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Available Feed Resources and Nutritive Value of Major Browse Species in East Dembia District, Central Gondar, Ethiopia

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Abstract: This study was conducted to assess the available feed resources, identify the most commonly used browse species as livestock feed and to determine their nutritive value from East Dembia district. Four kebeles (Sufankara, Grargie, Salj Gebeba and Atkilit Teleft) were selected purposively. Stratified random sampling was used for the selection of respondents. A total of 12 plots of 20m *20m (400m^2) were established at an interval of 200m along the transect line to identify and record the available browse species. The leaves and petioles of *A. abyssinica*, *C. africana*, *F. thonigii*, *F. sycomorus*, *V. amygdolina*, *M. arbutifolia* and *A. seyal* were collected for chemical analysis. General linear model procedure of SAS was used for statistical analysis. The mean CP content of the browse species ranged from 12.13% (*F. sycomorus*) to 29.74% (*V. amygdolina*). The IVDMD varied from 38.5% for *M. arbutifolia* to 71.67% for *F. sycomorus*. High gas production from immediately soluble component (a) was recorded for C. africana. The gas production from insoluble but potential degradable fraction (b) and production potential (a+b), organic matter digestibility, where high for *F. thounigii* but low for *V. amygdolina*. The browse species in the current study could be used as protein supplements to livestock fed on low quality feeds due to their high levels of crude protein, low fiber contents and high digestibility potentials. However, it is recommended that further studies need be undertaken in determining the nutritive value of the other browse components such as pods.

Key words: Browse species · Nutritive value · Crude protein · *in vitro* dry matter digestibility

INTRODUCTION

Ethiopia's national economy mainly relay on agriculture, which shares for more than 80% of income of the population [1]. Livestock production is one of the major area in the agricultural sector providing draught power, meat, milk and other products, serves as a source of additional income both for smallholder farmers and livestock owners' [2, 3].

In Ethiopia, Ahmed *et al*. [4] indicated that regardless of having ample number of farm animals, its contribution to GDP is limited to 20% and per unit productivity is quite low. The main bottleneck impediment to such low productivity is insufficient year round livestock feed supply in terms of quantity and quality, particularly during the dry season [5]. In the mixed crop-livestock farming systems of the Ethiopian highlands, feed resources accessible for livestock production are obtained from permanent marginal pastures and seasonal pastures between cropping cycles, crop residues and crop aftermath grazing. However, these feed resources are very low in quality having high fibre, with low to moderate digestibility and low levels of nitrogen [6]. Consequently, such low quality feeds are linked with a low voluntary intake, thus resulting in inadequate nutrient supply, low productivity and even weight loss.

On top of this, it is generally true that population of Ethiopia is increasing very fast. This boosts demands for more arable land to produce more food for humans, which continuously reduces the amount of land accessible for grazing and browsing [7].

The livelong insufficient nutrient supply may adversely affect productive performance of animals. In spite of these limitations, marginal pastures and crop residues could offer essential source of energy for ruminant livestock if provided with protein-rich feeds.

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This calls for an action to be taken to fill gap and serve as a bridge between the dry and wet seasons. In an effort to lessen the animal feed supply problem, looking for potential feed resources, especially those which survive during the dry season, ought to have due attention. In this view, the use of browse species has great potential and a paramount importance to alleviate the problem of feed supply. Browse species could be used as a short-term measure when the period shifts from wet to dry seasons since they stay green [8].

Being major sources of animal feeds in Africa, browse species are highly valued by farmers [9]. They play a very prominent role in areas where moisture is inadequate [10]. These browse plants contain appreciable amounts of nutrients that are deficient in other feed resources such as crop residues during dry periods [11]. Furthermore, the ability of most browse species to remain green for a longer period is accredited to deep root systems, which enable them to dig up water and nutrients from deep in the soil structure and this contribute to the increased CP content of the foliage [12].

East Dembya district, where this study was carried out, is characterized by mixed crop-livestock production, woyna-dega climatic condition and sources of ample browse species. Browse species play a key role in providing and making a large contribution to livestock nutrition as they depend on such species during dry season. In spite of the availability of the indigenous browse species as livestock feed, little research has so far been done which assessed the extent of its utilization, inventory of the major species and evaluation of the potential nutritive values. Therefore, this study was conducted based on the following general and specific objectives; to assess the available feed resources and identify the major browse species utilized by livestock and to determine their nutritive value in East Dembia district, to assess the available feed resources, identify the major browse species and determine the chemical composition, *in vitro* gas production and digestibility of the major browse species important as feed for livestock

MATERIAL AND METHODS

Description of the Study Site: East Dembia district is situated at 37°09' 60.00" E longitude and 12°39' 59.99" N latitude and bordered with Gondar town and Lay Armachiho in the North, Alefa in the west and part of Lake Tana in the south. Its altitude ranges from 1370 to 1950 meter asl and the main rainy seasons of the area occurs from June to mid of September, while the dry season spells from November to April. The area receives an average annual minimum and maximum rain fall of 700 mm and 1175mm, respectively. The daily mean minimum and maximum temperature is 11°C and 32°C, respectively.

Survey Data Collection

Data Collection Techniques and Selection of the Study Site and Sampling Methods: Primary and secondary sources were used to collect the data. The actual household survey was conducted from September to late October 2017 with a pre-tested questionnaire. East Dembia district consists of 30 farmer kebeles, out of which 4 kebeles were selected purposively for the study. Those kebeles were selected based on the availability, accessibility and abundance of browse species.

Household and Key Informants Selection: A total of 120 respondents were selected by using Yemane's sample size determination formula [13]. $n = \frac{N}{1+N(e2)}$ where, n= sample size; N= total number of household and e= sampling error.

From each kebele 30 farmers who have livestock were selected randomly. In addition, the selection of key informants (KIs) was done through a guided village tour. During the focus group discussion, issues not well indicated by interviewed farmers were clarified and checked.

Identification and Sampling of Browse Species: A reconnaissance survey of the study area was made before the actual data collection. The available browse species were listed and major browse species were ranked according to animal preference and availability at each selected kebele. Along two transects, each 1.5km in length, a total of 12 plots were established for the sampling of browse species. At 200m interval over the transect line, quadrates of 20 *20m (400m^2) were used for collecting the sample. For plant identification, the common prioritized browse samples were collected from the study sites and made by key informants, knowledgeable farmers and forage experts. The sample of browses species were collected at the beginning of the dry season (October-end of November).

Browse Species Sample Collection and Preparation for Chemical Analysis: For chemical analysis of the browse species, the sample were hand plucked with a mixture of leaves and petiole (edible parts), a combined sample of 1.5 kilogram on fresh bases from ten plants were used. Parts of the sample were dried at 65°C to constant weight for chemical analysis after fresh samples dried under shade. Thereafter, the samples were separately ground in a Willey mill to pass through 1mm sieve. Then, the samples were kept in air tight plastic bags pending further analysis.

Chemical Analysis: All the chemical analyses were performed in Hawassa University, animal nutrition laboratory, except for the CP analysis which was conducted in Debre Birhan research centre. Chemical analyses of browse samples were determined using standard analytical methods. Dry matter and ash contents of samples of browse species were determined according to the procedures of [14]. Kjeldahl method [14] was used to determine total nitrogen (N) and crude protein (CP) was calculated as N x 6.25. Neutral detergent fiber (NDF) was analyzed using the detergent extraction method as described by Van Soest*et al.* [15] and acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest *et al.* [16] using Ankom fiber analyzer.

In *vitro* Dry Matter Digestibility: *In vitro* dry matter digestibility (IVDMD) of the samples of browse species was determined by the method of Tilley and Terry [17] as modified by Van Soest *et al.* [16].

***In vitro* Gas Production:** Samples of the browse species were incubated *in vitro* with rumen fluid in calibrated glass syringes following the same procedures as of Menke and Steingass [18].

Statistical Analyses: Survey data was analyzed by using descriptive statistics using SPSS statistical software (SPSS, version 15). Data from the chemical composition, IVDMD and gas production of most commonly utilized browses were subjected to one-way analysis of variance (ANOVA) procedure using SAS software version 9.2 [19]. Significant differences between individual means were declared using the least significant difference (LSD). The model used for the analyses of chemical composition, *in vitro* dry matter digestibility and *in vitro* gas production was: $Yij= \mu + bi + eij$, where, Yij= response variable; μ= overall mean; bi= browse species and eij= the random error.

Table 1: Dominant browse species available

Species	Index	Rank
M.arbutifolia	0.21	1
A. seyal	0.20	2
F. thoungii	0.19	3
V. amygdolina	0.13	4
A. abyssinica	0.12	5
C. africana	0.07	7
F. sycomorus	0.08	6

Index = sum of (4 times first order + 3 times second order + 2 times third order + 1 times fourth order) for individual variables divided by the sum of (4 times first order + 3 times second order + 2 times third order + 1 times fourth order) for all variables.

RESULTS

Dominant Browse Species: The browse species in order of relative dominance in the study area is presented in Table 1. The availability of browse species used as feed for livestock was not the same throughout the study area.

Nutritive Values of Browse Species

Chemical Composition and in Vitro Dry Matter Digestibility of Browse Species: The chemical composition of the major browse species (leaves and petioles) are presented in Table 2. The ash content varied ($P<0.05$) among species and ranged between 7.9 for *M. arbutifolia* to 17.03 for *F. sycomorus*. CP content varied significantly between species ($P<0.05$). The mean crude protein content of the browse species ranged between 12.13 for *F. sycomorus* and 29.74% for *V. amygdolina*. The NDF concentration for the browse species varied ($P<0.05$) and was between 20.93% (*V. amygdolina*) and 47.51% (*C. africana*). Moreover, the IVDM range varied from 38.5% for *M. arbutifolia* to 71.67% for *F. sycomorus*.

***In vitro* Gas Production of Major Browse Species:** Fig 1. shows gas production at various incubation time (ml/200mg DM) of the browse species examined.

On the other hand, *in vitro* gas production parameters of the major browse species are presented in Table 3. Gas production from immediately soluble component (a) varied from 22.1 for *V. amygdolina* to 26.93 for *C. africana*. Gas production from insoluble but potential degradable portion (b) ranged between 26.1 for *V. amygdolina* and 42.17 for *F. thoungii*.

Organic Matter Digestibility, Short Chain Fatty Acids and Metabolisable Energy of Major Browse Species: Metabolisable energy (ME), organic matter digestibility (OMD) and short chain fatty acids (SCFA) of the browse

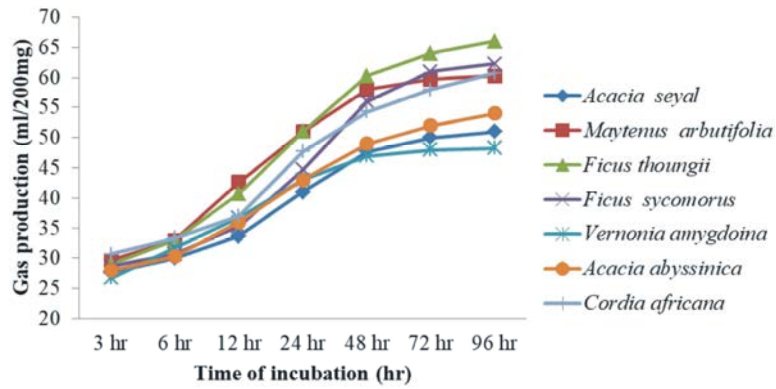

Fig. 1: *In vitro* gas production (ml/200mg DM) of browse species at different incubation time

Table 2: Mean chemical composition and *in vitro* dry matter digestibility of browse species (%DM)

Browse species	Lab DM%	Ash	CP	NDF	ADF	ADL	IVDMD
V.amygdolina	91.55^{abc}	12.77^{b}	29.74^{a}	20.93^{d}	12.10^{b}	3.98^{d}	47.33^{cd}
F. thoungii	92.55^{ab}	14.79^{ab}	15.87^{ef}	44.69^{ab}	32.29^{a}	11.27^{ab}	51.09^{bc}
C. africana	94.17^{a}	14.82^{ab}	18.13^{de}	47.51^{a}	32.35^{a}	13.38^{a}	65.65^{a}
F. sycomorus	94.61^{a}	17.03^{a}	12.13^{f}	38.76^{abc}	27.41^{a}	10.94^{abc}	71.67^{a}
A. seyal	93.67^{ab}	9.95^{c}	20.76^{cd}	36.72^{bc}	26.23^{a}	14.36^{a}	42.59^{ed}
M. arbutifolia	90.79^{bc}	7.90^{c}	27.01^{ab}	34.60^{bc}	24.91^{a}	7.31^{bcd}	38.5^{e}
A. abyssinica	89.05^{c}	14.03^{b}	24.44^{bc}	32.12^{c}	16.03^{b}	4.93^{dc}	57.14^{b}
Mean	92.34	13.04	21.15	36.48	24.48	9.45	53.42

Column means with different superscript letter is significantly different ($P<0.05$)

Table 3: *In vitro* gas production characteristics of major browse species

Browse species	a	b	a+b	C (hr^{-1})
A. abyssinica	24.66	29.50	54.15	0.04
A. seyal	24.52	27.83	52.35	0.04
C. Africana	26.93	34.55	61.48	0.03
F. sycomorus	24.40	41.38	65.78	0.03
F. thoungii	24.25	42.17	66.42	0.04
M. arbutifolia	23.32	37.00	60.32	0.06
V. amygdolina	22.10	26.10	48.16	0.07

a= gas production from immediately soluble component; b=gas production from insoluble but potential degradable portion; a+b=gas production potential; c=gas production rate constant

Table 4: Organic matter digestibility, short chain fatty acids and metabolisable energy of major browse species

Browse species	OMD%	ME (MJ/kg DM)	SCFA (mmol/L)
A. seyal	63.4	7.9	0.9
M. arbutifolia	73.2	9.3	1.16
F. thoungii	75.1	9.3	1.17
F. sycomorus	70.9	8.3	1
V. amygdolina	63.1	8.2	0.98
A. abyssinica	64.8	8.2	0.97
C. africanA	69.6	8.8	1.1

OMD=Organic matter digestibility, ME=Metabolisable energy, SCFA=Short chain fatty acid

OMD (%): OMD (%) = 18.53+ 0.9239 *Gas production (48 hrs) + 0.0540 *Crude protein (Menke & Steingass, 1988)

ME (KJ/gDM): ME (KJ/gDM) = 2.20+0.136 *Gas production (24 hrs) +0.0057* Crude protein

SCFA: SCFA + 0.0239*Gas production (at 24 hrs) - 0.0601 [32].

species are presented in Table 4. *F.thoungii* has the highest OMD (%) and the lowest was recorded for *V. amygdolina* and metabolizable energy content of browse species observed in this study ranged from 7.9 for *A. seyal* to 9.3 for *F. thoungii*. Furthermore, *F. thoungii* has the highest while *Acacia seyal* recorded the lowest SCFA production amongst the studied browse species.

DISCUSSION

According to the present finding, *Maytenus arbutifolia*, *Acacia seyal* and *Ficus thounigii* were more dominant followed by *Vernonia amygdolina* and *Acacia abyssinica*.

The present study revealed that, the ash contents of browse species such as *F. sycomorus, F. thoungii* and *C. Africana* were relatively high, which implies that the browse species could have high mineral concentrations hence potential as feed supplements to ruminant livestock fed on poor quality roughages.

The CP content of browse species was in accordance with the range (12.5%-31.9%) reported by Getachew [20] in Ginchi watershed Area. Most of the Ethiopian dry forages and roughages analyzed earlier had a CP content of less than 9%, which implies that the microbial requirement can hardly be met unless supplemented with protein rich feeds [21]. Thus, the high CP content in all the evaluated browse species in this study (12.13-29.74%) suggested that these species have a potential for supplementing protein to poor quality feeds.

The NDF value (47.51) for *C. africana* was lower than the report (54.5) by Belete *et al*. [22] while that of *M. arbutifolia* was slightly higher than the report by the same author. The observed differences in NDF content between species is probably due to the effect of species variability, ability of the soil to supply nutrients to the plant, maturity of the plant [23], as well as the proportion of different browsed components in the harvested samples. The NDF contents of the browses in the current study lie below the critical value of 60% which was indicated by Reed and Goe [24], hence may resulting in increased voluntary feed intake, feed conversion efficiency and shorter rumination time.

On the other hand, the IVDMD values for *F. thoungii* (51.09) and *F. sycomorus* (71.67) were higher than the result obtained by Kassahun [7]. This variation might be due to various factors like harvesting regimen, season and location. The variability in IVDMD of browse species also could be partly due to the differences in CP, NDF, ADF and ADL contents.

***In vitro* Gas Production of Major Browse Species:** The amount of gas produced when feeds are incubated *in vitro* has been reported to be closely associated to digestibility of feed for ruminants [25]. Hence, the gas produced can be considered as a good indication of substrate fermentation to VFAs and an estimate of potential digestibility in the rumen. The higher gas production observed for *F. thoungii* and *M. arbutifolia* therefore suggested that a higher digestibility of these browse species. Babayemi, Demeyer and Fievez [26] argued that the variation in gas production probably be due to the variability in nature and level of fibre, potency of the rumen liquor for incubation and the presence of secondary metabolites.

Moreover, slowly fermentable fraction ('b' value) of browse species observed in this study was within the range values (18.18-64.93) reported by Mahala and Elseed [27]. The rate of gas production (c) ranged between 0.03 for *C. africana* and *F. sycomorus* and 0.07 for *V. amygdolina*. The gas production potential ranged between 48.16 for *V. amygdolina* and 66.42 for *F. thoungii*. Osuga *et al.*[28] argued that variation in potential gas production of the browse species could be attributed to difference in chemical composition, more importantly to CP and fibre components.

The OMD obtained in this result was well above the range OMD value (42.2-58.08) reported by Merga *et al.* [29], for browse species from Borana rangeland. This inconsistency might be due to differences in fiber fraction [30] and organic matter content [31] of the evaluated browse species.

The ME of the present finding was higher than earlier report (4.53-6.48) of Okunade *et al*. [31]. This disparity is probably due to differences in CP content in addition to other factors for the browse species studied.

The SCFA observed in this result is by far greater as compared to the finding of Okunade *et al.* [31] who indicated that SCFA value of the browse species was ranging between -0.02 and 0.05mmol/liter. The variation might be due to differences in carbohydrate content of the browse species.

CONCLUSION

The present finding revealed that despite having variation in fodder availability and preference, nearly all livestock species consumed browses in the study area. In general, among the browse species evaluated for their nutritional values, some of the species like *M. arbutifolia* and *V. amygdolina* were the browses which have relatively high CP content and consisting low fiber fraction. In the light of this, the browse species can be used as a potential to supplement poor quality feeds such as crop residues, crop stubbles and pasture hay which are common in the study area. Furthermore, the high OMD and ME value of *F. thoungii* and *M. arbutifolia*, would make the browse potential supplement of low quality roughages.

Recommendation: Apart from chemical composition, further study is recommended to determine biomass yield and nutritive value in terms of methane production and anti-nutritional factors such as tannin content for efficient utilization of the browse species in the future. It is also recommended to conduct feeding and *in vivo* digestibility trial after appropriate identification from previous similar studies, on the most promising browse species such as *M. arbutifolia and V. amygdolina*. In addition, parts of browse species used as livestock feed such as pods and other components not considered in the present study should be evaluated for their nutritional qualities.

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