Short Note [Nota corta]

NUTRITIONAL CHARACTERIZATION OF SELECTED INDIGENOUS BROWSE SPECIES IN NORTHERN ETHIOPIA †

[CARACTERIZACIÓN NUTRICIONAL DE ALGUNAS ESPECIES INDÍGENAS DE RAMONEO DEL NORTE DE ETIOPÍA]

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SUMMARY

Background. Utilization of indigenous browse species have considerable potential to improve the nutritional deficiencies of low quality ruminant feeds under farmers' condition. However, there is scarcity of scientific information on their nutritive value and ultimate impact on animals' performance in Southern Tigray, Ethiopia. **Objective.** To evaluate the chemical composition, *in vitro* dry matter digestibility (IVDMD) and *in sacco* degradability of selected indigenous browse species as animal feed in Southern Tigray, Ethiopia**. Methodology**. Chemical analysis, IVDMD and *in sacco* degradability evaluation were done, following standard procedures, on leaf samples collected from nine dominantly available browse species (*Ziziphus spina-Chiristi, Acacia tortilis, Balanites aegyptiaca, Grewia mollies, Carissa spinarum, Acacia etbaica, Pittosporum viridiflorum, Olea europaea and Dodonaoea angustifolia)* during the main rainy season (end of September, 2020). **Results**. The crude protein (CP) contents of the browse species ranged from 9.96 to 23.32% on dry matter (DM) basis. The fiber components were highest for *P. viridiflorum* and lowest for *D. angustifolia.* The highest values of IVDMD (64.75%) and metabolizable energy (9.01 MJ/Kg DM) were recorded for *Z. spina –Chiristi.* All *in vitro* digestibility parameters were positively correlated with CP content but negatively correlated with acid detergent lignin (ADL) contents of the browses. The highest *in sacco* DM disappearance was recorded for *Z. spina–Chiristi* at 48 and 72 hours. The concentration of calcium (Ca*)* ranged from 0.69% for *O. europaea* to 0.98% for *G. mollis.* The mean Ca to Phosphorus (P) ratio was 2.7:1. **Implications.** The information generated in this study is useful for efficient utilization of these valuable indigenous browse species in the study area. **Conclusions**. All studied browse species could be considered as potential feed sources to supplement low quality roughages.

Keywords: Indigenous browse; *In vitro* digestibility; *In sacco* degradability.

RESUMEN

Antecedentes. La utilización de especies autóctonas de ramoneo tiene un potencial considerable para mejorar las deficiencias nutricionales de los alimentos de baja calidad para rumiantes en las condiciones de granja. Sin embargo, hay escasez de información científica sobre su valor nutritivo y su impacto final en el desempeño de los animales en el sur de Tigray, Etiopía. **Objetivo**. Evaluar la composición química, la digestibilidad de la materia seca *in vitro* (DIVMS) y la degradabilidad *in sacco* de especies de ramoneo autóctonas seleccionadas como alimento para animales en el sur de Tigray, Etiopía. **Metodología**. Se realizaron análisis químicos, DIVMS y evaluación de la degradabilidad *in sacco*, siguiendo procedimientos estándar, en muestras de hojas recolectadas de nueve especies de ramoneo predominantemente disponibles (*Ziziphus spina-Chiristi*, *Acacia tortilis*, *Balanites aegyptiaca*, *Grewia mollies*, *Carissa spinarum*, *Acacia etbaica*, *Pittosporum viridiflorum*, *Olea europaea* y *Dodonaoea angustifolia*) durante la temporada principal de lluvias (finales de septiembre de 2020). **Resultados.** El contenido de proteína cruda (PB) de las especies ramoneadoras osciló entre 9.96 y 23.32% sobre la base de materia seca (MS). Los componentes de fibra fueron más altos para *P. viridiflorum* y más bajos para *D. angustifolia*. Los valores más altos de DIVMS (64.75%) y

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energía metabolizable (9.01 MJ/Kg MS) se registraron para *Z. spina –Chiristi*. Todos los parámetros de digestibilidad *in vitro* se correlacionaron positivamente con el contenido de PB pero se correlacionaron negativamente con el contenido de lignina detergente ácida (ADL) de los forrajes. La mayor desaparición de MS *in sacco* se registró para *Z. spina-Chiristi* a las 48 y 72 h. La concentración de calcio (Ca) osciló entre 0.69% para *O. europaea* y 0.98% para *G. mollis*. La relación media de Ca a Fósforo (P) fue de 2.7:1. **Implicaciones.** La información generada en este estudio es útil para la utilización eficiente de estas valiosas especies de ramoneo autóctonas en el área de estudio. **Conclusiones.** Todas las especies de ramoneo estudiadas podrían considerarse como fuentes potenciales de alimento para complementar los forrajes de baja calidad.

Palabras clave: Arbustos nativos; Digestibilidad *in vitro*; Degradabilidad *in sacco*.

INTRODUCTION

The contribution of the livestock sector to Ethiopia's economy is below its potential compared to regional and continental averages (Bimrew and Yeshambel, 2019; Gashaw; 2015). This is largely because of low availability of good quality animal feed (Zereu and Lijalem, 2016; Ajebu *et al*., 2013). Ruminant animals mostly rely on natural pastures and crop residues (Malede and Takele, 2014). However, the utilization of natural pasture and crop residues for enhancing livestock performance is constrained by their inherent low nutritional value (Ajebu *et al*., 2013). This suggests that the performance of livestock fed such poor quality feed resources cannot be enhanced unless different mechanisms that can enhance feed quality are applied. In this view, indigenous browse species have considerable potential as sustainable supplement for poor quality feeds (Shenkute *et al*., 2012) and improve ruminant livestock production (Anele *et al*., 2009). Indigenous browse species contain high levels of protein, minerals and vitamins and play important roles in improving the nutritional value of roughage feeds (Dambe *et al*., 2015).

The indigenous browse species evaluated in the current study are widely available and they are highly preferred and prioritized feed sources in Southern Tigray zone (Belay *et al*., 2019). Despite the wider availability of indigenous browse species, there is limited scientific information regarding their nutritional value. Lack of such scientific information on the nutritive value of indigenous browse species and their ultimate impact on animals' performance limit their potential contribution to animal production, and use in different feeding schemes and strategies. It has been documented that site specific evaluation of browse species is imperative as it can contribute to further establishment, adaptation and utilization as livestock feed (Malede and Takele, 2014). The identification, farmers' preferences and prioritization of the common browse trees has been done in Southern Tigray (Belay *et al*., 2019 and Tesfay and Solomon, 2020). Therefore, nutritional characterization of indigenous browse species is of paramount importance in order to design efficient feeding practices, and incorporate these less recognized and invaluable resources to the feeding systems in the study area. The objective of this research work was therefore to determine the nutrient and mineral composition, *in vitro* dry matter digestibility (IVDMD) and *in sacco* degradability of nine predominate indigenous browses in Southern Tigray, Ethiopia.

MATERIALS AND METHODS

Description of study area

Samples were collected from Southern Tigray, Ethiopia. The area is located between 12°14'53.9" - 13˚6'08" N latitude and 39˚10'45.7"-39˚53'41.7" E longitude with an elevation 1350-3925 meter above sea level. It is situated 680 km north of Addis Ababa and about180 km south of Mekelle. It covers an area of 9446 square km with a total population of 538422. On average the area has mean annual rainfall and temperature of 600 mm and 30˚C respectively.

Sample collection and chemical analysis

Nine dominant indigenous browse species (*Ziziphus spina-chiristi*, *Acacia tortilis*, *Balanites aegyptiaca*, *Grewia mollies*, *Carissa spinarum*, *Acacia etbaica*, *Pittosporum viridiflorum*, *Olea europaea* and *Dodonaoea angustifolia*) were considered for this study. These browse species were selected based on their wider availability in the area and farmers' preference (Belay et al., 2019; Tesfay and Solomon, 2020). Fresh leaves of the selected browse species were hand plucked at the end of the main rainy season (end of September, 2020). Samples of the selected browse species were collected from ten plants of each species, weighed and dried under the shade and pooled for each species. Then after, air dried pooled samples of each species were thoroughly mixed and composite samples were taken from each browse species, oven dried at 60˚C for 48 hours and ground separately in a Wiley mill to pass through 1mm mesh sieve for subsequent chemical analysis and *in vitro* digestibility; while parts of the samples were ground to pass through a 2 mm mesh sieve to be used for *in sacco* digestibility determination. The ground samples were kept in air-tight containers until used for analysis.

The determination of dry matter (DM), ether extract (EE) and ash were done according to AOAC (2005). The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1991). Nitrogen was determined by Kjeldhal procedure and crude protein (CP) calculated as N×6.25. Hemicelluloses and cellulose were calculated as NDF minus ADF and ADF minus ADL respectively. Calcium (Ca) was determined from ash using atomic absorption spectrophotometer (Singh *et al.,* 2005). The potassium (K) content was analyzed using flame photometer and the phosphorus (P) was measured by spectrophotometric method (AOAC, 2005).

In vitro dry matter digestibility (IVDMD)

The two stage *in vitro* rumen fluid-pepsin technique developed by Tilley and Terry (1963) was used to determine IVDMD of sample leaves. Rumen liquor was collected from three rumen-cannulated 50% (Boran x Friesian) crossbred steers in the morning before the morning feeding. The rumen content from each steer was then transported to the laboratory separately using pre-warmed (39˚C) thermos flasks. In the laboratory, the rumen content from each steer was thoroughly mixed separately and thereafter filtered using cheese cloth into beakers placed in a water bath set at 39˚C while being flushed with carbon dioxide to create an anaerobic environmental condition. Duplicate samples weighing 0.5 g were incubated with 50 ml of rumen liquor in 100 ml test tube in water bath at 39°C for a period of 48 h for microbial digestion followed by another 48 h for enzyme digestion with pepsin. At the end of fermentation, the flasks were removed from the water bath and the residue was washed twice with hot water and twice with acetone until the filtrate become colorless. Blank samples containing buffered rumen fluid only were also incubated in duplicates for adjustment. The residues were oven dried overnight at 105˚C to determine IVDMD. The samples were then ashed for five hours in a muffle furnace at a temperature of 600˚C to determine *in vitro* OM digestibility (IVOMD). Thus, IVDMD was calculated using the formula shown below.

IVDMD % = [(Initial dry sample weight - (Residue - Blank)) / Initial dry sample weight] x 100

In vitro organic matter digestibility was calculated as the difference between the organic matter in the original sample and in the residue. Metabolizable energy (ME) content was estimated using the equation of McDonald *et al*. (2002), as ME (MJ kg^{-1} DM) = 0.016 x *in-vitro* DOM (g kg^{-1} DM), where DOM = *In vitro* digestible organic matter.

In sacco degradability study

In sacco dry matter (DM) degradability of samples of indigenous browse species were carried out at Holetta Agricultural Research Center using rumen-cannulated 50 % (Boran-Friesian) crossbred steers. *In sacco* degradability was determined according to the procedure of Orskov and McDonald (1979). *In sacco* rumen degradability of DM of leaves of each browse species were determined by incubating about 3 g of duplicate samples contained in nylon bags (41µm pore size and 6.5×14 cm dimension) in three rumen fistulated Boran × Friesian steers for 0, 6, 12, 24, 36, 48, 72 and 96 hrs. At the end of the incubation period, samples containing bags, including zero hour bags were washed gently using clean water after removal from the rumen. After washing, the bags containing samples were dried in an oven at 105 ˚C for 24 hours. The dried bags were taken out of the oven and allowed to cool down in desiccators and weighed immediately. The percentages of disappearance of DM at each incubation time were calculated from the proportion remaining in the bag after incubation in the rumen. The DM disappearance (DMD) data were fitted to the exponential equation $Y=a+b\ (1-e^{-ct})$ described by Ørskov and McDonald (1979) using the Naway Excel Programme (Chen, 1995), where, Y= the potential disappearance of DM at time t, a=rapidly degradable fraction, b=the potential, but slowly degradable fraction, c=the rate of degradation of b, e= the natural logarithm, t=time. The potential degradability (PD) was determined using the equation: PD=a+b. Effective degradability (ED) for DM was calculated following the methods of Ørskov and McDonald (1979): ED=a + ((bc/(k+c)), Where k is the estimated rate of out flow from the rumen (assumed to be 0.04/h), and a, b, and c are the same parameters as described earlier.

Statistical analyses

Data were analyzed using general linear model (GLM) procedure of SAS (2003), version 9.2. Single factor analysis of variance (ANOVA) was used to assess the effects of browses on nutrient composition, *in vitro* digestibility and *in Sacco* degradability of the nine indigenous browse species. The statistical model used was: $Y_{ij} = \mu + B_i + e_{ij}$ where: Y_{ij} is dependent variable, µ is the overall mean, B_i is the effect of browse species and e_{ij} is the random error. The means were separated using Duncan multiple range test. Differences between means were considered statistically different if $p < 0.05$. Correlation analysis was conducted to determine the correlation coefficient (r) of *in vitro* DM and OM digestibility with chemical composition of browses.

RESULTS

Chemical composition of browse species

The chemical composition of the browse species are given in Table 1. The crude protein (CP) values of browse species ranged from 9.96 to 22.32% of DM. *Ziziphus spina-chirsti* and *Acacia tortilis* had the highest CP content while the lowest content was recorded

Table 1. Chemical composition (%DM) of indigenous browse species.

Browse species	% DM								
	DM	**OM**	**Ash**	**CP**	**NDF**	**ADF**	**ADL**	**hemicellulose**	**cellulose**
Ziziphus spina-chirsti	90.83^{ab}	91.38^{bc}	8.63^{bc}	22.3^{a}	34.85^{b}	19.31^{cd}	6.01^{b}	15.04^{cd}	13.3^{bc}
Acacia tortilis	90.48^{ab}	91.11^{bc}	8.9^{b}	22.14^{a}	6.97^{ab}	17.25^{e}	6.13^{b}	19.73^{ab}	11.12^{d}
Balanites aegyptiaca	93.11^{a}	85.8^{d}	14.2^{a}	15.64^{c}	36.36^{b}	17.55^{de}	6.14^{b}	20.74^{a}	11.41^{cd}
Grewia mollis	92.31^{a}	94.43^{ab}	5.57^{de}	12.32^{d}	37.56^{ab}	20.14^{bc}	6.18^{b}	13.34^{de}	14.08^{b}
Carissa spinarum	92.49^{a}	89.77^{cd}	10.23^{b}	9.96^{e}	30.97^{c}	19.44^{c}	9.07^{a}	11.51^{ef}	10.36^{d}
Acacia etbaica	92.5^{a}	96.1^{a}	3.93^{e}	13.7^{d}	29.6^{c}	21.48^{b}	9.61^{a}	10.74^{ef}	11.92^{cd}
P. viridiflorum	92.3^{a}	91.56^{bc}	8.44^{bc}	10.4^{e}	39.65^{a}	21.82^{ab}	8.76^{a}	17.84^{abc}	13.06^{bc}
Olea europaea	92.52^{a}	93.08^{abc}	6.92^{cd}	19.79^{d}	36.15^{b}	23.65^{a}	6.8^{b}	17.32^{bc}	16.92^{a}
Dodonaoea angustifolia	88.02^{b}	86.47^{d}	13.53^{a}	18.33^{b}	19.47^{d}	9.62^{f}	6.33^{b}	9.81^{f}	3.29^{e}
S.E.M	**2.43**	**4.4**	**1.01**	**0.95**	**2.6**	**0.94**	**0.6**	**2.9**	**1**
SL	***	***	***	***	***	***	***	***	***

$^{a-f}$ Means with the different letter in a column are significantly different; DM=Dry matter; OM=Organic matter, CP=Crude protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL =Acid detergent lignin; ***= P<0.001; S.E.M=standard error of the means; SL=Significance level

for *Carissa spinarum* species (p<0.05). The NDF and ADF concentrations of browse species varied from 19.47 to 39.65 and 9.62 to 23.65 % of DM respectively. P*ittosporum viridiflorum* had the highest NDF, ADF and ADL concentration while *Dodonaoea angustifolia* had the lowest (p<0.05) values. The highest (p<0.05) organic matter (OM) concentration were obtained from *Acacia etbaica* and lowest for *Balanites aegyptiaca (p<0.05)*. The highest hemicelluloses content was observed in *Balanites aegyptiaca* and *Acacia tortilis* while the lowest was in *Dodonaoea angustifolia* browse species.

In vitro digestibility of browse species

The *in vitro* dry matter digestibility (IVDMD), *in vitro* organic matter digestibility (IVOMD*)* and metabolizable energy (ME) contents significantly varied among the different indigenous browse species (p<0.00 1) (Table 2). The highest values of IVDMD, IVOMD and EME were recorded for *Ziziphus spina-chirsti* 64.75%, 56.3% and 9.01 MJ/Kg DM respectively; while the lowest values for these variables were obtained in *Acacia etbaica* 46.39%, 36.79% and 5.89 MJ/Kg DM respectively.

Correlations of *in vitro* digestibility parameters with chemical composition of browse species

The correlation coefficients (r) between *in vitro* digestibility parameters and chemical constituents of browse species are presented in Table 3. All *in vitro* digestibility parameters (IVDMD, IVOMD and EME) were positively correlated (p<0.001) with CP content but negatively correlated (p<0.001) with ADL content of the browses. The hemicellulose concentration of browse species had positive and significant correlation with all *in vitro* digestibility parameters (p<0.05).

Table 2. IVDMD, IVOMD and EME content of indigenous browse species.

Browse species	DM%		(MJ/Kg DM)
	IVDMD	IVOMD	EME
Ziziphus spina-chirsti	64.75 ^{a}	56.3^{a}	9.01^{a}
Acacia tortilis	57.36^{c}	48.45^{b}	7.75^{ab}
Balanites aegyptiaca	62.74^{ab}	54.15^{a}	8.67^{a}
Grewia mollis	63.21^{ab}	54.66^{a}	8.75^{a}
Carissa spinarum	51.49^{d}	42.21^{c}	6.76^{bc}
Acacia etbaica	46.39^{d}	36.79^{e}	5.89^{c}
Pittosporum viridiflorum	48.71^{e}	39.26^{cd}	6.28^{c}
Olea europaea	61.3^{b}	52.63 ^{a}	8.42^{a}
Dodonaoea angustifolia	56.88^{c}	48.27^{b}	7.67^{ab}
SEM	1.5	4.2	0.5
SL	***	***	***

$^{a-e}$ Mean values with different superscripts in a column are significantly different; IVDMD=In vitro dry matter digestibility; IVOMD=In vitro Organic matter digestibility; ME= Metabolizable energy; S.E.M=standard error of the means; *SL=Significance level*****= P<0.001*

Table 3. Correlation coefficient (r) of digestibility parameters with chemical composition of browses.

	IVDMD	IVOMD	EME
DM	0.06132	0.06931	0.01947
ASH	0.11330	0.11821	0.10694
OM	-0.11152	-0.04415	-0.08457
CP	0.68319***	0.68223***	0.66367***
NDF	0.22134	0.22115	0.22771
ADF	-0.32348	-0.33177	-0.31295
ADL	-0.75919***	-0.76242***	-0.72232***
Hemicellulose	0.50930**	0.45156*	0.45558*
Cellulose	0.06137	0.01892	0.05196

*DM = Dry Matter; OM = Organic Matter; CP = Crude Protein; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber; ADL= Acid Detergent Lignin; IVDMD = In vitro dry matter digestibility; IVOMD = In vitro organic matter digestibility; ***p<0.001; **p<0.01; *p<0.05*

In sacco degradability of browse species

The *in sacco* dry matter degradability characteristic of indigenous browse species are presented in Table 4. *In sacco* dry matter degradability characteristics of indigenous browse species showed high variation among browse species (p<0.001). *Balanites aegyptiaca* had the highest soluble fraction (aDM) and degradation rate (cDM) while *Pittosporum viridiflorum* had the lowest aDM and cDM. Degradation rate (cDM) of all investigated browse species was above the lower limit ($\geq$ 0.03). Slowly degradable fraction (bDM) ranged from 46.54% for *Balanites aegyptiaca* to 75.34% for *Ziziphus spina-chirsti*. Potential degradable (PDDM) fraction varied from 88.01% for *Dodonaoea angustifolia* to 59.71% for *Acacia tortilis*. The effective degradability (EDDM) of browse species was maximum (63.96%) for *Balanites aegyptiaca* and minimum (40.58%) for *Pittosporum viridiflorum*.

Mineral profile of browse species

The macro mineral concentration of the browse species is given in Table 5. The concentration of Calcium ranged from 0.69% for *Olea europaea* to 0.98% for *Grewia mollis*. The highest amount (0.41%) of Phosphorus was recorded in *Acacia tortilis* while the minimum (0.25%) was for Acacia etbaica. Non-significant variation was observed in potassium content of browse species.

DISCUSSION

Chemical composition of browse species

Except *Carissa spinarum*, the CP content of indigenous browse species in the current study was in line with findings of Njidda and Nasiru (2010) and Theart *et al*. (2015) who reported 14 to 21% and 13 to 25% respectively. Most tropical browse species are rich in CP and can be used to supplement poor quality roughages to increase productivity of ruminant (Makkar and Becker, 1998; Njidda and Nasiru, 2010; Theart *et al.*, 2015) which is consistent with the results obtained in the current experiment.

In this study, the NDF and ADF values of browse species varied from 14 to 48 and 9 to 29% DM, respectively, which is comparable with the findings of Amsalu *et al.* (2017) and Fadel Elseed *et al*. (2002). For legume forages, NDF contents below 40 % would be considered good quality, while above 50% would be

Table 4. *In-Sacco* dry matter degradability parameters of browse species.

Browse species	%DM				
	aDM	bDM	cDM(%/h)	PDDM	EDDM at K=0.03
Ziziphus spina-chirsti	10.34^{d}	75.34^{a}	0.05^{c}	85.54^{b}	63.71^{a}
Acacia tortilis	9.19^{def}	50.52^{g}	0.05^{c}	59.71^{g}	54.55^{b}
Balanites aegyptiaca	31.28^{a}	46.54^{h}	0.15^{a}	77.82^{d}	63.96^{a}
Grewia mollis	10.01^{de}	53.11^{f}	0.07^{b}	63.28^{f}	47.17^{c}
Carissa spinarum	11.84^{c}	61.37^{d}	0.04^{cd}	73.18^{e}	47.13^{c}
Acacia etbaica	8.295^{f}	55.91^{e}	0.04^{cd}	64.22^{f}	44.02^{d}
Dodonaoea angustifolia	15.88^{b}	72.13^{b}	0.07^{b}	88.01^{a}	54.47^{b}
Olea europaea	8.82^{ef}	73.11^{b}	0.03^{d}	81.93^{c}	44.15^{d}
Pittosporum viridiflorum	6.31^{g}	67.53^{c}	0.031^{d}	72.34^{c}	40.58^{e}
SL	***	***	***	***	***

*$^{a-h}$ values with different superscripts in a column are significantly different; aDM = rapidly degradable DM fraction; bDM = slowly degradable DM fraction; cDM = Rate of DM degradation; PDDM = Potential DM degradation; EDDM = Effective DM degradability;***= P<0.001; SL= significant level*

Table 5. Macro mineral content of indigenous browse species.

Browse species	Macro mineral (%DM)			
	Ca	***P***	***K***	***Ca : P***
Ziziphus spina-chirsti	0.96[ab]	0.32[abc]	0.8	3.00
Acacia tortilis	0.93[ab]	0.40[a]	1.09	2.33
Balanites aegyptiaca	0.80[cde]	0.32[bc]	2.66	2.50
Grewia mollis	0.98[a]	0.39[ab]	0.95	2.51
Carissa spinarum	0.85[abcd]	0.32[abc]	4.85	2.66
Acacia etbaica	0.84[bcd]	0.25[c]	1.38	3.36
Pittosporum viridiflorum	0.87[bcd]	0,26[c]	0.91	3.35
Olea europaea	0.69[e]	0.29[c]	1.93	2.38
Dodonaoea angustifolia	0.72[de]	0.32[abc]	4.32	2.25
SEM	0.004	0.002	-	
SL	***	***	NS	

[a-e] *Mean values with different superscripts in a column are significantly different; P= Phosphorus; K=Potassium; C*a *= Calcium;***= P<0.001; NS = Non significance;* S.E.M=standard error of the means; *SL= significant level*

considered poor. Feeds with more than 65% NDF contents are classified as low quality (Singh and Oosting, 1992). In this view, the NDF contents of the nine browse species in the current study is below 40% indicating that they are good quality feed resources for ruminants. The highest NDF, ADF and ADL content of *Pittosporum viridiflorum* in this study indicated that this browse would limit dry matter intake and digestibility. On the other hand, the low NDF, ADF and ADL content in *Dodonaoea angustifolia* could be associated with better dry matter intake and digestibility potential of the browse. Similarly, Derero and Kitaw (2018) reported that feeds with high NDF and ADF are the least digestible.

In vitro dry matter digestibility of browse species

The highest degradability *of Ziziphus spina-chirsti* might be due to its high CP value, while the lowest degradability of *Acacia etbaica* could be associated with its high ADL and ADF. The higher digestibility and degradability of forages is usually linked to higher CP content which provides nitrogen for microbial activity in the rumen (Yahaya *et al.*, 2000). It is well accepted that forage degradation in the rumen is mainly affected by the cell wall content and its lignification (Njidda and Nasiru, 2010). Theart *et al*. (2015) reported negative correlation of NDF, ADF and lignin with *in vitro* digestibility. It is well established that low content of ADF and ADL are indicators of good forage quality (Van Soest, 1994). In this regard, low contents of ADF and ADL obtained in this study suggests that these browse species have better digestibility and nutrient availability potential to be used as supplement to low quality ruminant feeds.

Correlation of *in vitro* digestibility parameters with chemical composition of browse species

The positive correlation between all *in vitro* digestibility parameters and CP in the study is in line with the reports of Theart *et al*. (2015) from similar browse species in South Africa and Njidda and Ikhimioya (2010) from browse species in Nigeria. A positive correlation between *in vitro* digestibility and CP indicate that as the crude protein content in forages increases, the *in vitro* digestibility improved (Amsalu *et al*., 2018; Njidda and Ikhimioya, 2010; Njidda and Nasiru, 2010; Theart *et al*., 2015). The negative correlation between *in vitro* digestibility and ADL observed in this study is similar to the findings of Theart *et al*. (2015) and Njidda and Ikhimioya (2010). McDonald *et al*. (2002) also reported that digestibility of feeds is negatively correlated with ADF and ADL contents. It is well accepted that forage degradation in the rumen is mainly affected by the cell well content and its lignification (Van Soest, 1994).

In sacco degradability of browse species

The highest DM Disappearance record for *Balanites aegyptiaca* at lowest incubation hours could be due to its high rapidly degradable DM fraction content (Table 4). The highest DM disappearance record for *Dodonaoea angustifolia* starting from 24 hrs up to 96 hrs of incubation period could be associated with its low ADF content and high concentration of slowly degradable DM fraction. The highest aDM and cDM observed in *Balanites aegyptiaca* could be associated with its high soluble ash and hemicellulose concentration, while the low aDM and CDM in *Pittosporum viridiflorum* could be due to its high concentration of ADL and ADF. The degradation rate (cDM) of all investigated browse species was above the lower limit ($\geq$ 0.03) which is an indicator of high quality feeds. Feed stuffs with degradation rate (cDM) lower than the constant (0.03) could be categorized as low quality feed (Osuji *et al*., 1995).

Mineral profile of browse species

The range of Calcium concentration (0.69 - 0.98%) and Phosphorus concentration (0.25 -0.4 %) of browse species in this study are greater than the Calcium and Phosphorus requirements of lactating dairy cows. The Ca requirement for a lactating cow is 0.30% and P is 0.20% of the diet dry matter. These requirements decrease in non–lactating cows (McDonald *et al.*, 2002). The Calcium and Phosphorus concentrations of browse species in this study are greater than the Calcium and Phosphorus concentration of most tropical legumes. Most legumes in tropical areas contain calcium levels ranging from 0.86 -1.02 % DM ((Rubanza *et al.,* 2006). Phosphorus levels of most browse species ranged from 0.1– 0.5 % DM as noted by Mtui *et al*. (2009). The mean Calcium to phosphorus (2.7:1) of browse species in the current study was above the recommended (2:1) value for normal physiological function of ruminants (McDonald *et al*., 2002)

CONCLUSION

All browse species in the current study had high CP concentration and low contents of NDF and ADF. This suggested that these browse species could be considered as potential forages to supplement low quality roughages. The highest CP and IVDMD of Ziziphus *spina-chirsti,* coupled with its high *in sacco* DMD would make this species good potential supplement to low quality roughages. The browse species could be used as good sources of Calcium and Phosphorus minerals for lactating cows. However, further feeding experiments with various types of ruminant animals would be important for efficient utilization of these valuable indigenous browse species.

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