International Journal of Forestry and Horticulture (IJFH)
Volume 8, Issue 2, 2022, PP 1-14
ISSN No. (Online) 2454–9487
DOI: http://dx.doi.org/10.20431/2454-9487.0802001
www.arcjournals.org

Evaluation of Nutritive Value of Indigenous Fodder Trees and Shrubs in Highland Agro Forestry Practices of Hadiya & Kembata-Tembaro Zones, Southern-Ethiopia

Getachew Mulugeta Geleto*, Wondimu Ayele

**Wachemo University College of Agricultural Sciences, Department of Natural Resource Management, Hossana, Ethiopia*
Wachemo University College of Agricultural Sciences,Department of Animal Science

Corresponding Author:** ***Getachew Mulugeta Geleto, *Wachemo University College of Agricultural Sciences, Department of Natural Resource Management, Hossana, Ethiopia*

Abstract: *The shortage of animal fodder is a priority problem in the mountainous landscapes of Ethiopia.Leaves of indigenous trees and shrubs species were used as a source of supplementalanimal feed especially during dry season. Fodder trees are playing a crucial role to meet the deficiency of animal feeds in highland areas during the dry season. To know the preference of the farmers'and nutritive value of the highland indigenous fodder treesand shrubs thus a study was conducted in highland agro forestry practices of Hadiya & Kembata-Tembaro Zones, Southern Ethiopia. The six important indigenous fodder trees and shrubs were taken in this study for biomass estimation and chemical analysis were Buddlejapolystachya, Dombeyatorrida, Erythrinabrucei, Hageniaabyssinica, Vernoniaamygdalina, Yushaniaalpine and Chamaecytisuspalmensisca. The first six were indigenous, and the last one was an exotic species.The potential leaf biomass yield of the selected indigenous fodder trees and shrubs ranges from 40.82 kg forChamaecytisuspalmensisca to 317.18 kg for Erythrinabruceiin the study area and vary significantly ($P < 0.05$) among the selected indigenous fodder trees and shrubs. The six selected indigenous fodder species had chemical composition of 191 - 236 mg g^{-1} Crude protein, 357 – 545 mg g^{-1} Neutral detergent fiber, 301 – 449mg g^{-1} Acid detergent fiber,56 – 171 mg g^{-1} Acid detergent lignin, Digestible energy, 240.58 - 348.52in Mcal kg^{-1} dry matter indicating their wide variability among species ($P < 0.05$). The study revealed that Yushaniaalpine, Vernoniaamygdalina, Erythrinabrucei and Buddlejapolystachya were promising indigenous fodder trees and shrubs interims of the farmers' preferences and the chemical analysis of nutritive values. Therefore, we should promote indigenous fodder trees and shrubs over exotic fodder tree species in the highland agro-ecology where there are limited feed resources in dry season.*

Keywords: *farmers' preference, indigenous fodder trees, nutritional value, Ethiopia*

1. INTRODUCTION

Agroforestry is a dynamic, ecologically based natural resources management system in which trees and/or shrubs are grown in association with agricultural crops, pastures or livestock either simultaneously or sequentially on the same unit of land (Nair, 1993; ICRAF, 2002). In this system there is ecological and economic interaction between the trees/shrubs and other components including human being (Nair, 1993; ICRAF, 2002; Alao and Shuaibu, 2013; Atangana et al., 2013; Atangana et al., 2014).

The livestock production system provides smallholders with a number of benefits, but it also possess real threats to the environment, which can be mitigated through methods such as farmland enclosure, mixed farming systems with agroforestry interventions. The production of livestock in East Africa has to date mostly focused on these interventions (Cecchi et al., 2010; Dawson et al., 2014; Baudron et al., 2015). It has been reported that status of animal protein deficiency in developing world is caused by shortage of forage (Azim et al., 2011; Gaikwad et al., 2017). Shortage of feed supply in terms of both quantity and quality is the main constraint limiting the realization of exploitation of the full potential of the livestock resources. If animals are not properly fed, they cannot express their genetic potential for production and reproduction (Adugna et al., 2012).

Fodder tree and shrub have always played a role in feeding livestock. They are increasingly recognized as important component of animal feeding; especially as supplies of protein in different parts of world. Different scholars (e.g. Speedy and Pugliese, 1992; Chakeredza et al., 2007; Abebe et al., 2008; Aynalem and Taye, 2008) studied and reviewed about the importance of these fodder trees and shrubs in different area at different time. To meet the maintenance requirement of animal for part of the year the contribution from trees and shrubs is significant. The fodder trees/shrubs that contain high level of crude protein, mineral matter and digestibility are acceptable by the livestock, because of their deep root system; they continue to produce well into the dry season (Dicko and Sikena, 1992; Speedy and Pugliese, 1992; Paterson et al., 1998).

African farmers have fed tree foliage to their livestock for centuries, using wild browse or trees that grow naturally on their farms (Le Houe´rou, 1980).Fodder trees are widely grown in the East African highlands, including Kenya, Uganda, Tanzania and Rwanda, primarily among dairy farmers (Wambugu C et.al, 2011).As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers. Browses have multiple roles in farming systems such as feed, fuel wood and as human and veterinary medicines (Luseba and Van der Merwe 2006). These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons and dry periods. They have deep root systems enabling the extraction of water and nutrients from deep in the soil profile (Teferi et al., 2008). In Ethiopia 85% of the population depends on agriculture for their livelihood. Agriculture is the basis for the entire socio-economic development, provides about 80% of total employment, and is the source of 85% of earnings from export (EEA, 2002). Livestock is an integral component for most of the agricultural activities in the country. The livestock sector has a share of 12-16% of the total Gross Domestic Product (GDP), and 30-35% of agricultural GDP (Ayele et al., 2002, LMA, 1999).

In many tropical countries the shortage of fodder, particularly in the dry season, is a major constraint to animal production. In the tropical regions of Ethiopia, cattle frequently suffer significant weight losses during the dry season as fodder is not only limited in supply but is also of poor nutritive value. The shortage of animal feed is a priority problem in the mountainous landscapes of Ethiopia (ICRAF 1990; Seyoum et al 2001). In the highlands of Ethiopia (2500–3000 meters above sea level), grasses and barley straw are major sources of animal feed. However, grasses and barley straw are characterized by low digestibility, low protein content, and poor mineral composition (Kabaija and Little 1987; Seyoum and Zinash1989). In addition to grasses and crop residues, where few or no alternative feed resources are available, the foliage of woody plants are important components of sheep and cattle diets. Farmers cut branches of trees and feed them to animals. Some farmers allow their animals to feed on fallen leaves under the fodder plants. There are also a few farmers who feed leaves with salts (Kindu et al 2006). Hence, the utilization of woody fodder species as a supplemental feed is becoming increasingly important in the highlands. In the highlands, exotic trees and shrubs such as Leucaenaleucocephala (Lam.) deWit., Sesbaniasesban (L.) Merr., Gliricidiasepium (Jacq.) Steud., and Calliandracalothyrsus Meissn have been introduced and promoted to increase biomass for supplemental animal feed and soil fertility management.

In recent years, some researchers have examined local tree species and involved farmers in their search for promising fodder trees (Bayer, 1990; Rusten and Gold, 1991; Antilla et al., 1994; Kanzilla, 1994; Morrison et al., 1996; Thapa et al., 1997; Thorne et al., 1999). Local fodder trees and shrubs have the advantage over exotic ones in that they are well adapted to the local environment, farmers know them, and locally available planting material is abundant. Involving farmers in the process is important because as potential users of new technologies, their knowledge and preferences are critical (Haugerud and Collinson, 1990).Twenty-nine indigenous fodder tree species used by farmers were identified in Dendi and Jeldu Districts, West Shewa Zone, central Ethiopia (Kindy et al., 2011)..The major limiting factor for livestock production is feed in terms of both quantity and quality. To curb the problem of feed shortage, use of indigenous multipurpose fodder trees could be regarded as good option. Indigenous multipurpose fodder trees are potentially good protein supplements for ruminants, particularly during the critical periods of the year when the quantity and quality of herbage is limited (Takele et al., 2014). Indigenous browse shrub and tree foliages represent locally available crude protein and mineral supplements for ruminant livestock in the tropics and these plants remain green during the dry season and provide vegetation with better nutritive value than other annual grass and herbaceous species (Aregawi et al., 2008).

Indigenous MPFTs are grown as part of the farming system. Although most of the indigenous fodder tree species are not primarily grown for fodder but for other purposes, they are readily available for livestock feed.Multipurpose fodder trees (MPFTs) are woody perennials grown for several functions (for example, shelter, shade, land sustainability) within the land-use system (Moges Y. 2004).The traditional knowledge and management practices on fodder trees offer relevant techniques and insights for foresters and other relevant scientists. Roothaert (2000) hypothesized that knowledge of individual farmers would be consistent enough to form a basis for selecting the most useful fodder species. In addition, farmer's preferences and cultural practices also need to be considered when species are screened for their appropriateness. Farmers in some parts of the world have some practical knowledge about the quality of fodder trees (Bayer 1990, Thapa *et al*. 1997). Taping this knowledge would be much faster and cheaper than carrying out elaborate analysis in laboratories, for the purpose of screening the nutritive values of trees. However, previous studies in this field have shown variable correlation between farmer's knowledge and laboratory assessment (Thapa *et al.* 1997). It was hypothesized that there is a strong relation between farmer's assessment and the combination of laboratory analysis, and that farmer's assessment could be used more often in future to save time and costs (Roothaert 2000).No study has been taken to investigate nutritive value of indigenous fodder trees and shrubs in the study area. Hence, this study has conducted to fulfill such gaps. Therefore, this project was initiated for the following objectives.

1.1. Objectives were

To evaluate nutritive value of indigenous fodder trees and shrubs

To find out fodder production potential of trees and shrubs

To assess farmers perception towards indigenous fodder trees

2. Materials and Methods

2.1. Descripti0on of the Study Area

This study has been carried out in some selected districts of Hadiya and Kembata-Tembaro zones, Southern Ethiopia (Figure 1). The study sites were selected purposively with the consideration and presence of indigenous fodder tree species as well as the farmers experience on livestock management. The selected districts from Hadiya zone were Misha and Lemo, and Angacha, Kacha-Bira and Tembaro districts from Kembata-Tembaro zone of Southern Ethiopia.

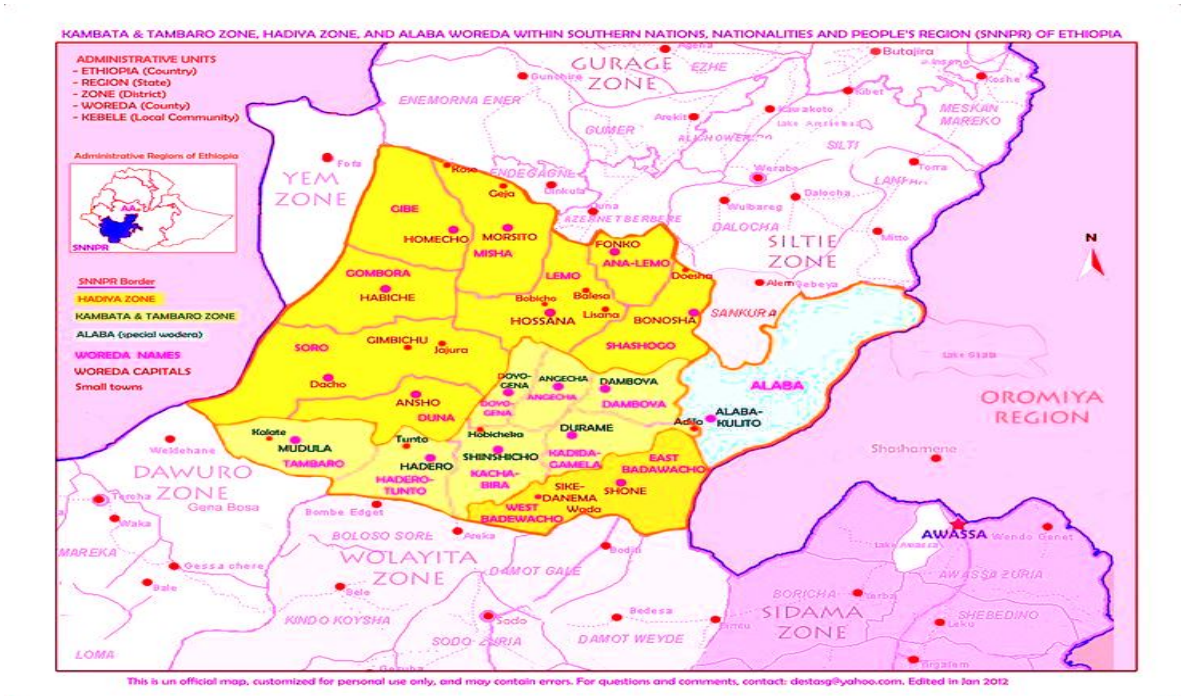

Figure1. *Map of Hadiya and Kembata-Tembaro zone in SNNPR, Ethiopia*

2.2. Sampling Procedures

The study locations were purposively selected from the highland agroforestry practices of each zone. Thirty households were randomly selected in each zone. The sample of households was not stratified by gender. All household members involved in fodder tree management – the household head, the spouse, other relatives and employees – were normally interviewed together. In some cases only male or female respondents were available. Farmers without cows (less than 20% of farmers in each of the three zones) were excluded from the survey. Interviews were conducted using a pre-tested. The questions were asked on the following topics: agroforestry practices, livestock, fodder tree species and use, quality aspects. Interviews began with a tour of the farm to view the common fodder trees that the farmer grew and used. The languages used during the survey were Hadiyassa and Kembatissa in the respective zones. The tour around the farm was an important tool to identify the species and minimize confusion about their botanical names. Samples of several morphological parts for every local species name were collected and the allocation of botanical names was cross-checked with the National Herbarium of Ethiopia.

Farmers were asked to rank their six most important fodder tree species in order of importance. All farmers then scored each species on selected criteria which were determined by a group of seven farmers in each zone through informal interviews prior to the survey. In addition, two criteria, palatability, growth rate, ease propagation and regrowth after cutting were determined by the researchers in order to obtain information about biomass production potential. Data were also analyzed by SPSS, either using descriptive statistics, in case of basic information on fodder trees, or SAS in case of nutritive value of fodder tree species and fodder production potential.

2.3. Description of Indigenous Fodder tree and Shrub Species

African farmers have fed tree foliage to their livestock for centuries, using wild browse or trees that grow naturally on their farms (Le Houe´rou, 1980).Fodder trees are widely grown in the East African highlands, including Kenya, Uganda, Tanzania and Rwanda, primarily among dairy farmers (Wambugu C et.al, 2011). The most common indigenous multipurpose fodder trees and shrubs (Table 1) were selected for detailed scientific study in highlands of some selected districts of Hadiya and Kembata-Tembaro zones, Southern Ethiopia.

Table1. *Description of indigenous fodder tree and shrub species*

Species	Family name	Altitude range (masl)	Estimated age of trees (year)	Propagation
Hageniaabyssinica	Rosaceae	2000 - 2400	7-9	Seed
Buddlejapolystachya	Loganiaceae	2200 - 2900	5 - 6	Seed, cutting
Dombeyatorrida	Sterculiaceae	2100 - 3000	6 - 7	Seed
Erythrinabrucei	Papilionoideae	2300- 2600	8 - 9	Seed, cutting
Yushaniaalpina	Poaceae	2400- 3200	3 - 4	Culm, Rhizome
Vernoniaamygdalina	Compositae	2300- 2700	5 - 7	Cutting
Acacia abyssinica	Minosoideae	2100- 2800	6 - 8	Seed

The most prevalent indigenous fodder trees and shrubs and exotic fodder species were evaluated for nutritive value and their potential fodder production. Farmers' preferred species were screened using the following characteristics: palatability, fast growth rate, ease propagation, harmlessness to animals, availability during the dry season, coppicing ability, high biomass, and fast to intermediate growth. *Chamaecytisuspalmensis* an exotic fodder species was included in the study for the purpose of comparison with the indigenous species. *Chamaecytisus* and *Erythrina* fix nitrogen, unlike the other indigenous species that wereincluded in the present study. The botanical names of the indigenous fodder trees and shrubs evaluated were given as follows: *Hageniaabyssinica, Buddlejapolystachya*, *Dombeyatorrida*, *Erythrinabrucei*, *Yushaniaalpine*, *Vernoniaamygdalina* and *Chamaecytisus-palmensis.*

2.4. Leaf Samples Collection and Processing

The leaf samples were collected from selected six indigenous fodder trees and shrubs from agroforestry practices of highland agro-climatein Hadiya and Kembata-Tembaro zones.Most

dominant indigenous fodder tree and shrubs leaves in the zones, which are being used for feeding ruminants locally were collected (Figure 2).The green leaves were rinsed in distilled water to remove dust and stored in a refrigerator to be freeze dried as soon as possible after collection. All the leaves were cut into small pieces so as to facilitate easy handling and uniform sampling for analysis. Samples were driedin the hot air oven at 65^0C for 24 hrs and ground to pass through 1 mm sieve,grinded and stored in polythene bags at room temperature until they were needed for further analysis. All samples were collected within 25 days to minimize effects of sampling time on nutrient composition. These samples were analyzed chemically. The procedures were followed are described below: Foliage samples were air dried until the weight of dry matter became constant. The moisture content was determined by drying the sample at 75^0C to a constant weight. The difference between the fresh and dry weight were used for calculation of moisture content of the sample. The dry matter percentage was calculated by following formula: The air dried foliage samples were oven dried at 100 ^{0}C for 24 hrs for chemical analysis.

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of leaves}}{\text{Fresh weight of leaves}} \text{X } 100$$

Figure2. *Collection of Hageniaabyssinica (Left) and Yushania alpine (Right) leaves from standing trees.*

2.5. Chemical Analysis of Fodder Leaves

Indigenous fodder trees and shrubs were evaluated for quality, preference and availability. The fodder quality parameters like crude protein (CP), in vitro dry mater digestibility (IVDMD), moisture content, and dry matter were estimated.Dry matter (DM) content was determined by drying the sample at 105oC in forced air oven till the constant weight. Crude protein (CP) was determined by Kjeldahl method (Anon., 1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by methods of Van Soest *et al*., (1991) without the use of alpha amylase but with use of sodium sulfite. All chemical analyses were done in triplicate. Digestible energy (DE) was calculated by determining the gross energy (Harris, 1970) of tree leaves and residues of leaves at 48 h of incubation of *in sacco*trial. This estimation of DE was further used for the calculation of ME contents by following equation (Anon., 2001). ME = 1.01 x DE–0.45.

2.6. Farmers' Preferences towards Fodder Trees and Shrubs

Farmers' preferences for certain fodder species were based on fodder values (palatability and ability to fatten), tree growth characteristics (fast regrowth, ease of propagation and establishment) and tree management issues. For farmers it is important that the trees are tolerant of frequent cutting and the cut fodder is easy to handle. Farmers like to plant various different species as they say that animals do notlike to eat the same fodder all the time(Figure 3), but prefer to consume mixtures ofseveral species.Questionnaires were developed and interview was conducted to assess the farmers' preferences for indigenous fodder trees and shrubs.

Figure3. *Sheep feed on Bamboo leaves and cows feed on Hageniaabyssinica leaves inthe study area*

2.7. Estimation of Leaf Fodder Biomass/yield

The leaf fodder yield/biomass was estimated for indigenous fodder trees and shrubs. In case of tall fodder trees the tree canopy was divided into three parts as upper, middle and lower canopy in each strata all number of branches having leaves were counted and the sample branches in all sides were cut and then the leaves weight was taken. In case of shrubs the total leaf yield/biomass was estimated by picking and weighing the whole leaves, also the checklist was prepared to collect fodder tree data in the field.

3. Data Analysis

To analyze the quantitative and qualitative data, statistical package for social sciences (SPSS 20 version) was used. Descriptive statistical methods such as frequency, percentage, mean, and standard deviation were used. For categorical variables, an ANOVA was used to test the difference between the fodder trees at the significance level (0.05). The nutritive values of indigenous fodder trees and shrubs as well as fodder production were analyzed employing SAS.

4. Results and Discussion

4.1. Fodder Trees and Shrubs in different Agroforestry Practices

In the highland of study zones and districts fodder trees were found in various agro forestry practices (Table2) such as home garden, parkland, boundary planting, live fence, woodlot, front-yard planting and trees on grazing land. The *Erythrinabrucei* was in home garden, parkland, boundary planting and live fenceagroforestry practices (Figure 5&6). Fodder or browse production from trees is one of the benefits of agroforestry. Fodder trees and shrubs become then important as a source of energy and protein to keep the animals' body healthy, improve growth rates and even increase milk and wool production (Azim et al., 2011).

Table2. *The selected highland indigenous fodder tree species in different agroforestry practices*

No	Scientific name	Family	Life form	Agroforestry practices
1	*Hageniaabyssinica*	Rosaseae	Tree	Hg, Pla, Bp
2	*Buddlejapolystachya*	Loganiaceae	Shrub	Lf
3	*Dombeyatorrida*	Sterculiaceae	Tree	Hg, Pla, Bp
4	*Erythrinabrucei*	Papilionoideae	Tree	Hg, Pla, Bp, Lf,
5	*Yushania alpine*	Poaceae	Grass	Bl
6	*Vernoniaamygdalina*	Compositae	Shrub	Lf,Pla
7	*Acacia abyssinica*	Minosoideae	Tree	Hg, Pla

Bl = Bamboo lot, Bp = Boundary planting, Hg = Homegarden, Lf = Live fence, Pla = Parkland agroforestry

Figure5. *Erythrinabrucei (left) and Hageniaabyssinica (right) as a boundary planting.*

Figure6. *Bamboo lot (Yushania alpine) at left and Vernoniaamygdalina with faba bean at right.*

4.2. Fodder Availability to Livestock

In both zones all interviewed respondents (100%) agreed that they face the shortage of fodder throughout the whole year thus intern constrained the productivity and production of livestock sector. The implication is that availability of fodder to livestock was a crunch, to be addressed if we are interested in improving the nutrition of the herds. The result of household survey revealed that, about 21.6% of the respondents have not integrated any fodder trees and shrubs into their farmlands whereas only 78.4 % of the respondents integrated fodder trees and shrubs into their farmlands. The foliage of tree present on farm land forms the alternative source of green fodder (Pandey and Singh, 1984) on one hand and supplements fuel and fruits on other.

4.3. Availability and Prevalence of Fodder Tree

The major animal feed sources in the study area during dry season were crop residues in the form of barley and wheat straw, grasses in the form of hay, tree fodder in the form of leaves and every part of enset. The indigenous multipurpose fodder trees could be an alternative green fresh fodder source to livestock in highlands of the study area. The survey revealed that the occurrence of fodder tree species (Table 3) were abundant (*Buddlejapolystachya*, *Erythrinabrucei, Yushaniaalpina* common (*Hageniaabyssinica, Dombeyatorrida, Vernoniaamygdalina*) and rare (*Acacia abyssinica* (Figure 5).Indigenous agro forestry systems play an essential role in supplementation of fodder wood requirement (Rawat and Vishwakarma, 2011).

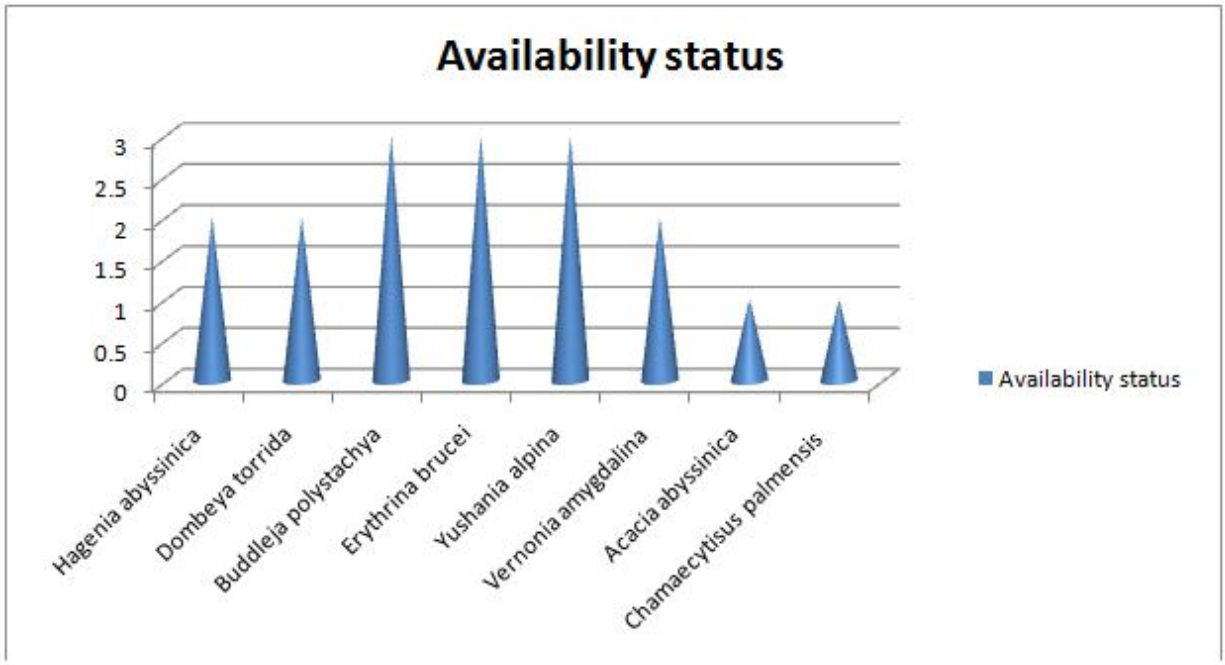

Figure5. *Availability status of fodder tree species: 3 = Abundant, 2 = Common, 1= Rare*

Table3. *Availability status and prevalence of indigenous fodder tree species in study area.*

Scientific Name	Local Name	Family	Prevalence (above msl)	Availability status
Hageniaabyssinica	Koso	Rosaseae	2000 - 3200	**
Buddlejapolystachya	Anfer	Loganiaceae	2000 - 3200	***
Dombeyatorrida	Wulkeffa	Sterculiaceae	2000 - 3200	**
Erythrinabrucei	Korich	Papilionoideae	2000 - 3200	***
Yushaniaalpina	Kerkaha	Poaceae	2000 - 3200	***
Vernoniaamygdalina	Girawa	Compositae	2000 - 3200	**
Acacia abyssinica	Girara	Minosoideae	2000 - 3200	*

*** = Abundant, ** = Common, * = Rare*

4.4. Feeding Season and other uses of Fodder Trees and Shrubs

Fodder tree species like *Buddlejapolystachya, Erythrinabruceim, Yushaniaalpine* and *Vernoniaamygdalina* could be fed throughout the whole year being evergreen species (Table 2). The evergreen fodder trees have advantage over deciduous tree species because they would be fed throughout the year. Almost all indigenous fodder trees and shrubs have multiple uses (Table 2).Indigenous browse shrub and tree foliages represent locally available crude protein and mineral supplements for ruminant livestock in the tropics and these plants remain green during the dry season and provide vegetation with better nutritive value than other annual grass and herbaceous species (Aregawi et al., 2008).

Table2. *Feeding season, nature and indigenous uses of highland fodder trees*

No	Scientific name	Feeding season	Nature	Indigenous uses
1	*Hageniaabyssinica*	Dry	Evergreen	Fd, Ti, Md, Fu
2	*Buddlejapolystachya*	Dry, Wet	Evergreen	Fd, Fu
3	*Dombeyatorrida*	Dry	Evergreen	Fd, Fu, Ti
4	*Erythrinabrucei*	Dry, Wet	Deciduous	Fd, Fu
5	*Yushaniaalpina*	Dry, Wet	Evergreen	Fd, Fu, Hc, Fe
6	*Vernoniaamygdalina*	Dry, Wet	Deciduous	Fd, Md, Fu,
7	*Acacia abyssinica*	Dry	Evergreen	Fd, Fu

Fd = Fodder, Fu = Fuel, Md = Medicinal,Hc = House construction,Ti = Timber, Fe = Fencing

4.5. Farmers' Preference Ranking of Fodder Trees and Shrubs

The farmers' preference status of seven indigenous fodder trees based on different criteria was recorded (Table 4). This study revealed that majority of the farmers agreed with *Yushania alpine* as a highly preferred species followed by *Vernoniaamygdalina* and *Erythrinabrucei* whereas, *Buddlejapolystachya*, *Hageniaabyssinica, Dombeyatorrida,* and *Acacia abyssinica* were lowest preferred species for palatability criteria (Jarial et al., 2013; Mondal et al., 2016). However, *Erythrinabrucei*, *Yushania alpine* and *Vernoniaamygdalina* were found to be highly preferred species for its ease propagation. Based on the growth rate *Yushania alpine, Erythrinabrucei* and *Buddlejapolystachya* were found to be highly preferred species.

Table4. *Criteria for preference ranking of different fodder trees*

No	Scientific name	Palatability	Ease of propagation	Growth rate	Forage yield (kg /tree)
1	*Hageniaabyssinica*	V	VI	VI	III
2	*Buddlejapolystachya*	IV	V	III	VII
3	*Dombeyatorrida*	VI	IV	V	II
4	*Erythrinabrucei*	III	I	II	I
5	*Yushania alpine*	I	II	I	VI
6	*Vernoniaamygdalina*	II	III	IV	V
7	*Acacia abyssinica*	VII	VII	VII	IV

4.6. Leaf Water Content of the Fodder Trees and Shrubs

The leaf water content was higher in Hageniaabyssinica than that of C. palmensis (Table 4). The moisture content pattern in indigenous fodder trees and shrubs was in the following order: H.abyssinica> B. polystachya> E.brucei> D.torrida> V.amygdalina> Y.alpine. Water content of almost all indigenous fodder trees was more than exotic fodder shrub (C. palmensis). Their water content result of our investigation is in line with the findings of JAMA et al. (2000).

Table4. *Water content (%) of the six selected indigenous fodder trees leaves*

Tree species	B. polystachya	D.torrida	E.brucei	H.abyssinica	V.amygdalina	Y. alpine	C.palmensis	SEM
Water content	75a	73a	74a	77a	71a	59b	58b	2.31

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

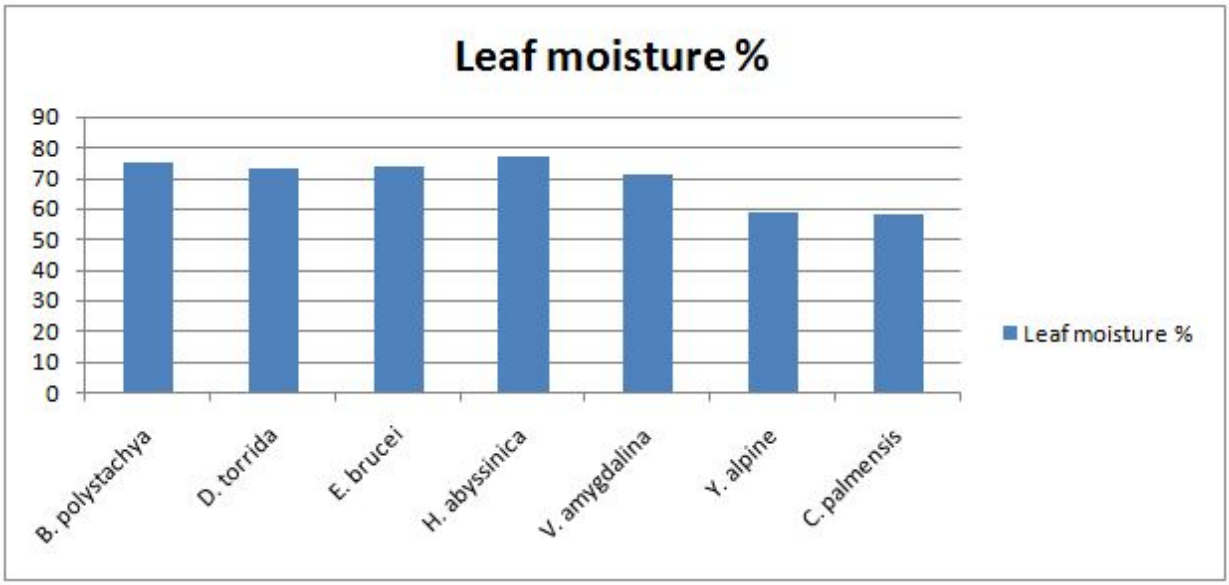

Figure. *Leaf water content of indigenous fodder trees and shrubs*

4.7. Dry Matter of Fodder Trees and Shrubs

Dry matter (Table 5) was the lowest in *Hageniaabyssinica* (50.82%) and the highest in *Chamaecytisuspalmensis*(56.29%). The dry matter pattern in indigenous fodder trees and shrubs was in the following order: C.palmensis> Y.alpine > D.torrida> B. polystachya> E.brucei> V.amygdalina> H.abyssinica.

Table5. *Leaves dry matter (%) of the six selected indigenous fodder trees and shrubs*

Tree species	B. polystachya	D.torrida	E.brucei	H.abyssinica	V.amygdalina	Y.alpina	C.palmensis	SEM
Dry matter	53.00b	54.41a	52.60b	50.82b	51.35b	55.16a	56.29a	0.43

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

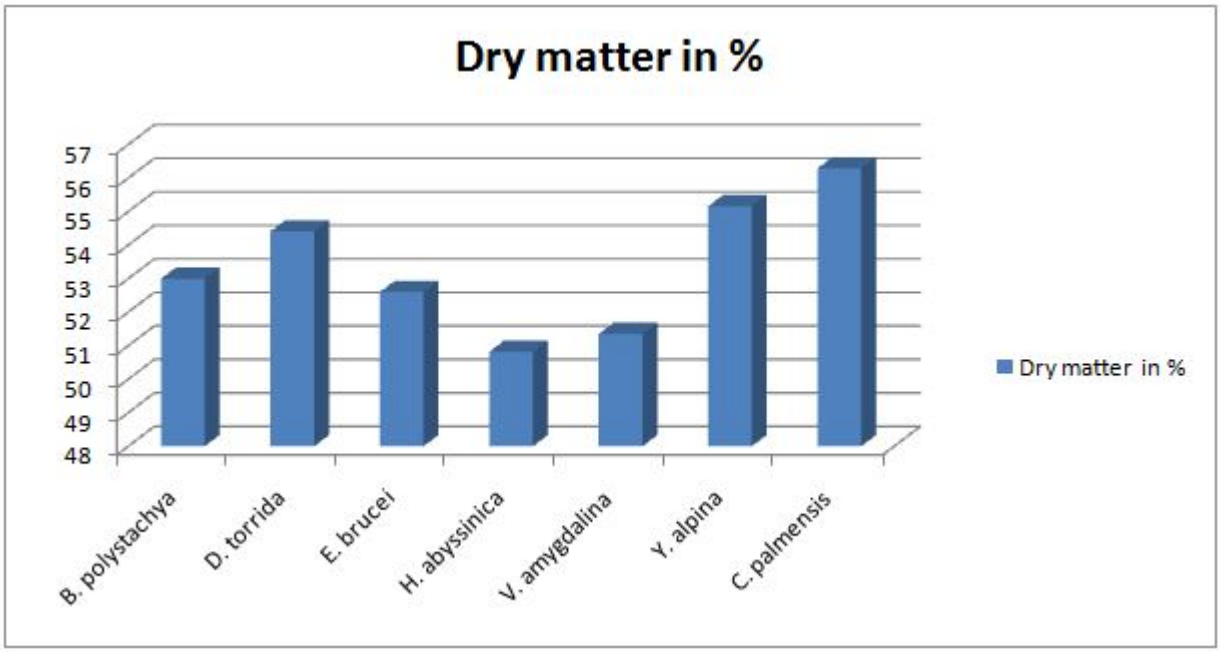

Figure. *Leaves dry matter (%) of the indigenous fodder trees and shrubs*

4.8. Potential Leaf Biomass Yield of Fodder Trees and Shrubs

Leaf biomass yield that can be used for animal feed differed ($P < 0.05$) among the six selected fodder tree species in all the study districts (Table 5). Biomass yield in all districts were greatest ($P < 0.05$) for E. brucei followed by H.abyssinica and D.torrida.Leaf biomass yield of the selected indigenous fodder tree species ranges from 40.82 kg to 317.18 in the study area. The variation among species in leaf biomass yield suggests differences in potential biomass yield that may be associated with differences in growth of the species. Generally, the result revealed that highest weight yield recorded in Erythrinabrucei followed by Hageniaabyssinica, Dombeyatorrida in the study area.

Table5. *Leaf biomass yields (kg) of the six selected indigenous fodder treesand shrubs*

Tree species	B. polystachya	D.torrida	E.brucei	H.abyssinica	V.amygdalina	Y.alpina	C.palmensis	SEM
Leaf yield	83.96b	232.52a	317.18a	265.74a	95.60b	56.31c	40.82c	8.97

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

4.9. Nutritive Value of Indigenous Fodder Trees and Shrubs

The leaf chemical composition of indigenous fodder trees and shrubs were depicted in Table 6. Crude protein content was the highest in *Erythrinabrucei* and the lowest in *Yushania alpine* ($P<0.05$). The CP content was in the order of *Erythrinabrucei*> *Dombeyatorrida*> *Vernoniaamygdalina*>

Buddlejapolystachya> Chamaecytisuspalmensis> Hageniaabyssinica> Yushania alpine. The CP content of the selected indigenous fodder trees and shrubs was within the range of 153 – 236 mg /g reported by Abebe M. et. Al (2008), Osuga IM.et.al (2008).However, the CP content of the foliage of all indigenous fodder trees species was much higher than the minimum required CP level (70 mg /g) of beef cattle (Minson and Milford 1967).The high CP content in the foliage of *Erythrinabrucei* and *Chamaecytisu s*palmensis could be due to the N-fixing ability of the species.

The content of NDF was greater for *Erythrinabrucei*than the other and the lower for *Hageniaabyssinica.* The NDF content of indigenous trees was similar to the finding of on similar issues (Solomon, M. et. al., 2003; Kaitho, R.J., 1997).The content of ADF was greater for *Erythrinabrucei*than the other and the lower for *Hageniaabyssinica.* The NDF, ADF, and ADL contents of the foliage in H. abyssinica were relatively low as compared to the other species. The contents of NDF and ADF in H. abyssinica, D. torrida, B. polystachya, E.*brucei,*V.*amygdalina,* Y. *alpine* and C. palmensis were within the ranges reported for browsed tree species by Larbi et al (1998), Abdulrazak et al (2000), El Hassan et al (2000), and Khanal and Subba (2001). High ADL content can limit the voluntary feed intake, digestibility, and nutrient utilization of ruminant animals (Khanal and Subba 2001).

The IVDMD value of *Hageniaabyssinica*, *Erythrinabrucei* and *Vernoniaamygdalina* in our study was high as compared to the IVDMD value reported for *Chamaecytisuspalmensis*, *Leucaenaleucocephala, Sesbaniasesban*, *Acacia angustissima,* and *Vernoniaamygdalina* (El Hassan et al 2000). The digestible energy of the foliage ofE.*brucei,* H. *abyssinica* and C. *palmensis* was significantly higher than the digestible energy of V.*amygdalina,* Y. *alpine,*D. *torrida* and B. *Polystachya* (Table 6).*Buddlejapolystachya* had the lowest digestible energy as compared to the other 6 species.Variations in the chemical composition of the fodder trees considered in this study could probably be due to difference in their ability to accumulate proteins at the stage of their leaf sampling, growth potential of the plant and possible differences in the amounts of minerals or nutrient in the soil (Salem, A. 2006).

Table6. *Leaf chemical composition of indigenous fodder trees and shrubs in the study area*

CP, NDF, ADF, and ADL are in mg g^{-1} , and DE is in $Mcalkg^{-1}$ dry matter; IVDMD is in % as described by Reed et al (1982). Means with different letters (a, b) within a row are significantly different (P , 0.05).

Foliage	B. polystachya	D. torrida	E brucei	H. abyssinica	V amygdalina	Y alpine	C. palmensis	SEM
CP	231.00a	235.00a	236.00a	191.00b	232.00a	223.00a	230.00a	8.31
NDF	524.00a	450.00b	545.00a	357.00c	525.00a	523.00a	539.00a	15.28
ADF	447.00a	352.00b	452.00a	301.00c	449.00a	374.00a	362.00a	17.76
ADL	171.00a	101.00b	102.00b	56.00c	168.00a	135.00a	123.00b	13.81
IVDMD	46.00c	57.00b	73.00a	71.00a	48.00c	57.00b	70.00a	3.12
DE	240.58b	265.66b	348.52a	332.00a	281.36b	274.72b	347.69a	12.57
ME	260.55c	290.78c	374.87a	360.27b	303.42c	296.25c	377.19a	14.30

CP=crude protein NDF=neutral detergent fiber ADF= acid detergent fiber ADL= acid detergent ligninIVDMD=invitro dry matter digestibility DE=digestible energy ME=metabolizable energy

5. Conclusion and Recommendation

The evaluated six indigenous fodder trees and shrubs had comparable nutritive values as that of exotic fodder shrub. The potential leaf biomass yield of the selected indigenous fodder trees and shrubs was higher than exotic fodder shrub.In general, the leaves of all investigated fodder tree and shrub species can be used as sources of supplemental fodder within a proper feeding management scheme. Therefore, we should promote indigenous fodder trees and shrubs over exotic fodder tree species in highland agro-ecology of Ethiopia.

References

Abdulrazak SA, Fujihara T, Ondiek JK, Ørskov ER. 2000. Nutritive evaluation of some acacia tree leaves from Kenya. Animal Feed Science and Technology 85: 89–98.

Abebe, M., S.J. Oosting, S. Fernandez-Rivera, A.J. Vander Zijpp, 2008.Multipurpose fodder trees in Ethiopia; Farmers' perception, constraints to adoption and effects of long-term supplementation on sheep performance.A PhD dissertation, Wageningen University, Wageningen, Netherlands.

AdugnaTolera, GetnetAssefa, DirbaGeleti, Lemma Gizachew, AlemayehuMengistu, 2012. Feed resources availability and quality. Livestock Feed Resources in Ethiopia: Challenges, Opportunities and the Need for Transformation. Ethiopian Animal Feeds Industry Association, Addis Ababa, Ethiopia, pp: 37-46.

Alao, J.S. and Shuaibu, R.B., 2013. Agroforestry practices and concepts in sustainable land use systems in Nigeria. Journal of horticulture and forestry, 5(10), pp: 156-159.

Antilla LS, Johansson GM and Johansson SG (1994) Browse preference of Orma livestock and chemical composition of Prosopisjuliflora and nine indigenous woody species in Bura, Eastern Kenya. East African Agricultural and Forestry Journal, Special Issue 58: 83–90

Aregawi, T., Melaku, S. and Nigatu, L. 2008. Management and utilization of browse species as livestock in semi-arid district of North Ethiopia. Livestock Research for Rural Development, Vol 20: http://www.lrrd.org/lrrd20/6/ areg20086.htm

Ayele, S., Assegid, W., Jabbar, M.A., Ahmed, M.M. and Belachew, H., 2002.Livestock marketing in Ethiopia.A review of structure, performance and development initiatives.Socio-economics and Policy Research Working Paper 52.ILRI, Nairobi, Kenya.

Aynalem Haile and TayeTolemariam, 2008. The feed values of indigenous multipurpose trees for sheep in Ethiopia: The case of Vernoniaamygdalina, Buddlejapolystachya and Maesalanceolata. Livestock Research for Rural Development, 20(3), pp: 1-7.

Azim, A., Ghazanfar, S., Latif, A. and Nadeem, M.A., 2011.Nutritional evaluation of some top fodder tree leaves and shrubs of district Chakwal, Pakistan in relation to ruminant‟s requirements. Pakistan Journal of Nutrition, 10(1), pp:54-59.

Bayer, W. 1990.Use of browse by *Fulani* cattle in Central Nigeria.*Agroforestry systems* 12:217-228.

Chakeredza, S., Hove, L., Akinnifesi, F.K., Franzel, S., Ajayi, O.C. and Sileshi, G., 2007, November. Managing fodder trees as a solution to human–livestock food conflicts and their contribution to income generation for smallholder farmers in southern Africa. In Natural Resources Forum. 31(4), pp:286-296.

Dawson, I.K., Carsan, S., Franzel, S., Kindt, R., van Breugel, P., Graudal, L., Lillesø, J.P.B., Orwa, C. and Jamnadass, R., 2014. Agroforestry, livestock, fodder production and climate change adaptation and mitigation in East Africa: issues and options. World Agroforestry Center, Nairobi. Kenya.

Dicko, M.S. and Sikena, L.K., 1992. Fodder trees and shrubs in range and farming systems in dry tropical Africa.Legume trees and other fodder trees as protein sources for livestock.FAO, Rome, pp.27-41.

EEA, 2002. Ethiopian Economic Association (EEA): A research report on land tenure and agricultural development in Ethiopia, October 2002, Addis Ababa, Ethiopia.

El Hassan SM, Kassi AL, Newbold CJ, Wallace RJ. 2000. Chemical composition and degradation characteristics of foliage of some African multipurpose trees. Animal Feed Science and Technology 86:27–37.

Etgen, W, and P Reaves. 1978. Dairy Cattle Feeding and Management. John Wiley and Sons, New York.

Gaikwad, U.S., Pawar, A.B. and Kadlag, A.D., 2017.Nutritional Status of Fodder Tree Leaves and Shrubs of Scarcity Zone of Maharashtra. Advances in Life Sciences, 7(1), pp: 11-14.

Haugerud A and Collinson MP (1990) Plants, genes, and people: Improving the relevance of plant breeding in Africa. ExplAgric 26: 341–362

ICRAF [International Center for Research in Agroforestry]. 1990. Agroforestry: Potentials and Research Needs for the Ethiopian Highlands. Agroforestry Research Network for Africa Report No 21. Nairobi, Kenya: ICRAF.

International Center for Research in Agroforestry (ICRAF), 2002. What Is Agroforestry? World Agroforestry Center, Nairobi.

Jarial, S., A. Kumar and V. Padmakumar. 2013. Assessment of feeding practices, nutritional status and gap for dairy buffaloes in hilly districts TehriGarhwal and Pithoragarh of Uttarakhand, India. Indian Journal of Animal Sciences 83: 960–963.

Kabaija E, Little DA. 1987. Potential of agricultural by-products as sources of mineral nutrients in ruminant diets. In: Said N, Dzowela BH, editors. Overcoming Constraints to the Efficient Utilization of Agricultural By-products as Animal Feed.

Kaitho, R.J., 1997. Nutritive value of browses as protein supplement (s) to poor quality roughages. PhD Theses, Department of Animal Nutrition, Wageningen Agricultural University, Wageningen, The Netherlands.

Kanzila M (1994) Survey of browse trees in Burundi, Rwanda and Zaire. Revue d'elevageet de MedecineVeterinaire des Pays Tropicaux 47(4): 415–424

Kenney, P, and J Black. 1984. 'Factors affecting diet selection by sheep. Potential intake rate and acceptability of feed'.Aust J Agric Res 35: 551–63.

Khanal RC, Subba DB. 2001. Nutritional evaluation of leaves from some major fodder trees cultivated in the hills of Nepal. Animal Feed Science and Technology 92:17–32.

Kindu M, Glatzel G, Sieghardt M: Evaluation of common indigenous tree and shrub species for soil fertility improvement and fodder production in the highland areas of western Shewa, Ethiopia.

Larbi A, Smith JW, Kurdi IO, Adekunle IO, Raji AM, Ladipo DO. 1998. Chemical composition, rumen degradation, and gas production characteristics of some multipurpose fodder trees and shrubs during wet and dry seasons in the humid tropics. Animal Feed Science and Technology 72:81–96.

Le Houe´rou HN(1980).Browse in Africa, the Current State of Knowledge.ILCA.

LMA, 1999.Livestock Marketing Authority (LMA). Annual report, Addis Ababa, Ethiopia

Luseba D and Van der Merwe D (2006).Ethnoveterinary medicine practices among Tsonga speaking people of South Africa. Onderstepoort Journal of Veterinary Research 73: 115- 122.

Minson DJ, Milford R. 1967. The voluntary intake and digestibility of diets containing different proportion of legume and mature Pangola grass (Digitariadecumbens). Australian Journal of Experimental Agriculture and Animal Husbandry 7:546–551.

Moges Y (2004) Recommeneded Agroforestry/Multipurpose trees for Borana lowlands, Middleland and their production techniques. Forestry Research Center, Dryland Forestry research project coordinator. Addis Ababa, Ethiopia.

Mondal, T., R. P. Yadav, J. K. Bisht, V. S. Meena and S. Kumar. 2016. Nutritional analysis of locally preferred fodder trees leaf in mid hills of Himalaya. In: Proc. International conference on Natural Resource Management Perspectives (R. Peshin, A.K. Dhawan, F. Bano and K.S. Risam, eds.). Indian Ecological Society. February 18-20, pp. 436.

Morrison BJ, Gold MA and Lantagne DO (1996) Incorporating indigenous knowledge of fodder trees into small-scale silvopastoral systems in Jamaica. AgroforSyst 34: 101–117.

Nair, P.R., 1993. An introduction to agroforestry.Springer Science & Business Media.

Osuga, I.M., C.C. Wambui, S.A. Abdulrazak,T. Ichinohe and T. Fujihara, 2008. Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semiarid area of Kenya.Journal of Animal. Science, 79: 582-589.

Pandey, U., Singh, J.S., 1984. Energy-flow relationship between agro-and forest ecosystem in Central Himalaya. Environ. Conserv. 11(1), 45-53.

Proceedings of the Fourth Annual Workshop, Cameroon, African Research Network for AgriculturalByproducts(ARNAB).www.fao.org/wairdocs/ilri/x5490e/x5490e00.htm#Contents; accessed on 10 January 2009.

Reed JD, McDowell RE, Van Soest PJ, Horvath PJ. 1982. Condensed tannins, a factor limiting the use of cassava forage. Journal of the Science of Food and Agriculture 33:213–220.

Roothaert, R.L. 2000.The Potential of indigenous and naturalized fodder trees and shrubs for intensive use in central Kenya.Doctoral thesis, Wageningen University, Netherlands. 169pp.

Rusten EP and Gold MA (1991) Understanding an indigenous knowledge system for tree fodder via multi-method on-farm research approach. AgroforSyst 15: 139–165.

Salem, A.Z.M., M.Z.M. Salem, M.M. El-Adawy and P.H. Robinson, 2006. Nutritive evaluations of some browse tree foliages during the dry season: Secondary compounds, feed intake and in vivo digestibility in sheep and goats. Journal of Animal Feed Science, 127: 251-267.

Seyoum, B. and S. Zinash, 1998. Utilization of teff straw as a livestock feed. 4: 173-185.

Seyoum B, Getnet A, Abate T, Dereje F. 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop–livestock production system in Ethiopia. In: Wall PC, editor. Wheat and Weeds: Fodder and Feed. Proceedings of Two Stakeholder Workshops. Santa Cruz, Bolivia: International Maize and Wheat Improvement Center, pp 207–226.

Solomon, M., J.P. Kurt and T. Azage, 2003.In vitro and in situ evaluation of selected multipurpose trees,wheat bran and Lablab purpureus as potential feed supplements to tef (Eragrostistef) straw.Jounal Animal Feed Science and Technology, 108: 159-179.

Speedy, A. and Pugliese, P.L., 1992.Legume trees and other fodder trees as protein sources for livestock (No. 633.3/S742).FAO.

Takele G., Lisanework N. and Getachew A. 2014.Evaluation of Potential Yield and Chemical Composition of Selected Indigenous Multi-Purpose Fodder Trees in Three Districts of Wolayta Zone, Southern Ethiopia. World Applied Sciences Journal 31 (3): 399-405.

Terefi A, Solomon M and Lisanework N (2008). Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. Livestock Research for Rural Development, 20.

Thapa, B., Walker, D.H. & Sinclair, F. L. 1997.Indigenous knowledge of the feeding value of tree fodder.*Animal Feed Science and Technology* 67: 97-114.

Thorne PJ, Subba DB, Walker DH, Thapa B, Wood CD and Sinclair FL (1999) The basis if indigenous knowledge of tree fodder quality and its implications for improving the use of tree fodder in developing countries. Animal Feed Science and Technology 81: 119–131

Wambugu C, Place F, Franzel S (2011). Research, development and scaling up the adoption of fodder shrub innovations in East Africa. Int J Agric Sustain, 9:100-109.

Citation: *Getachew Mulugeta Geleto & Wondimu Ayele. "Evaluation of Nutritive Value of Indigenous Fodder Trees and Shrubs in Highland Agro Forestry Practices of Hadiya & Kembata-Tembaro Zones, Southern-Ethiopia" International Journal of Forestry and Horticulture (IJFH), vol 8, no. 2, 2022, pp. 1-14. doi: http://dx.doi.org/10.20431/2454-9487. 0802001.*