nearly identical. Our results, however, were consistent with those of Rahman et al. (2015; 2020), who reported that the DM, OM, CP, and NDF levels (% DM) in Napier grass ranged from 21.6 to 24.0%, 88.9 to 91.6%, 9.5 to 9.8%, and 55.7 to 67.3%, respectively. Sesbania

leaves had an EE content of 3.69%, higher than hybrid Napier (1.02%) and native grass (1.46%). Although, Kabir et al. (2018) and Gholve et al. (2021) both reported more or less similar findings but the reverse was also true for EE (% DM) contents with the findings of Shahjalal and Topps (2000), which were ranging from 7.74 to 8.65 in Sesbanea species. The ME content of Sesbania forage was 9.21 MJ/kg DM, which was somewhat lower than hybrid Napier (9.93 MJ/kg DM) but higher than natural grass (7.17 MJ/kg DM). Although, Zarkawi et al. (2003) and Rahman et al. (2015) independently estimated the ME levels in Sesbania plants and hybrid Napier to be 6.84 MJ/kg DM and 7.5 MJ/kg DM respectively, which were lower than our results.

Nutrient intake

The total daily nutrient intake of Black Bengal goats fed Sesbania, Napier, and local grass is shown in Table 2. According to the findings, Black Bengal goats fed Sesbania leaves consumed more total DM, CP, and ME than those fed the hybrid Napier and native grass, but there was no significant difference in dry matter intake (DM) between the Napier and control groups. Diets containing Sesbania (414.9 and 335.7g/d) showed higher intakes of NDF and ADF than diets comprising Napier (294.9 and 188.9g/d) and native grass (323.2 and 192.6g/d). The low consumption in the native grass (control group) may be due to the greater fiber fraction in the basal diet, a lower intake of dietary crude protein, and a lower level of nutrients digestibility.

According to Taye (2009), ram lambs given Sesbania together with Napier grass demonstrated higher daily DM intake and improved feed conversion efficiency than lambs fed only Napier fodder. Manaye et al. (2009) and Gholve et al. (2013) conversely reported the same results even though sheep were offered Napier grass coupled with Sesbania in different ratios. The DM intake (g/kg BW) for T_1, T_2, and T_3 groups in the current study was 73.4, 67.6, and 64.5, respectively. These values appear to be consistent with the findings of Bekele et al. (2013) for *S. aculeata* in Arsi-Bale sheep. However, they also indicated a quadratic effect of Sesban plant inclusion, where DM intake decreased by over 67% with increasing Sesbania forage inclusion. The fact may be caused by several anti-nutritional factors like condensed tannins that might have restricted its total consumption of the same feed at a higher level of inclusion by reducing the palatability (McDonald et al. 2002).

Nutrient digestibility

Table 3 displays the apparent nutrient digestibility (%) for DM, CP, OM, ADF, and NDF. It can be seen that Sesbania fodder had a greater level of nutritional digestion than animals fed Napier and natural grass. However, the apparent digestibility of DM and OM of Sesbania was insignificant, but the CP, OM, and ADF digestibility were statistically ($p<0.05$) higher in our results than the diets containing Napier and the control groups.

Singh et al. (1980) noted high levels of DM, CP, and OM (66.5, 80.8, and 69.5%, respectively) when *S. aegyptiaca* was exclusively fed to 6-7 months old barbari goats. The digestible DM, CP, and OM in the current findings were higher than those reported by Shahjalal and Topps (2000), who reported digestible DM, CP, and OM in their study as 55, 49, and 61% for roadside grass and 62, 69, and 63% for *S. aculeata,* respectively. Additionally, they also mentioned that goats given Sesbania leaves had higher ($p<0.05$) DM intake and digestible OM intake (g/d), than those received roadside grass suggested that the leaves are more pleasant and digestible to goats. The goat may need to intake higher digestible organic matter to fulfill their requirements for growth and maintenance. The findings were not consistent with those of Khalili and Varvikko (1992), who claimed that digestible CP decreased with increase of *S. sesban* intake compared to concentrate supplementation. Khanum et al. (2010) also noted lower nutrient digestibility of DM, and CP from feeding of *S. aculeata* to sheep at day-50 after sowing, which were 59.46 and 65.70, respectively. These results do not match our current findings. Increased ($p<0.05$) DM, CP, and OM digestibility was reported by Manaye et al. (2009) in Napier-Sesbania mixed diet supplemented to sheep as opposed to only Napier grass feeding group. According to Bekele et al. (2013), the digestibility of DM, OM ($p<0.01$) and CP ($p<0.001$) were higher in Sesbania supplemented group compared to the Arsi-Bale sheep given native grass hay as the control.

Body weight changes of Black Bengal goats

The results of body weight changes of Black Bengal goat, fed with different diets are detailed in Table 4. It is evident that the total weight gain (g/d) and average daily gain (g/d) of goats receiving Sesbania fodder were increased significantly ($p<0.05$). Although the initial and final body weights (kg) were not significantly ($p<0.05$) different among the treatment groups but goats fed with Sesbania leaves (T_1) showed the highest final body weight in the last week (8^{th} weeks) compared to other groups (T_2 and T_3) (Fig 1). The increased growth rates in the Sesbania and Napier supplemented groups were probably attributed to the availability of high-quality energy and protein, as well as their improved assimilation and conversion to body tissue. Similar trend was observed by Islam et al. (2021), who reported that supplementing with tree foliage significantly increased milk production ($p<0.01$) and average daily BW gain ($p<0.05$; $p<0.01$) in cows and calves compared to the control group when Sesbania and Leucaena were supplemented. The findings were also consistent

Table 1: Chemical composition (g/100gm DM) of the experimental feeds

Feeds	DM (%)	On DM basis (%)						ME (MJ/kg DM)
		CP	EE	Ash	OM	NDF	ADF	
Sesbania	21.71	25.25	3.96	6.81	93.29	41.21	29.76	9.21
Napier	18.6	10.47	1.02	5.61	94.39	67.92	41.98	9.93
Native Grass	14.87	11.63	2.46	4.93	90.61	36.90	31.23	7.17
Concentrated Mixture	90.94	18.49	2.55	6.74	93.26	53.18	23.39	10.43

DM = Dry matter, CP = Crude protein, EE = Ether extract, OM = Organic matter, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ME = Metabolic energy.
Concentrate ingredients composed of 30% wheat bran, 16% rice polish, 20% kheshari bran, 20% broken maize, 10% soybean meal, 2% vitamin-mineral premix, 1% DCP (Di-calcium Phosphate), and 1% salt

Table 2: Average daily intake of nutrients of Black Bengal Goat

Intake	Treatment			SEM	*p*-value
	Sesbania (T_1)	Napier (T_2)	Native Grass (T_3)		
Dry matter intake					
Concentrated (g/d)	215.5^{a}	164.5	158.7	14.48	0.016
Straw (g/d)	165.8	152.3	132.9	16.67	0.756
Green fodder (g/d)	403.2^{ab}	283.8^{b}	327.6^{c}	19.55	0.000
Total (g/d)	784.5^{a}	601.6	619.2^{a}	9.74	0.486
(g/kg BW $^{0.75}$/d)	73.4^{a}	67.6^{a}	64.5	1.45	0.974
(% of BW)	3.65	3.23	2.68	0.06	0.859
Total CP (g/d)	97.24^{a}	78.75^{b}	59.8^{b}	2.33	0.013
Total OM (g/d)	763.6	659.9	508.3	10.76	0.195
Total NDF (g/d)	414.9^{ab}	294.9^{a}	323.2	6.44	0.007
Total ADF (g/d)	335.7	188.9	192.6	5.27	0.299
Total ME (MJ/d)	7.8^{ab}	6.2^{a}	5.3^{b}	1.30	0.026

^{abc} Means with different superscripts in a same row are significantly different at $p<0.05$; SEM = Standard error of mean; abbreviations as in Table 1

Table 3: Apparent nutrient digestibility of feeds in Black Bengal Goat

Nutrient Digestibility	Treatment			SEM	*p*-value
	Sesbania (T_1)	Napier (T_2)	Native Grass (T_3)		
DM (%)	75.45^{a}	73.59	57.82^{a}	1.26	0.456
CP (%)	79.24^{ab}	70.75^{b}	50.58^{b}	2.33	0.001
OM (%)	63.65^{ab}	59.98^{a}	61.20^{a}	0.76	0.015
ADF (%)	68.23^{a}	53.08^{b}	56.73^{a}	1.59	0.024
NDF (%)	63.41	58.53	63.54^{a}	2.67	0.195

^{ab} Means with different superscripts in a same row are significantly different at $p<0.05$; SEM = Standard error of mean; abbreviations as in Table 1.

Table 4: Growth rate and feed intake of Black Bengal Goat fed experimental feeds

Parameters	Treatment			SEM	*p*-value
	Sesbania (T_1)	Napier (T_2)	Native Grass (T_3)		
Initial body weight(kg)	9.47	9.77	9.59	0.589	0.987
Final body weight(kg)	14.93^{ab}	13.81^{a}	13.12^{a}	0.785	0.036
Total weight gain (kg)	5.46^{ab}	4.04^{a}	3.53^{b}	0.041	0.000
Avg. daily gain(g/kg)	97.50^{ab}	72.15^{a}	63.04^{a}	0.831	0. 003

^{ab} Means with different superscripts in a same row are significantly different at $p<0.05$; SEM = Standard error of mean; abbreviations as in Table 1

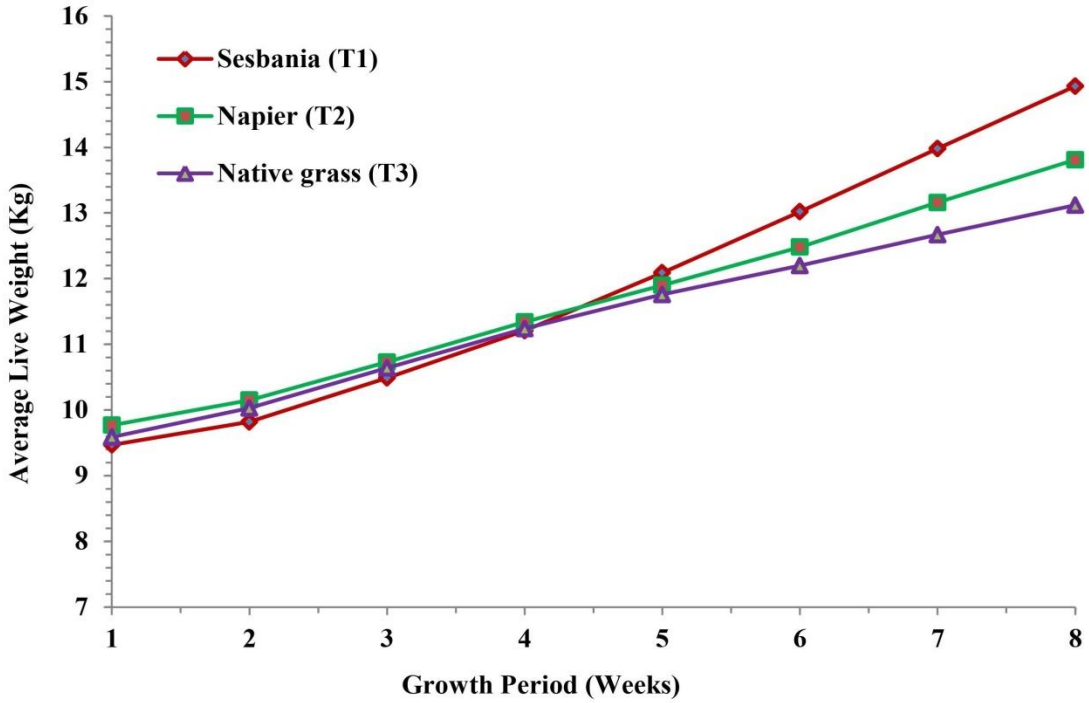

Fig. 1: Average live weight (kg) changes of Black Bengal goat fed of Sesbania, Napier and Native grass

with the observations of Alam et al. (2009) and Hidosa (2017).

According to Manaye et al. (2009), sheep fed a diet containing Sesbania foliage had an average daily body weight gain of 103 g/day, which was considerably higher ($p<0.01$) than the control groups. Shahjalal and Topps (2000) mentioned that goats given Sesbanea leaves showed greater changes ($p<0.05$) in total weight (kg) and live weight (g/d) gain than goats given roadside grass. The average daily BW gains from the present study's feeding of Sesbania, Napier, and natural grass were 97.50, 72.15, and 63.04 g/day, respectively. These values were complementary with the expected level formulated by ICAR (2013), which set the daily growth rate for goats at 50 g/day and the nutritional requirements for a weight of 15kg. In addition, Taye (2009) observed that the average final weight, total BW gain and average daily weight gain were significantly different ($p<0.05$) among treatment groups with various Napier-Sesbania combinations, which also supported our findings. However, many researchers in the past have reported increased body weight in ruminants supplemented with Sesbanea leaves (Alam et al. 2009; Mayane et al. 2009; Gholve et al. 2021). In contrast, both Zarkawi et al. (2003) and Rahman et al. (2015) reported that animals fed with various tree forage-basal diets did not differ significantly ($p<0.05$) in the body weight gain.

Conclusions

The results of the present research work indicated that goats fed foliage from Sesbania showed improved feed intake, digestibility, and growth performance without experiencing any negative effects in contrast to hybrid Napier and local native grasses. As Sesbania species are superior in terms of digestible organic matter, digestible crude protein, and digestible metabolic energy concentrations. Therefore, our research suggests that Sesbania is novel, unconventional, and high-quality forage that may be utilized as a substitute feed source for goats rising in smallholder agricultural systems.

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Conflict of Interest

All authors declare there is no conflict of interest to accomplish this study.

Author's contribution:

Md. Ruhul Amin planned the experimental design; Mst. Shakila Pervin and Abu Hena Md. Asif conducted the research trials and/or processing; Md. Ashraf Zaman Faruk analyzed the data and wrote the manuscript. All authors critical reviewed and finally approved the manuscript for publication.

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