Original Research Article

Evaluation of replacing concentrate with Mulato II and Greenleaf desmodium *(Desmodium intortum)* forages on intake, digestibility and growth performance of Farta sheep

Abstract

This study evaluated the substitution effect of concentrate with Mulato II and *Desmodium intortum* mixed forages on the intake, digestibility, and growth performance of Farta sheep fed a basal diet of natural pasture hay (NPH) for a period of 90 days. Twenty- five yearling male Farta sheep were blocked based on their initial body weight (18±1.36 kg) (mean±SD) and randomly assigned into the five treatment diets in a completely randomized block design. The five treatment diets were made in such a way that the concentrate mix was progressively replaced by Mulato II and *Desmodium intortum* mixed forages at a proportion of 0, 20, 40, 60, and 80%. The data on feed intake, digestibility, and body weight change was analyzed using the general linear model procedure of SAS version 9.4.The results showed that total dry matter intake, final body weight, average daily gain, and feed conversion efficiency of sheep were not affected by the substitution of concentrate with Mulato II and *Desmodium intortum* forages. In conclusion, supplementation of Mulato II and *D. intortum* forages up to 80% could replace the concentrate in the diet of Farta sheep without any adverse effect on the growth performance.

Key words: *digestibility, Farta sheep, growth performance, improved forages*

1. INTRODUCTION

Lack of sufficient nutrients is the common feed related challenge that highly hampered sheep production (Montoya et al 2023; Tarafdar et al 2024). Grasses and crop residues which make up the major feed resources for livestock are low in CP (usually less than <7%) coupled with high NDF (>55%) (Bogale et al 2008) and their availability is season specific.

Consequently, exploring alternative feed ingredients is compulsory to efficiently utilize bulky and fibrous crop residues as they cannot improve productivity when they are fed alone (Tolera and Sundstol 2000; Taye 2009; Tulu et al 2024). It is obvious that many smallholder farmers in most parts of the country cannot afford and/ or access conventional concentrate feeds for their animals because of scarcity and expensive costs (Beigh et al 2021). Bracharia hybrid cv Mulato II (Mulato II) and *Desmodium* *intortum* (*D. intortum*) are among the potential forages that can be used as an appropriate alternative to enhance the performance of sheep as these forages could produce cheaper rations thereby filling the gap of energy and protein in the diets of animals.

Both Mulato II and *D. intortum* are used in push-pull technology predominantly to control crop pest and weed in many parts of Ethiopia (Khan et al 2014). With the exception of very limited studies in supplementing Mulato II and *D. intortum* separately for animal evaluation experiments, there is a lack of data describing the use of Mulato II and *D. intortum* mixed forage as a supplement in sheep ration. In previous findings, Mulato II grass supplementation had improved the performance of sheep fed natural pasture hay as a basal diet (Adnew et al 2021). The supplementation value of *D. intortum* hay for sheep was also reported by Tolera and Sundstol (2000). Hence, the present study was conducted to evaluate whether Mulato II and *D. intortum* forages could be a potential alternative supplement to concentrate on feed intake, digestibility, and body weight change of Farta sheep fed natural pasture hay as a basal diet.

2. MATERIALS AND METHODS

2.1 Description of the study area

This feeding trial was conducted in sheep and goat farm at Bahir Dar University, Zenzelma Campus, which lies between 110 37'N and 370 28'E. The altitude of the area is 1911 m.a.s.l. The annual average temperature was 29 ^{0}C. The annual rainfall of the area was 1428-1521mm. The main rainy season spells from June to September.

2.2 Experimental animals and their management

For this study, twenty-five yearling male Farta sheep with an average initial body weight of 18.2±1.36 kg (mean ± SD) were purchased from the local market of Farta district by Bahir Dar University. The age of each sheep was estimated based on dentition and oral history provided by the owners. After arrival, they were housed in separate concrete house equipped with adequate floor space, feed and water troughs. Before the commencement of the experiment, sheep were placed on individual pen for 15 days of preliminary period. This was to enable experimental animals get accustom to the new environment and acclimatize the test feeds. Each pen was disinfected carefully before heading animals in and cleaned daily. All sheep were identified with ear tag, vaccinated, and dewormed. Furthermore, they were closely observed and checked for incidence and sign of any ill health and disorders.

2.3 Experimental feed preparation

With the exception of Mulato II and *D. intortum* forages, the remaining feed ingredients were obtained from Bahir Dar University livestock feed store. Mulato II and *D. intortum* forages were produced from the research site of Bahir Dar University at Ambomesik kebele. At four months of age, the forages were harvested by hand using sickle. The forages were dried under shade to prepare hay. *D. intortum* was spread over a canvas to protect leaf loss while drying (Tolera and Sandstol, 2000). At the experimental site, each forage species was chopped through a chopper for appropriate feeding. Mulato II and *D. intortum* forages were mixed at a ratio of 3:7, respectively. The maize grain was ground at Bahir Dar University livestock feed processing unit.

2.4 Experimental design and treatments

At the end of the preliminary period, animals were weighed after overnight fasting for two consecutive days and the average body weight was used to categorize them into blocks. Then, the sheep within each block were assigned randomly to one of the five treatment diets using Completely Randomized Block Design (RCBD). Basal and supplemental diets were offered separately. The supplemental diets (400g/day/head) were offered twice a day, at 8:00 AM and 16:00 PM on equal proportion basis. The sheep were offered with the basal diet *ad libitum* with the amount fed adjusted weekly to allow a 20% refusal. Clean water was provided as *ad libitum*. All sheep also had access to salt. The feeding trial was lasted for 90 days.

Five dietary treatments were used for this sheep evaluation experiment. Based on the previous recommendation for yearling Farta sheep, the supplement diet was offered at 400 g/h/day (Asmare et al 2010). The concentrate was replaced progressively by Mulato II and *D. intortum* forages at a proportion of 0, 20%, 40%, 60% and 80% with nearly iso-nitrogenous and iso-caloric level in all treatments using trial and error method. The treatment setup of the experiment containing natural pasture hay as a basal diet for this study is presented in Table 1.

Table 1. Physical proportion of feed ingredients and nutrient concentration of treatment diets (% DM basis, unless specified)

Feed ingredients	**Treatment diets**				
	T1	**T2**	**T3**	**T4**	**T5**
Natural pasture hay	*Ad lib*	*Ad lib*	*Ad lib*	*Ad lib*	*Ad lib*
Physical proportion of feed ingredients					
Noug seed cake	20.8	17.88	14.25	12	6.5
Wheat bran	49	41.34	30	20	9.5
Ground maize grain	29.2	19.78	14.75	7	3
MII	0	6	12	18	24

D. intortum	0	14	28	42	56
Common salt	1	1	1	1	1
Total	100	100	100	100	100
Nutrient content of the treatment diets					
CP	17.2	16.8	16.0	15.6	15
ME, MJ/kg DM	8.9	8.5	8.1	7.7	7.4

T1:NPH ad libitum+ concentrate only; T2:NPH ad libitum+ 80% concentrate +20% Mulato II and D. intortum; T3: NPH ad libitum+ 60% concentrate +40% Mulato II and D. intortum; T4: NPH ad libitum+ 40% concentrate + 60% Mulato II and D. intortum; T5:NPH ad libitum+ 20% concentrate +80% Mulato II and D. intortum

2.5 Body weight measurements and feed conversion efficiency

The feed offered and refusals were recorded daily for each sheep throughout the study period. The feed intake was determined by subtracting the hay refusal from the daily feed offer. Initial body weight was taken at the start of the actual feeding experiment. Subsamples of feed offered and refusals were collected on daily basis through a plastic bag from each treatment diets at the morning prior to providing the daily offer to the sheep. Then, the subsamples were pulled for each treatment diets and prepared for chemical analysis. Body weight was measured every 10 days after overnight fasting in the morning before feed offer. The final body weight measurement was taken at the end of the feeding experiment. The daily body weight gain was computed as the difference between final and initial body weight divided by number of feeding days. Feed conversion efficiency (FCE) was calculated by dividing the average daily weight gain to average daily feed intake in gram. That is,

$$FCE = \frac{ADG(g)}{ADFI\ (g)}$$

Where, ADG= Average daily weight gain and ADFI= Average daily feed intake

2.6 Digestibility trial

The digestibility trial was conducted using all experimental animals at the end of the feeding trial. The experimental animals were allowed to adapt harnessing of faecal collection bags for four days before the actual data collection. The fecal sample was collected separately using fecal collection bag fitted to each experimental animal for 7 consecutive days. Before any new feed offer, feed refusals and feces were collected and weighed every day in the morning. The daily fecal samples collected from each experimental animal were kept and frozen at -10 ^{0}C in refrigerator. At the end of the digestibility trial, a composite fecal sample of 20% was taken after thorough mixing and pooled over the collection period for each animal. The collected fecal sample for dry matter digestibility determination was partially dried at 65 ^{0}C for 72 hrs. Then, the oven dried sub- samples were ground to pass through a 1 mm sieve size and stored in an airtight polyethylene bag pending chemical analysis. The apparent digestibility percentage was computed using the following formula:

$$\text{Apparent digestibility\%} = \frac{\text{Nutrient in feed} - \text{nutrient in faeces}}{\text{Nutrient in feed}} * 100$$

2.7 Chemical analysis

Samples of feed offered were analyzed before the start of the feeding trial. Samples of feed offered and refusal were collected daily for each sheep from each treatment. Collected samples were pooled per treatment over the experimental period and stored in plastic bags pending analysis. Samples of feeds, refusals and faeces were kept in an oven and dried at 65 ^{0}C for 48 hrs. Then, the dried samples were ground using Willey mill to pass though 1mm sieve size and were kept packed in a plastic bag pending further analysis. DM and Ash contents of forage samples were determined following the procedure of AOAC (2005). The dry matter content of partially dried feed samples was determined by drying the sample in forced draft oven at 105 ^{0}C overnight. Partial DM is the dry matter content remaining after forage is heated in a forced air oven at 55 to 60 ^{0}C to less than complete dryness. Ash was determined by complete burning or igniting feed samples in a muffle furnace at 550 °C for three hours. Organic matter (OM) percentage was calculated as the difference between DM and ash percentage. Kjeldhal procedure (AOAC 2005) was used to determine total nitrogen (N) and crude protein (CP) was calculated as N*6.25. Acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) were analyzed using (Van Soest et al 1991).

2.8 Statistical analysis

The feeding and digestion experiment data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS version 9.4. Least significance difference (LSD) test was used to separate the treatment mean at 5% significant level. Statistical analysis was not performed for the chemical composition of feed ingredients and treatment diets. The model statement for growth and digestion trial was:

$Yij = \mu + Ti + Bj + \varepsilon ijk$

Where Yijk= response variable

μ = overall mean

Ti= treatment effect

Bj= block effect

Eijk= residual error

3. RESULTS

3.1 Chemical composition of experimental feeds and treatments

The chemical composition of feed ingredients, treatments, and hay refusals for this experiment is presented in Table 2. The CP value (6.38%) of the natural pasture hay was the lowest, but its NDF content (71.32%) was the highest compared to the supplement feeds. Whereas, noug seed cake had the highest CP value (31.15%) than the remaining feed ingredients. As expected, the hay refusals had lower crude protein percentage and higher NDF, ADF, and ADL contents than the corresponding offered diets.

Table 2. Chemical composition of experimental feed ingredients and treatments (% DM basis unless specified)

	Chemical composition					
	DM	**ASH**	**CP**	**NDF**	**ADF**	**ADL**
Feed ingredients						
NPH	91.52	9.36	6.38	71.32	47.6	17.84
NSC	89.58	9.91	31.15	43.35	20.96	6.77
WB	91.76	12	16	51.88	16.89	4.56
GMG	88.9	8.8	10	41.54	21.87	4.17
MII	92.13	12.68	10.5	64.54	13.92	8.71
DI	89.39	9.67	14.49	55.1	36.45	9.98
Treatment feeds						
T1	90.25	7.5	13.45	43.2	32.8	10.6
T2	90.47	7.73	12.66	46.5	33.4	11.3
T3	91.52	8.86	11.46	46.7	35.2	11.7
T4	91.68	9.41	10.55	47.3	36	12.9
T5	91.76	9.83	9.87	49.5	38.26	15.2
Hay refusals						
T1	91.62	8.71	3.81	69.94	41.1	16
T2	92.4	9.78	3.67	71.46	45	15.34
T3	92.1	10.11	3.56	71.98	51	13.5
T4	92	9.63	3.64	70.45	49.8	11.2
T5	90.91	10.56	3.55	72.57	46.25	14.51

DM= dry matter; OM= organic matter; CP= crude protein; NDF= Neutral detergent fiber; ADF= acid detergent fiber; ADL= Acid detergent lignin; NPH: natural pasture hay; NSC: Noug seed cake; WB: wheat bran; GMG: ground maize grain; MII: Mulato II; DI: Desmodium intortum; T1:NPH ad libitum+ concentrate only; T2:NPH ad libitum+ 80% concentrate +20% Mulato II and D. intortum; T3: NPH ad libitum+ 60% concentrate +40% Mulato II and D. intortum; T4: NPH ad libitum+ 40% concentrate + 60% Mulato II and D. intortum; T5:NPH ad libitum+ 20% concentrate +80% Mulato II and D. intortum

3.2 Feed and nutrient intake

Table 3 shows the daily DM and nutrient intake of Farta sheep fed natural pasture hay *ad libitum* and supplemented with Mulato II and *D. intortum* mixed forages substituting concentrate. The basal hay intake, TDMI, TDMI (%BW) and TDMI expressed as gram per metabolic body weight were not affected by the different treatment diets (P>0.05). The sheep consumed all the supplements at T1, T2, and T3 groups. Besides, OMI, CPI, NDFI, ADFI and ADLI of sheep were varied between the treatments (P<0.05). The total CPI of sheep assigned in T1 (102.9 g/day), T2 (102.6 g/day), and T3 (101.96 g/day) was statistically similar and relatively greater than those assigned in T4 (101.3 g/day) and T5 (100.97 g/day). The highest NDFI (381.81 g/day), ADFI (295.12 g/day), and ADLI (117.24 g/day) were observed in sheep fed T1.

Table 3. Mean daily feed and nutrient intake of Farta sheep fed natural pasture hay supplemented with Mulato II and *D. intortum* mixed forages substituting concentrate at different levels

Intake (g/day DM)	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	***P* value**
NPH	383.64	382.48	381.76	381.23	379.96	1.296	0.91
Supplement	396^{a}	396^{a}	396^{a}	390.64^{b}	391.38^{b}	0.625	0.0002
TDMI	779.64	778.48	777.76	771.87	771.34	1.464	0.108
TDMI (%BW)	3.1	3.2	3.2	3.22	3.4	0.034	0.13
TDMI (g/kgW$^{0.75}$/day)	69.7	71.1	71.2	71.2	74.2	0.56	0.169
Total nutrient intake							
OM	695.44^{a}	693.63^{a}	695.32^{a}	684.65^{b}	682.64^{b}	1.603	0.002
CP	102.9^{a}	102.6^{a}	101.96^{ab}	101.3^{b}	100.97^{b}	0.227	0.004
NDF	336.81^{c}	361.68^{b}	363.21^{b}	365.1^{b}	381.81^{a}	3.003	<0.0001
ADF	255.72^{e}	260.01^{d}	273.77^{c}	277.87^{b}	295.12^{a}	2.892	<0.0001
ADL	82.64^{e}	87.97^{d}	91^{c}	99.57^{b}	117.24^{a}	2.474	<0.0001

TDMI= total dry matter intake; OM= organic matter; CP= crude protein; NDF= Neutral detergent fiber; ADF= acid detergent fiber; ADL= Acid detergent lignin; NPH= natural pasture hay; T1= NPH ad libitum+ concentrate only; T2= NPH ad libitum+ 80% concentrate +20% Mulato II and D. intortum; T3= NPH ad libitum+ 60% concentrate +40% Mulato II and D. intortum; T4= NPH ad libitum+ 40% concentrate + 60% Mulato II and D. intortum; T5= NPH ad libitum+ 20% concentrate +80% Mulato II and D. intortum

3.3 Apparent digestibility of dry matter and nutrients

The apparent digestibility of DM and nutrients by sheep fed natural pasture hay basal diet and supplemented with Mulato II and *D. intortum* mixed forages substituting concentrate are shown in Table 4. Insignificant differences were observed between treatments (P>0.05) in terms of the digestibility of DM, OM, CP, NDF and ADF. Despite the non-significant effect, the apparent digestibility values for DM (70.74%), OM

(72.82%), CP (67.18%), NDF (67.55%) and ADF (50.12%) were higher for sheep fed T1, while the lower values were obtained from T5.

Table 4. Digestibility of DM and nutrients in Farta sheep fed natural pasture hay supplemented with Mulato II and *D.intortum* mixed forages replacing concentrate

Digestibility (%)	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	***P* value**
DM	70.74	67.82	66.43	65.98	64.42	0.802	0.173
OM	72.82	72.03	70.5	69.34	68.15	0.646	0.153
CP	67.18	66.65	65.9	65.3	64.33	0.334	0.08
NDF	67.55	67.26	66.66	66.06	65.69	0.239	0.061
ADF	50.12	49.84	49.42	49.3	48.54	0.258	0.4

DM= dry matter; OM= organic matter; CP= crude protein; NDF= Neutral detergent fiber; ADF= acid detergent fiber; T1:NPH ad libitum+ concentrate only; T2:NPH ad libitum+ 80% concentrate +20% Mulato II and D. intortum; T3: NPH ad libitum+ 60% concentrate +40% Mulato II and D. intortum; T4: NPH ad libitum+ 40% concentrate + 60% Mulato II and D. intortum; T5:NPH ad libitum+ 20% concentrate +80% Mulato II and D. intortum

3.4 Body weight gain and feed conversion efficiency

The body weight measurements and feed conversion efficiency of Farta sheep fed natural pasture hay and supplemented with Mulato II and *D. intortum* forages replacing concentrate mix are presented in Table 5. The FBW, ADG, and FCE of sheep had no variation (P>0.05) across the five treatment diets. Nonetheless, the FBW and ADG were ranged from 22.7 to 25 kg and 51.78 to 73.78 g/h/day, respectively. Similarly, the FCE of sheep was found in the range (0.067-0.095).

Table 5. Body weight measurements and feed conversion efficiency in Farta sheep fed natural pasture hay supplemented with Mulato II and *D. intortum* mixed forages substituting concentrate

Parameters	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	***P* value**
Initial BW (Kg)	18.4	17.9	18.1	18.2	18.1	0.272	0.962
Final BW (Kg)	25	24.4	24.3	24	22.7	0.254	0.058
ADG (g d^{-1})	73.78	71.33	68.44	64.44	51.78	2.68	0.087
FCE	0.095	0.092	0.088	0.084	0.067	0.003	0.098

BW= body weight; ADG= average daily gain; FCE= feed conversion efficiency; T1: NPH ad libitum+ concentrate only; T2: NPH ad libitum+ 80% concentrate +20% Mulato II and D. intortum; T3: NPH ad libitum+ 60% concentrate +40% Mulato II and D. intortum; T4: NPH ad libitum+ 40% concentrate + 60% Mulato II and D. intortum; T5: NPH ad libitum+ 20% concentrate +80% Mulato II and D. intortum

3.5 Correlation between DM, nutrient intake, digestibility, and body weight gain of Farta sheep

The correlation between DM, nutrient intake, digestibility, and weight gain of Frata sheep are presented in Table 6. The DMI and OMI were positively correlated (P<0.05) with CPI. The OMI was also positively correlated (P<0.05) with DMD, OMD, NDFD, ADFD, ADG, but negatively correlated (P<0.05) with NDFI and ADFI. In addition, the CPI was positively correlated (P<0.05) with DMD, OMD, CPD, NDFD, ADFD, and ADG, but, it was negatively correlated (P<0.05) with NDFI, ADFI. Similarly, the NDFI was positively correlated (P<0.05) with ADFI while it was negatively correlated (P<0.05) with DMD, OMD, CPD, NDFD, ADFD, and ADG. Furthermore, the DMD and CPD were positively correlated (P<0.05) with ADFD and ADG. However, the fiber digestibility (NDFD and ADFD) did not show any significant correlation (P>0.05) with ADG.

Table 6. The correlation between DM, nutrient intake, digestibility, and weight gain of Farta sheep

	DMI	OMI	CPI	NDFI	ADFI	DMD	OMD	CPD	NDFD	ADFD	ADG
DMI	1	0.4^{*}	0.6^{**}	0.17^{ns}	0.12^{ns}	0.21^{ns}	0.1^{ns}	-0.03^{ns}	0.21^{ns}	0.21^{ns}	0.13^{ns}
OMI		1	0.95^{***}	-0.37^{ns}	-0.47^{*}	0.44^{*}	0.42^{*}	0.37^{ns}	0.56^{**}	0.43^{*}	0.51^{**}
CPI			1	-0.42^{*}	-0.52^{**}	0.49^{**}	0.45^{*}	0.39^{*}	0.59^{**}	0.46^{*}	0.51^{**}
NDFI				1	0.89^{***}	-0.48^{*}	-0.44^{*}	-0.55^{**}	-0.46^{*}	-0.33^{ns}	-0.46^{*}
ADFI					1	-0.46^{*}	-0.5^{**}	-0.6^{***}	-0.54^{**}	-0.38^{ns}	-0.53^{**}
DMD						1	0.24^{ns}	0.17^{ns}	0.23^{ns}	0.47^{*}	0.46^{*}
OMD							1	0.3^{ns}	0.78^{***}	0.18^{ns}	0.39^{*}
CPD								1	0.38^{ns}	0.58^{**}	0.51^{**}
NDFD									1	0.38^{ns}	0.17^{ns}
ADFD										1	0.27^{ns}
ADG											1

*=$P<0.5$; **=$P<0.01$; $P<0.001$; ns= not significant; DMI=dry matter intake; OMI= organic matter intake; NDFI= neutral detergent fiber intake; ADFI= acid detergent fiber intake; DMD= dry matter digestibility; OMD= organic matter digestibility; CPD= crude protein digestibility; NDFD=neutral detergent fiber digestibility; ADFD= acid detergent fiber digestibility; ADG= average daily gain

4. DISCUSSION

4.1 Chemical composition of experimental feeds and treatments

In the present study, the CP content (6.38%) of the natural pasture hay was slightly comparable to the result (5.46%) observed by Mekonen et al (2023). Nonetheless, the NDF content (71.32%) of natural pasture hay in this study agreed with the figure (71.3%) indicated by Mekonen et al (2023). Inconsistent to our finding, Tsegaye et al (2018) observed slightly higher NDF (72%) content for natural pasture hay. The difference in NDF content of the natural pasture hay among studies could be due to species composition, stage of maturity at harvest, soil status and management practice. In fact, the low CP and high NDF, ADF, and ADL values of the natural pasture hay observed in this experiment, is an indicator of the typical features of most low-quality roughages available for livestock in Sub-Saharan Africa (Tolera and Sundstol 2000). This suggests sole natural pasture hay could not support even the maintenance requirement of sheep. According to Van Soest (1994), feeds with low CP contents (3-7%) impair the rumen function. Thus, supplementation is very crucial for animals striving with sole natural pasture hay-based diet (Tesfay and Tesfay 2013).

In line with the current result (31.15%), Nega and Melaku (2009) reported a CP value of 31.26% for Noug seed cake. On the other hand, Tesfay and Tesfay (2013) observed higher CP content (35.3%) for Noug seed cake. The variation in CP content could be attributed to the differences in the efficiency and methods used to extract oil from Noug seed. For example, expeller process with high temperatures and pressures may denature the protein and reduce its digestibility by lowering of its nutritive value. In solvent extraction process, comparatively low temperature with no pressing are used which does not alter the protein value of the meals (McDonald et al 2010).

The CP value (16%) of wheat bran in the current study slightly agreed with the result (16.4%) indicated by Estifanos and Melaku (2009). While, it was lower than the CP content (20.1%) reported by Betsha and Melaku (2009).The variation in CP content of wheat bran in these studies could arise from the effect of processing in milling industries and the quality of the grain used for milling (McDonald et al 2002).

Nowadays, the use of improved forages particularly grasses and legumes as a supplement to low quality feeds has been taken as a means of averting feed related crises in East Africa. In the current study, the CP content (10.5%) of Mulato II grass hay was slightly lower than that of Adnew et al. (2021) who documented a CP value of (12.1%) for the same cultivar. Mutimura et al (2018) also reported higher CP value (15.79%) for *Brachiaria Brizantha* cv. Piata grass but lower NDF (32.93%) and ADF (32.38%) contents compared to the current study. The disparity in CP, NDF, and ADF concentration between these studies could be associated with growing environment, stage of harvest, season, management and cultivars. Moreover, the CP (14.49%), NDF (55.1%), and ADF (36.45%) values of *D. intortum* were relatively higher than the finding of Tolera and Sundstol (2000) who found (13.8, 53.3, and 35.1%) for CP, NDF, and ADF contents of the same cultivar, respectively. Further, Korir et al (2022) reported a lower CP (10.7%), but, higher NDF (56.6%) and ADF (42.2%) contents for the same cultivar compared to the current result. The discrepancy in nutritive value of *D. intortum* might be attributed to differences in stage of maturity at harvest, soil condition, proportion of leaves to stems and post-harvest handling. The CP contents of Mulato II (10.5%) and *D. intortum* (14.49%) recorded in this experiment exceeded the CP (7%) requirement for maintenance, suggesting their potential to supplement animals striving with low quality roughages such as natural pasture hay. On top of this, the hay refusals had lower CP and higher fiber components (NDF, ADF, AND ADL contents) than the offered treatment feeds which most likely be due to the selection of more palatable parts of the hay. Indeed, sheep and goats are selective in their feeding habit. They select the most nutritious part of a particular feed. Consequently, more lignified constituents of the hay parts were unselected which mainly contributed to the low CP coupled with high fiber components of the hay refusals in the current study.

4.2 Daily feed and nutrient intake of Farta sheep

According to McDonald et al (2010), feed intake and the quality of the diet are strongly interrelated. Feed intake is mainly influenced by feed and animal related factors. Several studies showed that fiber components (NDF, ADF, and ADL) in roughages cause physical constraints on intake (Van Soest 1994; Betsha and Melaku 2009; Mutimura et al 2018).

Although the sheep had statistically similar DMI of the natural pasture hay between the treatments, there was a tendency to slightly decline in TDMI of basal diet from T1 to T5 as the level of Mulato II and *D. intortum* mixed forages increased in the supplement. The bulkiness of the forage hay might contribute to the gut fill thereby depressing basal diet intake. In contrast to the current finding (379.96- 383.64 g/day), the natural pasture hay (basal diet) was observed to increase progressively (327-453 g/day) when forage legume hay increased in the supplement (Baloyi et al 2008). The variation in basal diet intake in these studies presumably due to inherent differences in the type, level, and quality of supplements used in those feeding experiments. The sheep consumed all the supplements offered at T1, T2, and T3 treatment groups probably because of no preclude as a result of high fiber inclusion. The TDMI (771.34-779. 64 g/day) found in this study was much lower than the figure (1127-1360 g/day) reported by Obeidat et al (2018) for growing Awassi sheep fed alfalfa hay and wheat straw mixed forage. But, Jaapar et al (2022) reported relatively lower total DMI (380- 410 g/day) for sheep fed graded level of *Brachairia decumbens*.
The TDMI as percent of body weight obtained (3.1- 3.4%) in this study was found within the DMI range (2–6%) recommended for ruminants by ARC (1980). Further, the metabolic body weight (69.7-74.2 g/kg $W^{0.75}$ per day) in this experiment was also found within the figure (57.6-78.1 g/kg $W^{0.75}$ per day) reported by Betsha and Melaku (2009) for Somali goats fed *Hyparrhenia rufa* dominated hay supplemented with different levels of groundnut cake- wheat bran mixture. The CP intake (100.97-102.9 g/day) recorded in the present study was higher than the result (28.4-66.8 g/day) for Farta sheep reported by Adinew et al (2021), but lower than the range (71.1-112 g/day) for Adilo sheep supplemented with oat-vetch mixed forage (Mengsitu et al 2021). The current finding also disagreed with that of Shitaneh et al (2021) who reported relatively higher CPI (100.54-126.97 g/day) for Gumuz sheep supplemented with cowpea substituting noug seed cake. Such a discrepancy in TDMI and CPI could probably be due to the variation in the composition of feeds, quality, and levels of supplementation. The likely reason behind the highest NDFI (381.81 g/day), ADFI (295.12 g/day), and ADLI (117.24 g/day)

for sheep assigned in T5 could be due to the concentration of high cell wall components as the level of forage supplements increased. In due regard, quality of feed, rate of digestion, and voluntary feed intake are positively correlated in ruminant nutrition (McDonald, et al 2002).

4.3 Apparent digestibility of dry matter and nutrients

The digestibility of feed and its quality are positively associated. A feed having a DM digestibility of less than 55% is considered to be poor quality, but feeds exceeding 65% is high quality (David 2007). As a result, the DM digestibility of treatment feeds (64.42-70.74%) observed in this experiment could suggest its potential to improve the body weight of sheep owing to its good quality. Consistent to the present finding, Tulu et al (2024) noted that no significant difference in the apparent digestibility coefficient of DM, OM, CP, NDF, and ADF was observed for Horro sheep fed *Cajanus cajan* and *Lablab purpureus* varieties substituting conventional concentrate. The non-significant variation in apparent digestibility coefficients of nutrients could suggest the potential of forage supplements to replace concentrates in the diet of sheep. The provision of high-quality feeds enabled ruminal microbes to get nutrients that enhance the total digestibility of dietary nutrients (McDonald et al 2010).

And yet, values for the digestibility of DM (64.42-70.74%) in this study was found with in the range (62-79%) for Farta sheep fed natural pasture and Mulato II grass hay as a basal diet supplemented with concentrate mixture reported by Adinew et al (2021). In contrary to our work, lower mean DM digestibility range (29.5-67.2%) was noticed by Tolera and Sundstol (2000) for local sheep supplemented with graded levels of *D. intortum* hay. The CP digestibility coefficient (64.33-67.18%) obtained in the current finding was not comparable with a recent study by Tulu et al (2024) who found CP digestibility in the range (50.3- 64.8%) for Horro sheep supplemented with *Cajanus cajan*, *Lablab purpureus* and concentrate mixture. The discordant among these studies in DM and CP digestibilities might be due to the variation in the nutritional values particularly in terms of CP and fiber components, the composition of feeds and sheep breeds used in those experiments. According to McDonald et al (2010), protein rich feeds promote high microbial population which enhance rumen fermentation while, feeds with lower CP content could affect the rumen fermentation which in turn depress digestibility.

4.4 Body weight gain and feed conversion efficiency

The non-significant effect observed as a result of the substitution of concentrate with Mulato II and *D. intortum* mixed forages on final body weight (FBW) and average daily gain (ADG) of Farta sheep among the five treatment diets might be due to similar feed intake and digestibility across those treatment diets. This could also suggest the potential of Mulato II and *D. intortum* forages to replace the concentrate without affecting the performance of the sheep. In line with this study, Shitaneh et al. (2021)

showed that Gumuz sheep fed cowpea as a replacement to noug seed cake had statistically similar FBW across all treatments. The insignificant result of FBW found in the present finding was also comparable with the study reported by Dida et al (2023) for Gumuz sheep fed with neem leaves, Stylosanthes fruticose and Dolichose lablab replacing concentrate mix. Moreover, the positive growth performance of Farta sheep across the experimental periods is shown in Figure 1. From this finding, it observed that, all the five treatment diets positively enhanced the growth performance of the sheep which implies the comparative nutritional values of the forage supplements (Mulato II and *D. intortum*) relative to the offered concentrate feeds.

Further, inconsistent to our result (51.78- 73.78 g/day), Beigh et al (2021) reported lower body weight gain (54.12- 62.87g/day) for sheep fed an increased level of Elm *(Ulmus wallichiana)* leaf meal as a partial substitute for concentrate mixture. The discrepancy in ADG observed between these studies could probably be due to the variation in feed composition, quality, level of inclusion in the total ration and genetic potential of the breed. On top of this, a positive relationship between FCE and ADG has been reported in earlier studies (Estifanos and Melaku 2009). Due to similar intake and ADG across the five treatment diets, similar FCE was observed in the current finding for those experimental diets.

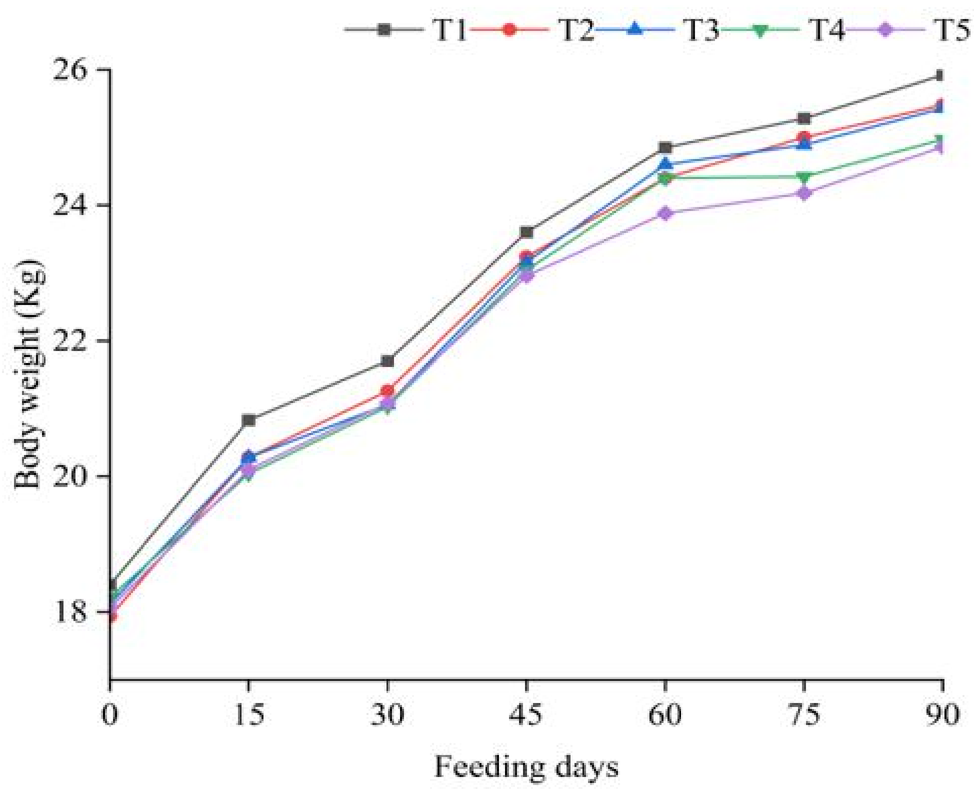

Figure 1. Trends in body weight changes for Farta sheep fed natural pasture hay basal diet and supplemented with Mulato II and *D. intortum* mixed forages substituting concentrate

Correlation between DM, nutrient intake, digestibility, and body weight gain of Farta sheep

The presence of a significant positive correlation between DMI and CPI in our study could suggest an increase in DMI is a result of enhanced CPI in sheep. In line with our finding, Shitaneh et al (2021) reported a significant positive correlation between DMI and CPI for Gumuz sheep supplemented with *Vigna unguiculata* hay replacing noug seed cake. The significant positive correlation between DMI and CPI was also reported in earlier study on sheep (Estifanos and Melaku 2009). In addition, the positive correlation between CPI and DMD, OMD, CPD, NDFD, ADFD, and ADG might be due to efficient provision of protein and utilization by rumen microbes thereby enhancing rumen fermentation. The positive correlation between CPI, CPD, and ADG in the current study agreed with the finding by Nega and Melaku (2009) who observed similar association between CPI, CPD, and ADG for Farta sheep fed hay supplemented with wheat bran and or noug seed cake.

5. CONCLUSION

The current study revealed that the supplementation of Mulato II and *D. intortum* forages could substitute concentrate in the diet of Farta sheep fed natural pasture hay up to 80% inclusion level without affecting its intake and wait gain. This study also indicates the potential of Mulato II and *D. intortum* forages in improving the growth performance of Farta sheep in the same way as concentrates did. This is very crucial to exploit Mulato II and *D. intortum* forages as an alternative quality feed compared to the inaccessible and expensive conventional concentrates.

ETHICAL STATEMENT FOR THE EXPERIMENTAL ANIMAL CARE

There is no well-organized ethical committee at the institution. However, this study was conducted in compliance with regulations governing the care and management of experimental animals.

Disclaimer (Artificial intelligence)

Author(s) hereby declare 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.

REFERENCES

Adinew, W., Abraha, B., Tassew, A., & Asimare, B. (2021). Combination of Urochloa hybrid Mulato II and natural pasture hays as a basal diet for growing Farta lambs in Ethiopia.Tropical grasslands-Forrajes Tropicales,9(2): 206-215. https://doi.org/10.17138/tgft(9)206-215

Asmare, B., Melaku, S., & Peters, K. J. (2010). Supplementation of Farta sheep fed hay with graded levels of concentrate mix consisting of noug seed meal and rice bran. *Tropical Animal Health and Production*, *42*, 1345-1352.

ARC (Agricultural Research Council). (1980). The nutrient requirements of ruminant livestock, technical review Agricultural Research Council working party.

AOAC (Association of Analytical Chemists International). (2005). Official methods of analysis of the Association of Analytical Chemists International. Official Methods: Gaithersburg, MD, USA.

Baloyi, J.J., Ngongoni, N.T., & Hamudikuwanda, H. (2008). The effect feeding forage legumes as nitrogen supplement on growth performance of sheep. Tropical Animal Health and Production, 40:457–462. https://doi.org/10.1007/s11250-007-9120-3

Beigh, AY., Ganai, AM., & Wnai, MI. (2021). Evaluation of Himalyan Elm (*Ulmus wallichiana*) leaf meal as a partial substitute for concentrate mixture in total mixed ration of sheep. Small ruminant Research, 196: 106331. https://doi.org/10.1016/j.smallrumres.2021.106331

Betsha, S., & Melaku, S. (2009). Supplementation of *Hyparrhenia rufa*-dominated hay with groundnut cake –wheat bran mix: effects on feed intake, digestibility, and nitrogen balance of Somali goats. Tropical Animal Health and Production, 41:927-933. https://doi.org/10.1007/s11250-008-9281-8

Bogale, S., Melaku, S., & Yami, A. (2008). Potential use of crop residues as livestock feed resources under conditions of smallholder farmers in Bale highlands of Ethiopia. Tropical and Sub-tropical Agro-ecosystems, 8, 107–114. Available at: http://www.redalyc.org/articulo.oa?id=93980110

David, G. (2007). Supplementary feeding of sheep and beef cattle. 2nd ed. Land links. Press. http://doi.org/10.1071/9780643094376

Dida, M.F., Beyene, A.T., & Damtew, H.A. (2023). Does *Azadirachita indica leaves, Stylosanthes fruticosa* and *Dolichus lablab* substitute conventional concentrate mixture: Evidence from the sheep feeding trial. *Journal of Agriculture and Food Researc., 12*(2023), Article 100591.https://doi.org/10.1016/j.jafr.2023.1005919.55-10.31

Estifanos, A., & Melaku, S. (2009). Supplementation of graded levels of wheat bran to intact and castrated Afar sheep fed urea treated tef straw: effects on feed intake, digestibility, body weight and carcass characteristics. East African Journal of Science, 3: 29-36. http://doi.org/10.4314/eajsci.v3i1.42783

Jaapar, M. S., Chung, L. T., Nayan, N., Muniandy, K. V., Hamdan, H. M., Jusoh, S., & Jesse, F. A. (2023). Digestibility, Growth Performance, Body Measurement and Hormone of Sheep Fed with Different Levels of Brachiaria decumbens Diets. *Tropical Life Sciences Research*, *34*(1), 67.

Khan, Z., Midega, C., Pittchar, J., & Pickett, J. (2014). Push–Pull: A Novel IPM Strategy for the Green Revolution in Africa. In: Peshin, R., Pimentel, D. (eds) Integrated

Pest Management. Springer,Dordrecht. https://doi.org/10.1007/978-94-007-7802-3_13

Korir, D., Eckard, R., Goopy, J., Arndt, C., Merbold, L., & Marquardt, S. (2022). Effect of replacing Brachiaria hay with either *Desmodium intortum* or dairy concentrate on animal performance and enteric methane emissions of low-yielding dairy cows. Frontiers in Animal science, 3: 963323. http://doi.org/3389/fanim.2022.963323

MCDonald, P., Edwards, RA., Greenhalgh, J.D., & Morgan, CA. (2002). Animal Nutrition. 6th ed., Prentice hall, London. Available at: http://books.google.et/books?id=jxUXns91aAEC

MCDonald, P., Edwards, RA., Greenhalgh, JD., Morgan, CA., Sinclair, LA., & Wilkinson, RG. (2010). Animal Nutrition. 7th ed. Longman group UK Ltd, Harlow,UK. Available at: http://books.google.et/books?id=ACWIcQAACAAJ

Mekonen, T., Tolera, A., Nurfeta, A., Barry, J. B., & Yigrem, S. (2023). Effects of substituting noug seed cake with pigeon pea leaves or desmodium hay on performance of male dairy calves. Tropical Animal Health and Production, 55:155. https://doi.org/10.1007/s11250-023-03538-y

Montoya, U.S., Chará, J.D., Murgueitio, R.E., Correa-Londoño, G.A., & Barahona-Rosales, R. (2023). Producción forrajera y consumo en ganaderías colombianas con diversos sistemas de pastoreo incluyendo sistemas silvopastoriles. *Livestock Research for Rural Development. Volume 35, Article #7.* Retrieved October 7, 2024, from http://www.lrrd.org/lrrd35/1/3507smon.html

Mutimura, M., Ebong, C., Rao, IM., & Nsahlai, IV. (2018). Effects of supplementation of Brachiaria brizantha cv. Piat_a and Napier grass with Desmodium distortum on feed intake, digesta kinetics and milk production in crossbred dairy cows. Animal Nutrition xxx,1-5.

Nega, A., & Melaku, S. (2009). Feed intake, digestibility and body weight change in Farta sheep fed hay supplemented with rice bran and/or noug seed (*Guizotia abyssinica*) meal. Tropical animal Health and Production. 41:507–515. https://doi.org/10.1007/s11250-008-9215-5

Obeidat, B.S., Subih, H.S., Taylor, J.B., & Obeidat, M.D. (2018). Alfalfa hay improves nursing performance of Awassi ewes and performance of growing lambs when used as a source of forage compared with wheat straw. Tropical animal health and production. https://doi.org/10.1007/s11250-018-1735-z

Shitaneh, E., Asmare, B., Kahliew, A., Arega, H., & Abebe, A. (2021). Appraisal of cowpea (Vigna unguiculata) hay as a replacement for noug seed (Guizotia abissynica) cake in the ration of Gumuz lambs in Ethiopia. Veterinary Medicine and Science, 2308-2332. http://doi.org/10.1002/vms3.617

Tarafder, P., Islam, S. S., Islam, M.S., Rana, H. M. A. & Sun, M.A. (2024). Effect of feeding straw-urea-molasses mixture (SUM) on live weight gain of crossbred sheep. *Livestock Research for Rural Development. Volume 36, Article #59.* Retrieved October 5, 2024, from http://www.lrrd.org/lrrd36/5/3659sard.html

Taye, M. (2009). Growth of Washera ram lambs fed on Napier (Pennisetum purpureum) and Sesbania (Sesbania sesban) mixture at different levels of combination. *Livestock Res Rural Dev*, *21*, 12.

Tesfay, T., & Tesfay, Y. (2013). Partial replacement of dried Leucaena leucocephala (Lam.) de Wit leaves for Noug (Guizotia abyssinica) (L.f.) Cass. seed cake in the diet of highland sheep fed on wheat straw. Tropical Animal Health and Prodroduction, 45:379–385. cabidigitallibrary.org/doi/full/10.5555/20133093056

Tolera, A., & Sundstol, F. (2000). Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity 1. Feed intake, digestibility and body weight change. Animal Feed Science and Technology, 85:239-257. https://doi.org/10.1016/S0377-8401(00)00135-8

Tsegaye, M., Tolera, A., Nurfeta, A., Ashagrie, A. K. & Kebreab, E. (2023). Milk yield and composition of crossbred and indigenous Boran cows fed hay supplemented with various levels of energy. *Livestock Research for Rural Development. Volume 35, Article #48.* Retrieved October 7, 2024, from http://www.lrrd.org/lrrd35/5/3548kild.html

Tulu, A., Temesgen, W., Gemechu, T., Gadisa, B., & Diribsa, M. (2024). Cajanus cajan and Lablab purpureus leaf meal-potential supplements over conventional protein sources for yearling Horro sheep fed a basal diet of fodder oat (Avena sativa) hay. Veterinary and Animal Science. 16:100376.

Van Soest, PJ., James, B., Robertson, & Betty, A. L. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of dairy science* 74, no. 10: 3583-3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2

Van Soest, PJ. (1994). Nutritional ecology of the ruminant. 2nd ed. London: Cornell University; 19:244–52. https://www.google.com.et/books/edition