Preference, Voluntary Feed Intake, and Digestibility of Sheep Fed Untreated Rice Straw and Supplemented with Sole or Combined Fodder Tree Leaves

F. Idan, T. Adogla-Bessa, and K. Amaning-Kwarteng

***Abstract* —Three experiments were conducted to measure the preference, voluntary feed intake (VFI), and digestibility of forest type (FT) sheep fed untreated rice straw (RS) and supplemented with either sole or combined fodder tree leaves [Leucaena (L), Samanea (S) or Gliricidia (G) and their equal combinations]. The preference index (PI) was determined by consumption difference of the three fodder tree leaves (FTL), using 12 FT sheep (6 rams and 6 ewes of average weight 17.0 ± 1 kg). The sheep were offered the FTL in a cafeteria-style, and the consumption within the first 1 h was used to rank them. The sheep showed marked preference ($P < 0.0001$) for Leucaena over either Samanea or Gliricidia. The PI followed this order: Leucaena > Samanea > Gliricidia. For the VFI study, a total of 24 FT sheep (16 rams and 8 ewes) of average weight 17.0 ± 1.0 kg were randomly assigned to 1 of 8 dietary treatments in a completely randomized design. The treatments were T1 (100% urea-ammoniated straw), T2 (RS + 100% L), T3 (RS + 100% S), T4 (RS + 100% G), T5 (RS + 50% L: 50% S), T6 (RS + 50% L: 50% G), T7 (RS + 50% G: 50% S), T8 (RS + 33% L: 33% G: 33% S). There were significant differences in the total and straw DM intakes. Total DM intake ranged from (523 to 694 g/d) whilst straw DM intake ranged from (430 to 692 g/d). The highest ($P < 0.0001$) total and straw DM intake were observed in sheep fed T8 and T1 diets compared to the other treatment diets. Feeding sole Gliricidia resulted in the lowest straw and total DM intakes but combining it with either Leucaena or Samanea improved intakes. In the digestibility study, 16 rams (average weight = 17.0 ± 1.0 kg) and same treatments for the VFI study were used to determine DM digestibility (DMD) and digestible organic matter in dry matter (DOMD). The DMD values ranged from 52.50% to 67.20 % while the DOMD was between 55.14 and 70.36%. Feeding T1 resulted in the highest ($P = 0.027$) DMD, and ($P < 0.0001$) DOMD but combining the FTL improved DMD and DOMD for the supplemented diets. The results of the study indicated that feeding combined FTL (3 FTL) resulted in a similar performance as that of the urea-ammoniated straw and could be used a low-cost protein supplement for sheep on low-quality roughage.**

***Index Terms* — Digestible organic matter in dry matter, dry matter digestibility, preference, voluntary feed intake.**

I. INTRODUCTION

In developing countries, crop residues and other agricultural by-products are the major feedstuff for ruminants. This is because the utilization of land favors the production of food crops instead of production of fodder for livestock production. Therefore, natural pasture serves as a source of reliable feed supply for small ruminants but only during the rainy/wet season. However, during the dry season, available pasture to support small ruminant production is quantitatively and qualitatively poor making crop residues the only major source of feed resources. One major crop residue available in large quantities in rice producing areas in Ghana is rice straw (RS).

Rice straw is a byproduct of rice production at harvest and is primarily utilized as feed for ruminants especially during the dry season. Moreover, RS contains very low energy and crude protein and is high in NDF and ADF thus limiting its utilization by rumen microorganisms and subsequently affecting livestock performance. Treating rice straw with urea is a common practice that is safe to use and usually utilized to supply inorganic nitrogen (N) that is lacking in RS [1]. According to [2] the addition of urea to RS improves the fiber degradation in the rumen. However, feeding urea-treated rice straw as a sole diet to sheep is reported to improve digestibility, but the associated low VFI results in negative N balance and loss of body weight [3]. Nitrogen deficiency and growth performance could be enhanced through the supplementation of low-quality roughages with either concentrates or fodder tree leaves. Although the use of concentrates as supplements is a common practice that could improve the utilization of low-quality roughages, it is not economically feasible to smallholder farmers due to the associated cost [4].

The main factor limiting the performance of small ruminants on pasture and cereal residue-based diets is energy and protein intake. The intake of mature pastures/forages and cereal straws are often limited due to the crudeprotein (CP) content. Voluntary feed intake is reported to decline rapidly as forage CP falls below 7%, a relationship attributed to a deficiency of N in the rumen, thus limiting microbial activity [5]. Because pasture is the primary source of energy for ruminants, improving the intake through supplementation with fodder tree leaves will increase animal performance. Thus, supplementing low-quality roughages with fodder tree leaves could stimulate

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VFI, alleviate CP deficiency, and enhance microbial digestion of the forage.

Leguminous fodder trees such as Leucaena, Samanea, and Gliricidia have high CP, minerals, and degradability and can provide by-pass protein when used as supplement to low-quality roughages. However, various species of animals react differently towards different types of feeds when offered at a specified period. The differences in the consumption of fodder tree leaves species might be attributed to differences in palatability. This might be affected by plant chemistry [6], plant morphology [7], [8] and plant phenology [9], [10], intake and digestibility. A lot of work has been done with fodder tree leaves as supplements to ruminants consuming poor quality roughages. However, there is a limited information on the use of combined fodder tree leaves on the intake and performance of small ruminants on foraged based diets. Therefore, the objective of the study was to measure the relative preference, intake, and digestibility of sheep fed untreated rice straw and supplemented with three fodder tree leaves solely or in equal combination.

II. Materials And Methods

A. Experimental Site

The experiment was conducted at the Livestock and Poultry Research Centre (LIPREC), University of Ghana of the Coastal Savanna Zone in the Accra plains. The mean rainfall for the area is between 508 mm to 743 mm with a mean temperature range of approximately 24.3°C and 32.9°C. The major rainy season occurs from April to July and the minor rainy season from September to October. The dry season is from November to March.

B. Preparation of feedstuffs

The rice straw (Jasmine Rice) was obtained from the Small-Scale Irrigation Agricultural Project, Ashaiman in the Greater Accra Region of Ghana. The RS was chopped into approximately 30 mm using an electric forage cutter and a portion used to prepare the urea-ammoniated straw. The urea-ammoniated straw (UAS) was prepared by spreading chopped RS into a concrete culvert lined with polythene sheets. The straw was ammoniated by spraying each layer of 16 kg rice straw with urea solution (1 kg urea in 10 liters of water) as described by [11]. The fodder tree leaves (*Leucaena leucocephala, Samanea saman, and Gliricidia sepium*) were obtained from matured woodlots at LIPREC, University of Ghana. The fresh fodder tree leaves were harvested by hand-cutting and wilted a day before they were offered to the animals. The harvested foliage was wilted to a DM content of approximately 80%. A random sample was taken for all the experimental forages and oven-dried at 55ºC for 48 h and was finely ground to pass through a 1 mm mesh sieve and stored in air-tight plastic bags until required for analysis.

C. Dietary Treatments and Experimental Design

The experiments were arranged in a completely randomized design. For the preference study, there were 3 treatments (fodder tree leaves) and six replicates (FT sheep). The treatments were made up of 1) *Leucaena leucocephala* (T1), 2) *Samanea saman* (T2), *and* 3) *Gliricidia sepium* (T3). In the case of the voluntary feed intake (VFI) and digestibility studies, 8 treatments (3 FTLs and their combinations and UAS) and 3 replicates per treatment were used. The treatments comprised of 1) Urea-ammoniated Straw (T1); 2) Untreated rice straw (RS) + 100% *Leucaena leucocephala* (T2); 3) RS + 100% *Gliricidia sepium* (T3), 4) RS + 100% *Samanea saman* (T4), 5) RS + 50% L: 50% G (T5) 6) RS + 50% L: 50% S (T6), 7) RS + 50% S: 50% G (T7), and 8) RS + 33% L: 33% S: 33% G (T8). The urea-ammoniated straw was used as the positive control diet for both the intake and the digestibility studies.

D. Animals, Housing, and Management

For the preference index study, six forest type sheep (3 females and 3 intact males) of average body weight of 17.0 ± 1.0 kg housed in individual pens were used for the study. The house was made up of wooden sides, concrete floor, and asbestos roofing sheets. Each pen house had a wooden feeding trough and a plastic water trough. Lighting was provided 12 h a day throughout the experimental period. Mineral salt lick and water were provided *ad libitum* throughout the study period. To measure the preference of FTL by sheep, each of the 6 sheep were offered the 3 foliage in a cafeteria style around 8: 30 am each morning before feeding. After feeding the FTL, all the sheep were provided urea-ammoniated straw at 5% of the body weight. Two weeks (14 d) was set aside as the adjustment period while data was collected for the next 7 d. The consumption of each of the foliage within the first one hour was measured and used to rank the feed in order of preference by sheep to determine the preference index.

In the case of the voluntary feed intake and digestibility studies, twenty-four FT sheep (16 rams and 8 ewes) with a mean live weight of 17.0 ± 1.0 kg were used to measure the VFI and digestibility of dry matter of the forages. The intake study was made up of 14 d adaptation period and 14 d of data collection. The animals were housed in individual pens and were offered the experimental diets two times a day. Apart from the sheep on the positive control diet which were offered only urea-ammoniated straw, the rest were fed RS and supplemented with either sole or combined fodder tree leaves. For the sheep fed the foliage, the fodder tree leaves, or their combinations were fed prior to feeding the RS. To eliminate preference, the fodder tree leaves were mixed thoroughly to prevent selective consumption of sheep on combined foliage treatments.

The digestibility study consisted of 14 d adjustment period and 14 d data collection period with 16 intact males. Unlike the VFI study, the digestibility study was conducted with only intact males. Each sheep was fitted with a fecal bag for the collection of feces. During the data collection period, daily feed intake and refusal, and fecal output of the individual sheep were measured. The feces were bulked per animal into a composite and stored in a freezer for DM and N analysis later. Mineral salt lick and water were provided *ad libitum* throughout the experimental period for both the VFI and digestibility studies.

E. Chemical Analysis and Calculations

At the end of each experiment, stored forages and fecal samples were dried in an oven at 55ºC to constant weight for dry matter determination. They were then ground using a laboratory mill through a 1 mm sieve and subsequently analyzed for the proximate contents using the standard methods of A.O.A.C [12]. Organic matter (OM) determination was done by subtracting residual ash obtained after ashing at 550ºC for 6 hours from the dry matter. Dry matter intake (DMI) and digestible organic matter in dry matter (DOMD) were also determined. Feed intake was calculated as DM Intake = Feed offered Daily – Daily Feed Refusals. Digestibility of the feed was calculated using the relation below:

$$\text{DM Digestibility (\%)} = \frac{\text{DM Intake} - \text{Fecal DM}}{\text{DM Intake}} \times 100$$

$$\text{DOMD (\%)} = \frac{\text{OM Intake} - \text{Fecal OM}}{\text{OM Intake}} \times 100$$

F. Statistical Analysis

In the preference studies, there were three treatments (FTL) and six replicates (animals). For the intake and digestibility studies there were eight treatments (3 FTL and their combinations and urea ammoniated straw). The experimental data were analyzed as CRD through analysis of variance (ANOVA) using the General Linear Model procedure of SAS 9.4 [13]. Mean differences were considered significant at ($P \leq 0.05$) using Tukey's test.

III. Results

The ingredients and chemical composition of the feeds used in the formulation of the experimental diets is presented in Table I. The DM and OM contents of the straws were higher than that of the fodder tree leaves. The DM values of the fodder tree leaves ranged from 57.80 to 74.70 %, while the OM values were between 49.80 and 67.49 %. The CP concentrations of the foliage was between 22.90 to 27.11 %. Combining the fodder tree leaves increased the CP content above Samanea and Gliricidia. The NDF varied between 30.04 and 40.50 % while the ADF ranged from 17.57 to 31.36 %. The total ash contents of the fodders, singly and in the investigated combinations ranged from 5.00 to 10.16 %. Table II shows the chemical composition of the experimental diets.

The preference index as determined by the mean consumption of the fodder tree leaves by sheep is presented in Table III. The type of fodder tree leaf significantly affected both the as-fed and DM consumption by the sheep. Providing Leucaena foliage to sheep resulted in the highest ($P < 0.0001$) mean consumption compared to either the Samanea or Gliricidia foliage. The Gliricidia foliage was the consumed fodder by the sheep. The preference of sheep for the fodder tree leaves followed this order: *Leucaena leucocephala* > *Samanea saman* > *Gliricidia sepium.*

TABLE I: Ingredients And Chemical Composition Of Feeds Used In The Formulation Of The Experimental Diets[1]

Item	DM	OM	CP	NDF	ADF	Ash
Forage			**(%)**			
RS	93.70	76.39	6.68	58.90	51.70	17.31
UAS	89.50	69.27	10.02	54.20	50.10	20.23
Leucaena (L)	67.00	56.90	27.11	30.04	17.56	10.16
Samanea (S)	73.90	66.13	24.05	40.62	31.35	7.77
Gliricidia (G)	57.80	49.80	22.90	30.29	20.35	8.00
50 L: 50 S	67.70	62.50	25.68	35.52	26.18	9.00
50 L: 50 G	59.30	52.69	26.83	30.57	22.46	9.10
50 S: 50 G	64.20	55.94	25.27	31.40	28.98	7.86
33 L: 33 S: 33G	74.70	67.49	25.81	37.49	20.55	9.21

[1]Experimental diets consisted of rice straw in combination with either sole or combined fodder tree leaves, rice straw treated with urea, and fed as a sole diet.
RS = Untreated rice straw; UAS = Urea ammoniated rice straw; DM = Dry matter; OM = Organic matter; CP = Crude protein; 50 L: 50 S = 50% Leucaena and
50% Samanea; 50 L: 50 G = 50% Leucaena and 50% Gliricidia; 50 S: 50 G = 50% Samanea and 50% Gliricidia; 33 L: 33 S: 33G = 33% Leucaena, 33% Samanea and 33% Gliricidia.

TABLE II: Composition Of The Experimental Diets

Diets	T1	T2	T3	T4	T5	T6	T7	T8
Feed Ingredients				**(%)**				
RS	93.75	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Urea	6.25	0	0	0	0	0	0	0
Leucaena (L)	0	25.00	0	0	12.50	12.50	0	8.34
Samanea (S)	0	0	25.00	0	12.50	0	12.50	8.33
Gliricidia (G)	0	0	0	25.00	0	12.50	12.50	8.33
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis								
DM, %	89.50	87.03	88.75	84.73	87.20	85.10	86.33	88.95
OM, %	69.27	71.52	73.83	69.74	72.92	70.47	71.28	74.17
CP, %	10.02	11.79	11.02	10.74	11.43	11.72	11.33	11.46
NDF, %	54.20	51.69	54.33	51.75	53.06	51.82	52.03	53.55
ADF, %	50.10	43.17	46.61	43.86	45.32	44.39	46.02	43.19
Ash, %	20.23	15.52	14.93	14.98	15.23	15.26	14.95	15.28

RS = Untreated rice straw; T1 = Urea ammoniated rice straw; T2 = RS supplemented with Leucaena foliage; T3 = RS supplemented with Samanea; T4 = RS supplemented with Gliricidia; T5 = RS supplemented with 50% Leucaena and 50% Samanea; T6 = RS supplemented with 50 %Leucaena and 50% Gliricidia; T7 = RS supplemented with 50% Samanea and 50% Gliricidia; T8 = RS supplemented with 33% Leucaena, 33% Samanea, and 33% Gliricidia.

TABLE III: MEAN CONSUMPTION OF LEUCAENA, SAMANEA, AND GLIRICIDIA FOLIAGE BY SHEEP (G/H)[1]

Fodder Species	As-Fed Intake	Dry Matter Intake
Leucaena	147.21^{a}	98.63^{a}
Samanea	126.67^{b}	93.60^{b}
Gliricidia	18.58^{c}	10.74^{c}
SEM	2.69	1.42
P Value	<0.0001	<0.0001

[1]Foliage was harvested and wilted for a day and offered in a cafeteria style to sheep for 1 h.
^{a,b,c} Means in the same column with the different superscripts are significantly different ($P < 0.05$).
SEM = Standard error of the mean.

The effect of the treatment diets on voluntary feed intake and DM digestibility of sheep is presented in Table IV. Treatment diets significantly ($P < 0.0001$) affected the DM intake (DMI) of straw, foliage, and CP of sheep. Feeding UAS (T1) resulted in the highest DMI of straw compared to the other treatment diets. The DM intake of straw by T4 and T8 was significantly higher than that of T2, T3, T5, T6, and T7. The sheep fed T1 had the lowest ($P < 0.0001$) CP intake compared to those fed the other treatment diets. The total DMI intake for sheep fed the T1 and T8 was similar ($P > 0.05$) but both were higher ($P < 0.0001$) than the other treatment diets. Moreover, no difference ($P = 0.703$) was observed in the DMI as a percentage of BW of sheep fed the different treatment diets.

The DM digestibility (DMD) and the digestible OM in DM (DOMD) was significantly influenced by dietary treatment. Feeding sole Leucaena and Samanea resulted in lower DMD ($P = 0.027$) compared to feeding urea ammoniated straw. However, apart from T7, combining the fodder tree leaves resulted in a similar DMD compared to the UAS diet. The DOMD was increased ($P < 0.0001$) for sheep fed T1 compared to the other treatment diets. There was variability in DOMD of sheep fed the fodder tree leaves with those fed the T4 and T7 having the highest and lowest ($P < 0.0001$) respectively.

As shown in Table IV, both the foliage DMI intake and foliage DMI intake as a percentage of BW were affected by the type of foliage or their combinations fed to sheep. Feeding combined fodder tree leaves (T5, T7, and T8) resulted in higher foliage DMI compared to the other supplemented diets. As a percentage of BW, foliage DMI was not significantly different for the sheep the combined foliage, but all were higher than those on T3 and T4. Feeding sheep sole Leucaena as a supplement to RS resulted in similar foliage DMI as a percentage of BW.

TABLE IV: MEAN DRY MATTER INTAKE (G/ANIMAL/DAY), DM DIGESTIBILITY (%), CP INTAKE AND DM INTAKE/ BODY WEIGHT VALUE OF A SOLE DIET OF LEUCAENA, SAMANEA AND GLIRICIDIA AND THEIR COMBINATIONS FED TO SHEEP

Diets	Straw DMI, g/animal/d	Total DMI, g/animal/d	Foliage DMI, g/animal/d	Foliage DMI, % of BW	CP Intake, g/100g/ animal/d	Total DMI/BW, g/kg	DMD, %	DOMD, %
T1	692^{a}	692^{a}	0	0	10.50^{b}	0.045	67.50^{a}	70.36^{a}
T2	453^{d}	574^{c}	121^{c}	22.50^{b}	25.50^{a}	0.035	58.75^{c}	61.57^{c}
T3	454^{d}	556^{c}	102^{d}	18.50^{c}	24.00^{a}	0.040	58.95^{c}	61.84^{c}
T4	430^{e}	524^{d}	94^{e}	16.00^{cd}	22.00^{a}	0.050	52.50^{d}	55.14^{d}
T5	464^{c}	610^{b}	146^{a}	24.00^{b}	23.00^{a}	0.045	61.00^{ba}	63.55^{c}
T6	464^{c}	587^{bc}	123^{c}	22.50^{b}	27.00^{a}	0.050	61.50^{ba}	63.56^{c}
T7	469^{c}	600^{b}	131^{b}	27.50^{a}	26.50^{a}	0.050	60.95^{ba}	62.26^{c}
T8	552^{b}	694^{a}	142^{a}	28.00^{a}	26.50^{a}	0.055	62.50^{ba}	65.53^{b}
SEM	5.00	6.76	0.83	1.00	0.94	0.01	1.20	0.030
P Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.703	0.027	<0.0001

T1 = Urea ammoniated rice straw; T2 = RS supplemented with Leucaena foliage; T3 = RS supplemented with Samanea foliage; T4 = RS supplemented with Gliricidia; T5 = RS supplemented with 50% Leucaena and 50% Samanea; T6 = RS supplemented with 50 %Leucaena and 50% Gliricidia; T7 = RS supplemented with 50% Samanea and 50% Gliricidia; T8 = RS supplemented with 33% Leucaena, 33% Samanea and 33% Gliricidia. DMD = Dry matter digestibility, OMD = Digestible organic matter in dry matter.
^{a,b,c,d,e} Means in the same column with the different superscripts are significantly different ($P < 0.05$). SEM = Standard error of the mean.

IV. DISCUSSION

In most developing countries, small ruminants are raised on natural pasture with little or no supplementation by the producers. Therefore, good quality forage to support livestock production is normally scarce in the dry season due to prolonged droughts, continuous over-grazing, and lack of range improvement interventions [14]. According to [15], the nutritive value of the predominant pasture species during the dry season remain very poor with an average CP content of less than 7%, resulting in low CP intake by livestock.

The available feed resources for feeding livestock during the dry season are mostly cereal crop residues such as rice straw. Rice straw is abundantly available from small- and large-scale rice cultivating fields and serve as the main source of roughage for livestock. However, feeding only RS provides insufficient nutrients to maintain ruminants on high production levels due to the low nutritive value, lower digestibility, and lower CP intake. According to [1], high level of lignification and silicification, and low nitrogen content of RS, slow down and limit ruminal degradation of carbohydrates as well as reduces N intake thus affecting its utilization as feed for ruminants. The poor fermentation of rice straw coupled with low N degradability reduces the rate of disappearance in the rumen thus decreasing feed intake [16].

Research has indicated that treating straw with urea or sodium or calcium hydroxide could increase the nutritive value, palatability, and degradability of straw and hence increase the intake compared to untreated rice straw [17]-[19]. However, due to the price of urea, sodium or calcium hydroxide, supplementation of RS with fodder tree leaves could be more effective approach by small holder ruminant producers. Supplementing FTL to ruminants fed untreated rice straw is thought to increase N intake, digestibility, and improvement in ruminant performance. However, the nutrient content/chemical composition, digestibility, and palatability of the fodder tree leaf determines its true feeding value. From the current study, the chemical composition (DM, CP, OM, and minerals) of the FTL and the rice straw were similar to those reported by other researchers [20]-[22]. Generally, differences in chemical composition of FTL have been attributed to differences in cultural practices (such as rates of fertilizer application), maturity, period of harvest [23], variety, environmental conditions and agronomic factors [24]. The crude protein concentrations in the FTL of 22.90 – 27.11 % obtained in this study were well above the minimum requirements of 6.0 – 11.0 % suggested by [25] for moderate livestock production. In comparison to the FTL, the rice straws had higher DM but lower CP content. Treating the RS with urea increased the CP content to that of the supplemented diets.

Herbivores by their nature can select from a wide range of feedstuffs to obtain nutrients needed for sustaining their essential body functions [26], [27]. The observed selective intake of the three FTL during the current study shows that the sheep had marked preference for *Leucaena leucocephala* to both *Samanea saman* or *Gliricidia sepium*, and Samanea to Gliricidia. Blair [28] suggested that small ruminants cannot survive on large amount of low-quality forage due to the low reticule-rumen capacity, and have therefore, developed a selection mechanism for fodder tree leaves with high protein content. This is consistent with the results of the current study where the sheep selected *Leucaena* over *Samanea* and *Gliricidia* partly due to the highest CP content and palatability. This agreed with [29] who reported that preferences for sheep and goats correlate positively with N content of forages.

Research has indicated that small ruminants tend to avoid foliage/browses with offensive odor. This could probably be the reason for the partial refusal of the *Gliricidia* in the current study. Similar observations were made by [30] where goats took five days to adapt to prescribed intakes of fresh and dried Gliricidia leaves. This initial reluctance of animals to eat *Gliricidia* according to [31] is attributed to the odor of the leaves. The result of the current study indicated partial acceptance of *Gliricidia* while total rejection was observed by [21]. The preference of fodder trees leaves has also been reported to have a very strong relationship with the ash content of the leaves [32]. Walker [33] and Hadjigeorgiou et al. [34] observed positive relationship between the ash content and relative preference index (RPI). This agreed with the results obtained in the current study where Leucaena recorded the highest intake during the preference trial as a result of the highest ash content. Thus, the ash content which measures the mineral content might be a plant linked factor that affects the acceptability of fodder trees.

It is a common knowledge that RPI partially relates negatively with the fiber content, hence fodder tree leaves with high NDF, ADF, and lignin content tend to be less preferred. From the study, the NDF, ADF, and lignin content of Leucaena was relatively low and correlated with the intake thus resulting in the highest preference. On the contrary the fiber contents (NDF and ADF) of the Gliricidia leaves although comparable to Leucaena had no positive impact on RPI, probably due to the odor and other anti-nutrients that might be present in it. In accordance with the current study, the preference of Leucaena corroborated with [35] who suggested that feedstuffs with low NDF (20 – 35%) are more digestible and are therefore preferred by ruminants.

Feed intake is a measure of diet appreciation, selection, and consumption by an animal [36]. It is regarded as one of the major factors that determine the potential of animal performance. However, feeding low-quality forages such as rice straw tend to hinder the productivity of small ruminants due to a lower palatability, DM intake and digestibility, high-fiber content, and lower nutritive value. Therefore, by treating rice straw or low-quality roughages with urea or supplementing with concentrates or fodder tree leaves microbial fermentation in the rumen increases thus maximizing total DM intake and improving ruminant performance [19], [37], [38]. From the current study, the straw DMI ranged from (430 – 692 g/d) and was significantly higher for the sheep fed urea treated rice straw (T1) compared to those fed untreated rice straw and supplemented with FTL. The improved feed intake of fed T1 compared to those fed RS could be attributed to increased nutritive value, palatability, and degradability of straw due to the addition of urea [18], [19]. This is because RS is highly lignified and has low nitrogen, mineral, and vitamin contents. Additionally, the relatively low intake of RS by sheep fed the supplemented diets might be due to the substitution effect of the fodder tree leaves due to their high nutrient content, thus satisfying the nutrient requirement of the sheep without additional straw DM intake. This agreed with [39], who reported that straw DMI by sheep decreased in the supplemented groups compared to the control diet even though a basal diet of urea treated straw was fed. In the case of the supplemented diets, combining the fodder tree leaves compared to a sole FTL resulted in higher straw DMI. Comparatively, feeding the sheep T8 (3 FTL) significantly improved straw DM intake compared to feeding (2 FTL). This is consistent with the results obtained by [40] where the supplementation of *Sesbania* and *Leucaena* mixture increased the DMI intake of straw by sheep. From the current study the variations in the straw intake could be attributed to the differences in the composition of the FTL used.

The total DMI of (523 – 692 g/d) obtained from the current study were higher than those obtained by [41] (430.5 – 528.4 g/d) but lower than [42] (1009.4 – 1,080.7 g/d) in a similar work. There were significant differences in the total DMI of sheep fed the different treatment diets. The total DMI increased with the feeding of treated rice straw compared to feeding RS and supplemented sole FTL. Combining the FTL further increased the total DMI of the supplemented diets. However, feeding the sheep T8 (3 FTL) resulted in a similar total DMI compared to the urea treated rice straw (T1). This indicated that

T8 might have created a favorable rumen environment resulting in enhanced fermentation of the RS, thus increasing microbial protein synthesis, rate and extent of digestion which resulted in increased DM intakes. In all, the total DMI for all the experimental diets were high. The high intakes could be related to the high CP content of the experimental diets which were all above the minimum requirement suggested by [43] for moderate production. However, the variations in the intakes could be attributed to the differences in the CP and fiber contents of the feedstuffs. While Smith et al. [44] reported increased in *ad libitum* intake as the protein content of a diet increased, the results obtained from the current study were inconsistent with their observation. Although, the CP content of the *Leucaena* diet was the highest compared to the other experimental diets, it did not translate into the highest total DM intake. The variability in the intake could also be attributed to the differences in the level of anti-nutritive factors in the different supplemented diets. Reed [45] reported a decline in DMI due to the presence of tannins and this might explain why the sheep fed *Gliricidia* diet had the lowest total DM intake. Other factors may include degradability of the browses and nature of basal diet of the animals [46]. The differences in the DM of the supplements may also have contributed to the differences in the total DM intake.

The DMI of the fodder tree leaves and the FTL dry matter intake as a percentage of the BW were significantly different. Feeding T5 and T8 resulted in the highest FTL dry matter intake compared to the other FTL. According to [47], the voluntary feed intake of FTL is influenced to a large extent by the crude protein content. This partially agreed with the results from the current study where the Gliricidia diet with the lowest CP content had the lowest intake. However, the *Leucaena* diet which had the highest CP did not result in the highest intake. The reluctance of ruminants to consume Gliricidia has been attributed not only to the CP content but also the odor and other anti-nutritive factors present in the leaves [31], [48]. Other researchers attributed the rejection of the Gliricidia to the presence of potential toxic substance known as coumarin which changes to dicoumarol when the leaves are crushed [49]. However, Chadhokar [50] observed that no long-term detrimental effects on sheep and cattle occur once the animals are accustomed to the feed. Research has indicated that sheep prefer to be selective and are easily bored by consuming the same feed every day [51]. This is consistent with the current study where the sheep fed the combined FTL especially T5 and T8 had the highest DM intake. Adegun [52] investigated the voluntary feed intake and nutrient utilization of West African dwarf sheep fed supplements of *Moringa oleifera* and *Gliricidia sepium* fodders. The author observed that feeding *Gliricidia* singly resulted in lower DM intake of the foliage. However, combining the *Moringa* and *Gliricidia* fodders resulted in higher VFI compared to feeding either Moringa or Gliricidia indicating that there were better production outcomes in FTL mixtures than single FTL. The higher intakes could be attributed to improved palatability due to the combination of the two fodders which is consistent with the results obtained in the current study. The FTL dry matter intake as a percentage of BW increased mostly for the combined FTL with sheep fed T3 and T4 having the lowest. This indicated that the sheep fed the experimental diets apart from T3 and T4 diet derived 22.50 to 27.50 of BW from consuming the fodder tree leaves. The observed improved performance as shown in the FTL intake as a percentage of BW in the current study might be due to the supply of high-quality energy and protein from the combined FTL sources compared to sole FTL.

The apparent DMD and DOMD values obtained was an indication that all the rumen environments were favorable for the digestibility of the diets. The differences observed may be due to the chemical composition of the feedstuffs [53]. The lowest DMD and DOMD in the sole *Gliricidia* diet could be due to the lower DM content of the diet compared to the others. According to [54] DM and OM digestibility is dependent on the cell wall constituents of diets with feedstuffs having higher fiber (NDF and ADF) being less digestible than those with lower fiber contents. This was inconsistent with the results of the current study where the fiber content had no effect on DMD and DOMD values. Apparently higher digestibility values were obtained in favor of the sheep fed T8 compared to those fed sole FTL. The non-significant differences observed among the combined FTL for DMD could be attributed to the cell wall constituents (fiber), especially NDF [55]. This indicates that combining the browses will reduce the NDF content thus improving the intake and digestibility of the diets of the sheep.

V. Conclusions

From the current study, the preference of sheep varied among the fodder tree species under consideration. The species which was most preferred was *Leucaena leucocephala*, while *Gliricidia sepium* was the least preferred species, with *Samanea saman* being intermediate, indicating that the sheep consumed more Leucaena within the allotted time for measurement.

Feeding Leucaena, Samanea or Gliricidia singly as supplement to sheep fed a basal diet of rice straw did not adversely affect the voluntary feed intake and digestibility. However, combining the fodder tree leaves further improved the intake and digestibility of sheep than the sole fodder tree leaves mainly due to synergistical effects. Additionally, combining all the three fodder tree leaves (33% L: 33% S: 33% G) as supplement resulted in the most effective means of improving intake and digestibility of FT sheep. This indicated that combined fodder tree leaves could be utilized as the most effective cheap source of protein supplements for improving the performance of small ruminants.

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