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Research Article

Effects of Mung Bean Haulms on Growth Performance, Feed Intake, Digestibility, and Nitrogen Balance in Damani Sheep

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ABSTRACT

Introduction: Mung bean (*Vigna radiata* L.) is a protein-rich grain and an important short-duration legume crop widely cultivated in Pakistan. Mung bean haulms (MBH) can be used as a forage for livestock, particularly small ruminants. The present study aimed to evaluate the effects of MBH on nutrient intake, digestibility, nitrogen balance, growth performance, and blood biochemical parameters in growing Damani lambs.

Materials and methods: Twelve healthy male Damani lambs, weighing 18-20 kg and aged 6-8 months, were randomly assigned to one of four dietary treatment groups in a randomized complete block design, with three lambs per group. The study consisted of a control group fed the basal diet (R1), and three treatment groups fed the basal diet supplemented with 33% MBH (R2), 66% MBH (R3), and 100% MBH (R4) for 90 days.

Results: The current result indicated that dry matter intake and crude protein intake increased linearly with MBH inclusion, reaching maximum values in R4 (955.4 g/d and 115.96 g/d, respectively). Apparent digestibility of neutral detergent fiber and acid detergent fiber was significantly higher in R3 and R4 than in R1 and R2. Nitrogen retention was highest in R4 (7.5 g/d), accounting for 38.4% of intake, and lowest in R1. Lambs in R4 achieved the highest final body weight (38.92 kg), total body weight gain (20.90 kg), and average daily gain (232.2 g/d) compared to the control group. Hemoglobin, packed cell volume, red blood cell count, and blood glucose increased significantly with higher MBH levels, while blood urea nitrogen peaked in R3 compared to the control group.
Conclusion: Complete replacement of alfalfa with MBH (100%, R4) improved nutrient utilization, growth performance, and metabolic health, also significantly reducing feed costs.

1. Introduction

Livestock production is a cornerstone of Pakistan's agricultural economy, contributing approximately 62% to agricultural GDP and 14.36% to the national GDP while supporting the livelihoods of millions of rural households[1]. Small ruminants, particularly sheep and goats, play a pivotal role in this sector by supplying meat, milk, and wool to both rural and urban populations. Often described as the "poor man's cow" these animals are integral to the income and food security of smallholder farmers, especially in arid and semi-arid regions where large ruminants are less feasible[2]. Among indigenous sheep breeds, the Damani is a dual-purpose (meat and wool) breed well adapted to the hot, dry conditions of Dera Ismail Khan and Bannu districts in Khyber Pakhtunkhwa province in Pakistan. Damani sheep are medium-sized and valued for their ability to thrive on low-quality forages, yet their productivity remains constrained by chronic nutritional deficiencies[3]. Seasonal feed shortages, particularly during the dry winter months (October–March), exacerbate the situations, as natural rangelands degrade and high-quality forages such as alfalfa hay become expensive and scarce[4].

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Mung bean (*Vigna radiata L.*) is an important short-duration legume crop widely grown across South and Southeast Asia for its protein-rich grains. After harvest, the remaining stems and leaves, collectively termed haulms, constitute a voluminous, low-cost agricultural by-product. Mung bean haulms (MBH) contain moderate levels of crude protein (approximately 11–12% on a dry-matter basis) and fibre, along with reasonable metabolizable energy, making them a promising alternative roughage for ruminants[5,6]. Utilization of such crop residues aligns with circular-economy principles by converting what is often burned or wasted into valuable livestock feed, thereby reducing both environmental pressure and feeding costs for smallholders.

Previous studies have demonstrated the potential of legume haulms to improve intake and digestibility in sheep when substituted for conventional forages[7,8]. For instance, enhanced dry-matter intake and nitrogen utilization in sheep offered wheat straw supplemented with various agro-industrial by-products, including legume residues[7]. Similarly, common bean residues could replace wheat straw or maize silage without adverse effects on performance and, in some cases, with improved fibre digestibility[8]. However, results have been inconsistent regarding optimal inclusion levels, and data specific to graded replacement of alfalfa with MBH in indigenous Pakistani breeds such as Damani remain limited. Anti-nutritional factors (for example, saponins, trypsin inhibitors, phytic acid, tannins, and polyphenols) present in legume haulms may also influence nitrogen utilization at higher inclusion rates, underscoring the need for breed- and region-specific evaluation[9].

It was hypothesized that complete replacement of MBH with alfalfa hay would maintain or improve performance while substantially lowering feed costs, thereby offering a sustainable feeding strategy for small-ruminant production in resource-constrained areas of Pakistan. Therefore, the present study was conducted to evaluate the effects of replacing alfalfa hay with graded levels (0%, 33%, 66%, and 100%) of MBH in iso-nitrogenous and iso-caloric total mixed rations on dry matter intake, nutrient digestibility, nitrogen balance, growth performance, and selected blood biochemical parameters in growing Damani lambs.

2. Materials and Methods

2.1. Ethical approval

The study was conducted and approved according to the guidelines of college of veterinary medicine and agriculture of Peshawar in Pakistan.

2.2. Site of experiment

The trail was conducted at the Livestock Research and Development Station, Paharpur, District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. The station lies in a semi-arid zone characterized by hot summers, mild winters, and average annual rainfall of 250–300 mm. Laboratory analyses of feed and faecal samples were performed at the Department of Animal Nutrition, The University of Agriculture, Peshawar, Pakistan.

2.3. Experimental animal and design

A total of twelve clinically healthy male Damani lambs (average initial body weight of 18–20 kg; age of 6–8 months) were selected for the trail. Prior to commencement of the trial, animals were subjected to routine health management practices, including deworming and vaccination. Animals were dewormed using Albendazole suspension (10 mg/kg body weight; ICI Pakistan Ltd. Orally) [10, 11]. Vaccination protocols included administration of Peste des Petits Ruminants (PPR) vaccine (live attenuated, 1 ml subcutaneous; Veterinary Research Institute, Lahore, Pakistan), Foot and Mouth Disease (FMD) vaccine (2 ml intramuscular; Mustafa Brothers, Pakistan), and Enterotoxaemia (ET) vaccine (1 ml subcutaneous; Veterinary Research Institute, Lahore, Pakistan), in accordance with national recommendations for small ruminants[12,13]. Animals were housed individually in well-ventilated pens measuring 1.5 × 2.0 m (3 m² per lamb), each equipped with feeding troughs and water buckets to facilitate precise measurement of feed intake and fecal collection. Clean drinking water was provided *ad libitum* throughout the experimental period, and pens were regularly cleaned to maintain hygienic conditions and minimize disease risk.

2.4. Experimental design and diets

The feeding trial was conducted using a Randomized Complete Block Design (RCBD) to minimize variation among experimental units. Lambs were blocked according to their initial body weight and age and randomly allocated within each block to one of four dietary treatments with three replicates per treatment. The experimental diets were formulated as total mixed rations (TMR) containing graded levels of MBH. The control group (R1) received a basal diet without MBH, R2, R3 and R4 was formulated with 33, 66 and 100% mung bean haulm incorporated with basal diet as shown in Table 1. All diets were balanced to meet the nutrient requirements of growing lambs according to NRC (2007) standards [14]. Feed was offered twice daily, in the morning and evening, at a level equivalent to 4% of body weight on a dry matter basis. A 10-day adaptation period preceded the 90-day experimental feeding trial to allow animals to adjust to their respective diets and housing conditions.

Table 1. Diet ingredients and composition for lambs

Ingredients (% as fed basis)	R1	R2	R3	R4
Mung bean haulms	0	15	30	45
Alfalfa	45	30	15	0
Maize	20	20	20	20
Wheat bran	18	18	18	18
Cotton Seed Cake	16	16	16	16
Salt	0.5	0.5	0.5	0.5
Vitamin/mineral mix	0.5	0.5	0.5	0.5
Total	100	100	100	100

R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms

2.6. Data collection and measurement

Data on nutrient intake, digestibility, nitrogen balance, and growth performance were systematically recorded during the experimental period. Dry matter intake was measured daily by subtracting feed refusals from the total feed offered, with refusals collected and weighed each morning before fresh feed distribution. Digestibility trials were conducted using total fecal collection over a 7-day period[15]. Feces were weighed, homogenized, and subsampled daily. Samples were oven-dried at 60 °C for 48 hours, ground to pass through a 1-mm sieve, and analyzed for proximate composition. For nitrogen balance, nitrogen intake was calculated from the nitrogen content of feed consumed[16]. Fecal nitrogen was determined from dried fecal samples, while urinary nitrogen was measured from daily urine collections. Urine was collected in acidified containers containing 10 ml of 10% sulfuric acid to prevent nitrogen volatilization. Nitrogen concentration was analyzed using the Kjeldahl method[17]. Nitrogen retention was calculated as:

$$N\ \text{retention} = N\ \text{intake} - (N\ \text{feces} + N\ \text{urine})$$

Growth performance was assessed by recording live body weights of lambs weekly before morning feeding, using a digital weighing balance with ±0.1 kg accuracy. Average daily gain (ADG) was computed as the difference between final and initial body weight divided by the number of experimental days.

2.7. Proximate analysis

Representative samples of all feed ingredients were collected during the experimental period and subjected to proximate analysis following the procedures of AOAC (2000)[18]. Samples were oven-dried at 60 °C for 48 hours, ground to pass through a 1-mm sieve, and stored in airtight containers until analysis. Dry matter was determined by oven-drying at 105 °C until constant weight was achieved, while crude protein was measured using the Kjeldahl method, with nitrogen values multiplied by 6.25 to obtain protein content. Ether extract was determined by Soxhlet extraction using petroleum ether, and crude fiber was analyzed through sequential acid and alkali digestion followed by ashing of the residue. Ash content was measured by incinerating samples in a muffle furnace at 550 °C for four hours, and nitrogen-free extract (NFE) was calculated by difference by subtracting the percentages of moisture, crude protein, ether extract (crude fat), crude fiber, and ash from 100. In addition, fiber fractions including neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to the method of Van Soest et al. (1991) [19] using an Ankom Fiber Analyzer (Ankom Technology, USA). All analyses were performed in triplicate to ensure accuracy and reproducibility.

2.8. Statistical analysis

All collected data were subjected to evaluation using a Randomized Complete Block Design (RCBD). The data were analyzed through one-way analysis of variance (ANOVA) to determine the effect of dietary treatments. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.05$. Statistical analyses were performed using SPSS software (Version 22.0, IBM Corp., Armonk, NY, USA). Results were expressed as mean ± standard error of the mean (SEM).

3. Results

3.1. Nutrient intake

The effect of MBH inclusion in the diet of Damani sheep is shown in Table 2. The incorporation of MBH significantly affected intake of nutrients ($p < 0.05$). Dry matter intake increased significantly with increasing MBH level with R4 showing highest intake (955.4 g/d), followed compared to control (911.8 g/d, $p < 0.05$). Likewise, crude protein intake (CPI) also increased significantly across treatments, with the highest value observed in R4 (115.96 g/d) and the lowest in R1 (86.1 g/d, $p < 0.05$).

Table 2. Effects of mung bean haulms on apparent nutrient intake of Damani sheep

Treatment (g/day)	R1	R2	R3	R4	SEM	Pvalue
DMI	911.8^{c}	923.9^{bc}	945.7^{ab}	955.4^{a}	24.2	0.002
CPI	86.1^{c}	105.7^{b}	108.2^{b}	115.96^{a}	5.1	0.001

^{a,b,c} Means with different superscripts within a row differ significantly ($p < 0.05$),
R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms, DMI: Dry matter intake, CPI: Crude protein intake, SEM: Standard error of mean

3.2. Apparent nutrient digestibility

The apparent fiber digestibility of MBH is shown in Table 3. Neutral detergent fiber (NDF) digestibility significantly increased from 17.01% in R1 to 28.6% in R4 ($p < 0.05$). Similarly, the digestibility of acid detergent fiber (ADF) increased progressively, with R4 depicting highest value (18.6%) and R1 the lowest (13.01%, $p < 0.05$).

Table 3. Effects of mung bean haulms on apparent digestibility of Damani sheep

Variables (%)	R1	R2	R3	R4	SEM	Pvalue
NDF digestibility	17.01^{c}	22.9^{b}	26.3^{a}	28.6^{a}	2.91	0.002
ADF digestibility	13.01^{c}	15.9^{b}	17.3^{a}	18.6^{a}	1.42	0.002

^{a,b,c} Means bearing different superscripts within a rows differ significantly ($p < 0.05$). R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, SEM: Standard error of mean

3.3. Nitrogen balance

The nitrogen balance exhibits how efficiently the animal utilizes dietary protein. The inclusion of MBH in the diet significantly increases nitrogen intake reaching 19.5 g/d in R4 compared to 10.3 g/d in R1 ($p < 0.05$). Fecal and urinary nitrogen excretion also increased significantly ($p < 0.05$). Moreover, nitrogen retention was highest in R4 (7.5 g/d; 38.4% of intake) and lowest in R1 (2.4 g/d; 23.3% of intake), demonstrating a significant difference among treatments (Table 4, $p < 0.05$).

Table 4. Effects of mung bean haulms on nitrogen balance in Damani sheep

Variable (g/d)	R1	R2	R3	R4	SEM	Pvalue
Nitrogen intake	10.3^{c}	14.3^{b}	15.7^{b}	19.5^{a}	0.07	0.002
Fecal Nitrogen	5.1^{c}	6.2^{b}	6.9^{ab}	7.6^{a}	0.27	0.001
Urinary Nitrogen	2.8^{c}	3.2^{bc}	4.01^{b}	4.4^{a}	0.31	0.003
Nitrogen retained	2.4^{c}	4.9^{b}	4.8^{b}	7.5^{a}	0.38	0.002
Nitrogen retained (% of intake)	23.3^{c}	34.2^{b}	30.5^{b}	38.4^{a}	2.8	0.002

^{a,b,c} Means bearing different superscripts within a rows differ significantly ($p < 0.05$).
R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms, SEM: Standard error of mean

3.4. Growth performance

Table 5 demonstrates the influence of MBH in growth characteristics of Damani sheep. Initial body weight did not differ among treatments ($p > 0.05$). Significant increase was observed in the final body weight, with R4 showing the highest value (38.92 kg, $p > 0.05$). Body weight gain (BWG) and average daily gain (ADG) were also significantly influenced, with the addition of bean with R4 exhibiting the greatest ADG (232.2 g/d), compared to R1 (215.8 g/d, $p > 0.05$).

Table 5. Effects of mung bean haulms on growth performance of Damani sheep

Parameters (Kg)	R1	R2	R3	R4	SEM	P-value
IBW	17.1	17.9	16.8	18.1	0.4	NS
FBW	36.56^{b}	32.03^{c}	36.98^{b}	38.92^{a}	0.6	0.001
BWG	19.42^{b}	14.11^{c}	20.39^{a}	20.90^{a}	2.3	0.002
ADG (g/day)	215.8^{b}	156.8^{c}	226.6^{b}	232.2^{a}	26.5	0.002

^{a,b,c} Means bearing different superscripts within a rows differ significantly ($p < 0.05$).
R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms, IBW: Initial body weight, FBW: Final body weight, BWG: Body weight gain, ADG: Average daily gain

3.5. Hematological and serum biochemical parameters

Table 6 demonstrates that increasing inclusion of MBH significantly influenced hematological and serum biochemical variable. Hemoglobin, packed cell volume, and red blood cell counts increased significantly with increasing haulm inclusion, with R4 showing the highest values ($p > 0.05$). Likewise, White blood cell count, and creatinine were not affected by the inclusion of beans in the diet. Blood glucose concentrations increased across treatments, with R4 showing the highest value (61.4 mg/dL, $p > 0.05$). Blood urea nitrogen differed among treatments, with the highest value observed in R3 (36.8 mg/dL, $p > 0.05$).

Table 6. Effects of Mung bean haulms inclusion on hematological and serum biochemical parameters of Damani sheep

Parameter	R1	R2	R3	R4	SEM	P-value
Hb (g/dL)	9.8^{c}	10.1^{bc}	10.4^{ab}	10.9^{a}	0.21	0.04
PCV (%)	28.4^{c}	29.1^{bc}	30.3^{ab}	31.2^{a}	0.52	0.03
RBC (×10⁶/µL)	9.1^{c}	9.4^{bc}	9.8^{ab}	10.2^{a}	0.18	0.05
WBC (×10³/µL)	8.7	8.9	9.3	9.6	0.24	NS
Blood Glucose (mg/dL)	52.3^{c}	54.8^{bc}	57.6^{ab}	61.4^{a}	1.12	0.01
BUN (mg/dL)	28.6^{c}	30.1^{bc}	36.8^{a}	32.4^{b}	0.87	0.02
Creatinine (mg/dL)	1.02	1.05	1.11	1.08	0.03	NS

^{a,b,c} Means bearing different superscripts within a rows differ significantly ($p < 0.05$).
R1: Basal diet, R2: Basal diet + 33% mung bean haulms, R3: Basal diet + 66% mung bean haulms, R4: Basal diet + 100% mung bean haulms, Hb: Hemoglobin, PCV: Packed Cell Volume, RBC: Red blood cell, WBC: White blood cell, BUN: Blood urea nitrogen

4. Discussion

The present study showed that replacing alfalfa with MBH did not adversely affect feed intake; instead, dry matter intake increased linearly as the proportion of MBH increased. Complete replacement of alfalfa resulted in significantly higher feed consumption, consistent with previous findings in sheep fed MBH[7,8]. In contrast, sheep receiving 33% MBH exhibited the lowest intake and digestibility. The observed intake pattern may be explained by dietary energy regulation, as animals adjust feed intake to meet energy requirements, with higher intake occurring when dietary energy density is lower[23].

The results of this study indicate that increasing the inclusion of MBH in the diet of Damani lambs positively influenced feed intake, nutrient digestibility, nitrogen balance, and growth performance. Feed intake increased progressively from R1 to R4, suggesting that MBH is palatable and supports better rumen fill, consistent with earlier findings[7], who reported higher intake in sheep supplemented with legume haulms. Digestibility of crude protein, NDF, and ADF also improved at higher MBH levels, likely due to enhanced rumen microbial activity and better synchronization of fermentable nitrogen and energy[20]. Although the 33% MBH diet showed slightly lower intake and digestibility, the overall trend aligns with previous work demonstrating that legume such as cowpea can effectively replace conventional forages without compromising nutrient utilization[21]. In the present study, similar energy and protein contents among diets likely limited large differences in overall intake. Nonetheless, replacing alfalfa with MBH significantly improved the digestibility of dry matter, NDF, and ADF compared with the control diet, although the increase in ADF digestibility was relatively modest.

Nitrogen retention was highest in the 100% MBH diet, reflecting improved nitrogen intake and utilization, similar to the study[7]. The negative nitrogen balance in the 66% MBH group may be attributed to anti-nutritional factors such as phytic acid, protease inhibitors and tannins or temporary metabolic imbalance[22]. Growth performance followed the same pattern, with lambs on the 100% MBH diet achieving the greatest weight gain and most efficient feed conversion, supporting earlier findings that MBH-based diets enhance growth in small ruminants[23]. Economically, MBH proved more cost-effective than alfalfa, consistent with McMeniman et al. [24], who emphasized the value of crop residues as low-cost feed resources. In line with Kaswari et al. [20], excessive urinary nitrogen excretion may also reflect imbalanced amino acid supply or surplus crude protein intake. Given the seasonal scarcity and high cost of alfalfa in Pakistan, MBH offers a sustainable and affordable alternative. Overall, the findings demonstrate that MBH can fully replace alfalfa in lamb diets while improving intake, digestibility, nitrogen retention, and growth performance, making it a practical option for smallholder farmers facing fodder shortages.

5. Conclusion

This experiment suggests that MBH can completely replace alfalfa hay in total mixed rations for growing Damani lambs without compromising performance. The 100% inclusion level (R4) resulted in the highest dry matter intake, fibre digestibility, nitrogen retention, final body weight, and average daily gain while maintaining normal blood biochemical parameters. These improvements, combined with substantially lower feeding costs, demonstrate that MBH are a superior, locally available roughage source compared with expensive alfalfa. This study confirms that MBH offer a sustainable, cost-effective, and nutritionally efficient alternative for small-ruminant feeding in Pakistan.

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical considerations

The authors have strictly adhered to ethical standards, including the prevention of plagiarism, data fabrication, and falsification. This manuscript is original, has not been published previously, and is not under consideration elsewhere. All authors have provided consent for publication and declare that no research misconduct has occurred during the study. No AI tools was used to conduct this study.

Authors' contributions

Muhammad Shoaib and Muhammad Nauman Manzoor contributed to the conceptualization, data curation, and investigation; Ihtisham ul haq and Qurat ul Ain Badhana handled the methodology, software, and original draft preparation; Dr. Muhammad Tahir Khan and Farhan Anwar were responsible for validation, visualization, supervision, and investigation; and Arshad Zahoor performed the writing, reviewing, and editing. All authors read and approved the final version of the manuscript.

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