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SEASONAL VARIATION IN NUTRITIVE VALUE OF SOME BROWSE AND GRASS SPECIES IN BORANA RANGELAND, SOUTHERN ETHIOPIA

[VARIACIONES ESTACIONALES EN EL VALOR NUTRITIVO DE ALGUNOS ARBUSTOS Y ESPECIES DE PASTO EN LOS AGOSTADEROS DE BORANA, SURESTE DE ETIOPIA]

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SUMMARY

The Borana rangeland has diverse species of woody and herbaceous plants which are useful as forage. Chemical analysis, *in vitro* dry matter digestibility (IVDMD) and *in sacco* degradability study were conducted on feed samples collected from browse and grass species during the hot dry and main rainy seasons. Chemical analysis and IVDMD were done for *Acacia brevispica*, *A. nilotica*, *A. seyal*, *A. tortilis*, *Balanites aegyptiaca*, *Grewia bicolor*, *G. tembensis*, *Rhus natalensis*, *Vernonia cinerascens* and *Maracaa* and grass species *Cenchrus ciliaris*, *Chrysopogon aucheri* and *P. mezianum* while *in sacco* degradability was done for *A. nilotica*, *B. aegyptiaca*, *G. bicolor*, *R. natalensis* and *C. aucheri*. The crude protein content (CP) of the browse species was higher in the rainy season except *A. seyal* which had higher value in the dry season (210 g/kg DM). The condensed tannin (CT) concentration ranged from 1.2 to 332 g/kg DM in *B. aegyptiaca* and *A. tortilis*, respectively. The NDF and ADF were highest in *G. tembensis* and *G. bicolor* while lowest values were in *A. nilotica* and *A. seyal* in the dry season, respectively. During the rainy season *G. tembensis* had highest NDF (750.9 g/kg DM) and lowest was in *A. nilotica* (128.1 g/ kg DM). The IVDMD among the browse varied from 965.7 to 718.9 and 974.7 to 676.3 in the dry and rainy seasons, respectively. In grass species CP was from 56 to 78. The NDF ranged from 728 to 749 g/kg DM and from 673 to 709 g/kg DM in dry and rainy seasons, respectively. The IVDMD was higher in the rainy season (698.2-811.5 vs 577.8-620.2). The *in sacco* DM degradability was highest for *A. nilotica* followed by *B. aegyptiaca* and lowest was in *C. aucheri*. The browse had high feed potential based on chemical and digestibility/degradability values recorded in this study while grasses could be considered as moderate. Among the grasses, *C. ciliaris* and *C. aucheri* are promising in terms of the digestibility values. However this conclusion needs to be supported by animal experiments and knowledge of the local community.

Key words: Borana pastoralists; Digestibility; Hot dry season; Main rainy season.

RESUMEN

Los agostaderos de Borana tienen una diversidad de especies leñosas y herbaceas que son útiles como forrajes. Se realizaron análisis químico, digestibilidad *in vitro* de la materia seca (IVDMD) y degradabilidad *in sacco* de muestras de alimento colectadas de arbustos y pastos durante las estaciones cálido-seca y lluviosa. Las especies analizadas para composición química e IVDMD fueron *Acacia brevispica*, *A. nilotica*, *A. seyal*, *A. tortilis*, *Balanites aegyptiaca*, *Grewia bicolor*, *G. tembensis*, *Rhus natalensis*, *Vernonia cinerascens* y *Maracaa* y las especies de pasto *Cenchrus ciliaris*, *Chrysopogon aucheri* y *P. mezianum* mientras que los estudios de degradabilidad *in sacco* fueron realizados en *A. nilotica*, *B. aegyptiaca*, *G. bicolor*, *R. natalensis* y *C. aucheri*. El contenido de proteína cruda (CP) en los arbustos fue mayor en la época de lluvia excepto *A. seyal* que tuvo mayor contenido en la época seca (210 g/kg MS). El contenido de taninos condensados (CT) fluctuó de 1.2 a 332 g/kg MS en *B. aegyptiaca* y *A. tortilis*, respectivamente. El contenido de NDF y ADF fue mayor en *G. tembensis* y *G. bicolor* y menor en *A. nilotica* y *A. seyal* en la época seca. Durante la época de lluvia *G. tembensis* tuvo mayor NDF (750.9 g/kg MS) y el meor fue *A. nilotica* (128.1 g/kg MS). La

IVDMD entre las arbustivas fue de 965.7 a 718.9 y de 974.7 a 676.3 en las épocas de seca y lluvia respectivamente. En los pastos el contenido de CP fue de 56 a 78 g/kg MS). El contenido de NDF fluctuó de 728 a 749 g/kg MS y de 673 a 709 g/kg MS en la época de seca y lluvia respectivamente. La IVDMD fue mayor en la época de lluvia (698.2-811.5 vs 577.8-620.2). La degradabilidad *in sacco* de la MS fue mayor para *A. nilotica* seguida de *B. aegyptiaca* y fue menor para *C. aucheri*. Basados en la composición química y la digestibilidad/degradabilidad, los arbustos tienen un potencia alimenticio alto, mientras que el potencial de los pastos es moderado. Entre los pastos *C. ciliaris* y *C. aucheri* son promisorios por sus valores de digestibilidad. Sin embargo, estas conclusiones necesitan ser apoyadas con trabajos de alimentación animal y el conocimiento de las comunidades locales.

Palabras clave: Pastoralismo; Borana; digestibilidad; sequía; lluvia.

INTRODUCTION

The Ethiopian lowlands are situated below 1500 m asl and comprise about 61% of the national land area. The Borana rangelands of southern Ethiopia cover about 95,000 km^2 and are predominantly inhabited by the Borana pastoralists (Coppock, 1994). The Borana pastoral system has traditionally been based on cattle husbandry for wealth accumulation and milk production while small ruminants provide quick cash income (Desta and Coppock, 2004). The semi-arid rangelands support livestock that are valuable as sources of food and cash income for the pastoral and agro-pastoral population, as source of foreign currency for the nation, and for provision of draught power for smallholders in the highlands (McCarthy, *et al.*, 2002).

Cossin and Upton (1987) characterized the Borana rangeland as one of the most productive systems of traditional pastoral lands in East Africa, which supports diverse valuable vegetation. The dominant herbaceous plants in the study area are perennial grasses which include *Cenchrus, Cynodon, Themeda, Pennisetum, Entropogon, Bothriochloa, Brachiaria, Sporobolus, Panicum, Chloris, Aristida, Dactyloxenium, Leptothrium, Heteropagon* and *Hyparrhenia* (Coppock, 1994). Browse constitutes substantial amount of the diet of goats, camels and sheep in the Borana rangelands (Coppock, 1994) and a similar trend is observed in other arid and semi-arid regions of Ethiopia. Trees and shrubs are important sources of fodder for livestock in the tropics and dry environments and withstand harsh climatic conditions better than herbaceous species (Silanikove *et al*., 1996). Browse species maintain their green leaves longer into the dry season (Coppock, 1994) and are known to supply better crude protein (CP) and minerals (Devendra, 1990; Coppock, 1994). According to Coppock (1994) the most common woody genera in the study area include: *Acacia, Commiphora, Combretum, Cordia, Terminalia, Aspilia, Albizia, Juniperus, Rhus, Boscia, Boswellia, Cadaba, Balanites, Salvadora, Dobera, Pappea, Grewia*, *Delonix* and *Boswellia* spp. Gemedo (2006) reported a total of 327 plant species in Borana lowlands among which 118 species were identified as useful forage plants.

However, the widespread encroachment of undesirable woody plants in the Borana rangelands has become a serious concern of the pastoralists, researchers and development workers in the area. According to Angassa (2007) 83% of the Borana rangelands have been threatened by a combination of bush encroachment and invasion by unpalatable forbs, while only 17% of the rangelands were free from either bush encroachment or invasion by unpalatable forbs. This situation has negative impact on herbaceous growth and biomass production. In support of the above statement, the report of Van Wijigaerden (1985) reveals that in the East African savanna ecosystem an increase in bush cover by 10% reduces grazing by 7%, while grazing is eliminated completely when bush cover reaches 90%.

Due to the change in vegetation, the composition of livestock species in the area is changing. Desta (2000) reported increasing numbers of browsers like camels in Borana pastoral system in response to increased woody plants though Borana are traditionally known to keep cattle. The population of small ruminants and particularly that of goats is believed to have increased in recent years (personal communication with pastoralists). While it is critical to maintain the balance of the ecosystem in the Borana rangelands to sustain the pastoral production system, it is important to utilize the wide range of woody and herbaceous plants as sources of forage. The availability and quality of the different browse and grass species is believed to vary from season to season due to marked seasonality in rainfall distribution that affects the growth and development of the plant species, particularly that of the grasses and other herbaceous species. Therefore, the present study was undertaken to evaluate the seasonal variations in nutritive value of some important native browse and grass species in the area.

MATERIALS AND METHODS

Description of study area

The study was conducted in the Dirre and Yabello districts of Borana zone, Oromia National Regional State, southern Ethiopia. The area receives bi-modal rainfall pattern, with the main rains (*ganna*) falling between March and May, and short rains (*hagayya*) falling between October and November (Cossins and Upton, 1987) followed by the hot dry season (*bona hagayya*). The cool dry season (*adolesa*) comes after the main rains between June and August. However, the actual length of the rainy season is getting shorter and shorter through time and the area is prone to more frequent drought (Tolera and Abebe, 2007).

Sampling, sample preparation and chemical analysis

Sampling of forage material was conducted once in each of the two major seasons, hot dry and main rainy seasons. Four sites were selected in the above mentioned two districts, which included two ranches and two communal grazing lands in four pastoral associations (Smallest administrative unit in pastoral areas). Four transects were constructed in each site and it covered areas between 1350 to 1780 m asl. Transects were about 1.5 km in length and sampled at 50 m intervals. The leaves of the selected browse species were hand plucked when available along transects, while grass samples were harvested at about five cm above the ground. Samples of same species within transects were bulked for analysis.

The forage samples collected were oven-dried at 50^0C for 72 h and ground to pass through 1 mm sieve for chemical analysis and *in vitro* digestibility and 2 mm sieve size for *in sacco* degradability study. The ground samples were kept in air-tight containers until used for analysis. The determination of DM, ash and nitrogen was done according to AOAC (1990). NDF and ADF were analyzed following the procedure of Van Soest and Robertson (1985). Digestion was undertaken using ANKOM Fiber Analyzer[220] (ANKOM Technology 05/03, Macedon, NY USA) and F57, ANKOM filter bags). Condensed tannin was analyzed according to Maxson and Rooney (1972).

In Vitro dry matter digestibility (IVDMD)

The IVDMD was determined following the procedure of Van Soest and Robertson (1985). Feed samples were incubated in Daisy Incubator (ANKOM Technology 05/03, Macedon, NY USA) using F57 ANKOM filter bags and subsequent digestion was carried out in ANKOM Fiber Analyzer[220]. Rumen fluid used in this study was obtained from two rumen fistulated sheep offered 600 g Rhodes grass (*Chloris gayana*) hay; 200 g fresh alfalfa (*Medicago sativa*) and 200 g concentrate mix on daily basis in two equal portions.

In sacco degradability study

To determine the *in sacco* DM degradation and degradability characteristics, about 2.5 g of feed sample were placed in nylon bags and incubated in the rumen of three rumen-fistulated sheep. The sheep were kept in individual pens and offered 600 g Rhodes grass hay; 200 g fresh alfalfa and 200 g concentrate mix daily in two equal portions. Clean drinking water was provided everyday. Nylon bags were withdrawn at 4, 8, 16, 24, 72, 96 h of incubation and immediately rinsed in tap water. This was followed by machine washing in three cycles which lasted 15, 10 and 5 minutes. The 0 h measurement was obtained by washing and drying duplicate bags with samples which were not incubated in the rumen. The data were fitted to the exponential equation $P = a+b(1-e^{-ct})$ of Ørskov and McDonald (1979), where P is DM degradation at time t. Since the washing loss (A) was higher than the estimated rapidly soluble fraction or the zero time intercept of the exponential (a), the lag time was estimated according to McDonald (1981) by fitting the model $P = A$ for $t \leq t_0$, $p = a+b(1-e^{-ct})$ for $t>t_0$ and the degradation characteristics of the forage samples were defined as A= washing loss (represents the soluble fraction of the feed); B = (a+b)-A, representing the insoluble but slowly degradable fraction; c = the rate of degradation of B and the lag phase (L) = (1/c)loge[b/(a+b-A)] (Ørskov and Ryle, 1990). Potential degradation (PD) was estimated as (A+B), while effective degradability (ED) of DM calculated according to Dhanoa (1988) using the formula $ED = A+ [Bc/(c+k)]$ at rumen outflow rates (k) of 0.05 h^{-1}.

Statistical analysis

Analysis of variance was carried out on chemical composition, IVDMD and *in sacco* degradability using General Linear Model procedure of Statistical Analysis System (SAS, 2001). Species, season and their interactions were the independent variables while DM, ash, CP, CT, NDF, ADF, IVDMD were the dependent variables.

RESULTS

Chemical composition and IVDMD of browse species

Chemical composition and IVDMD of the browse species are presented in Table 1. The chemical composition of the browse species, except the ADF content, was influenced by both the species of the plants and the season, while the ADF content and

IVDMD were not influenced (P>0.05) by season. Among the browse species total ash content (g/kg DM) was lowest in *A. nilotica* both in dry (60 g/kg DM) and rainy (42 g/kg DM) seasons while the highest was for *G. tembenses* (114 g/kg DM) in the wet season.

The CP content of the browse species ranged from 109 g/kg DM in *R. natalensis* to 210 g/kg DM in *A. seyal* in the dry season. Corresponding values for rainy season ranged from 134 to 196 g/kg DM in *R. natalensis* and *A. brevispica*, respectively. The CP content of the browse species, except for *A. seyal*, was higher in the rainy season than in the dry season. A very wide variation was recorded in condensed tannin (CT) concentration between the browse species within the seasons. It ranged from 1.2 g/kg DM in *B. aegyptiaca* to 196 g/kg DM in *R. natalensis* in the dry season. In the rainy season, *G. tembensis* and *B. aegyptiaca* had the lowest (2 g/kg DM) while *A. tortilis* had highest (332 g/kg DM). A higher concentration of CT was recorded in the rainy than in the dry season for all of the browse species with the exception of *G. bicolor* and G. *tembensis*.

Table 1. Chemical composition and IVDMD of the leaves of some browse species in the Borana rangelands during the hot dry and main rainy seasons.

Season/Species	N	Chemical Components (g/kg DM)					IVDMD (g/kg DM)
		Ash	CP	CT	NDF	ADF	
Hot dry season							
Acacia brevispica	2	65.8±16.8	172.2±3.2	82.9±11.9	483.6±18.8	252.7±9.5	808.4±14.8
Acacia nilotica	14	60.7±10.5	131.9±11.1	110.8±29.4	167.9±37.7	111.6±25.4	965.7±16.5
Acacia seyal	1	73.9	210.8	121.1	170.9	109.5	948.1
Acacia tortilis	3	66.6±9.7	144.8±6.5	182.5±28.1	219.5±45.8	160.7±33.0	908.4±39.9
Balanites aegyptiaca	14	108.2±15.1	137.7±16.5	1.2±0.6	346.6±30.1	249.2±20.7	843.8±35.2
Grewia bicolor	11	89.2±14.1	146.7±16.8	136.2±33.4	436.1±17.4	277.4±15.4	718.9±88.8
Grewia tembensis	2	95.3±34.5	160.6±1.5	79.2±111.0	574.6±87.8	243.6±7.8	919.8±27.2
Rhus natalensis	12	108.2±12.9	109.8 ±13.6	196.7±62.3	331.6±49.4	217.9±37.0	852.9±50.0
Main rainy season							
Acacia brevispica	2	61.1±0.2	196.2±1.3	105.3±13.1	318.0±1.8	190.9 ±4.5	818.2±14.2
Acacia nilotica	12	42.5±6.4	154.3±10.9	114.9±16.8	128.1±11.6	84.7±6.4	974.7±10.3
Acacia seyal	6	78.0 ±8.4	158.6 ±41.0	210.5±70.2	230.0 ±41.7	153.6 ±19.7	914.7±22.7
Acacia tortilis	4	62.3±5.4	177.8±7.7	332.1±17.2	217.6 ±15.4	154.7±11.9	886.9±17.5
Balanites aegyptiaca	9	112.3 ±16.5	160.6±23.0	1.8±1.1	459.8±51.8	250.0±18.0	846.2±22.2
Grewia bicolor	11	78.8±7.2	155.2±14.7	110.5±66.6	517.4±120.6	288.8±48.6	676.3±37.7
Grewia tembensis	12	114.8±11.2	195.6±16.2	2.0±2.5	750.9±174.0	281.1±49.8	889.3±26.6
Rhus natalensis	11	77.7±11.4	134.1±19.1	253.8±67.5	460.3±120.7	312.0±113.7	825.1±32.5
Vernonia cinerscens	11	83.9±8.8	144.7±14.1	3.3±3.5	461.9±100.4	251.6±31.9	933.5±14.0
Maracaa[1]	4	86.7±13.9	136.5 ±24.8	5.4±3.1	444.7±60.0	347.2±53.9	736.2±123.4
Species		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Season		0.0092	0.0008	0.0079	0.0037	NS	NS
Interaction		0.0001	0.0067	0.0001	0.0007	0.0003	NS

[1]=Local name; DM = dry matter; CP = crude protein; CT = condensed tannins; NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDMD = in vitro DM digestibility; NS = not significant

The NDF content of the browse species varied between species and seasons (P<0.05). The highest NDF content was recorded for *G. tembensis* in the dry and rainy seasons while *A. nilotica* had lowest in both seasons. In both dry and rainy seasons, *Acacia brevispica*, *A. nilotica* and A. *tortilis* had lower NDF contents while *B. aegyptiaca*, *G. bicolor*, *G. tembensis* and *R. natalensis* had relatively higher NDF contents. In the dry season, the lowest ADF contents were recorded for *A. seyal* while the highest value was recorded for *G. bicolor*. In the rainy season as well *A. nilotica* and *A. seyal* had the lowest ADF content while *Maracaa* had the highest. In the dry season, the IVDMD ranged from 718 in *G. bicolor* to 965 in *A. nilotica*. *Grewia tembensis* had the second highest (919.8) IVDMD next to *A. nilotica*. The highest IVDMD in the rainy season was in A. *nilotica* (974) followed by *Vernonia cinerascens* (933.5) while the lowest values were recorded for *G. bicolor* (676.3) and *Maracaa* (736.2). The browse species did not follow a strict trend regarding CP, NDF fraction and in vitro digestibility. During the wet period when there is increased growth by plants accumulation of secondary compounds could be high depending on the species. This may influence the digestibility of forages.

Chemical composition and IVDMD of grass species

The chemical composition and IVDMD of the grass species are presented in Table 2. The ash content varied from 113 g/kg DM in *Pennisetum mezianum* to 128 g/kg DM in *Cenchrus ciliaris* in the dry season while in the rainy season, the ash content highest (123) in *P. mezianum*, although the differences were not significant. The total ash recorded for grass species were higher than for browses except for *G. tembensis*. The CP content of the grass species was lower than those recorded for the browse species (Table 1) in both seasons. The lowest CP was in *P. mezianum* (56 g/kg DM) in the rainy season while the highest was in the dry season for *C. ciliaris* (79 g/kg DM).

The NDF content of the grass species varied from 621 g/kg DM in *C. ciliaris* in the rainy season to 683 g/kg DM in *P. mezianum* in the dry season. The ADF content varied from 404 to 618 g/kg DM in the dry season. *Pennisetum mezianum* had the lowest IVDMD in both seasons while *C. aucheri* and *C. ciliaris* had the highest in the dry and rainy seasons, respectively.

***In sacco* dry matter degradability of leaves of browse forage species**

The dry matter disappearance of five forage species (four browse and one grass species) during the hot dry and main rainy seasons at different incubation time are presented in Figure 1 and 2. Significant variations were observed in DM degradability between the species throughout incubation time. *Acacia nilotica* had the highest degradability values followed by *B. aegyptiaca* at all incubation time during both seasons while *C. aucheri* had the lowest values. DM degradability of browse in dry season was higher than the corresponding values in the rainy season up to 24 h incubation time. After 48 h incubation time *A. nilotica* and *B. aegyptiaca* had higher degradability in the rainy season compared to values in dry season while *R. natalensis* attained higher value at after 96 h in rainy season. Among the browses, *G. bicolor* had the lowest (0.634) DM degradability value.

Table 2: Chemical composition and IVDMD of three grass species in the Borana rangelands during the hot dry and main rainy seasons

Species by season	N[1]	Chemical component (g/kg DM)				IVDM D (g/kg DM)
		Ash	CP	NDF	ADF	
Hot dry season						
Cenchrus ciliaris	3	133.0±53.5	82.9±6.5	749.8±17.4	654.8±35.9	597.3±64.2
Chrysopogon aucheri	14	126.3±23.5	83.9±3.9	728.3±14.6	481±115	620.2±33.4
Pennisetum mezianum	2	108.3±19.6	80.6±0.5	732.8±8.2	405.8±0.6	577.8±5.9
Main rainy season						
Cenchrus ciliaris	7	128±18.7	72.4±10.6	673.6±25	504±41.2	811.5±60.2
Chrysopogon aucheri	14	126±14.4	82.4±5.7	709.9±18.8	555.2±22.3	715±37.0
Pennisetum mezianum	2	120.5± 2.4	57.9±3.5	705.1±22.8	573±21.1	698.2±23.3
Species	0.0070	NS	0.0004	NS	0.0678	0.0276
Season	0.0116	NS	0.0001	<0.0001	Ns	<0.0001
Interaction	NS	NS	0.0057	0.0015	0.0005	0.0039

[1]=number of samples; DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber;IVDMD = in vitro DM digestibility; NS = not significant

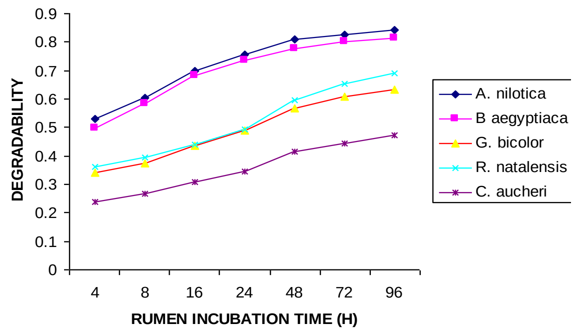

Figure 1. DM disappearance of browse leaves and one grass samples taken in the hot dry season at different rumen incubation times (n= 3 incubations per sample)

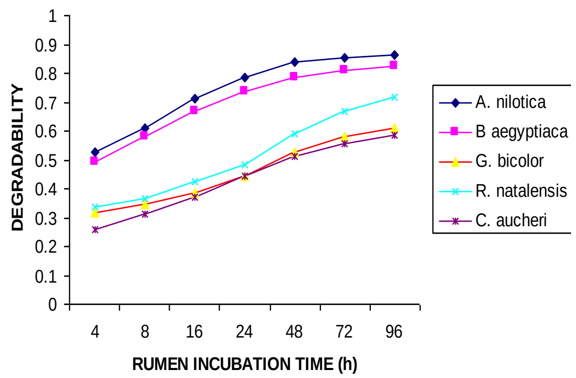

Figure 2. DM disappearance of browse leaf and one grass samples taken in the main rainy season at different rumen incubation times (n= 3 incubations per sample)

Table 3 presents DM degradability at 48 h incubation time and degradability characteristics during the hot dry and rainy seasons. During the dry season DM degradability after 48 h incubation ranged from 0.810 to 0.417 in *A. nilotica* and *C. aucheri*, respectively. The washing loss varied from 0.166 in *C. aucheri* to 0.427 in *A. nilotica*. The values for the insoluble, but fermentable, fraction (B) ranged from 0.385 in *C. aucheri* to 0.484 in *R. natalensis*. *Cryospogon aucheri* scored lowest potential (A+B) and effective degradability (ED) values (0.588; 0.309), respectively while the highest values were recorded for *A. nilotica* (0.843; 0.665) for both parameters. The rate constant c was highest in *B. aegyptiaca* (0.089) and lowest in *R. natalensis* (0.020). The lag phase ranged from 3.092 to 0.169 in R. *natalensis* and *C. aucheri*, respectively.

During the rainy season, DM degradability after 48 h incubation varied from 0.512 in *C. aucheri* to 0.837 in *A. nilotica*. The second lowest value was recorded in *G. bicolor* (0.529) whereas *B. aegyptiaca* had the second highest value after *A. nilotica*. It is important to note that *A. nilotica* had the highest DM degradability in both season followed by *B. aegyptiaca*. The washing loss (A) was highest in *B. aegyptiaca* (0.434) and lowest in *C. aucheri* (0.204). *Rhus natalensis* and B. *aegyptiaca* had the highest and lowest insoluble fraction, respectively. The potential degradability varied from 0.871 in *R. natalensis* to 0.625 in *C. aucheri* while effective degradability was highest in *A. nilotica* and lowest in *C. aucheri*. The rate constant was similar for *A. nilotica* (0.0789) and *B. aegyptaica* (0.0791) but lowest in *G. bicolor*. The lag phase was highest in *R. natalensis* (5.067) followed by *G. bicolor* (2.117*).*

Table 3. DM disappearance from nylon bag after 48 h incubation and DM degradability characteristics of some selected browse leaves and one grass in the Borana rangelands during the hot dry and main rainy seasons (means of 3 incubations per sample)

Species by season	DMD 48 h	A[b]	B[c]	A+B[d]	c[e]	L[f]	ED[g]	RSD[h]
Hot dry season								
Acacia nilotica	0.810	0.427	0.416	0.843	0.0737	0.592	0.665	1.6667
Balanites aegyptiaca	0.778	0.413	0.388	0.828	0.089	2.238	0.641	1.5050
Grewia bicolor	0.567	0.294	0.404	0.696	0.035	0.776	0.429	1.4257
Rhus natalensis	0.597	0.332	0.484	0.816	0.0207	3.092	0.453	1.5045
Chrysopogon aucheri	0.417	0.166	0.385	0.548	0.0273	0.169	0.309	8.4795
Main rainy season								
Acacia nilotica	0.837	0.414	0.454	0.868	0.0789	0.6704	0.676	1.619
Balanites aegyptiaca	0.784	0.434	0.404	0.842	0.0791	2.117	0.635	1.4788
Grewia bicolor	0.529	0.263	0.464	0.729	0.024	2.198	0.389	1.766
Rhus natalensis	0.591	0.335	0.540	0.871	0.017	5.067	0.441	1.762
Chrysopogon aucheri	0.512	0.204	0.421	0.625	0.0390	0.9345	0.370	1.2484
S.E.M[a]	1.1029	0.5866	1.774	1.829	0.0055	0.549	0.841	
Species	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
Interaction	<.0001	<.0001	NS	NS	NS	NS	<.0001	

a Standard error of the means; b Washing loss; c Insoluble but fermentable fraction; d Potential degradability;e Rate of degradation of B (fraction/h); f Lag phase (h); g Effective degradability at an outflow rate of $0.05h^{-1}$;h Residual standard deviation

DISCUSSION

Chemical composition

Several factors contribute towards the nutritive value of forages which include species, plant part, stage of maturity and climatic variables. The wide variation in chemical composition between browse and grass species was as expected. The CP content of browse was high as compared to grass in both seasons in this study. Most browse species have the ability to maintain their greenness and nutritive value through the dry season when grasses dry up and deteriorate both in quality and quantity (Tolera *et al*., 1997). However the CP values of browse species in this study are lower than values reported by Abdulrazak *et al.* (2000), Woodward and Coppock (1995) and Gemedo (2004) with only few comparable values (Table 4). Differences in CP content between the browses may arise due to differences in protein accumulation in them during growth (Salem *et al.,* 2006). In Sahelian and Sudanian areas of West Africa variation in CP was estimated to be between 100 and 206 g/kg DM (Breman and Kessler, 1995). In the present study none of the browse species fell below this low margin as opposed to grass species. The low CP content of grasses reported in this study agrees with reports of Woodward and Coppock (1995) for herbaceous species and Berhane and Eik (2006) and Tesfaye *et al.* (2009) for grasses although the magnitude is not sam (Table 4).

The total ash values reported for browse species in current study are slightly lower than the values reported by Gemedo (2004), which may be due to differences in soils from where samples were harvested. Browses had lower ash value than the values recorded for grasses in this study. The individual mineral elements that are supplied by a given feed are more important than just total ash. Therefore it is important to further investigate the mineral content of browses in the study area.

A very wide variation in CT content was recorded in this study between species. The variation ranged from 1.18 in B. *aegyptiaca* to 332 g/kg DM in *A. tortilis* in rain season. Several factors are known to have significant effect on condensed tannin analysis. Such factors include initial harvesting, drying and extraction method of the forage material. Even within species condensed tannin can vary over at least a 4 to 6 fold range depending on plant provenance (Schofield *et al.,* 2001). Abdulrazak *et al.* (2000) reported a very low TCT (total condensed tannin) values for *A. brevispica, A. nilotica, A. seyal* and *A. tortilis* than the values obtained in the present study. However, the trend was similar in both studies that *A. brevispica* had the lowest concentration followed by *A. nilotica, A. seyal* and *A. tortilis*. Max *et al.* (2007) reported CT content of *A. tortilis* (307.4 g/kg DM) in the wet season which is quite similar with value reported in this study for same species in rainy season. The values reported by Larbi *et al.* (1998) for multipurpose tree and shrubs are also in agreement with the present report. The variation in CT content between seasons observed in this study is consistent with reports of Max *et al.* (2007) and Larbi *et al.* (1998). Contents of CT were higher in wet season than in dry season although there are some inconsistencies. Such high CT values could protect the young growing leaves from damage. Condensed tannins are generally known to affect negatively digestibility of forages if beyond certain limit (about 6%) but also the type of CT may together with concentration play great role.

Fiber in forages is often the main source of energy for fore-gut fermenters (Graham and Åman, 1991). The mean NDF value for the individual browse species reported in this study is lower than the values reported by Larbi et al. (1998), Merkel *et al.* (1999) and Gemedo (2004) except for *G. tembensis*. However, there is similarity with values reported by El hassen *et al.* (2000), Abdulrazak et al. (2000) Tesfay et al. (2008) and Tefera *et al.* (2008). The NDF value reported by Tolera *et al.* (1997) for the introduced multipurpose tree into Ethiopian highlands, Tagasaste (*Chamaecytisus Palmensis*) favorably compares with present report. The ADF values in this study agree with previous reports of Merkel et al. (1999) Abdulrazak *et al.* (2000), Tesfay *et al.* (2009) and Tefera *et al*, (2008). Higher NDF and ADF values were recorded for grasses compared to the browse species in this study. Similar values have been reported by Tesfay *et al.* (2009). Coupled with low CP content particularly during the dry season, such high fiber content may impair digestibility and voluntary intake by ruminants. Digestibility of fiber is an important parameter of forage quality.

In vitro dry matter digestibility (IVDMD)

The IVDMD values recorded in this study are generally higher for browse species as compared to grasses. This could be due to high CP and low fiber content in browse species. This phenomenon is particularly important in the dry season. The values reported by Tesfay *et al.* (2009) for browse is consistent with the present study while the values for grasses in the dry season are lower (Table 4). The report of Woodward and Coppock (1995) on browse and herbaceous species agrees with the present data although some inconsistencies exist. When the overall IVDMD is considered browse species will be in the order of: *A. nilotica, Vernonia cinerascens, A. seyal, A. tortilis, G. tembensis, B. aegyptiaca, R. natalensis, A. brevispica, Maracaa* and *G. bicolor*. However, this rank may not hold when the real situation in Borana area is taken into consideration. Fruits from *A. tortilis* and *A. nilotica* are highly appreciated and regarded as concentrate by Borana pastoralist but the leaves of these trees including *A. seyal* are not on the top of their list. In semi-arid areas like Borana lowlands where drought is frequent, feed availability during such times is critical. *G. tembensis* and *Vernonia cinerascens* are among top forages (both from this data and pastoralists knowledge) but their abundance and availability during dry periods may limit their contribution. On the other hand, *R. natalensis* which is considered as less nutritious and moderate digestibility could provide large proportion of forage consumed by goats and camels in the dry season. Woodward and Coppock (1995) reported high selection by goats for this species during the dry season. It is also one of the forages fed to kids during the dry season. Nutritive value is a function of feed intake and the efficiency of extraction of nutrients from the feed during digestion (Mandal, 1997).Therefore, such results should be combined with animal experiments and indigenous knowledge of pastoralists.

Table 4. Reference reports used in the discussion

Reference	Forage species	Chemical components			
		CP	**CT[1]**	**NDF**	**ADF**
Abdulrazak, *et al*. (2000)	*Acacia brevispica*	213 (g/kg DM)	1.1		
	Acacia seyal	134 (g/kg DM)	2.8		
	Acacia tortilis	172 (g/kg DM)	25		
	Acacia nilitica	172(g/kg DM)	11		
Adugna *et al*., (1997)	*Chamaecytisus* (Tagasaste)			389 (g/kg DM)	
Merkel, *et al*., (1999)	*Calliandra calothyrsus*			53%	30%
	Gliricidia sepium			47%	25%
Gemedo (2004)		Rain (Hot dry) Season (g/kg)		Rain (Hot dry) Season (g/kg)	Rain (Hot dry) Season (g/kg)
	Acacia brevispica	206.45 (232.72)		412.09 (358.93)	269.98 (232.36)
	Acacia tortilis	201.24 (117.47)		451.16 (302.07)	336.66 (335.34)
	Balanites aegyptiaca	205.99 (142.10)		460.25 (362.12)	298.71 (303.51)
	Grewia bicolor	133.72 (159.93)		499.13 (363.56)	367.99 (352.31)
	Grewia tembensis	178.72 (186.51)		404.99 (293.23)	250.45 (279.61)
	Rhus natalensis	131.91 (120.86)		596.00 (283.75)	383.31 (239.63)
Woodward & Coppock(1995)		N (% DM)			
	Acacia brevispica	5.9 (3.5)			
	Acacia nilitica	3.5 (2.0)			
	Acacia seyal	3.8 (2.4)			
	Acacia tortilis	3.5 (2.4)			
	Grewia tembensis	5.2 (2.2)			
	Rhus natalensis	2.4 (2.7)			
	Herbaceous spp	1.6 (0.8)			
Tesfay, *et al*., (2009)				Rain (Dry) season (g/kg DM)	Rain (Dry) season (g/kg DM)
	Acacia etbaica			294.0 (372.5)	221.0 (280.7)
	Cadaba farinose			192.2 (236.8)	133.7 (172.2)
	Dichrostaches cinera			436.8 (457.2)	304.3 (363.7)
	Capparis tomentosa			422.2 (461.9)	215.8 (235.8)
	Rhus natalensis			372.7 (399.2)	293.3 (266.3)

[1]= mg/g DM; DM = dry matter; CP = crude protein; CT = condensed tannins; NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDMD = in vitro DM digestibility;

In sacco degradability study

The *in sacco* degradability was carried out for four browse and one grass species. The large variation in ruminal degradation recorded for *A. nilotica* and *B. aegyptiaca* during both seasons compared to other species could be attributed to their moderate CP and fiber contents and also lower CT levels. The grass (*C. aucheri*) which had a low soluble fraction and slow degradation rate for the insoluble fraction scored the lowest value during both seasons. The dry matter degradability value reported for *A. nilotica* by Abdulrazak *et al.* (2000) was extremely low than in the present study. This difference could be due to low soluble fraction and rate of degradation of the insoluble fraction and high fiber content recorded for this specie in their study which could be also amount of twigs and fine stems included. However, DM degradability reported for *Acacia nubica* in their study compares with that of *A. nilotica* and *B. agyptaica* in the present study. The high dry matter degradability of *A. nilotica* and *B. agyptiaca* in the present study could be attributed to the high soluble fraction, potential degradability and rate of degradation of the insoluble fraction. *Rhus natalensis,* on the other hand, with high potential degradability like *A. nilotica* and *B. aegyptiaca* had low degradability due to its low degradation rate of the insoluble fraction and prolonged lag phase. The dry matter degradability reported by Balogun *et al.* (1998) for *Albizia lebbeck, A. richardiana* and *Combretum apiculatum* are comparable to the values reported for *G. bicolor* in the present study while *Leucaena leucocephala* had similar dry matter degradation with that of *R. natalensis*. The high to medium dry matter degradability of browse species in the present study suggests that they are of great value as livestock feed in the arid environments of the country. On the other hand, Balogun *et al.* (1998) reported very high dry matter degradability (81.6/83.2) for *Panicum maximum* which contrasts with data for *C. aucheri* in our study. This may be attributed to genetic differences, maturity level and proportion of leaf to stem and management conditions.

CONCLUSION

The browse species evaluated have good potential as livestock feed and particularly as supplement for low quality roughages during the dry season. The grass species were also shown to have moderate potential based on their *in vitro* digestibility values. However, the results need to be further confirmed in animal experiments whether the potential could be translated into animal performance. The wide range of woody species available in the region should be utilized to increase livestock production while undertaking some bush control measures to maintain the balance between the woody and the herbaceous species.

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