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Chemical Composition and *In sacco* Dry Matter Degradability of Selected Browse and Grass Species in Abobo District, Gambella Regional State, Ethiopia

[1]Bizelew Gelayenew, [2]Ajebu Nurfeta, [3] Getnet Assefa and [1]Getahun Asebe

[1]Gambella University, College of Agriculture and Natural Resource,
Department of Animal Science, Gambella, Ethiopia
[2]Hawassa University, College of Agriculture,
Department of Animal and Range Sciences, Hawassa, Ethiopia
[3]Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia

Abstract: This study was conducted to evaluate on the chemical composition and *in sacco* dry matter (DM) degradability of browse and grass species collected in Abobo district. Based on their persistence and utilization as feeds of ruminant livestock species, the edible portions of leaves and fine stems of samples of five browse and five grass species were selected and harvested during wet and dry seasons. For browse species, the crude protein (CP) content varied from 14.2% in *L. fraxinifolius* to 24.4% in *F. virosa* during wet season and ranged between 7.6% in *S. kunthianum* to 20.2% in *F. virosa* during the dry season. The acid detergent lignin (ADL) content ranged between 9.1% in *V. amygdalina* to 17.5% in *A. seyal* during the wet season, while during the dry season it varied from 7.4% in *F. virosa* to 14.3% in *S. kunthianum*. Similarly, for grass species the CP content ranged between 4.2% in *H. rufa* to 18.1% in *A. gayanus* during wet season, but during the dry season it varied from 3.8% in *H. rufa* to 15.0% in *A. gayanus*. *In sacco* DM degradability and degradability characteristics varied ($P<0.05$) within and between seasons. At 48 hour of incubation the highest ($P<0.05$) DM degradability of browse species was recorded in *F. virosa* (77.2%) while the lowest was measured in *A. seyal* and *S. kunthianum* during the wet season, while during the dry season the highest figure was in *V. amygdalina* (76.9%) while the lowest was for *L. fraxinifolius* (43.9%) and *S. kunthianum* (45.5%). Similarly, the highest DM degradability of grasses was recorded in *C. dactylon* (52.4%) during the wet season, but during the dry season the highest was obtained in *A. gayanus* (55.3%). In conclusion, the selected browse species and *Andropogon gayanus* grass can be used as supplementary to poor quality roughages to fill the gap especially in dry season for feeding of ruminant livestock when roughages are in short supply and low in crude protein content.

Key words: Browse · Grass · Seasonal Variation · Chemical Composition · Degradability

INTRODUCTION

The main sources of feed for ruminants are grasses and browses in sub-Saharan Africa [1] under extensive production system. Yet natural pastures are generally poorly managed due to over stocking and communal grazing resulting in sever land degradation [2] in addition to the poor quality of feed from such sources. The quality and availability of forages vary depending on season which in turn affects the performance of animals [3-6]. There existed species and seasonal variations in chemical composition of grass and browse species [7]. Moreover, the land traditionally used for grazing is declining from year to year due to population increase and the shift of grazing land to crop farming [8]. As a result, the performance of animals is affected especially during dry season due to shortage and poor quality of the available feeds. To overcome the problem, there are several methods of improving the productivity of animals. One of such method is supplementation with tree legumes through cut and carries system or allowing animals to graze or browse under small scale production systems.

Corresponding Author: Bizelew Gelayenew, Gambella University, College of Agriculture and Natural Resource, Gambella, Ethiopia.

During the dry season, in the present study, grazing is limited to grass lands found along riverbanks and swamps. There is lack of information about the nutritional qualities of grass and browse species in the study area. Hence, evaluation of the nutritive value of such forages is essential to provide a basis for the establishment of adequate diets for ruminants composed of grass and browse forages [1]. Availability of such information is a paramount importance in designing the development strategies, research plans and any intervention options for both livestock production and natural resource management. Therefore, the objective of this study was to evaluate the chemical composition and *in sacco* dry matter degradability of selected browse and grass species during the wet and dry seasons.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in Abobo district, Gambella Regional State (GRS) which is located in the south-western part of Ethiopia. It is situated in the lowlands of the Baro-Akobo River Basin between latitudes of 6°22′ and 8°30′ N and longitudes of 33°10′ and 35°50′ E. The range of annual rainfall and average temperature are 800-1400 mm and 34.4°C, respectively [9]. The rainfall is uni-modal and occurs in the lowlands from May to October [10]. It varies with season and about 80-90 percent of the rainfall occurs during the wet season. December, January, February and March are the driest months; less than 2 percent of the annual rainfall occurs in these months over the lowlands of the region while about 4 to 6 per cent occurs in the highlands [9].

For Age Sampling: The commonly available forage species (grasses and browses) were collected from the selected sites. Sampling of the forage was made from a total of 6 representative grazing sites. Each range site was further divided into three randomly selected sample sites (9 for each site). Based on their persistence and utilization as feed for livestock the edible portions of leaves and fine stems of major browse and grass forage species were harvested during wet (September) and dry (March) seasons. The forage samples were air-dried under the shade and kept in a properly labeled bag until processing. The dried samples were ground in Willy Mill to pass through 1- and 2-mm sieve size for the determination of chemical composition and *in sacco* dry matter (DM) degradability, respectively. The milled samples were kept in airtight plastic bags pending the chemical analysis and degradability study.

***In sacco* Degradability Study:** The *in sacco* DM degradability was determined by incubating about 3 g of ground samples in duplicate nylon bags (Pore size of 40-50µm and 9 cm × 14 cm in dimension) in the rumen of three fistulated crossbred (Boran × Fresian) steers weighing about 600 kg kept under maintenance ration. The steers were managed in door and were offered ad libitum natural pasture hay (about 6.5% CP) supplemented in the morning with 2 kg concentrate per head. The concentrate was a mixture of 44% noug cake (*Guzotia abyssinica*), 55% wheat bran and 1% salt. Water was provided ad libitum. Rumen degradability was determined by incubating the samples for 6, 12, 24, 48, 72 and 96 hours. Immediately on removal from the rumen, the bags were rinsed thoroughly under running tap water until clear water appeared at the end. Then the bags were dried in a forced-draught oven at 65°C for 72 hours. Duplicate bags were dried in the same way to determine the DM content of the samples. Washing losses were determined by soaking duplicate bags per sample in cold tap water for about half an hour and washed in a similar procedure as that of the incubated bags. The dried bags were taken out of the oven and dry weights were recorded. The degradability was measured in terms of disappearance of DM and expressed as percentage as follows:

$$\text{Dry matter disappearance (DMD)} = \frac{((BW + S_1DM_1) - (BW + RW))}{(S_1 \times DM_1)}$$

where:
BW = Empty bag weight; RW = Dried residue weight; S_1 = Sample weight; DM1 = Dry matter content of the original sample.

The degradability constants were determined using the exponential equation p = a+b ($1-e^{-ct}$) as described by Ørskov and McDonald [11] using the Neway Excel programme [9], where *p* = % DM degradability at time *t*. The lag time was estimated by fitting the model p = A for $t = t_0$, p = a + b ($1-e^{-ct}$) for $t > t_0$ [10]. The degradation characteristics of the feeds were defined as A = washing loss (readily soluble fraction); B = (a+b)-A, representing the insoluble but fermentable fraction; c = the rate of degradation of B and the lag phase (L) = 1/c $\log_e$[b/ (a+b-A)] [14]. Potential degradation (PD) was estimated as (A+B), while effective degradability (ED) of DM was calculated according to Dhanoa [15] using the formula ED = A+ [Bc /(c+k)] at rumen outflow rates (k) of 3% h^{-1}.

Chemical Analysis of Feed Samples: Dry matter and ash contents of feed samples were determined according to the procedures of AOAC [16]. Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was calculated as N × 6.25. The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to the procedure of Van Soest and Robertson [17].

Statistical Analyses: The chemical compositions of major browse and grass forage species in the dry and wet seasons were determined using descriptive statistics. The *in sacco* DM degradability and degradability characteristics were analyzed using the general linear model (GLM) procedure of the statistical analysis system software [18]. Significant differences between means were tested using Duncan's multiple range tests.

The model used for the nylon bag data analysis was:

$$Y_{ijk} = \mu + F_i + \beta_j + S_k + FS_{ik} + e_{ijk},$$

where;
μ = Overall mean;
F_i = Forage species;
β_j = Replication (animals) effect;
S_k = Season effect;
Fs_{ik} = Interaction effect;
e_{ijk} = The random error.

RESULTS AND DISSCUSSION

Chemical Composition of Selected Browse and Grass Forage Species

Browse Species: The chemical compositions of selected browse species are presented in Table 1. Among the browse species, the lowest ash content was observed in *A. seyal* and *V. amygdalina* during dry and wet seasons, respectively, while the highest was in *L. fraxinifolius*, in both seasons. This finding was within the range of values (5.44 to 25%; 7.69 to 25.28%) reported for other browse species by Samson [19] and Zewdie [20], respectively. Among the browse species, the highest CP content was observed in *F. virosa* (20.2% and 24.4%) during dry and wet seasons, respectively. During dry season these species also can maintain fairly its leaves and remain green. This indicated that they could be used as a supplement to low quality feed during dry season. *S. kunthianum* had the lowest CP (7.6%) content during dry season and *L. fraxinifolius* (14.2%) during wet season. This finding was comparable with the values (10.3% and 12.47% CP) reported by Samson [19] for other browse forage species during dry and wet seasons, respectively. Seasonal variations in chemical compositions were observed among different multipurpose trees [21, 22]. Likewise, the differences observed in chemical composition among the browse species were agreed with the findings of Apori *et al*. [23] and Yayneshet *et al*. [24]. According to Turgut and Yanar [25] the variation in nutrient composition of forages could be attributed to variety, stage of maturity at harvest time, soil type, weather conditions and management practices such as level of fertilization. Moreover, plant species, growing, conditions (soil, climate and grazing) and the ratio of leaf to twig and stage of maturity at sampling affect the nutritive value of forages [26]. Generally, the browse species were characterized by high content of CP which makes them suitable as protein supplements to poor quality pasture and fibrous crop residues. During dry season, except *L. fraxinifolius* and *S. kunthianum* all the browse species were found to contain a CP concentration above the threshold CP content (11-12%) but, only *A. gayanys* among grass species had above aforementioned threshold level which is required for moderate level of ruminant production [27]. All the studied forage species during wet and dry seasons had the CP content greater than the level (6-8%), except *H. rufa*, *O. abyssinica* and *S. arundinaceum* grass species, below which appetite and forage intakes are depressed [28]. For optimum activity of micro-organisms in the rumen, about 6–8% rumen degradable CP is required [29, 30].

The highest acid detergent lignin (ADL) content was observed in *A. seyal* (17.5%) during dry season and *S. kunthianum* (14.3%) during wet season. *A. seyal* was exceptional because of its high ADL content during the dry season, low value in the wet season and relatively low ADF content in both seasons. The CP content of *A. seyal* was acceptable to be used as a supplement because the CP content was concurred with the average figure of quality wheat bran. This result is comparable with other finding of the same browse forage species in the northern Ethiopia [31], who reported that *A. seyal* had a CP content of 18.8% and 15.2% during wet and dry seasons, respectively.

There was a wide variation in CP, NDF, ADF, ADL and ash contents within a season for both wet and dry season which was coincided with the result of Larbi *et al*. [32] who observed significant variation among seasons. Because during wet season the herbages were young, green and lush while during the dry seasons the majority

Table 1: Mean values of chemical composition of browse forage species during the dry and wet seasons

Season and species	DM%	Chemical composition (%DM)				
Dry season		Ash	CP	NDF	ADF	Lignin
Acacia seyal	89.1	7.7	15.5	42.7	28.7	17.5
Flueggea virosa	90.4	10.3	20.2	40.3	30.3	9.2
Lecaniodiscus fraxinifolius	90.8	14.4	7.9	63.2	58.0	10.9
Stereospermum kunthianum	91.2	13.0	7.6	65.1	57.4	11.7
Vernonia amygdalina	92.3	8.8	14.1	47.6	36.5	9.1
Wet season						
Acacia seyal	84.0	7.6	19.3	38.3	20.2	7.8
Flueggea virosa	88.9	9.1	24.4	34.9	24.8	7.4
Lecaniodiscus fraxinifolius	89.2	12.8	14.2	59.7	44.8	13.3
Stereospermum kunthianum	90.7	12.1	16.9	64.6	50.9	14.3
Vernonia amygdalina	88.9	6.2	16.2	50.2	37.9	10.6

DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, Dry season = November -April, Wet season= May - October

of herbages were over matured and lignified. Moreover, within a season some of the forage species were evergreen due to their natural features, grown on the riverside and at re-growth stages after burning of the natural pasture. The seasonal differences in the chemical composition of browse species were associated to the differences in climatic conditions between seasons, which influence cell wall lignifications [33, 34]. The observed variations in CP, NDF and ADF contents of the browse species during dry and wet seasons were agreed with previous reports for browse forage species in the humid tropics [32].

Generally, the chemical composition of the browse forage species consumed by livestock (Table 1) showed that high CP and low to medium NDF and ADL contents. The CP, ADL and NDF contents are indicative of the quality of forages, since feed quality increases with increasing CP contents and/or decreasing NDF and ADL contents. The majority of browse forage species in the present study had high CP values and relatively low in fiber compared to most other grasses which were used as livestock feed.

Grass Species: Chemical composition of selected grass species are presented in Table 2. The chemical composition showed wide variation among the grass species. Ash and CP contents were highest for *A. gayanus* during dry and wet season. The CP content in the present study was agreed with the CP content of many leguminous forages and *Panicum miliaceum* reported in northern Ethiopia [31]. The high CP content (15.0%; 18.1% in the dry and wet seasons, respectively) makes *A. gayanus* suitable as protein supplements to poor quality pasture and fibrous crop residues in the study area. This finding was concurred with the result of Shenkute [35], who reported that the CP content for most of immature grasses ranged from 7.2 to 20.2% of DM, whereas for matured grasses ranged from 5.6 to 11.5% of DM. *S. arundinaceum* and *H. rufa* had the lowest ash and CP contents, respectively. Among grass species, *A. gayanus* exceptionally had the highest CP (15%, 18.1%) content during dry and wet seasons, respectively. It was agreed with that of leguminous browse forage species. Therefore, this grass species could be used as a protein supplement to poor quality pasture and fibrous crop residues for feeding of ruminants particularly during the dry season. In general, the CP content of grass species during the dry season is low. This study corresponded with that reported for tropical forages [36]. In general, the overall mean values of CP during the dry season were lower than those of the wet seasons, while the NDF, ADF and lignin contents were higher. These were agreed with the studies by Berhane *et al*. [31] and Yayneshet *et al*. [24] who reported seasonal variation among grass species. The NDF and ADF contents of *A. gayanus* were the lowest of all grasses during the dry season. These results were concurred with other grass species in northern Ethiopia [31]. *H. rufa* had the highest NDF and ADF contents during both seasons. The NDF content during the dry season ranged from 77.0% in *A. gayanus* to 83.7% in *H. rufa*. During the wet season also the lowest NDF was measured in *A. gayanus* (64.4 %) and the highest was recorded for *H. rufa* (83.5%). These grasses contain greater than 64% NDF. According to Singh and Oosting [37] if the roughage contains above 65% NDF, it is considered as poor quality feed. Moreover, Alemu [38] indicated that the NDF content that ranged from 67% to 78% to be high enough to limit DM intake and digestibility. Generally, there is a negative correlation between NDF concentration of forage and intake, due to the need to hold the forage in the rumen for further mastication and fermentation by microorganisms [39].

Table 2: Mean values of chemical composition of selected grass species during the dry and wet season

Season and species		Chemical composition (% DM)				
Dry season	DM%	Ash	CP	NDF	ADF	Lignin
Andropogon gayanus	91.2	16.9	15.0	77.0	46.4	6.1
Cynodon dactylon	91.6	10.7	7.4	82.5	49.3	9.6
Hyparrhenia rufa	91.8	9.7	3.8	83.7	56.5	8.9
Oxythanthera abyssinica	90.2	12.6	5.4	80.7	56.0	10.5
Sorghum arundinaceum	91.5	9.1	5.3	83.0	52.2	10.2
Wet season						
Andropogon gayanus	89.3	13.3	18.1	64.4	39.6	4.7
Cynodon dactylon	91.5	9.9	9.3	75.3	35.9	5.9
Hyparrhenia rufa	91.9	9.6	4.2	83.5	57.2	9.3
Oxythanthera abyssinica	89.4	11.0	9.9	80.4	50.8	7.0
Sorghum arundinaceum	91.0	5.5	9.8	75.0	43.9	6.4

DM =dry matter, CP =crude protein, NDF= neutral detergent fiber, ADF= acid detergent fiber, Dry season=November - April, Wet season=May - October

Table 3: Dry matter degradability of five selected browse species at different times of incubation in the rumen during wet and dry seasons

		Incubation time (h)						
Season	Browse species	0	6	12	24	48	72	96
Wet	*Accacia seyal*	7.53	16.16^{c}	20.82^{d}	26.30^{e}	32.54^{c}	35.52^{c}	36.15^{d}
	Flueggea virosa	21.51	34.06^{a}	48.43^{a}	62.28^{a}	77.20^{a}	83.07^{a}	83.78^{a}
	Lecaniodiscus fraxinifolius	23.87	27.65^{b}	34.73^{b}	43.28^{b}	53.40^{b}	58.38^{b}	58.88^{c}
	Stereospermum kunthianum	22.48	26.00^{b}	28.99^{c}	32, 28^{d}	36.71^{c}	39.01^{c}	40.81^{d}
	Vernonia amygdalina	18.54	24.67^{b}	29.91^{c}	39.75^{c}	51.21^{b}	60.87^{b}	64.56^{b}
	SEM	-	0.45	0.37	0.45	0.76	0.51	0.67
Dry	*Accacia seyal*	4.15	5.80^{d}	9.32^{c}	13.94^{d}	21.69^{d}	25.73^{d}	26.53^{d}
	Flueggea virosa	20.60	35.25^{a}	44.38^{a}	52.55^{b}	63.06^{b}	67.40^{b}	70.79^{b}
	Lecaniodiscus fraxinifolius	23.72	26.23^{c}	31.24^{b}	36.47^{c}	43.93^{c}	48.86^{c}	50.42^{c}
	Stereospermum kunthianum	19.77	26.28^{c}	32.69^{b}	39.05^{c}	45.47^{c}	48.83^{c}	50.47^{c}
	Vernonia amygdalina	21.22	30.77^{b}	44.91^{a}	57.90^{a}	76.93^{a}	81.98^{a}	83.89^{a}
	SEM	-	0.50	0.32	0.65	0.82	0.75	0.77
					Significance			
S.V		0	6	12	24	48	72	96
Season		-	NS	NS	NS	NS	NS	NS
Browse		-	***	***	***	***	***	***
S×B		-	***	***	***	***	***	***

abcd= means with different superscripts in the same column and the same hour are statistically different (P<0.05), 0 hour= washing loss, S. V= source of variation, SEM= standard error of mean, S x B= season and browse species interaction, Wet season= May - October, Dry season=November - April, *p<0.05, **p<0.01, ***p<0.001

Dry Matter Degradability and Degradability Characteristics of Selected Browse and Grass Species: Dry Matter Degradability: Data on dry matter (DM) degradability are presented in Table 3 and Table 4 for browse and grass species, respectively. Differences in DM degradability were found at all incubation periods (6-96). The DM degradability allows the description of the quantity of nutrients effectively degraded in the rumen of livestock and the outflow rate of food from the rumen [40]. At all incubation hours there were season x feed interaction (P< 0.001) for both grass and browse species. During dry season the highest (P<0.05) DM degradability was measured in *V. amygdalina* and the lowest (P<0.05) was recorded for *A. seyal* at 24, 48, 72 and 96 hours of incubation. During wet season, the DM degradability in browse species was highest (P<0.05) in *F. virosa* at all incubation hours. This was agreed with results reported by Aina *et al*. [41] for other browse forage species. Variation in chemical composition could be one of the contributing factors for the difference in DM degradability in the current experiment. Similarly, Adugna and Sundstøl [42] indicated that the variation in DM degradability could be caused by NDF, cellulose and hemicellulose contents.

Table 4: Dry matter degradability of five selected grass species at different times of incubation the rumen during wet and dry seasons

Season	Grass species	Incubation time (h)						
		0	6	12	24	48	72	96
Wet	*Andropogon gayanus*	19.05	23.88[a]	27.34[b]	32.13[bc]	39.23[c]	42.02[c]	43.63[c]
	Cynodon dactylon	18.86	24.32[a]	30.96[a]	39.26[a]	52.36[a]	59.00[a]	61.01[a]
	Hyparrhenia rufa	12.65	18.62[b]	23.33[c]	29.08[c]	38.35[c]	43.96[bc]	46.04[bc]
	Oxythanthera abyssinica	14.16	19.33[b]	23.85[c]	30.00[c]	39.80[c]	46.42[b]	48.10[b]
	Sorghum arundinaceum	13.72	19.41[b]	27.41[b]	34.35[b]	48.46[b]	55.61[a]	59.01[a]
	SEM	-	0.39	0.41	0.46	0.48	0.52	0.51
Dry	*Andropogon gayanus*	19.34	24.57[a]	32.96[a]	43.76[a]	55.30[a]	63.53[a]	65.68[a]
	Cynodon dactylon	10.38	16.29[b]	20.66[b]	26.71[b]	35.85[c]	40.03[dc]	41.83[c]
	Hyparrhenia rufa	8.18	13.62[bc]	18.00[c]	25.76[b]	39.58[b]	48.36[b]	51.43[b]
	Oxythanthera abyssinica	8.79	13.13[c]	17.75[c]	24.72[b]	34.65[c]	41.70[c]	43.73[c]
	Sorghum arundinaceum	6.03	12.23[c]	16.62[c]	21.78[c]	31.75[c]	38.64[d]	41.37[c]
	SEM	-	0.37	0.38	0.28	0.29	0.24	0.47
		Significance						
S.V		0	6	12	24	48	72	96
Season		-	***	***	***	***	***	***
Grass		-	***	***	***	***	***	***
S×G		-	***	***	***	***	***	***

abcd=means with different superscripts in the same column and the same hour are statistically different (P<0.05), 0 hour= washing loss, S. V= source of variation, SEM= standard error of mean, S x G= season and grass species interaction, Wet season= May - October, Dry season=November - April, *p<0.05, **p<0.01, ***p<0.001

During wet season, *C. dactylon* had higher (P < 0.05) DM degradability than other grass species at all incubation periods except for *S. arundinaceum* at 72 and 96 h. *A. gayanus* had the highest (P < 0.05) DM degradability during dry season at all incubation period. The variation of *in sacco* degradability has practical implication as there is positive correlation between degradability and voluntary feed intake and digestibility [43]. In general, DM degradability of each forage species increased progressively as incubation period increased during both seasons. The DM degradability varied between the two seasons which was concurred with the report of Camacho *et al*. [44] for browse species and Berhane *et al*. [31] for grass species.

Degradability Characteristics of Selected Browse Forage Species: The DM degradation characteristics of the browse forage species for the wet and dry seasons are presented in Table 5. There was an interaction (P<0.001) of season × species for all degradability characteristics. During the wet season, the rapidly degradable fraction was lowest (P<0.05) for *A. seyal* (8.29%) and highest (P<0.05) for *S. kunthianum* (22.81%) and *L. fraxinifolius (22.74%)*. Similarly, Anele *et al*. [22] observed interaction between season and species for PD, ED, the rapidly degradable fraction and the insoluble, but potentially degradable fraction for different multipurpose trees. In the present study, the rapidly degradable fraction was lower than the values reported by Solomon *et al*. [45] and Lebopa *et al*. [46] for other browse species. During the dry season the lowest (P<0.05) rapidly degradable fraction was observed in *A. seyal (*3.05%), while the highest was recorded in *L. fraxinifolius (*23.19%). This is an important characteristic of roughage since the contribution of the rapidly degradable fraction to the gut fill is little and almost completely digestible [47].

During wet season, the slowly degradable fraction was lowest (P<0.05) for *S. kunthianum* (18.65%) and *A. seyal* (27.89%) and highest (P<0.05) for *F. virosa (*64.39%) and *V. amygdalina* (56.48%) which were within the range of the values reported by Solomon *et al*. [45] and Lebopa *et al*. [46], except *S. kunthianum.* The slowly degradable DM fraction ranged from 27.55% for *A. seyal* to 66.9% for *V. amygdalina* during dry season.

During wet season, the rate of DM degradation was higher (P<0.05) for *A. seyal* (0.047/h) and *F. virosa* (0.043/h) than *L. fraxinifolius*, *S. kunthianum* and *V. amygdalina*. The rate of degradation varied from 0.022/h for *A. seyal* to 0.048/h for *F. virosa* during dry season. The rate of degradation was by far lower than the range values (0.034 to 0.081/h) reported by Ngodigha and Oji [48]. Moreover, the mean rate of degradation was also lower than the values reported by Solomon *et al*. [45] in other browse species. Both the slowly degradable fraction and the rate of degradation were within the range values (19.2% to 70.4% and 0.01 to 0.7/h, respectively)

Table 5: Degradability characteristics of selected browse forage species during wet and dry season

	Wet season					Dry season				
	a	b	PD	ED		a	b	PD	ED	
Species	%				c (/h)	%				c (/h)
Accacia seyal	8.29^{d}	27.89^{c}	36.18^{d}	25.26^{d}	0.047^{a}	3.05^{c}	27.55^{c}	30.60^{d}	14.76^{d}	0.022^{c}
Flueggea virosa	20.92^{b}	64.39^{a}	85.31^{a}	59.00^{a}	0.043^{a}	22.05^{a}	47.49^{b}	69.53^{b}	51.06^{b}	0.048^{a}
Lecaniodiscus fraxinifolius	22.74^{a}	39.56^{b}	62.30^{c}	42.50^{b}	0.030^{b}	23.19^{a}	31.29^{c}	54.47^{c}	36.74^{c}	0.023^{c}
Stereospermum kunthianum	22.81^{a}	18.65^{c}	41.46^{d}	32.14^{c}	0.030^{b}	19.88^{b}	30.79^{c}	50.67^{c}	37.61^{c}	0.042^{ab}
Vernonia amygdalina	18.44^{c}	56.48^{a}	74.93^{b}	40.29^{b}	0.021^{b}	19.92^{b}	66.94^{a}	86.86^{a}	56.65^{a}	0.037^{b}
SEM	0.17	1.35	1.35	0.33	0.00138	0.24	1.18	1.00	0.39	0.001

Significance

S.V.	a	b	PD	ED	C
Season	**	NS	NS	NS	NS
Browse	***	***	***	***	***
S×B	***	***	***	***	NS

$^{a-b-c-d}$ means with in a column with different superscripts are significantly different ($P < 0.05$), a: rapidly degradable fraction, b: insoluble, but slowly degradable component, c: the rate of degradation of '*b*' component, PD: potential degradability (a + b), ED: effective degradability at outflow rate of $0.03h^{-1}$, DM: dry matter, SEM: standard error of mean, Wet season: May -October, Dry season: November – April, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ NS=non-significant, S.V. =source of variation, S x B=season and browse species interaction

reported by Solomon *et al.* [45]. In the present observation, some of the browse species had higher levels of NDF and lignin during both seasons and lower rate of degradation and effective degradability were also recorded for some browse species. These results were agreed with the report of Ferri *et al*. [49], who indicated that higher levels of NDF and lignin could be responsible for the lower rate of degradation and effective degradability.

The potential degradability ranged from 36.18% in *A. seyal* to 85.3% in *F. virosa* during wet season. For the dry season, the potential degradability of DM was lowest (30.60%) for *A. seyal* and highest (86.86%) for *V. amygdalina*. The current PD value was lower than the findings (46.2% to 95.2%) reported by Solomon *et al*. [45]. The current study was also revealed that *S. kunthianum* and *V. amygdlina* had higher PD during dry season than those of the wet season since the samples were collected at re-growth stage after burning. Moreover, the other possible reason could be associated with the seasonal variation of most browse trees that contain secondary plant compounds such as tannins, alkaloids, non-protein amino acids, cyanogenic glycosides, oligosaccharides, saponins, etc., that substantially limit utilization by ruminants [50, 51].

During wet season, the effective degradability for *F. virosa* (59.0 %) was highest, while the lowest was recorded for *A. seyal* (25.26%). Highest effective degradability of DM was observed in *V. amygdalina* (56.65%), while the lowest was recorded in *A. seyal* (14.7%) during dry season. The mean effective degradability value was higher (P<0.05) than that reported (33.83%) by Ngodigha and Oji [48]. Both ED and PD were lower than the values reported by Solomon *et al*. [45] for other browse species. Anele *et al*. [22] observed variation in rapidly degradable fraction, slowly degradable fraction, PD and ED for multipurpose trees among seasons. In general, all the degradability characteristics (a, b, PD, ED and c) during the dry season were lower compared with those of the wet season. Measurements of degradability characteristics are very important as there is strong correlation with digestible DM intake [52]. Moreover, Kibon and Ørskov [53] observed a positive relationship between degradability characteristics, voluntary feed intake and digestibility. Thus, the inter-species differences in DM degradation observed could result in different intakes of the browses when fed as sole diet.

The potential degradability of DM characteristics obtained in the *in sacco* technique is being utilized in ranking feeds [32, 54]. Thus, based on their potential degradability (PD) characteristics of dry matter during the wet season, the browse forage species ranking was *F.virosa* > *V. amygdalina* > *L. fraxinifolius* > *S. kunthianum* > *A. seyal,* while during the dry season ranking was *V. amygdalina* > *F.virosa* > *L. fraxinifolius* > *S. kunthianum* > *A. seyal.* The higher potential degradability would imply a greater potential in the nutritive value of browse leaves. Further studies are therefore recommended to determine whether the observed superiority in extent of the potential degradability characteristics of DM could be transformed into greater animal output, which is a better determinant of forage quality [55].

Table 6: Dry matter degradability characteristics of selected grass species during wet and dry season

	Wet season					Dry season				
	a	b	PD	ED	c (/h)	a	b	PD	ED	c (/h)
Species	%					%				
Andropogon gayanus	19.28[a]	25.76[c]	45.04[c]	32.21[c]	0.03[a]	18.41[a]	51.79[a]	70.20[a]	42.89[a]	0.027[a]
Cynodon dactylon	18.29[a]	47.77[a]	66.05[a]	40.08[a]	0.025[ab]	10.64[b]	33.51[c]	44.14[c]	27.00[bc]	0.029[a]
Hyparrhenia rufa	13.04[c]	37.03[b]	50.07[b]	29.76[c]	0.026[ab]	7.85[dc]	54.69[a]	62.53[b]	28.11[b]	0.018[b]
Oxythanthera abyssinica	14.27[b]	38.70[b]	52.97[b]	30.93[c]	0.022[b]	8.49[c]	41.25[b]	49.74[c]	25.56[c]	0.021[b]
Sorghum arundinaceum	13.52[bc]	51.52a	65.05[a]	35.96[b]	0.023[b]	6.80[d]	40.44[b]	47.24[c]	23.28[b]	0.021[b]
SEM	0.15	0.57	0.61	0.38	0.00082	0.15	0.85	0.82	0.24	0.001

Significance					
S.V	a	b	PD	ED	C
Season	***	***	NS	***	NS
Grass	***	***	*	***	**
S×G	***	***	***	***	NS

[abcd]means with in a column with different superscripts are significantly different ($P < 0.05$), a: rapidly degradable fraction, b: insoluble, but potentially (slowly) degradable component, c: the rate of degradation of '*b*' component, PD: potential degradability (a+b), ED: effective degradability at outflow rate of $0.03h^{-1}$, DM: dry matter, SEM: standard error of mean, Wet season: May - October, Dry season: November - April, *p<0.05, **p<0.01, ***p<0.001, NS=non-significant, S.V. =source of variation, S x G=season and grass species interaction

Degradability Characteristics of Selected Grass Species: The degradation characteristics of the grass species for the wet and dry seasons are presented in Table 6. There was an interaction effect (P<0.001) of season × species for all degradation characteristics of grass species except the rate of degradation which was only influenced by grass species. This was comparable with the findings of Berhane *et al*. [31] who observed variation in gas production characteristics of grass species in the lowlands of northern Ethiopia.

During the wet season, the highest (P<0.05) rapidly degradable fraction was observed in *A. gayanus* (19.28%) and *C. dectylon* (18.27%), while the lowest was recorded in *H. rufa* (13.04 %). Moreover, the rapidly degradable fraction was highest in *A. gayanus* (18.41%) and the lowest was observed in *S. arundinaceum* (6.80%) and *H. rufa* (7.85%) during the dry season.

During wet season, the lowest (P<0.05) slowly degradable fraction was observed in *A. gayanus* (25.76 %) and the highest (P<0.05) was in *S. arundinaceum* (51.52 %) and in *C. dectylon* (47.77%). The lowest slowly degradable DM fraction was recorded in *C. dectylon* (33.5%), while the highest was observed in *H. rufa* (54.69%) and *A. gayanus* (51.79%) during dry season. According to Ørskov [56], the lignin content of forages affects the extent of digestion of slowly degradable fraction. As can be seen from the current experiment there were variation in the lignin content of grass species (Table 2). Therefore, the response to feeding of these grasses could be affected by the amount of the slowly degradable fraction. This is because, negative correlation was observed between slowly degradable fraction and DM intake, digestibility and weight gain [43].

The rate of DM degradation was higher (P<0.05) in *A. gayanus, C. dectylon* and *H. rufa* than *S. arundinaceum* and *O. abyssinica* during wet season. During dry season, the rate of DM degradation was higher (P<0.05) in *C. dectylon* (0.029/h) and *A. gayanus* (0.027/h) than *S. arundinaceum* (0.021/h), *H. rufa* (0.018/h) and *O. abyssinica* (0.021/h). Ferri *et al*. [49] indicated that higher contents of NDF and lignin could be the main cause for the low level of degradation rate. According to Adugna and Sundsøl [43] there was a positive correlation between rate of degradation and growth rate in sheep. Therefore, those feeds with high rate of degradation could promote good growth.

During wet season, the potential degradability ranged from 45.04 % for *A. gayanus* to 66.05% for *C. dectylon* and 65.05 % for *S. arundinaceum*. The potential degradability of DM was highest (P<0.05) in *A. gayanus* (70.20%) and the lowest (P<0.05) was measured in *C. dectylon* (44.14%), *O. abyssinica* (49.74%) and *S. arundinaceum* (47.24%) for dry season. The differences in PD could influence the utilization of these grasses. Because, Adugna *et al*. [57] indicated that low potential degradability was indicator of poor digestibility in some browse species.

The highest (P<0.05) effective degradability was measured in *C. dectylon* (40.08%), while the lowest (P<0.05) was recorded in *H. rufa* (29.76%), *A. gayanus* (32.21%) and *O. abyssinica* (30.93%) during wet season. During dry season, the highest effective degradability was recorded for *A. gayanus* (42.89%), while the lowest was observed in *S. arundinaceum* (23.28%), *C. dectylon* (27.00%) *and O. abyssinica* (25.56%). Ferri *et al*. [49] indicated that higher contents of NDF and lignin could be the main cause for the low level of effective degradability. Moreover, it was showed that the concentration of ADF could bring about a change in effective degradability [58]. The current finding revealed that *A. gayanus* and *H. rufa* possess higher PD during dry season than those of the wet season since the samples were collected near the riverside and after burning of the natural pasture, respectively. In agreement with our results, Anele *et al*. [22] reported significant differences among seasons in DM degradation characteristics of grass species. The observed differences in DM degradation characteristics could be due the variation in chemical composition which was affected by species and season.

One of the most important uses of *in sacco* feed evaluation technique is that it could be used for ranking feeds based on either their energy or nitrogen supply for ruminants. Thus, based on their potential degradability of dry matter characteristics during the wet season, the grass forage species ranking was *C. dectylon* > *S. arundinaceum* > *O. abyssinica* > *H. rufa* > *A. gayanus*. But the ranking during the dry season was *A. gayanus* > *H. rufa* > *O. abyssinica* > *S. arundinaceum* > *C. dectylon*.

CONCLUSION

Feed shortage was one of the main constraints which lead the farmers to travel for a long distance in search of feed for feeding of their livestock during the dry season in the study area. Ruminant livestock species were mainly relied on grazing of natural pasture and crop residues which need to be supplemented. If not supplemented these natural pasture and crop residues with the selected browse species and *Andropogon gayanus* grass species even did not fulfill the maintenance requirement. So, these browse species (*V. amygdalina*, *F.virosa*, *L. fraxinifolius*, *S. kunthianum*, *A. seyal*) evaluated have good potential as livestock feed and particularly as supplement for low quality roughages during the dry season. The grass species (*Andropogon gayanus*) was also shown to have potential based on their crude protein and *in sacco* dry matter degradability values. However, these results need to be further tested in animal experiments whether the potential feeds could be transformed into animal performance or not.

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