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Effect of Graded Levels of Pigeon Pea (Cajanus cajan L.) Foliage Supplementation on Feed Intake, Nutrient Digestibility, and Growth Performance of Gumuz Sheep Fed Napier Grass

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Abstract

This study evaluated the effects of supplementing Napier grass (*Pennisetum purpureum* Schumach.) with graded levels of wilted pigeon pea (*Cajanus cajan* L.) foliage versus a conventional concentrate mixture on feed intake, nutrient digestibility, growth performance, and feed conversion efficiency (FCE) of indigenous Gumuz sheep. Twenty intact male Gumuz sheep with an initial body weight of 18.48 ± 1.20 kg were arranged in a randomized complete block design across four treatments: Napier grass *ad libitum* + 350 g DM/day concentrate mixture (T1, control); Napier grass *ad libitum* plus 200 g DM/day (T2); 300 g DM/day (T3); and 400 g DM/day pigeon pea foliage (T4). Daily dry matter intake (DMI) and crude protein (CP) intake differed significantly among treatments, with T1 recording the highest intakes, followed by a linear increase across pigeon pea levels from T2 to T4. Apparent digestibility of DM, organic matter (OM), and CP was highest in T1. Among the pigeon pea treatments, DM, OM, and neutral detergent fiber (NDF) digestibility increased as pigeon pea level increased, reaching 72.64% DM digestibility in T4. Final body weight, body weight change (BWC), and average daily gain (ADG) were highest in T1, whereas differences among the pigeon pea treatments for these growth parameters were not significant. However, FCE differed significantly, with T2 recording the highest biological efficiency compared to T3, T1, and T4. Supplementing Napier grass with pigeon pea foliage effectively supported positive nutrient balance and daily weight gains (74.22–83.89 g/day) in Gumuz sheep. Among the legume supplementation levels evaluated, 200 g DM/day achieved the highest feed conversion efficiency, demonstrating that low-level pigeon pea supplementation provides a practical, high-quality forage-legume alternative to commercial concentrates for smallholder sheep production systems in western Ethiopia.

1. Introduction

In Ethiopia, feed scarcity is one of the most critical problems constraining the productivity of livestock, particularly among smallholder mixed crop-livestock production systems, where feed resources are highly seasonal in quality and quantity (Duguma and Janssens, 2021). In western parts of Ethiopia, natural pasture, maize and sorghum Stover, communal grazing lands, and grasses on the roadside are the major sources of feed resources. Research conducted by Fetene et al. (2025) revealed that feed scarcity increased animal deaths, increased the cost of production, and depressed the output of crops and livestock. Therefore, improving the availability and nutritive value of locally available crop residues and other crop by-products is one of the strategies for improving the productivity of livestock and minimizing its sensitivity to seasonal fluctuations in feed supply (Sime and Duguma, 2025).

Protein supplementation for low-quality basal feeds is one of the promising strategies to improve nutrient utilization and animal performance (Obeidat et al., 2019). Usually, mature tropical grasses and crop residues contain relatively low levels of CP and high levels of structural carbohydrates that may limit ruminal microbial activity, feed intake, and nutrient utilization if they are fed as the main source of basal diet (Van Soest, 1994). Targeted supplementation of protein feeds may enhance nitrogen supply to the rumen microbes and minimize the deficit of nutrients provided by fibers in the basal diet. However,

the effect will be influenced by the quality and quantity of the basal forage, supplement formulation, supplementation level, animal species, and physiological status (Assegid et al., 2021; Tulu et al., 2024).

Napier grass (*Pennisetum purpureum* Schumach.; syn. *Cenchrus purpureus*) is increasingly used as a cultivated forage and has the potential to provide substantial and relatively regular green forage in western Ethiopia. However, the nutritive value of Napier grass varies with genotype, maturity, harvesting interval, growing conditions, and management practices (Tulu et al., 2021). The Pigeon pea (*Cajanus cajan*) is a multipurpose tropical legume with potential to provide protein-rich foliage for livestock feeding. Its adaptability, biomass production, and nutritional characteristics have led to increasing interest in its utilization as a livestock feed, particularly in smallholder production systems where conventional protein supplements may be costly or unavailable (Gargi et al., 2022). In western Ethiopia, pigeon pea has demonstrated potential as a forage resource with substantial dry matter production. The use of pigeon pea foliage may therefore provide a locally produced source of dietary protein for animals consuming low-quality grass-based diets.

The study indicates that graded levels of dry pigeon pea foliage in growing Arsi-Bale goats can influence dry matter intake, crude protein digestibility, and average daily gain, which increased with increasing supplementation level (Assegid et al. 2021). Similarly, Tulu et al. (2024) demonstrated *Cajanus cajan* and *Lablab purpureus* leaf meals as alternative protein supplements for yearling Horro sheep fed fodder-oat hay differed among forage-legume in responses of feed intake, nutrient digestibility and growth varieties and conventional protein supplements. Moreover, a study by Teklehaymanot (2024) also showed that pigeon pea foliage generated positive economic returns and could be considered an alternative feed resource where access to conventional concentrate is limited.

Studies by Tiruneh et al. (2020) and Adugna et al. (2020) have shown that the indigenous Gumuz sheep can respond to improvements in dietary quality, but information remains limited regarding the utilization of forage-legume supplementation in Napier-grass-based diets. Moreover, lack of information on the response of growing Gumuz sheep to graded levels of pigeon pea foliage when compared with a conventional concentrate supplement. Determining this response is important because the nutritional value of a forage legume is expressed within the context of the complete diet, and the optimal supplementation level may differ according to basal forage quality, animal genotype, and production conditions. Therefore, the present study was conducted to evaluate the effects of supplementing Napier grass with increasing levels of pigeon pea foliage on feed intake, apparent nutrient digestibility, and live-weight performance of growing Gumuz sheep. The study was intended to determine whether pigeon pea foliage can improve the utilization of Napier grass and growth performance of Gumuz sheep and to identify an appropriate supplementation level for practical feeding under the production conditions of western Ethiopia.

2. Materials and methods

2.1. Study area

The experiment was conducted at the Assosa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), located in Benishangul-Gumuz Regional State, western Ethiopia. The center lies between 9°30' and 11°39' N latitude and 34°20' and 36°30' E longitude at an altitude of 1,272 to 1,573 m above sea level. The area is characterized by a warm sub-humid climate with a mean annual rainfall ranging from 700 to 1,450 mm and a mean annual temperature of 21–35°C. The region represents one of the major production areas of the indigenous Gumuz sheep, a breed well adapted to the hot lowland environment of western Ethiopia. The feeding trials were conducted from October 2023 to January 2024.

2.2. *Establishment and management of experimental forages*

Napier grass (*Pennisetum purpureum Schumach*.; ILRI accession 16804) was established from stem cuttings on 24 August 2022 on a 0.5 ha experimental field at Assosa Agricultural Research Center. During establishment, urea fertilizer was applied at 100 kg ha^{-1} to promote vegetative growth and biomass production. To manage the Napier grass, the producer used the method by Manaye et al. (2009). Beginning in August 2023, the stand was managed using staggered harvesting to ensure a continuous supply of forage with comparable maturity throughout the feeding trial. The field was divided into six equal plots, each harvested at two-week intervals to provide approximately three-month regrowth forage during the experimental period.

Tsigab pigeon pea (*Cajanus cajan*) improved variety was sown on 22 June 2023 on a 0.5 ha field during the main rainy season. Standard agronomic practices, including manual weed control, were applied throughout crop establishment. The foliage was harvested approximately 4.5 months after planting at the vegetative to early flowering stage. Before feeding, Napier grass and pigeon pea foliage were chopped into approximately 5 cm lengths and partially wilted overnight to reduce excess moisture and improve voluntary intake. The concentrate mixture used in the control treatment consisted of wheat bran and noug seed cake (53:47, DM basis).

2.3. Forage preparation and determination of dry matter

Napier grass (*Pennisetum purpureum* Schumach.) was used as the basal forage and offered to all experimental animals *ad libitum*. Representative samples of both the Napier grass and pigeon pea (*Cajanus cajan* L.) offered were collected weekly to determine their dry matter (DM) concentration. To determine DM, representative feed samples were dried weekly at 65°C in a Forced-Air Drying Oven (BOV-T50F, Biobase, Shandong, China). The quantity of wilted pigeon pea foliage offered to each animal was adjusted based on its measured DM concentration to achieve the designated supplementation levels of 200, 300, or 400 g DM $animal^{-1}$ day^{-1}. For the control treatment, animals received a concentrate mixture at a rate of 350 g DM $animal^{-1}$ day^{-1}. The concentrate was offered separately from the Napier grass basal forage.

2.4. Experimental Animals

Twenty intact male Gumuz sheep, approximately one year of age, with an average initial body weight of 18.48 ± 1.20 kg (mean ± SD), were purchased from the local livestock market in the Bambasi district area of western Ethiopia. The animals were selected to be apparently healthy and of relatively similar age and body size. The sheep were transported to Assosa Agricultural Research Center and quarantined for 21 days, during which they were treated with oxyclozanide against liver fluke and ivermectin against internal and external parasites and vaccinated against foot-and-mouth disease according to the routine animal-health protocol of the research center. At the end of the quarantine period, all sheep were placed in their respective individual pens and offered the experimental diet for 15 days to get them accustomed to the experimental feeds before commencing the actual feeding trial lasting for 90 days.

2.5. Experimental Design and Dietary Treatments

The experiment was conducted using a randomized complete block design (RCBD). The 20 sheep were blocked into five groups of four animals each according to initial body weight. Within each block, the four animals were randomly assigned to one of four dietary treatments, giving five animals per treatment in total, and each animal was independently assigned to a treatment.

The four dietary treatments consisted of Napier grass offered ad libitum as the basal forage and different sources and levels of supplementation. The control treatment (T1) received 350 g dry matter (DM) animal^{-1} day^{-1} of concentrate mixture, whereas T2, T3, and T4 received 200, 300, and 400 g DM animal^{-1} day^{-1} of wilted pigeon pea foliage, respectively. The animals were housed individually in pens measuring 1.2 × 1.0 m, allowing individual measurement of feed offered, refusals, and feed intake. Throughout the experimental period, the animals had free access to drinking water and a salt lick. The feeding trial lasted 90 days.

2.6. Feeding trial

The feeding trial lasted 90 days. Napier grass was offered ad libitum to all experimental animals as the basal forage. The amount of Napier grass offered to each animal was recorded daily, and the quantity offered was adjusted according to the previous day's refusal to maintain approximately 10% refusal and allow free access to the basal forage. The pigeon pea foliage was offered separately from the basal Napier grass. The quantity of wilted pigeon pea offered was adjusted according to the measured DM concentration to provide the designated daily DM supplementation level. Animals in the control treatment (T1) received 350 g DM animal^{-1} day^{-1} of concentrate mixture. Feed was offered twice daily at 08:00 and 16:00 h. Fresh drinking water and a salt lick were made available to the animals throughout the experimental period.

Feed refusals from each animal were collected and weighed every morning before the morning feed was offered. Daily records of feed offered and refused were maintained for each animal throughout the experimental period. Representative samples of feeds offered and refusals were collected during the experimental period for subsequent chemical analysis. Refusal samples from each animal were pooled over the experimental period, and a representative subsample was retained for laboratory analysis. For the pigeon pea treatments, total DM intake was calculated as Napier grass DM intake plus the

corresponding pigeon pea DM supplementation, whereas for the control treatment it was calculated as Napier grass DM intake plus 350 g DM/day of concentrate. The body weight measurements were taken in the morning after 12 h fasting using a suspended weighing scale with a sensitivity of 100 grams every 15-day interval before provision of feed and water.

2.7. Digestibility Trial

A digestibility trial was conducted after the completion of the feeding trial. All sheep were harnessed with fecal collecting bags to collect feces for digestibility determination. Sheep were allowed to acclimatize to the fecal collecting bags for 3 days, and this was followed by a collection of feces for 7 days. The collected feces were weighed daily, and 20% of the daily feces voided by each animal was sampled and pooled over the collection period for each sheep separately and stored in a deep freezer (-20^0C) using plastic bags. At the end of the digestibility trial, the collected fecal samples were thoroughly mixed, and 10% of the total collected sample from each animal was subsampled, weighed, partially dried at 60°C for 72 hours, ground, and stored in airtight polyethylene plastic bags pending chemical analysis. During the digestibility period, feed offered and refused was recorded daily, and samples from feed offered and refusals from each animal were taken daily to make a composite sample. The apparent digestibility of DM, OM, CP, NDF, and ADF was determined.

2.8. Chemical analyses

The DM of the feed and feces samples was determined at Assosa Agricultural Research Center. The samples of dried feeds, feces, and refusal were dried overnight at 105°C in a forced-draft oven for the determination of total DM content. Ash content was determined by combusting samples at 550°C overnight. The chemical composition was analyzed at Assosa University Animal Nutrition Laboratory. The Kjeldahl N was determined following the procedures of AOAC (1990). The Crude Protein (CP) was determined by Nx6.25, and OM was estimated by subtracting ash from 100. The Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) contents for offered and refused feed and feces samples and Acid Detergent Lignin (ADL) for offered feed samples were analyzed following the procedures of Van Soest and Robertson (1985).

2.9. Data analysis

Data from the experiments were subjected to analysis of variance using the general linear model (GLM) procedure in R software (Version 4.5.2). The treatment means were separated using the least significance difference (LSD). The model used for data analysis was:

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

Where: Y_{ij} = response variable, μ = overall mean, T_i = treatment effect, B_j = block effect, e_{ij}= random error.

3. Results and Discussion

3.1. *Chemical Composition of the Experimental Feeds*

The chemical composition of experimental feeds is shown in Table 1. Among the major forage feeds, CP concentrations were lowest in Napier grass, and NDF and ADF concentrations were highest in Napier grass. The pigeon pea foliage had considerably higher CP and lower NDF and ADF concentrations than Napier grass. The current study is in line with Alexander et al. (2007), who showed that 200 pigeon pea germplasm had CP content within the range of 16.25 to 25% CP. However, the CP content of pigeon pea foliage in the present study is higher than the values (21.3 and 23.2% DM) reported by Shenkute et al. (2013) and Nurfeta et al. (2013), respectively. This variation may be associated with differences in genotype, plant maturity at harvest, proportion of leaves to stems, growing conditions, and soil fertility. The CP concentration of Napier grass in the present study was lower than the 8.33% reported for ILRI 16804 by Tulu et al. (2021), while its NDF and ADF concentrations were broadly comparable with their values for the same accession.

Table 1
Chemical composition of feed ingredients used in the experiment

Feed ingredient	Chemical Composition (% for DM and % DM for Others)						
	DM	Ash	OM	CP	NDF	ADF	ADL
Napier grass	24.06	10.02	89.98	6.02	68.02	43.70	6.00
Pigeon pea foliage	45.75	6.08	93.92	25.01	52.14	34.38	8.44
Wheat Bran	86.33	5.14	94.86	17.28	42.43	12.84	3.66
Noug Seed Cake	89.46	7.02	92.98	36.01	38.15	18.45	7.44
Concentrate mixture	88.00	6.03	93.97	26.08	40.15	15.68	5.65

Concentrate: a mixture of 53% wheat bran and 47% Noug seed cake; DM = Dry matter; OM = Organic matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin.

3.2. Dry Matter and Nutrient Intake

Dry matter intake differed among dietary treatments (Table 2). Concentrate-supplemented sheep had the highest total DM intake compared with those receiving supplementary pigeon pea foliage. Total DM intake increased with increasing supplementation levels among the pigeon pea treatments from 200 to 400 g DM animal^{-1} day^{-1}. This study, in line with Kumsa et al. (2023), observed treatment-related differences in total DM and nutrient intakes in Black Head sheep receiving forage-legume supplements with Rhodes grass hay and wheat bran. The same treatment response was noted for CP, OM, Ash, and NDF intake. Crude protein intake was lowest at the 200g pigeon pea treatment, while CP intake increased with increasing pigeon pea supplementation; the control (concentrate) received the highest CP intake. ADF intake also differed among treatments, with the lowest intake at the 200g supplementation

level. In a Napier grass-based study, supplementation with graded levels of Sesbania sesban was associated with increased total DM and OM intake compared with Napier grass alone, and CP intake increased with the level of legume inclusion (Manaye et al., 2009). The response to treatment indicates that as the daily supply of pigeon pea foliage increased, intake was partly directed towards offsetting the comparatively low intake at the 200g level. Total nutrient intake for most nutrients remained higher in concentrate-supplemented sheep than at higher pigeon pea supplementation levels because of higher nutrient density.

Table 2
Daily dry matter and nutrient intakes of Gumuz sheep fed Napier grass and Pigeon pea leaves

Feed	Daily DM and nutrient intakes (g/day)					
	DM	Ash	OM	CP	NDF	ADF
Concentrate	675.01^{a}	53.54^{a}	615.04^{a}	111.67^{a}	359.91^{a}	191.97^{a}
Napier + 200 g Pigeon pea DM/day	428.99^{d}	32.36^{b}	394.73^{c}	55.54^{d}	247.82^{b}	158.83^{b}
Napier + 300 g Pigeon pea DM/day	495.68^{bc}	37.76^{b}	456.12^{c}	61.40^{c}	282.41^{b}	184.84^{ab}
Napier + 400 g Pigeon pea DM/day	565.59^{b}	38.81^{b}	524.16^{b}	72.82^{b}	315.88^{a}	206.91^{a}
S.E.M	4.74	1.69	15.83	1.00	17.33	7.81
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.007

mean values in columns having different superscripts differ significantly; *** = significant at P < 0.05; ns = not significant; SEM = standard error of the mean

3.3 Apparent Digestibility

Apparent digestibility of DM, OM, CP, NDF and ADF differed among dietary treatments (Table 3). DM and OM digestibility were highest in the concentrate treatment and generally improved with increasing pigeon pea supplementation. CP digestibility was also higher in the concentrate treatment, whereas the three pigeon pea treatments showed lower and relatively similar values. This response indicates that the greater CP concentration of pigeon pea foliage did not necessarily result in a proportional increase in apparent CP utilization. Differences in protein digestibility may be associated with the characteristics of the protein source, the balance of dietary nutrients, and interactions between dietary protein and fiber. Similarly, Teklehaymanot (2019) reported lower CP digestibility for Begait sheep supplemented with pigeon pea leaves (66.4%) than for those receiving a concentrate mixture (77%). Another study also indicate that pigeon pea leaves can maintain nutrient digestibility when used as a protein supplement, even when it replaces conventional protein sources (Nurfeta et al., 2013). However, the present result contrasts with Adebisi et al. (2023), who reported a linear increase in CP digestibility with increasing inclusion of pigeon pea foliage in diets of West African Dwarf rams. NDF digestibility showed a

numerically increased response among the pigeon pea treatments. The result indicates that ADF digestibility increased with increasing pigeon pea supplementation, with the highest value at 400 g DM animal^{-1} day^{-1}. It suggests that the addition of pigeon pea did not simply increase dietary protein but may also have improved utilization of the fibrous Napier-grass-based diet. However, the response was not uniform across all nutrients, as CP digestibility declined relative to the concentrate treatment.

Table 3
Dry matter and nutrient digestibility of Gumuz sheep fed elephant grass and pigeon pea leaves

Treatment	Apparent digestibility (%)				
	DM	OM	CP	NDF	ADF
Concentrate mixture	74.94^{a}	76.30^{a}	84.76^{a}	65.35^{a}	55.65^{a}
Napier + 200 g Pigeon pea DM/day	68.30^{c}	70.45^{c}	77.02^{b}	60.30^{b}	56.02^{b}
Napier + 300 g Pigeon pea DM/day	70.20^{c}	72.22^{bc}	76.65^{b}	62.33^{ab}	59.23^{ab}
Napier + 400 g Pigeon pea DM/day	72.64^{b}	74.63^{ab}	75.88^{b}	64.84^{ab}	61.99^{a}
S.E.M	0.600	0.56	0.54	1.02	0.89
p-value	< 0.001	< 0.001	< 0.001	0.007	< 0.001

Means with different superscripts in a column are significantly different at $P < 0.05$; S.E.M. = Standard error of the mean

3.4. Body Weight Change and Feed Conversion Efficiency

Body weight performance and feed conversion efficiency of Gumuz sheep are presented in Table 4. The dietary treatment significantly affected final body weight, body weight change, average daily weight gain, and feed conversion efficiency. The concentrate-supplemented sheep had the highest final body weight, followed by the sheep supplemented with 300 g pigeon pea foliage, 200 g pigeon pea foliage, and 400 g pigeon pea foliage. Final body weight was significantly higher in the concentrate treatment than in all pigeon pea-supplemented treatments. Similarly, body weight change was greatest in the concentrate treatment compared with sheep receiving 200, 300, and 400 g DM pigeon pea foliage animal^{-1} day^{-1}. Average daily weight gain followed the same pattern, with the concentrate treatment producing 106.33 g/day compared with 83.89, 79.44, and 74.22 g/day for the 200, 300, and 400g pigeon pea treatments, respectively.

The lower weight gain of the pigeon pea-supplemented sheep compared with the concentrate treatment occurred despite the progressive increase in DM, OM, and ADF digestibility observed with increasing pigeon pea supplementation (Table 3). This indicates that digestibility alone did not determine animal growth in the present experiment. The higher digestibility observed at the 400-g supplementation level was not accompanied by higher body weight gain. This apparent discrepancy may be related to differences in total DM intake, CP intake and utilization, energy supply, and the balance of nutrients

available to the animals. In particular, CP digestibility was substantially higher in the concentrate treatment (84.76%) than in the pigeon pea treatments (75.88–77.02%), which may have contributed to the greater growth response of the concentrate-supplemented sheep. The relatively high fiber concentration of the Napier-grass-based diets may also have constrained the supply of available energy, even when apparent fiber digestibility increased with pigeon pea supplementation.

Within the pigeon pea treatments, increasing supplementation from 200 to 400 g DM animal^{-1} day^{-1} did not increase body weight gain. Instead, ADG declined numerically from 83.89 g/day at 200 g to 79.44 and 74.22 g/day at 300 and 400 g, respectively. This response differs from the pattern observed for DM and ADF digestibility and suggests that increasing the amount of pigeon pea foliage beyond 200 g did not provide a corresponding improvement in growth performance. The lower ADG at the highest supplementation level may have resulted from changes in voluntary feed intake, dietary energy density, nutrient balance, or the characteristics of the pigeon pea foliage.

The present finding is consistent with the results of Teklehaymanot (2019), who evaluated Begait sheep fed hay supplemented with pigeon pea leaves or a concentrate mixture on an approximately iso-nitrogenous basis. In that study, the concentrate treatment produced the highest ADG (106.67 g/day), whereas sheep receiving 320 g DM pigeon pea leaves gained 51.56 g/day.

The present result is also broadly consistent with the more recent study of Tulu et al. (2024) in Horro sheep fed fodder oat hay supplemented with different Cajanus cajan varieties or a concentrate mixture. Their reported ADG was 81.4 g/day for the concentrate treatment and 68.6 g/day for the best-performing Cajanus treatment, while some Cajanus varieties produced lower gains of 56.1–62.2 g/day. Thus, the study provides evidence that legume foliage can support growth but that its growth response may be lower than or comparable with that of a concentrate supplement depending on the variety and diet.

In contrast, results were reported by Shenkute et al. (2015) for Arsi-Bale sheep supplemented with graded levels of pigeon pea leaves under farmer conditions, which increased average daily gain with pigeon pea supplementation, with the highest gain at the greater supplementation level. Such contrasting responses demonstrate that the growth response to pigeon pea is dependent on the basal diet, animal type, supplementation level, feed quality, and experimental conditions.

Feed conversion efficiency also differed among dietary treatments. The observed FCE numerically, the 200-g pigeon pea treatment had the highest FCE, whereas the 400-g treatment had the lowest value. The higher FCE observed at 200 g indicates that this treatment converted consumed dry matter into live weight relatively efficiently, despite having a lower absolute ADG than the concentrate treatment. In contrast, the 400-g treatment had both the lowest ADG among the pigeon pea treatments and the lowest FCE, suggesting that increasing pigeon pea supplementation beyond 200 g did not improve biological efficiency under the conditions of this experiment.

The results indicate that pigeon pea foliage was capable of supporting positive growth of Gumuz sheep when used to supplement a Napier-grass-based diet, but increasing the supplementation level from 200

to 400 g DM animal^{-1} day^{-1} did not improve growth performance. The concentrate treatment produced the greatest final body weight, body weight change, and average daily gain, while the 200-g pigeon pea treatment produced the highest numerical feed conversion efficiency. These results, together with the digestibility findings, suggest that pigeon pea foliage can provide a useful protein supplement, but its effect on animal performance depends on the level of inclusion and the overall nutrient balance of the diet.

Table 4
Body weight change and feed conversion efficiency of Gumuz sheep

Treatment	Mean live weight changes				
	Initial body weight (kg)	Final body weight (kg)	BWC (kg)	ADG (g/day)	FCE (g ADG/g DMI)
Concentrate mixture	18.43	28.00^{a}	9.57^{a}	106.33^{a}	0.15^{ab}
Napier + 200 g Pigeon pea DM/day	18.25	25.80^{b}	7.55^{b}	83.89^{b}	0.19^{a}
Napier + 300 g Pigeon pea DM/day	18.89	26.04^{ab}	7.15^{b}	79.44^{b}	0.16^{b}
Napier + 400 g Pigeon pea DM/day	18.37	25.05^{b}	6.68^{b}	74.22^{b}	0.13^{c}
S.E.M	0.27	0.54	0.28	3.10	0.007
p-value	0.38	0.009	< 0.001	0.001	< 0.001

mean values in a column having different superscripts differ significantly; at P < 0.05; SEM = Standard error of the mean, FCE= feed conversion efficiency, ADG= average daily gain, BWC= body weight change

4. Conclusion

Supplementing a basal diet of Napier grass with graded levels of dried pigeon pea (*Cajanus cajan*) foliage significantly improved total dry matter intake, nutrient intake, and apparent nutrient digestibility in growing Gumuz sheep. Although sheep receiving the concentrate mixture achieved superior final body weight, overall weight gain, and average daily gain, all levels of pigeon pea foliage supported positive growth performance ranging from 74.22 to 83.89 g/day. Increasing pigeon pea foliage inclusion from 200 g to 400 g DM/day enhanced dry matter and fiber digestibility but did not translate into proportional increases in body weight gain. Notably, the 200 g DM/day pigeon pea supplementation level yielded the highest feed conversion efficiency (0.19 g gain/g DMI), indicating that higher inclusion rates (> 200 g DM/day) reduce biological feed efficiency without additional weight gain benefits. Overall, pigeon pea foliage demonstrates strong potential as a high-quality, locally produced legume supplement to mitigate seasonal forage scarcity. In conclusion, supplementing a basal diet of Napier grass with 200 g DM/day of pigeon pea foliage offers an effective and biologically efficient supplementation level for growing

Gumuz sheep, achieving comparable daily weight gains to higher inclusion levels while maximizing feed conversion efficiency

Declarations

Ethics Approval

The animal experiment was reviewed and approved by the relevant ethics committee at Hawassa University. The experiment was conducted in accordance with the applicable institutional guidelines for the care and use of animals in research. The ethics committee did not provide an approval reference number.

Permissions for animal collection

The Gumuz sheep used in this experiment were purchased from a local livestock market in the Bambasi district of western Ethiopia. The animals were obtained through the local livestock market for research purposes. Any permissions required for the purchase, transport, and use of the animals were obtained from the relevant authorities, in accordance with applicable local regulations.

Conflict of Interest

The authors declare no conflict of interest.

Consent to Participate

Not applicable. This study involved an animal feeding experiment and did not involve human participants.

Consent to Publication

Not applicable.

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Author Contribution

Alayu Tarekegn conceptualization, methodology, software, validation, formal analysis, data curation, writing- original draft preparation, review and editing, visualization, project administration, investigation supervision, funding acquisition.

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Data Availability

This study is available upon reasonable request.

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