Original Research Article

Effect of Supplementing Wheat Bran, Cowpea (*Vigna unguiculata*) Hay, and Their Combinations to Begait Lambs Fed Natural Grass Hay as a Base Diet on Their Nutrient Digestibility and Dry Matter

ABSTRACT

Aim/Objective:

- to evaluate the effect of supplementing wheat bran (WB), cowpea hay (CPH), and mixes of the two on dry matter and nutrient digestibility of Begait lambs fed natural grass hay as a basal diet.
- to determine the ideal ratio for supplementing wheat bran and cowpea hay on the dry matter and nutritional digestibility of Begait lambs given natural grass hay as their baseline diet.

Study design: The study employed a randomized complete block design (RCBD) with five treatments and blocks.

Location and Length of Study: Northern Ethiopia, Humera Agricultural Research Center farm, starting December 2016 until November 2017.

Methodology: 25 intact male Begait lambs were bought from the local market, weighing an average of 28.02 ± 1.49 kg (mean ± SD) at 5 to 6 months of age. Based on their starting body weight, they were split into five groups and assigned randomly to each of the five treatments. The standard diet for T1, T2, T3, T4, and T5 consisted of giving natural grass hay *ad libitum* plus supplements of 300 g CPH, 225 g CPH + 75 g WB, 150 g CPH + 150 g WB, 75 g CPH + 225 g WB, and 300 g WB $DMday^{-1}$. All lambs in each treatment were equipped with a fecal-collection bag for three days, after which they were required to collect all of their excrement for seven days to measure nutrient use.

Result: Among the treatment groups, differences in DM, CP (P<.001), OM, and ADF (P<.01) digestibility were noted. T5 and T3 showed higher (P<.001) DM and CP digestibility, respectively, in comparison to the other treatment groups. There was no difference in the digestibility of ADF between T5 and T3, but it was higher for T5 than for the lambs in T1, T2, and T4. Conversely, T1 showed low digestion of OM and CP.

Conclusion: Thus, the study concluded that supplementing Begait lambs with an equal amount of cowpea to wheat bran (150 g CPH + 150 g WB) outweighs the dry matter and nutritional digestibility of the lambs and that it is crucial to address the feed scarcity in the study area at a reasonable cost.

Keywords: *Begait lamb; digestibility; Vigna unguiculata; wheat bran*

1. INTRODUCTION

In the next few years, it is anticipated that the global population will rise. The demand for cattle and livestock products will rise as a result. To address this demand, effective and sustainable feeding systems must be developed.

The main source of feed for ruminants in tropical regions is rangelands with native diverse vegetation, which includes grasses, legumes, trees, and shrubs. Ruminants rely on perennial grasses and agricultural byproducts, such as crop leftovers and agro-industrial byproducts, when pasture supply declines during dry seasons. Crop leftovers are fibrous remnants whose low digestion, low voluntary intake, and low levels of nitrogen, calories, minerals, and vitamins restrict their feeding usefulness [1]. Similar to this, forage quality and availability are unfavorable throughout the year, meaning that gains achieved during the wet season are either completely or partially lost during the dry season [2]. Thus, attempts have been made to increase the nutritional content of these fibrous feeds. Herbaceous legume forages could be one way to supplement.

The Humera Agricultural Research Center (HuARC) introduced several improved herbaceous legume forages, such as cowpea, lablab, and clitoria, to the area as intervention measures. Temesgen, a cowpea variety, was listed in the national variety release in 2014 G.C. as the best feed resource in the region and among other comparable agro-ecologies in the nation, based on monitoring and evaluation of the varieties [3]. It is a valuable crop because it serves two purposes well—as human food and as animal fodder.

Temesgen is distinguished by its high crude protein content (17.15% CP) and high herbage DM output (11.9 t ha-1). Because of its high protein content, it may be used to replace the protein that ruminants consume on roughages of lower quality [4, 5], including matured natural pasture hay [6]. Animal feeding trials were necessary to assure appropriate consumption because the importance of improving the digestibility of nutrients and dry matter is not given much attention in the existing literature. Thus, the following goals guided the conduct of this study: the objectives are:

- To ascertain the impact of supplementing wheat bran, cowpea (*Vigna unguiculata*) hay, and their combinations on the dry matter and nutritional digestibility of Begait lambs fed natural grass hay as their basal diet;

- To determine the ideal ratio for supplementing wheat bran and cowpea hay on the dry matter and nutritional digestibility of Begait lambs, provide natural grass hay as their fundamental diet.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The Humera Agricultural Research Center (HuARC), located in the western zone of Tigray, Northern Ethiopia, served as the study's on-site location. It is located at latitude 14º15' N and longitude 36º37' E, at an altitude of 608.9 m.a.s.l. Vertisol is the most common soil type. The climate at the location is semi-arid with a unimodal rainfall pattern. Mean maximum and minimum temperatures ranged from 33 to 41.7 and 17.5 to 22.2°C, respectively, and the summer/rainy season brought in 581.2 mm of mean annual rainfall [7].

2.2 Experimental Animals' Management

Twenty-five intact male Begait lambs, aged between five and six months and weighing an average of 28.02 ± 1.49 kg (mean ± SD), were purchased at the nearby market. The owner gave the age information, which was confirmed through dentition. They received vaccinations against common diseases, internal parasites, and external parasites upon arriving at the center. They were also dewormed and sprayed. The 90-day stay of the lambs was preceded by a 15-day period during which they were acclimated to their new surroundings

and food while considering animal welfare. During the experimental time, the lambs were housed in separate pens with plastic buckets for hydration and supplements and feeding troughs for hay.

2.3 Experimental Design and Treatments

Five blocks of each of the five treatments were employed in a randomized complete block design (RCBD) (Table 1). At the start of the feeding trial, lambs were grouped based on their initial body weight, which was calculated as the average of two subsequent weighings following an overnight fast. Each block's lambs were randomized to receive one of the five treatment meals. They were placed in separate pen that measured 115 cm in length and 85 cm in width in a shed that had natural ventilation. Every lamb had unrestricted access to fresh, clean water and common salt. The ten-day trial was divided into three days for the suitability of the fecal-collecting bag and seven days for the actual feces collection.

Table 1. Experimental Treatments

Treatment	Grass hay	Amount of CPH supplement (g)	Amount of WB supplement (g)	Supplement amount (g head^{-1}day^{-1})	CP (g)	ME (MJ)
1	*Ad libitum*	300	0	300	51.4	6.7
2	*Ad libitum*	225	75	300	50.9	7.9
3	*Ad libitum*	150	150	300	50.5	7.9
4	*Ad libitum*	75	225	300	49.9	7.2
5	*Ad libitum*	0	300	300	49.5	8.2

CPH: cow pea hay; WB: wheat bran; CP: crude protein; ME: metabolizable energy

The treatment setup was based on the suggestions of earlier authors [8] and [9], who supplemented 300 g of cowpea haulms and Desmodium hay to achieve substantial effects on growth performance, DM intake, and digestibility on sheep, respectively.

2.4 Digestibility Trial

To evaluate the use of various dietary components, all lambs engaged in a digestibility trial at the end of the feeding trial. This experiment was conducted using the same lambs and rations as the feeding trial. Every lamb in each treatment was equipped with a fecal collection bag for three days, after which they had to collect all of their excrement for seven days. Every day, specimens and records of food given and rejected were compiled. Every animal's daily fecal excretion was gathered and noted. Each animal's daily fecal output was measured by emptying the bag before providing food and drink in the morning. Each animal's excrement was carefully mixed, with 20% of it being sampled every day and kept in labeled deep freezers at -20^{0}C.

Throughout the collecting period, the samples were put together for each animal, and 20% of the composite sample was taken out, weighed, and partially dried at 60°C for 72 hours in a forced draft oven to achieve a constant weight. After being ground to fit through a 1 mm filter, the dry fecal samples were sealed in polyethylene bags and set aside for additional chemical examination. Ultimately, each lamb's apparent digestibility coefficients (ADC) were determined using the guidelines provided in [10]:

ADC (%) = ((nutrient intake – fecal excretions)/ nutrient intake) X 100 (1)

2.5 Chemical Analysis

To ascertain nutritional content, representative samples of feed and excrement were brought to the animal nutrition laboratory center at Haramaya University. As per the guidelines provided by the Association of Official Analytical Chemists [11], analysis was conducted for DM, ash, and N concentrations. By igniting in a muffle furnace at 550 degrees Celsius for six hours and oven drying at 105 degrees Celsius for a whole night, respectively, the ash and dry matter contents were ascertained.

Crude protein (CP) was calculated as N×6.25, and the nitrogen (N) concentration was ascertained using the Kjeldahl technique. The methods of [12] were used to determine the amounts of acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL). The formula for organic matter was 100 minus ash.

Table 2. Chemical composition of experimental feeds

Feed offered	DM %	CP	NDF	ADF	ADL	Ash
		DM %				
Cowpea hay	88.75	17.15	60.00	50.30	14.50	12.50
WB	88.22	16.50	38.46	16.35	5.75	6.45
Grass hay	90.65	5.46	77.15	53.28	14.76	9.13

CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; DM: dry matter; WB: wheat bran

2.6 Partial Budget Analysis

Using the method of [13], a partial budget analysis was carried out to assess the financial benefit of the different treatment options. It had a role in the benefits and variable costs computation. Total return (TR) in the analysis was defined as the difference in lamb selling prices for each treatment before and after the trial. For the computation of the variable expenses, the expenditures spent on various feedstuffs were taken into consideration. The actual feed intake for the duration of the feeding period was multiplied by the current price to determine the cost of the feeds.

The partial budget technique computes net return (NR), or the amount of money remaining after deducting total variable costs (TVC) from total returns (TR), and measures profit or losses, which are the differences between gains and expenses for the proposed change:

NR = TR-TVC (2).

The total cost of variable costs is the sum of all input costs that vary as a result of technology used for production changes. As a reference criterion for deciding whether to adopt new technology, the change in net return (ΔNR) was computed by subtracting the change in total variable cost (Δ TVC) from the change in total return (Δ TR).

ΔNR = ΔTR-ΔTVC (3)

The rise in net income (ΔNR) corresponding to each increased unit of expenditure (Δ TVC) is measured by the marginal rate of return (MRR). A percentage is used to express this.

MRR% = (Δ NR/Δ TVC) X 100 (4)

2.7 Analytical Statistics

Using the Generalized Linear Model (GLM) of the Statistical Analysis System for Windows (SAS, 2002), data on apparent digestibility coefficients were subjected to analyses of variance (ANOVA) technique by a randomized complete-block design to detect treatment effects. A Fisher's Least Significant Difference (LSD) test was used to compare treatment means at a 5% probability level. The experiment was analyzed using the following statistical model:

$Yij = \mu + Ti + \beta j + \varepsilon ij$ (5)
Where: Yij = response variable; μ = the overall mean; Ti = the i^{th} treatment effect; βj = the j^{th} block effect (initial BW); εij = i^{th} random error

3. RESULTS AND DISCUSSION

3.1 Digestibility of Nutrients and Dry Matter

Table 3 shows that there were differences in the digestibility of DM, CP ($P<.001$), OM, and ADF ($P<.01$) across the treatment groups. T1 revealed low digestion of OM and CP. T5 and T3 showed higher ($P<.001$) DM and CP digestibility, respectively, in comparison to the other treatment groups. There was no difference in the digestibility of ADF between T5 and T3; however, it was higher for T5 than for the lambs in T1, T2, and T4.

The lowered NDF and ADF contents of WB (Table 2) and increased CP consumption (Table 4) may be the cause of the higher DM and CP digestibility seen in T5 and T3, respectively. The combination of the two supplements in similar amounts may have promoted high rumen fermentation, permitted good synthesis of volatile fatty acids (VFAs) for absorption, and boosted rumen biomass production, as suggested by the higher CP digestibility in T3 [14]. Conversely, a lower CP intake (Table 4) may be the cause of the low digestion of DM and ADF seen in T4.

The obtained DM digestibility values are between 60 and 69%, which is considered to be an indication of a reasonably high digestible level [15]. Similar levels of nutrient availability from the various combinations of the treatment diets were indicated by the lack of a significant variation in NDF digestibility in the current investigation. Previous reports of comparable outcomes exist [16–18]. Furthermore, [19] observed that there was no noticeable distinction in the digestibility of NDF and ADF, which was explained by a potential decrease in rumen pH caused by giving the animals more digestible supplements, which in turn hurts the number of rumen bacteria that ferment cell walls. Microorganism activity in the rumen is necessary for digestion. For the bacteria to function properly, they also need energy, nitrogen, minerals, and an appropriate medium [20].

Table 3. Apparent digestibility coefficients of dry matter and nutrients of Begait lambs fed natural grass hay and supplemented with *Vigna unguiculata* hay, wheat bran, and their mixes

Digestibility (%)	Treatments					SL	PSE
	T1	T2	T3	T4	T5		
DM	61.36^{b}	61.29^{b}	62.69$^{b`}$	`61.57^{b}	69.94^{a}	***	0.981
OM	60.75^{b}	68.45^{a}	67.73^{a}	69.05^{a}	70.15^{a}	**	0.988
CP	58.84^{c}	66.06^{b}	70.87^{a}	62.92^{b}	65.15^{b}	***	1.139
NDF	60.10	65.53	65.08	66.21	66.41	ns	2.554
ADF	53.89^{b}	52.65^{b}	54.16^{ab}	50.68^{c}	55.79^{a}	**	0.511

*a-c, means with different superscripts in a row are significantly different; *** = (p<.001); **= (p<.01); ns: non-significant; PSE: pooled standard error of the mean; SL: level of significance; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; DM: dry matter; OM: organic matter; T1: received 300g cowpea hay; T2: received 225g cowpea hay + 75g wheat bran; T3: received 150g cowpea hay + 150g wheat bran; T4: received 75g cowpea hay + 225g wheat bran; T5: received 300g wheat bran*.

Table 4. Daily dry matter and nutrient intake of Begait lambs fed natural grass hay and supplemented with Vigna unguiculata hay, wheat bran, and their mixes

Intake ($gday^{-1}$)	T1	T2	T3	T4	T5	SL	PSE
Grass hay DM	387.11^{b}	369.41^{b}	419.41^{a}	330.99^{c}	373.47^{b}	***	6.801
Supplement DM	300.00	300.00	300.00	300.00	300.00	ns	0.000
Total DM	687.11^{b}	669.41^{b}	719.41^{a}	630.99^{c}	673.47^{b}	***	6.801
Total DM (%BW)	2.21^{a}	2.08^{bc}	2.17^{ab}	2.01^{c}	2.11^{b}	**	0.099
Nutrient							
Total OM	682.07^{a}	669.35^{bc}	723.27^{a}	641.55^{c}	689.30^{ab}	**	7.625
Total CP	84.800^{ab}	82.631^{ab}	85.38^{a}	79.218^{c}	82.338^{b}	**	0.599
Total NDF	526.79^{a}	491.04^{a}	514.64^{a}	422.66^{b}	445.37^{b}	***	9.754
Total ADF	400.50^{a}	358.35^{b}	353.70^{b}	277.08^{c}	279.21^{c}	***	11.109
ME($MJday^{-1}$)	6.74^{c}	7.91^{ab}	7.85^{ab}	7.24^{bc}	8.17^{a}	**	0.160

*a-c, means with different superscripts in a row are significantly different; ***= (p<.001); **= (p<.01); PSE: pooled standard error of mean; SL: level of significance; ME: metabolizable energy; ns: not significant difference; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; DM: dry matter; OM: organic matter; T1: received 300g cowpea hay; T2: received 225g cowpea hay + 75g wheat bran; T3: received 150g cowpea hay + 150g wheat bran; T4: received 75g cowpea hay + 225g wheat bran; T5: received 300g wheat bran.*

Source: [7]

3.2 Analysis of a Partial Budget

The lambs fed with 150 g cowpea hay and 150 g wheat bran (T3) exhibited a better net return and a change in net return, followed by 225 g cowpea hay and 75 g wheat bran (T2) (Table 5). The net return of lambs fed 225 g WB and 75 g cowpea hay (T4) was poor. The improved growth and physical state of the lambs may be the cause of the higher net return and net return change seen in T3. Conversely, a higher total variable cost may be the cause of the lower net return seen in T4.

The cost of supplementing with wheat bran was higher than that of a diet based on cowpea hay. The primary expenses associated with the cowpea hay-based treatment were clearing the ground, planting, weeding, harvesting, and chopping. Comparatively, the partial budget analysis showed that T3 had a greater MRR than the others, which would have resulted from the lambs' higher selling price. The marginal rate of return evaluates the increase in net income and the effects of extra investment in new technology on additional net return. Therefore, data showed that giving wheat bran as a supplement caused an economic loss, whereas providing an extra unit of one birr per lamb cost increment resulted in 0.50 and 1.25 birr advantage for T2 and T3, respectively.

4. CONCLUSION

This study revealed that food had an impact on the dry matter and nutrient digestibility of Begait lambs except NDF. Lambs fed 300 g of wheat bran and 150 g CPH + 150 g WB, respectively, exhibited higher levels of DM and CP digestibility. Thus, the study concluded that supplementing Begait lambs with an equal amount of cowpea to wheat bran (150 g CPH + 150 g WB) outweighs the dry matter and nutritional digestibility of the lambs and that it is crucial to address the feed scarcity in the study area at a reasonable cost.

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Table 5. Partial budget analysis of Begait lambs fed natural grass hay and supplemented with *Vigna unguiculata* hay, wheat bran, and their mixtures

	Treatments				
Variables (ETB)	**T1**	**T2**	**T3**	**T4**	**T5**
Animal count	5	5	5	5	5
Lambs purchase price (ETB head^{-1})	800	800	800	800	800
Total intake of the basal diet (kg head^{-1})	37.58	35.90	40.41	31.91	36.15
Total intake of cowpea hay (kg head^{-1})	30.42	22.82	15.21	7.61	0
Total intake of wheat bran (kg head^{-1})	0	7.65	15.3	22.95	30.6
Basal diet expenditure (ETB head^{-1})	27.43	26.21	29.49	23.29	26.39
Cost of cowpea (ETB head^{-1})	75.75	56.82	37.87	18.95	0
Cost of wheat bran (ETB head^{-1})	0	26.77	53.55	80.32	107.1
Total variable cost (ETB head^{-1})	103.18	109.81	120.92	122.57	133.49
Δ TVC	0	6.63	17.74	19.39	30.31
Selling price of sheep (ETB head^{-1})	1060	1070	1100	1040	1090
Total Rate of return (TRR)	260	270	300	240	290
ΔTRR	0	10	40	-20	30
Net return (NR) ETB head^{-1})	156.82	160.19	179.08	117.43	156.51
ΔNR	0	3.37	22.26	-39.39	-0.312
Marginal rate of return (MRR, %)	0	50.83	125.48	-203.15	-1.03

ETB: Ethiopian Birr; TVC: total variable cost; T1: 300g cowpea hay; T2: 225g cowpea hay + 75g wheat bran; T3: 150g cowpea hay + 150g wheat bran; T4: 75g cowpea hay + 225g wheat bran; T5: 300g wheat bran

COMPETING INTERESTS

The author has declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

The author, Gebreslasie Gebrekidan, carried out the experiment's design and execution, as well as the data analysis, interpretation, and article writing.

ETHICAL APPROVAL

"The author hereby declares that "Principles of Laboratory Animal Care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee."

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author hereby declares that NO generative AI technologies such as large language models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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APPENDIX

List of Tables in the Appendix

Appendix Table 1. Summary of ANOVA for apparent digestibility of dry matter and nutrients of experimental lambs

Digestibility	DF	MS	F-value	Pr >F	SL	CV (%)
DM	10.0	41.455	11.49	0.0009	***	2.997
OM	10.0	41.696	10.94	0.0011	**	2.904
CP	10.0	58.231	14.62	0.0004	***	3.082
NDF	10.0	20.371	0.16	0.955	ns	17.556
ADF	10.0	10.836	9.42	0.002	**	2.007

DF: error degree of freedom; MS: mean square of treatments; Pr: probability; CV: Coefficient of variance; SL: significant level; ns: non-significant; ADF: acid detergent fiber; CP: crude protein; NDF: neutral detergent fiber; OM: organic matter; DM: dry matter

Appendix Table 2. Summary of ANOVA for total dry matter and nutrient intake of experimental sheep

Intake (gd^{-1})	DF	MS	F-value	Pr >F	SL	CV (%)
Hay DM intake	20.0	5103.94	13.91	<.0001	***	5.09
Total DM	20.0	5103.94	13.91	<.0001	***	2.833
Total OM	20.0	4435.838	5.18	0.0050	**	4.298
Total CP	20.0	29.657	6.10	0.0022	**	2.662
Total NDF	20.0	9998.526	11.70	<.0001	***	6.089
Total ADF	20.0	14556.837	18.39	<.0001	***	8.429
ME (MJ/d)	10.0	1.0062	7.31	0.0051	**	4.894

DF: error degree of freedom; DM: dry matter; MS: mean square of treatments; Pr: probability; CV: Coefficient of variance; SL: significant level; ADF: acid detergent fiber; CP: crude protein; NDF: neutral detergent fiber; OM: organic matter; ME: metabolizable energy

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Appendix Fig. 1. Arrangement of lambs in the pen

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Appendix Fig. 2. Feces collection procedure/method