Indigenous tree and shrub species for fodder production in Galessa and Jeldu areas, West Shewa, Ethiopia

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Abstract

The foliage of indigenous tree and shrub species are used as source of supplemental animal feed in Galessa-Jeldu areas. A study was carried to identify and prioritise indigenous species for fodder production, and to evaluate chemical composition and anti-nutritional factors in the foliage and flower bud of indigenous fodder tree and shrub species. The species studied were *Hagenia abyssinica*, *Dombeya torrida*, *Buddleja polystachya* and *Chamaecytisus palmensis*. The chemical composition, tannin content and in vitro dry matter digestibility of foliage and flower bud samples were determined. The content of P in the foliage and flower bud of the four species ranged from 2.50 to 4.71mg g^{-1} and 2.24 to 5.37mg g^{-1} dry matter, respectively. The sodium content of the foliage and flower bud in the four species was not adequate to fulfill the minimum requirement of all classes of animals. The crude protein content of the foliage and flower bud in the four fodder species was much higher than the minimum required level. *B. polystachya* had a high content of acid detergent lignin and condensed tannin in the foliage. The in vitro dry matter digestibility of the foliage and flower bud from *H. abyssinica and C. palmensis* was reasonably high. The foliage and flower bud of all investigated woody species are potential to be used as sources of fodder with a proper feeding management scheme.

1. Introduction

Natural pasture and crop residues are major sources in the highlands. These feed resources are characterised by low digestibility, protein content and mineral composition (Seyoum and Zinash 1989). Fodder tree and shrub species are mostly required as supplement to low quality feeds. Fodder tree and shrub species are considered important contributors to grazing animal nutrition in the highlands of Galessa-Jeldu areas. During the dry and crop-fallow season, farmers traditionally feed indigenous fodder species to meet nutritional requirements of the grazing animals. So far, very little work has been done on the identification, prioritization and characterization of indigenous fodder and soil improving trees and shrubs in high altitude areas of Galessa-Jeldu areas. Similarly, farmers' local knowledge on indigenous fodder trees and shrub species are not strongly supported by scientific investigations. The objectives of the study were (a) to identify and prioritise indigenous species for fodder production, and (b) to evaluate chemical composition and anti-nutritional factors in the foliage and bud flower of indigenous fodder tree and shrub species.

2. Materials and methods

The study was conducted from 2004 to 2006 of Dendi and Jeldu Weredas (districts) in the western Shewa zone, Oromia region, Ethiopia (Figure 1). The altitude ranges from 2900 to 3200m. Barley is the most dominant crop, followed by potato and enset (*Ensete ventricosum*). Cattle, sheep and horses are dominant in the study sites. Accessibility and diversity of soil improving and fodder producing species were given much attention for the selection of the study area. A total of 14 villages in four kebeles (lower administrative units in the government structure) of Dendi and Jeldu weredas were considered for the study. Similarly, 9 to 12 households (3-4 rich, 3-4 medium income and 3-4 low income) from each village were considered for the survey. According to Eyobe *et al*. (1997), farmers with more than 3ha of land and sufficient number of oxen, cows and other farm animals are considered as rich farmers. Farmers who own 1-3ha of land, pair of oxen and other domestic animals is in the medium wealth category. Farmers that own less than 0.5ha of land with or without farm animals are grouped under low-income farmers.

Tree and shrub species' growing locations and composition were investigated through direct observation, as well as group and individual discussions approaches. A total of 150 farmers (respondents) participated for questionnaire survey (Roothaert and Franzel 2001, Thapa *et al*. 1997, Morrison *et al*. 1996, Mayr 1996). The farmers' criteria for the selection and prioritization of fodder species were identified through group discussion and quantified at the time of the questionnaire survey.

Hagenia abyssinica, *Dombeya torrida*, *Buddleja polystachya* and *Chamaecytisus palmensis* were included in the nutritional evaluation process of the fodder species as they are priority species of the farmers. *Chamaecytisus palmensis* (tree lucerne) was recently introduced an exotic N-fixing woody species.

Foliage (leaves and twigs) and flower bud samples were collected from *H. abyssinica*, *D. torrida*, *B. polystachya* and *C. palmensis*. Flower buds were included in the sampling scheme since most species produce an abundant quantity of flower buds that are palatable by livestock. The total number of composite foliage and flower bud samples was 24.

Total N content of the foliage and flower bud was determined following the Kjeldahl procedure. The total P, K, Ca, Mg and S content of the extracts were determined by the use of a simultaneous ICP-OES with an axial plasma and SCD (Perkin Elmer, OPTIMA 3000 XL). Crude protein (CP) was calculated by multiplying N * 6.25. Acid

Detergent Fibre (ADF), Acid Detergent Lignin (ADL), and Neutral Detergent Fibre (NDF) were determined by the methods of Van Soest and Robertson (1985). NDF was determined with amylase and sodium sulphite. The in vitro digestiblity was determined by the method of Van Soest and Robertson (1985). The insoluble NDF-bound proanthocyanidins (codensed tannins) were determined as described by Reed *et al*. (1982).

A one-way analysis of variance (ANOVA) was carried out on CP, mineral composition, ADF, NDF, ADL, condensed tannins and IVDMD using SAS (SAS institute 1999). Significance between means was tested using the Least Significant Difference (LSD).

3. Results

3.1. Household and farm characteristics

Out of 150 farmers, 85.3% were male and 14.7% female. Very low, low, intermediate and high-income farmers constitute 8.7%, 28%, 36.7% and 26.7%, respectively, of the total respondents. The household sizes of the respondents ranged from 2 to 14 persons. The mean household size was 7.53. Fifteen percent of the respondents had a household size of 7. There were more literate respondents than illiterate ones. Forty three percent of the respondents had attended formal education and 18.7% could write their names. On the other hand, the respondents who could not read and write at all made up 38%. The cultivable land holding of farmers ranged from 0-6 ha. The range for the number of cattle (oxen and cow) holding was between 0 and 5, sheep holding 0-30 and horse holding 0-5.

3.2. Tree and shrub species identified and ranked for fodder production

Farmers identified more than 30 tree and shrub species around homesteads, farmlands and other niches (Table 1). The fodder tree and shrub species were mainly concentrated around homesteads and in forests. More than 86% of the farmers need to plant trees around homesteads for better management and protection purposes. The percentage of farmers who mentioned a lack of seedlings, a free grazing livestock system, shortage of land and a lack of awareness as major problems for the planting of indigenous fodder species was 66%, 27%, 25% and 17%, respectively.

Farmers ranked fodder tree and shrub species based on plant and animal related criteria (Table 2). The most preferred tree species for fodder in their order of importance include: *H. abyssinica* > *D. torrid*a > *B. polystachya* > *Maytenus senegalen*sis (Table 3). About 98% of the farmers feed the fodder trees to cattle, 63% to sheep and 2% to horses. Tree leaves and straw fill the gap of the feed shortage in the dry season (April and May). Most farmers (64%) cut branches of trees and feed them to their animals. About 35% of the farmers collect fallen leaves under fodder trees and feed to their animals. There are also very few farmers (4%) who feed leaves of Dombeya torrida with salt. The mixture of leaves and salt enhances the fattening of oxen and sheep. The utilisation of industrial by-products (oil seed cake) is minimal. Only some rich farmers buy oil seed cake and feed it to their animals.

3.3. Mineral composition of the fodder tree and shrub species

Differences among species for P were more pronounced in the foliage than in the flower bud (Table 4). The Mg content in the foliage and flower bud of the three indigenous fodder species was high as compared to *C. palmensis*. *D. torrida* had the highest K content in the foliage and flower bud. The K level of the foliage and flower bud in the indigenous as well as exotic species was above the requirements and below the maximum tolerable concentration for beef and dairy cattle. The high K level in relation to Ca and Mg has been associated with reduced magnesium absorption. Potassium reduces Mg absorption when the K/(Ca + Mg) ratio exceeds 2.2 (Kemp and t'Hart 1957). The K/(Ca + Mg) ratios of the foliage of the four species were below the critical level.

The S content of the foliage in *D. torrida* and *B. polystachya* was higher than the S content of the foliage in *H. abyssinica* and *C. palmensis*. The S content of the flower bud in *D. torrida* was higher by 2.01 mg g-1 than the S content of the flower bud in *C. palmensis*. The Na content of the foliage and flower bud in the four species was comparable. The content of Na in the foliage and flower bud was below the requirement. Common salt or local mineral sources such as mineral soil can improve the deficiency of Na in the foliage and flower bud feed resources. Sodium is important to regulate osmotic pressure, acid-base and water balance in the animal body. Low levels of Na in feeds affect absorption of Mg (Martens *et al*. 1987). The Fe and Mn contents of the foliage in *C. palmensis* were higher than the Fe and Mn content in the three indigenous species. However, the four species did not show significant differences in the content of Fe and Mn in the flower bud. Manganese is a major component of enzymes and serves as an activator of enzymes. All the foliage and flower bud samples from the four species fulfill the Mn demand of beef and dairy cattle.

3.4. Chemical composition of the tree and shrub species

The crude protein content in the foliage and flower bud of the four species varied from 188 to 234mg g^{-1} and 124 to 170mg g^{-1}, respectively (Table 5). The CP content of the foliage in H. abyssinica and the flower bud in *C. palmensis* were low as compared to the other species. The CP content of the foliage and flower bud in the four species was much higher than the minimum required CP level (70mg g^{-1}) of beef cattle (Minson and Milford 1967). The CP content of *D. torrida* (234mg g^{-1}), *B. polystachya* (229mg g^{-1}) and *C. palmensis* (228mg g^{-1}) in the present study was high as compared to the CP range (134-213mg g^{-1}) reported for six *Acacia* species in Kenya (Abdulrazak *et al*. 2000). The high CP content in the foliage of C*. palmensis* can be accounted for by the N fixing ability of the species. The non-N-fixing species in our study only cycle the N present in the soil. On the other hand, *C. palmensis* cycles the N present in the soil and also adds N into the system through biological N fixation.

The NDF content of the foliage and flower bud in *H. abyssinica* was less by 215 and 383mg g^{-1} than the NDF content of the foliage and flower bud in *C. palmensis*, respectively (Table 4). The ADF content of the foliage in *H. abyssinica* and *D. torrida* was comparable. The ADF content of the flower bud was high in *B. polystachya* and low in *H. abyssinica*. The contents of NDF and ADF in *H. abyssinica*, *D. torrida*, *B. polystachya* and *C. palmensis* was within the range reported for browse tree species by El Hassan *et al*. (2000), Larbi *et al*. (1998), Abdulrazak *et al*. (2000) and Khanal and Subba (2001).

The ADL content of the foliage in *H. abyssinica* was less by 46, 71 and 119mg g^{-1} than the ADL content of the foliage in *D. torrida*, *C. palmensis* and *B. polystachya*, respectively. The ADL content of the flower bud in *H. abyssinica* was low as compared to other investigated species. The variability for CT content among species was more in the flower bud than in the foliage. The CT content of the flower bud in *D. torrida* was exceptionally high. High ADL and CT content can limit the voluntary feed intake, digestibility and nutrient utilisation of ruminant animals (Khanal and Subba 2001). The level of ADL and CT in foliage and flower bud of most of the species may not be considered to have effects on the feed intake and performance of ruminants because of two reasons. Firstly, farmers in the study area provide the foliage and flower bud of the fodder species not as a basal diet, but only as supplemental feed. Secondly, farmers do not find a sufficient quantity of foliage and flower bud to provide their animals for long duration.

The IVDMD of the foliage and the flower bud for *H. abyssinica* and *C. palmensis* was comparable. The high IVDMD of the foliage from *H. abyssinica* could be associated with the low level of NDF, ADF, ADL and CT. The IVDMD of *H. abyssinica* in our study was high as compared to the IVDMD reported for *Chamaecytisus palmensis*, *Leucanea leucocephala*, *Sesbania sesban* (15036), *Acacia angustissima* and *Vernonia amygdalina* (El Hassan *et al.* 2000).

4. Conclusions

The four woody fodder species had adequate mineral nutrients in their foliage and flower buds except for Na. The indigenous species had higher contents of P, K, Ca and Mg than the exotic species. The contents of Na, Fe and Mn in the foliage and flower bud both from the indigenous and exotic species were comparable. The three indigenous species had CP contents comparable to that of the exotic species. However, on top of the indigenous species, the N-fixing woody fodder species need to be integrated into the farming system to sustain the production of N rich fodder resources. The foliage NDF, ADF and ADL content in *H. abyssinica* and *D. torrida* was relatively low. The in vitro dry matter digestibility of the foliage and flower bud from *H. abyssnica* and *C. palmensis* was reasonably high. In general, the foliage and flower bud of all investigated woody species are potential to be used as sources of fodder with a proper feeding management scheme.

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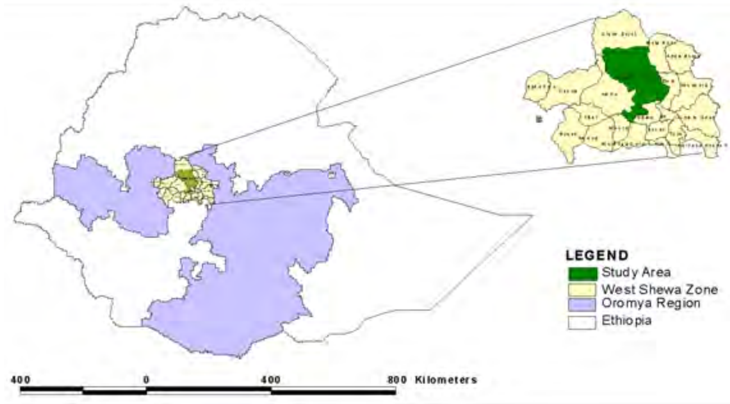

Figure 1: Location map of study area.

Table 1: Fodder tree and shrub species identified in the Galessa-Jeldu areas, wets Shewa, Ethiopia.

Species	Family	Local names
Dombeya torrida (J.F. Gmel.) P. Bamps	Sterculiaceae	Danisa
Hagenia abyssinica (Bruce) J.F. Gmel.	Rosaceae	Heto
Buddleja polystachya Fres.	Loganiaceae	Anfari
Maytenus senegalensis (Lam.) Exell.	Celastraceae	Kombolcha
Enset ventrcosum (Welw.) Sheeseman	Musaceae	Workie
Maesa lanceolata Forsk.	Myrsinaceae	Abeyi
Olea africana Mill.	Oleaceae	Ejersa
Rhamnus prinoides L' Her.	Rhamnaceae	Gesho
Rubus apetalus Poir.	Rosaceae	Gora/Yedega Injore
Rubus pinnatus Willd.	Rosaceae	Gura/ Yedega Injore
Salix subserrata Willd.	Salicaceae	Barodo
Vernonia amygdalina Del.	Asteraceae	Ibicha
Pittosporum viridiflorum Sims.	Pittosporaceae	Sole
Myrsine africana L.	Myrsinaceae	Kechemo
Arundinaria alpina K. Schum.	Bambusaceae	Kerkeha
Podocarpus gracilior Pilg.	Podocarpaceae	Birbirsa
Lantana trifolia L.	Verbenaceae	Kusaye (kese)
Hypericum revolutum Vahl	Hypericaceae	Hini (Ini)
Achyranthes aspera L.	Amaranthaceae	Dergu
Calpurnia subdecandra L' Her. Schweikerdt.	Papilionaceae	Cheka (digita)
Pterolobium stellatum (Forsk.) Chiov.	Caesalpiniaceae	Arangama/qontir
Apodytes dimidiata E. Mey. ex Benth.	Icacinaceae	Odabeda
Dracaena steudneri Schweinf. ex.	Agavaceae	Lankuso/Hareg
Stephania abyssinica (Qu. – Dill & A. Rich.) Walp.	Menispermaceae	Ido-Antuta/Yeayiti Areg
Clematis hirsuta Perr. & Guill.	Ranunculaceae	Hida, Idefeti/Azo hareg
Acacia abyssinica Hochst. ex Benth	Mimosaceae	Lafto/Bazra Girar
Nuxia congesta R. Br. ex Fres.	Loganiaceae	Qawisa/Chechiho
Maytenus ovatus (Wall. ex Wight & Arn.) Loes.	Celastraceae	Anjito/Atati
Vernonia auriculifera Hiern.	Asteraceae	Chochinga
Myrica salicifolia Hochst. ex A. Rich.	Myricaceae	Reji

Table 2. Criteria used by farmers to evaluate indigenous fodder tree and shrub species in Galessa-Jeldu areas of Central Ethiopia.

Criteria	No. of respondents[a]	Score
Tree related criteria[b]		
Availability in the dry season	150	555
High biomass	149	399
Coppicing ability	143	368
Fast growth	122	138
Animal related criteria[c]		
Palatable by animals	150	444
Harmless to animals	138	270
Improve weight of animals	53	64

Note: Sample size was 150 households. Score is sums of individual farmer value given to the respective criteria.
[a] Number of respondents who identified the criteria.
[b] If a farmer selected the criteria first, it received a value of 4; if second, a value of 3; if third, a value of 2 and if fourth, a value of 1.
[c] If a farmer selected the criteria first, it received a value of 3; if second, a value of 2; if third, a value of 1.

Table 3: Indigenous fodder tree and shrub species ranked based on farmers' criteria in the Galessa-Jeldu areas of Central Ethiopia.

Fodder species	No. of respondants[a]	Score
Hagenia abyssinica	148	790
Dombeya torrida	140	658
Buddleja polystachya	136	534
Maytenus senegalensis	128	417
Dracaena steudneri	92	227
Arundinaria alpina	68	131
Hypericum revolutum	59	110
Myrica salicifolia	55	107
Maytenus ovatus	15	28
Myrsine africana	7	27
Olea africana	10	27

Note:
Sample size was 150 households.
Each household scored six preferred fodder tree species.
[a] Number of respondants who selected the species in the top 6. If a farmer selected a species first, it received a value of 6; if second, a value of 5; if third, a value of 4; if fourth, a value of 3; if fifth, a value of 2 and if sixth, a value of 1.
Score is sums of individual farmer value given to the respective species.

Table 4: Macronutrient and micronutrient composition of four tree species.

Foliage	*H.abyssinica*	*D.torrida*	*B. polystachya*	*C. palmensis*	Normal requirment**
P (mg g^{-1})	3.71b	3.76b	4.71a	2.50c	1.2-4.8
K (mg g^{-1})	21.22b	27.00a	21.55b	14.93c	5.0-10.0
Ca (mg g^{-1})	9.69b	22.97a	10.93b	9.30b	1.9-8.2
Mg (mg g^{-1})	2.38ba	2.81a	2.07b	1.97b	1.0-2.5
S (mg g^{-1})	2.03c	3.62a	3.46a	2.55b	1.5-4.0
Na (µg g^{-1})	305a	224a	214a	268a	600-1800
Fe (µg g^{-1})	197b	364ba	284ba	450a	30-50
Mn (µg g^{-1})	61b	144b	104b	374a	20-40
Flower bud					
P (mg g^{-1})	4.54a	4.33a	5.37a	2.24b	1.2-4.8
K (mg g^{-1})	22.04ba	24.59a	16.52b	10.35c	5.0-10.0
Ca (mg g^{-1})	5.54b	10.59a	5.64b	2.08c	1.9-8.2
Mg (mg g^{-1})	2.53a	2.34a	1.67b	0.80c	1.0-2.5
S (mg g^{-1})	2.70b	3.74a	2.98b	1.73c	1.5-4.0
Na (µg g^{-1})	169a	200a	212a	179a	600-1800
Fe (µg g^{-1})	442a	263a	248a	223a	30-50
Mn (µg g^{-1})	39a	67a	44a	95a	20-40

Means with different letters within a row are significantly different ($p < 0.05$).

**Recommended mineral elements for all classes of ruminants according to NRC (1984, 1985, 1989, 1996).

Table 5: Foliage and flower bud nutritional value for four tree species in the highlands of central Ethiopia.

Foliage	*H. abyssinica*	*D. torrida*	*B. polystachya*	*C. palmensis*	SEM@
CP (mg g^{-1})	188b	234a	229a	228a	7.24
NDF (mg g^{-1})	356c	451b	526ba	571a	26.47
ADF (mg g^{-1})	303b	354b	449a	361ba	19.89
ADL (mg g^{-1})	54c	100bc	173a	125ba	14.79
CT (AU g^{-1})	4.59c	19.25b	29.76a	11.68c	2.98
IVDMD (%)	70a	59b	47c	71a	3.10
Flower bud					
CP (mg g^{-1})	170a	165a	170a	124b	7.63
NDF (mg g^{-1})	340c	610b	608b	723a	42.70
ADF (mg g^{-1})	295c	473a	435b	463ba	21.96
ADL (mg g^{-1})	73c	199a	162b	98c	15.78
CT (AU g^{-1})	9.34b	119.51a	24.40b	8.76b	14.18
IVDMD (%)	60a	52b	58a	60a	1.14

@ Standard error of the means (n = 12)

Means with different letters within a row are significantly different ($p < 0.05$).