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Supplementary effects of Noug Seed (*Guizotia abyssinica*) Cake with Sesbania (*Sesbania sesban*) Leaves on Feed Intake, Digestibility and Enteric Methane Emission in Arsi-Bale Sheep

Dufera BM[1,2]*, Wosen AM[2] and Gemeda BS[1]

[1]Department of Animal Science, Arsi University, Asella, Ethiopia

[2]Department of animal production studies, Addis Ababa University, Ethiopia

***Corresponding author:** Mr Birhanu Dufera, Arsi university, Ethiopia, Email: mamodufera@gmail.com

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Abstract

An experiment was conducted to study the effects of feeding the mixture *S. sesban (Sesbania sesban)* leaves, noug seed cake, and hay on feed intake, digestibility, and estimating enteric methane emission of Arsi-Bale sheep. The experiment was done having the nine-adult sheep of initial body weight 26.7 (±0. 14) kg. The experiment consisted of 7 days of digestibility and 90 days of feeding trials. The experiment employed a 3 x 3 cross over design with three treatments and three periods. There were three treatments including *S. sesban* leaves alone (T1), 27.6% *S. sesban* leaves + 27.6% hay +44.8% Noug seed cake (NSC) (T2) and 38.6% + 61.4% NSC (T3). Total dry matter intake (DMI) was higher ($P<0.001$) for sheep feed in 27.6% + 27.6% hay + 44.8% NSC (706.9g/day) compared to the rest of the treatments. However, the effect of *S. sesban* leaves alone decrease the total DMI. Digestibility of DM, OM, CP ($P<0.01$), NDF, and ADF were higher ($P<0.05$) between the treatments. Average daily gain (ADG) was higher ($P<0.01$) for sheep in feed 27.6% *S.sesban* leaves + 27.6% hay + 44.8% than those in feed *S. sesban* leaves alone. Increased level of *S. sesban* leaves supplement, in general, reduced growth in this study. However, there was no difference between 27.6% *S.sesban* leaves + 27.6% hay + 44.8% and 38.6% hay + 61.4% NSC. Estimation of enteric methane emissions factor and daily methane production was higher ($P<0.01$) in treatments T2 as compared to T3 and T1. And also, T3 higher than T1. Thus, it can be concluded that *S. sesban* leaves can be promoted as valuable feed resources for ruminants while concurrently reducing methane emissions.

Keywords: *S. sesban* Leaves; Arsi-Bale Sheep; Feed Intake; Digestibility and Enteric Methane Emission

Abbreviations: CP: Crude Protein; NDF: Neutral Detergent Fiber; IPCC: International Panel of Climate Change; EF: Emission Factor; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; ME: Metabolizable Energy; OM: Organic Matter; EME: Enteric Methane Emission; SPSS: Statistical Package for Social Sciences; DM: Dry Matter; HC: Hemi Cellulose; MPT: Multipurpose Trees; GEI: Gross Energy Intake: ADG: Average Daily Gain; NSC: Noug Seed Cake.

Introduction

Ethiopia has a spectacular livestock resource, currently estimated at 65.35 million head of cattle and 90.39 million sheep and goats CSA [1], in a variety of production systems that could be from mixed to pastoral crop-livestock production systems with different level of intensification. An economically small ruminant is important especially in developing countries like Ethiopia since they are immediate sources of cash income, ensure household food security, means to build assets and serve as saving account. However, the productivity of sheep is very low, mainly due to the inadequate production inputs such as feed. Moreover, unluckily, ruminants mutually contribute to and are affected by the increasing impact of climate change as a result of anthropogenic greenhouse gas emissions.

Most of the sheep in Ethiopia which are owned by smallholder farmers depend entirely on natural grasslands, crop straw, and crop aftermaths as sources of feeds. These feed resources contain less than 7% crude protein (CP) and more than 75% neutral detergent fiber (NDF) Seyoum, et al. [2] which compromise feed intake and digestibility, resulting in inadequate nutrient supply to satisfy the maintenance requirement of sheep, and thus cause severe weight losses and low productivity, particularly in the non-forage growing season [2].

This low productivity of sheep not only enhance methane emissions, making developing countries responsible for 75 % world enteric methane emissions but also in high emissions per unit of weight gain [3]. These emissions are one of the concern worldwide particularly in countries like Ethiopia where large populations of ruminants are located 1 in mixed farming production systems. Because these animals are mainly raised on the grazing natural pasture, aftermath and crop residues and to a lesser extent, improved feeds [4].

Tree and shrub legumes are important in producing large quantities of forage because of their deep-root systems and with correct management can produce green feed for much of the dry season. So indigenous multipurpose trees and legume forages such as *S. sesban (Sesbania sesban)* leaves can be used as an alternative protein supplement because of their green leaves. The decreasing availability of forage and the rapidly decreasing digestibility of forage as the dry season advances strongly affected feed intake. The digestibility of the grazed fodder was lower in the dry season than in the wet season, even though it increased from the middle of the dry season, more for goats and less for cattle.

The productivity of ruminants is limited by the low nitrogen and high fiber content of native pastures and crop residues, which form the basis of the diet in these regions [5]. In addition, ruminant production systems in the developing countries of the tropics are associated with lower feed efficiency and higher emission intensities as a consequence of low productivity, poor nutrition, and animals of low productive potentials. A considerable obstruction to improve our understanding of the contribution of small ruminant to GHGs in East Africa is the continued use of International Panel of Climate Change (IPCC) (Tier 1) default emission factor (EF) to estimate enteric methane emissions. The Tier 1 EF, which employs a universal factor for all animals of one species (in Africa) fails to properly accounts for differences in production systems across various climatic zones and absence of well-equipped laboratories in East Africa especially in Ethiopia as demonstrated using modelling approach [6]. Undoubtedly, there is a need to develop, at least, country specific estimates for small ruminants EF. This study, therefore, was conducted to evaluate the effect of *S. sesban* leave, noug seed cake, hay, and their mixtures on nutrient utilization and estimate of enteric methane emission of Arsi-Bale sheep.

Materials and Methods

Study Site

The experiment was conducted in the College of Agricultural and Environmental Science, Arsi University, located 3 km south of Asella town in the Arsi Administrative Zone of Oromia National Regional State. Assela is located at 175km southeast of Addis Ababa at 7057"N latitude and 3908" E longitude and has an altitude of 2400 m above sea level. The site has a bimodal rainfall pattern with a mean annual precipitation of about 725 mm. The main rainy season extends from June to September with a maximum rainfall in August, while the short rainy season is between Februarys to April. The mean minimum and maximum temperatures of the experimental site were 8.28°C and 23.3°C, respectively.

Experimental Diets, Treatments, and Design

The natural grass hay was harvested at about 50% flowering stage manually and sun-dried. The dried hay was piled and stored as loose hay under shade. The hay was chopped to a size of approximately 5-6 cm to facilitate intake. The *S. sesban* leaves meal was collected and prepared from the trees grown in the university area. Green leaves of the plant were harvested by cutting with a sickle manually from the branches. The harvested leaves were subjected to air-drying under shed separately for three to four days and turned up four times a day to ensure uniform drying and maintain green color. Noug seed (*Guizotia abyssinica)* cake (NSC) is purchased from Adama oil processing factory. The experimental diets were formulated according to the nutritional requirements and recommendations of the National Research Council NRC [7] to satisfy the maintenance requirements of adult sheep of 26.7 (±0. 14) kg body weight. The proportion of the dried *S. sesban* leaves' meal and concentrates are calculated based on the CP contents to make supplements iso-nitrogenous in all treatments. The experimental diets were mixed in a uniform way to avoid the selection of feed intake of the experimental animals. The three treatments were

Treatment 1: Hay + *S. sesban* leaves alone (T1)

Treatment 2: mixed ration (27.6% hay +27.6% *S. sesban* leaves + 44.8% NSC) (T2) and

Treatment 3: mixed ration (38.6% hay + 61.4% NSC) (T3)

Nine sheep were fed individually during the experimental period. The experimental feeds were offered twice a day in two equal portions at 08:00 and 16:00 hours. There was an adaptation period of 15 days to the experimental feeds before the commencement of data collection. Water was given ad libitum. Feed offered and refused was measured daily using a 5 kg sensitive balance with one gram precision, and the difference between the daily total feed offered and the daily refused was considered as daily feed intake on DM basis. Experimental lambs were housed in individual pens (0.70 m × 1.70 m) with concrete floors, a feeding trough, and a watering bucket. The pens were disinfected before moving animals in and then cleaned daily. The composition and nutrition levels of the three diets based on the 7were shown above. The three diets were fed according to the 3 × 3 cross-over design over 90 days in three periods, each 30 days, including 14 days of pre-feeding and 15 days for the collection period.

Digestibility Trial

To determine the digestibility of the experimental diets, the sheep were fitted with fecal collection bags(harness) for at least five days of the adaptation period followed by a 7 days feces collection period; during which time (April-June/2022) daily feed intake of each animal was recorded. Samples of feed offered, feed refused and feces were collected every day in the morning. Total feces voided in the harness were weighed daily during the collection period. After the collected feces from each animal were mixed thoroughly, 20% representative samples were taken daily and kept in deep freezer at -200C. At the end of the collection period, each sample from each animal was thoroughly mixed and enough samples were taken and dried at 60OC in a forced air oven for 72 hours to a constant weight. The apparent digestibility of DM, OM, CP, NDF, and ADF was determined using the following formula.

$$Apparent\ DM\ digestibility = \frac{DMI - Faecal\ DM\ output}{DMI} \times 100$$

$$Apparent\ digestibility\ of\ nutrient\ (\%) = \frac{Nutrient\ intake - Faecal\ nutrient\ excreted}{Nutrient\ intake} \times 100$$

Laboratory Analysis of Feeds and Feces

Sample of feeds offered and refusals as well as the partially dried feces were ground to pass through a 1mm sieve. The DM, OM, CP, and ash contents were determined according to AOAC [8]. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest PJ [9]. The metabolizable energy (ME) concentration (MJ/kg DM) of the rations was estimated using the equation of Mcdonald P [10] based on digestible organic matter (OM) in DM (DOMD) as:

$$DOMD = \frac{(OM\ intake\ (kg/d)) - (OM\ in\ feces\ (kg/d))}{DM\ intake\ (kg/d)}$$

$$ME\ (MJ/kg\ DM) = 0.016 \times DOMD\ (g/kg\ DM)$$

Estimating Enteric Methane Emission Factor (EF)

A precise estimate of enteric methane emission (EME) would be necessary for accurate preparation of national GHG inventory and assessment of costs and benefits of GHG mitigation from sheep. Development of EME prediction models could precisely estimate methane emissions from sheep.

When GE intake (MJ/day) was not reported in the published papers, it was estimated from DM intake, and GE concentration (MJ/kg DM) were calculated from chemical composition of diets Jentsch W, et al. [11], as follows:
GE intake (MJ/day) = DM intake (kg/day) * {[23.6 * CP (g/kg) + 39.8 * EE (g/kg) + (17.3* NFC (g/kg) + 18.9 * NDF (g/kg)]/1000}

Emission factors for enteric fermentation for each animal sub-category were calculated based on gross energy intake and the estimated methane conversion factor [12,13]. The sub-category enteric methane emission factors were then calculated using the following equation:

$$EF = \left[\frac{GE * \left(\frac{Ym}{100} \right) * 365}{55.65} \right]$$

Where:
EF = Emission factor, kg CH4 head -1 year -1
GE= gross energy intake, MJ head-1 day-1
Ym = methane conversion factor which is the percentage of gross energy in feed converted to methane, %
55.65 = the energy content of methane, MJ kg -1 CH4

Statistical Analysis

Data on feed intake, digestibility, BW change, gross energy intake, methane emission factor, and methane yield were subjected to ANOVA using Statistical Package for Social Sciences (IBM SPSS) software for window, Version 22.0 14. Whereas quantitative variables were analyzed using analysis of variance procedures and when the F-test showed significant differences, Tukey HSD at 5% significance level was used for comparison of means [14].

Results

Chemical Composition of the Treatment Feeds

The chemical composition of the experimental diets is presented in Table 1. The DM content was low in *S. sesban* but high in natural grass hay and noug seed cake. Organic matter content was high in *S. sesban* and low in natural grass hay and noug seed cake. The CP content was high *in S. sesban* and noug seed cake but low in natural grass hay. The NDF, ADF, and cellulose content high in *S. sesban* leaves and natural grass hay but low in noug seed cake. In contrary, ADL and ash content high in noug seed cake and low in *S. sesban* leaves and natural grass hay. Semi- cellulose was higher than in natural grass hay noug seed cake and *S. sesban* leaves.

Natural grass hay has been used as vital feed for livestock in the tropics. In this study, the CP content of the natural grass hay was slightly below the maintenance requirement (7%) for ruminants that required for microbial protein synthesis in the rumen which is in line with the result of Daniel T, et al. [15], Melesse A, et al. [16] and higher than the CP content reported by Melesse A, et al. [16]. Getahun K. et al. [17]. In generally, the nutrient compositions of the experimental feeds were within the range of Ethiopian feeds. The CP content of *S. sesban* leaves recorded in this study was lower than the reported by Solomon M, et al. [18] for the *S. sesban* 15019 accessions, Mekoya A, et al. [19], Wondwosen B, et al. [20] Solomon G, et al. [21]. The OM, NDF, ADF, and ADL obtained in this study were higher than the values reported for *S. sesban* leaves [18-20]. The OM and content of *S. sesban* leave in this study were similar reported by Solomon G, et al. [21] but the NDF and ADF content of *S.sesban* lower than reported by the same authors.

The CP content of NSC in the present study was lower than the report by Abebaw N, et al. [22], Fentie B, et al. [23], Zinash, et al. [24] but higher than the report by Jemberu D, et al. [25]. NDF, ADF, ADL and cellulose content of NSC in the present study were lower than the report by Abebaw N, et al. [22], Jemberu D, et al. [25] but higher for the content of OM and hemicellulose and lower for the content of DM by the same authors.

Feeds	DM	OM	CP	NDF	ADF	ADL	Ash	HC	Cellulose
	(g/kg)	g/kg DM							
Hay	924.3	932	65.9	595	348.8	54.7	68	246.2	294.1
NSC	927	930.9	270.5	324.1	163.6	99.7	69.1	160.5	63.9
S.sesban leaves	908.4	945.9	195.3	411.9	317.8	96.5	54.1	94.1	221.3
27.6 (hay:SSL):44.8NSC	921.1	935.3	194.5	423.1	260.5	86.4	64.7	162.6	174.1
38.6hay:61.4NSC	926	931.3	193.1	428.6	234	82.3	68.7	194.6	151.7

DM=dry matter; OM= organic matter; CP=crude protein; NDF= neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin; HC=Hemicellulose; SSL=*S. sesban* leaves, NSC=Noug seed cake

Table 1: Chemical composition of ingredients and experimental feeds.

DM and Nutrient Intake

Total daily DM intake was high significant (P<0.001) difference between T1 and T2 and also T3 (Table 2). Similarly, there is high significant (P<0.001) difference between T2 and T3. This is may be because of Anti-nutritional compounds found in the *S. sesban* leaves. The intake of DM as percent of BW was significantly (P<0.001) difference between T2 and T3 sheep compared to T1. The intake of OM, NDF, ADF, and ME were significantly (P<0.001) difference between T2 and T3 compared to T1 sheep. And also, the intake of CP was significantly (P<0.05) difference between T2 and T3 as compared to T1.

Total daily DM intake were significantly (p<0.001) different between sheep in mixed treatments than for the sole S.sesban leaves (Table 2). The low intake in sole *S. sesban* leaves may be due to the fact that *S. sesban* contains a substantial amount of anti-nutritional factors such as condensed tannins might have limited complete consumption of the same feed at a higher level of inclusion. Similarly, with the current finding, Solomon M, et al. [26], Solomon M, et al. [27], Solomon M, et al. [28] stated that variable quantities of refusals from feeding *S. sesban* to ewes and concluded that anti-nutritional factors in the same feed limit palatability and intake at a higher level of offer. It has been documented by Frutos P, et al. [29], that most browse species including *S. sesban* contain phenolic compounds that reduce voluntary feed intake and tannins were considered as anti-nutritive and/or toxic compounds when presented in feeds due to their decreasing the intake [30]. 10stated that tannins reduce the palatability of the browses and made them less preferred by animals. Other studies Bitende SN, et al. [31], Tibebu M, et al. [32] also showed that supplementation of Sesbania to grass or straw-based diet fed to different ruminant animal species increased the DM, OM and CP intakes. According to Ranjhan

SK, et al. [33] the ME requirement for sheep weighing 20-30 kg ranged between 5.86 to 8.37 MJ and in the current study, all the treatments satisfied the ME requirements.

Parameters	Treatment feeds				
	***S.sesban* leave**	**27.6 (hay:SSL):44.8NSC**	**38.6hay:61.4NSC**	**SEM**	**p-value**
Total DM intake (g d^{-})	507.6^{c}	(390.2 R:316.7C) 706.9^{a}	(240.9R:383.1 C) 624.0^{b}	43.2	<0.0001
DM intake (% BW)	1.9^{c}	2.7^{a}	2.3^{b}	44.3	<0.0001
OM intake (gd^{-})	480.9	671.4^{a}	582.7^{b}	47.3	<0.0001
CP intake (gd^{-})	100.5^{b}	109.9^{a}	109.9^{a}	7.93	<0.021
NDF intake (gd^{-})	213.3^{c}	318.0^{a}	278.2^{b}	64.3	<0.0001
ADF intake (gd^{-})	161.3^{b}	196.5^{a}	151.3^{b}	32.4	<0.001
ME (MJ/kg DM)	8.5^{b}	10.1^{a}	9.7^{a}	26.65	<0.001

Means followed by different superscript letters within a row for each treatment feed are significantly different at P < 0.05; C= Concentrate; R= Roughage; SEM = standard error of means; SSL; *S. sesban* leave; Noug seed cake; DM =Dry matter; OM=Organic matter; CP = Crude Protein; NDF= Neutral Detergent Fiber; ADF =Acid Detergent Fiber; ME= Metabolizable energy.
Table 2: Daily feed and nutrient intakes of Arsi-Bale sheep fed dried *S. sesban* leaves, and mixed different percentage of hay, *S. sesban* leaves and noug seed cake.

Dry Matter and Nutrient Digestibility

Nutrient digestibility values were given in Table 3. The DM and OM digestibility was significantly (P<0.01) differences between T2 and T3 compared to T1 (Table 3). The digestibility of CP and NDF were significantly (P<.001) difference between the treatments. The lower DM and nutrient digestibility in the sole of *S. sesban* leaves indicated that sole *S. sesban* leaves might not be used solely as a supplement of sheep in such type of basal diet. Multipurpose trees (MPT) are seldom fed to ruminants as a sole source of feed and, therefore, their important attributes are their ability to improve the digestibility and utilization of fibrous feeds when used as a supplement [34]. The different effects of *S. sesban* supplementation on the total DMI may be attributed to its palatability, anti-nutritional content, stage of maturity, means of supplementation, and the amounts added [21]. Furthermore, it was apparent that nutrient digestibility showed a decreasing trend as the level of inclusion of *S. sesban* in the supplement increased. Khalili H [35] stated that dietary crude protein digestibility decreases with increasing *S. sesban* supplementation compared to concentrate supplementation. This could be attributed to anti-nutritional factors contained in *S. sesban*. The deleterious effect of secondary plant metabolites such as tannin on nutrient digestibility has been well documented [27,28]. Tannins were considered as anti-nutritive and/or toxic compounds when present in feeds due to their decreasing the digestion of MPT 30. Similarly, tannin reacts with protein and form tannin–protein complex, which reduces rumen fermentation and eventually depress nutrient digestibility and voluntary feed intake [29]. In addition, Woldemeskel M, et al. [36] reported that the adverse effect on rumen metabolism and diminished digestibility due to tannins and diarrhoea induced by saponnins may reduce absorption and availability of ingredients in high level *S. sesban* (400 g) resulting in less adverse effects than low level (200 g).

Digestibility (%)	Treatments				
	T1	**T2**	**T3**	**SEM**	**P-value**
DM	60.7^{b}	77.9^{a}	70.0^{ab}	11.8	<0.008
OM	61.3^{b}	78.6^{a}	70.3^{ab}	12.2	<0.008
CP	72.3^{b}	84.0^{a}	79.9^{a}	12.2	<0.008
NDF	57.2^{b}	70.1^{a}	68.9^{a}	6.7	<0.029
ADF	51	65.6	63.8	5.2	<0.048

Means followed by different superscript letters within a row for each feed type are significantly different at P < 0.05; SEM = standard error of means; DM =Dry matter; OM=Organic matter; CP = Crude Protein; NDF= Neutral Detergent Fiber; ADF =Acid Detergent Fiber SSL= *S. sesban leave*; NSC= Noug seed cake; T1 = S. sesban leave; T2 = 27.6% (hay: SSL): 44.8%NSC; T3 = 38.6 %hay: 61.4%NSC.
Table 3: Dry matter and nutrient digestibility of Arsi-Bale sheep fed dried *S. sesban* leave, and mixed different percentage of hay, *S. sesban* leave and noug seed cake.

Prediction of Enteric Methane Emissions

Table 4 showed enteric CH4 emission factors and daily methane production of Arsi-Bale sheep fed different treatments of feed in the study area. Enteric fermentation emissions have been estimated using the IPCC Tier 2 model. The GE, EF, and DMP were significant (P<0.01) difference between the treatments. The quantification of methane emissions from livestock on a global scale relies on prediction models because measurements require specific equipment and may be expensive [37]. The average EF in the present study are similar for sheep Nandi and Bomet sheep (4.6 and 4.8 kg CH4per head per year) in Kenya [38]. Methane production from ruminants in small ruminant varies with the diet, which could be affected by the factors such as DM intake, diet composition, and digestibility. Because enteric CH4 emissions are strongly related to feed intake, all models include a measurement of intake, such as DMI, gross energy (GE) intake (GEI), ME intake, or NDFI. May be the reduction of CH4 production in *S. sesban* leaves in the current study could be associated with the DMI, GEI, NDFI Hristov AN [39] and fractions of tannin phenols and condensed tannins, which have the potential to modify rumen fermentation to reduce CH4 production [40]. An increased fibrous concentration, particularly NDF and ADF in treatment two and three resulted higher CH4 production. This might be explained by fact that high fiber in the feed could favor acetate production, thereby increasing hydrogen for methanogenesis [41]. In addition, it is a well-established nutrition principle that increasing the level of concentrate in the diet reduces the dietary energy converted to CH4 [42]. This occurs because feed rations rich in starch favor propionate production thereby reducing CH4 production per unit of fermentable organic matter in the rumen. Conversely, a roughage-based diet will favour acetate production and increase CH4 production per unit of fermentable organic matter in ruminants [43]. The reduction in CH4 output by shifting H2 flow towards alternative electron acceptors such as propionate significantly enhances the utilization of feeds and animal performance.

A significant portion of agricultural emissions in most developing countries come from ruminant livestock, which include cattle, sheep and goats [44]. The bulk of the emissions from ruminant livestock are in the form of methane produced through enteric fermentation.

The livestock feeding systems in Ethiopia are mainly dependent on natural grass, crop residues and high fiber diets that are deficient in nitrogen and digestible energy, limiting the animal performance. These high fiber diets rich in structural carbohydrates increase ruminal acetate-to-propionate ratio, thus produce more enteric CH4 but may limit manure CH4 production due to the resistance of excreted cell wall to microbial fermentation (Improving dietary quality can both improve animal performance and reduce CH4 production). It can also improve efficiency by reducing CH4 emissions per unit of animal product. In contrast, CH4 production in ruminants tends to increase with the age of the forage fed. The composition of both structural (i.e. fiber) and soluble carbohydrates is important in developing low CH4 emission rations. For example, CH4 production per unit of cellulose digested is reportedly three times that of hemicellulose [45]. The proportions of cellulose, hemicellulose and lignin in cell walls change as plants mature, leading to declines in both digestibility and CH4 emission per unit fed. Since structural carbohydrates produce more CH4 per unit of substrate digested than non-structural carbohydrates, adding grain to a forage diet increases starch intake and reduces fiber intake which, in turn, reduces rumen pH and favors the production of propionate rather than acetate in the rumen [46].

Parameters	Treatments			Over all	SEM	P-value
	T_1	T_2	T_3			
GEI (MJ/day)	9.29^c	12.94^a	11.15^b	11.12	188.46	0.0001
EF (kg $CH_4 head^{-1} year^{-1}$)	3.96^c	5.495^a	4.75^b	4.73	192.72	0.0001
DMP (g $CH_4 head^{-1} day^{-1}$)	10.5^c	14.63^a	12.9^b	12.685	43.2	0.0001

Means followed by different superscript letters within a row for each Parameters are significantly different at P < 0.01; SEM = standard error of means; DMP=Daily methane production; EF= Emission factor; GEI= Gross energy intake; T1 = *S. sesban* leave; T2 = 27.6 % (hay: *S. sesban* leave): 44.8% Noug seed cake; T3 = 38.6 %hay: 61.4% Noug seed cake.

Table 4: Gross energy intake and enteric methane emission factors for sheep fed dried *S. sesban* leave, and mixed different percentage of hay, *S. sesban* leave and noug seed cake.

Conclusion

This study indicated that the combination of feed-fed sheep with different proportions of noug seed cake; hay and *S. sesban* leave improved feed intake, digestibility, and DBW change compared to the *S.sesban* leave alone. Among the treatments (T) T2 and T3 resulted from a higher production performance than T1 and less performance on methane emission. Thus, it could be concluded that the S.sesban leaves, reduce methane emissions and it is an alternative strategy to improve the productivity of sheep under the smallholder farming system dominant in the tropics. Moreover, the enteric methane emission of higher in treatment 2 than in treatment 3 and treatment 1. This is because as feed intake increases methane emissions also increase depending on the quality of feed. Therefore, checking methane emissions with different feeds at different seasons was very important to identify the emission difference. Further, evaluation of different dietary feed ratios on growth performance vs enteric methane emissions at yearling age is very important to identify which feed is more emitted.

Conflict of Interest

The authors declare that they have no conflict of interests that could have appeared to influence the work reported in this paper.

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