# FARMERS' PREFERENCE AND KNOWLEDGE ON INDIGENOUS MULTIPURPOSE BROWSE SPECIES TOWARDS THEIR FEED VALUE IN NORTH WESTERN ETHIOPIA †

# [PREFERENCIA Y CONOCIMIENTO DE LOS AGRICULTORES SOBRE LAS ESPECIES MULTIUSOS NATIVAS HACIA SU VALOR COMO ALIMENTO EN EL NOROESTE DE ETIOPÍA]

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## SUMMARY

**Background.** Nowadays, in Ethiopia crop production is the dominant practice and indigenous browse species can make a large contribution to livestock feeding during dry season. However, few researches has been undertaken on the nutritional value of indigenous multipurpose browse species in this region, which means indigenous knowledge of multipurpose browse species is not strongly supported by scientific information. **Objective.** A study was conducted in the highland and lowlands of north western Ethiopia, to assess farmers' preference criteria, farmer's preference between the indigenous multipurpose browse species and the relationship of farmers' knowledge of multipurpose browse species (MPBs) foraging value with laboratory result. **Methodology.** Group discussions, preference ranking and scoring by a total of 60 farmers were conducted in two agro-ecologies. **Result.** The farmers' preference among MPB species which are browsed by cattle sheep and goat were determined considering availability, biomass yield, foraging value, palatability, multi-functionality and growth and re-growth ability. In the highland, the comparison among indigenous MPB species for their benefits and desired tree characteristics showed that farmers preferred *Albizia gummifera* for its availability and multi-functionality. In terms of feed value, growth and re-growth ability and palatability, the score for *Vernonia amygdalina* was higher than other MPB species. *Ficus thonningii* was preferred for its biomass yield. There was also a strong relationship between farmers' feed value score and laboratory results. Farmers were able to differentiate effectively MPB species that had high and low protein content and *in vitro* digestibility using their indigenous feed value indicator system. In lowland, the score for *Ficus sycomorus* followed by *Piliostigma thonningii* was higher for availability and *Cordia africana* was scored higher for multi-functionality and growth and re-growth ability. In terms of feed value and palatability, *Piliostigma thonningii* has the highest score. *Albizia malacophylla* was preferred and rated highest for biomass yield. But, the laboratory indicators were non-correlated (P > 0. 05) with the farmers' assessment of feed value score. **Implication.** The result of this study confirms that farmers have their own criteria to evaluate browse species and can differentiate the browse species that had high and low fiber content based on their indigenous knowledge. **Conclusion.** Therefore, we conclude that when incorporating locally available resources, farmers' preference criteria and indigenous knowledge is vital to efficiently utilize indigenous MPB species and to tackle feed shortage in the study area.

**Keywords:** Indigenous knowledge; multipurpose browses species; nutrient composition; preference score

## RESUMEN

**Antecedentes.** Hoy en día, en Etiopía, la producción de cultivos es la práctica dominante y las especies de ramoneo nativas pueden hacer una gran contribución a la alimentación del ganado durante la estación seca. Sin embargo, se han realizado pocas investigaciones sobre el valor nutricional de las especies autóctonas de ramoneo multipropósito en esta región, lo que significa que el conocimiento de las especies de ramoneadores multipropósito no está fuertemente respaldado por información científica. **Objetivo.** Se realizó un estudio en las tierras altas y bajas del noroeste de Etiopía, para evaluar los criterios de preferencia de los agricultores, la preferencia de los agricultores entre las especies nativas de ramoneo multipropósito y la relación entre el conocimiento de los agricultores sobre el

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valor de las especies multipropósito (MPB) con los resultados de laboratorio. **Metodología.** Se llevaron a cabo discusiones grupales, clasificación de preferencias y puntuación por un total de 60 agricultores en dos sistemas agroecológicos. **Resultados.** La preferencia de los agricultores entre las especies de MPB que son buscadas por ganado ovino y caprino se determinó considerando la disponibilidad, el rendimiento de biomasa, el valor de forrajeo, la palatabilidad, la multifuncionalidad y la capacidad de crecimiento y rebrote. En las tierras altas, la comparación entre las especies nativas de MPB por sus beneficios y las características deseadas de los árboles mostró que los agricultores preferían *Albizia gummifera* por su disponibilidad y multifuncionalidad. En términos de valor alimenticio, capacidad de crecimiento y rebrote y palatabilidad, la puntuación de *Vernonia amygdalina* fue más alta que la de otras especies de MPB. Se prefirió *Ficus thonningii* por su rendimiento de biomasa. También hubo una fuerte relación entre la puntuación del valor del pienso de los agricultores y los resultados de laboratorio. Los agricultores pudieron diferenciar de manera efectiva las especies de MPB que tenían alto y bajo contenido de proteína y digestibilidad *in vitro* utilizando su sistema de indicador de valor alimenticio indígena. En las tierras bajas, la puntuación para *Ficus sycomorus* seguida de *Piliostigma thonningii* fue más alta en disponibilidad y *Cordia africana* obtuvo una puntuación más alta en multifuncionalidad y capacidad de crecimiento y rebrote. En términos de valor alimenticio y palatabilidad, *Piliostigma thonningii* tiene la puntuación más alta. Se prefirió *Albizia malacophylla* y obtuvo la calificación más alta en cuanto a rendimiento de biomasa. Sin embargo, los indicadores de laboratorio no estaban correlacionados (P> 0.05) con la evaluación de los agricultores del puntaje del valor del alimento. **Implicación.** El resultado de este estudio confirma que los agricultores tienen sus propios criterios para evaluar las especies de ramoneo y pueden diferenciar las especies que tenían un contenido alto y bajo de fibra según su conocimiento indígena. **Conclusión.** Por lo tanto, al incorporar los recursos disponibles localmente, los criterios de preferencia de los agricultores y el conocimiento indígena son vitales para utilizar de manera eficiente las especies nativas de MPB y abordar la escasez de alimento en el área de estudio.

**Palabras clave:** Conocimiento indígena; especies de pajas polivalentes; composición de nutrientes; puntuación de preferencia

## INTRODUCTION

The scale of exotic browse species planting and utilization undertaken by smallholder farmers in Ethiopia has shown uneven success rates and did not meet the required goals (tackle feed shortage both in terms of quantity and quality) due to different reasons (Abebe *et al.,* 2008). Failure of some exotic fodder species to expand suggests the need to focus on indigenous browse species in order to exploit the advantages of indigenous multipurpose browse species over the exotic species in terms of adaptability to the local environment, resistance to pests and diseases, availability of local planting material, and familiarity to the farmers (Kindu *et al.,* 2009). Thus, there is a need to assess for locally available potential feed resources, which compete less with human food production and can provide the critical nutrients in the dry season feeds. Indigenous multipurpose browse species are believed to be nutritious, and known to be important to livestock production in promoting not only maintenance of animals but also in enhancing growth and milk production (Takele *et al.,* 2014). Efficient utilization of such feed resources is possible when the available and most preferred browse species are identified, and their nutritional status and farmers' interest as well as utilization practice are known.

In north western Ethiopia, crop production is the dominant practice and indigenous browse species can make a large contribution to livestock feeding during dry season. However, few researches has been undertaken on the nutritional value of indigenous multipurpose browse species in this region, which means indigenous knowledge of multipurpose browse species is not strongly supported by scientific information (Kindu *et al.,* 2009). Moreover, there is no detailed information available on the species used by farmers, preference among indigenous multipurpose browse species (MPBs) and the reasons underlying the preferences in the Ethiopian highlands (Abebe *et al.,* 2008). This suggests that there is a need to assess these feed resources in order to sufficiently understand their nutritional profile and the knowledge of farmers for efficient utilization and to identify their relative potential. Therefore, the objectives of this study were: to assess the farmers' preference criteria, farmers' preference between MPBs and the relationship between farmers' indigenous knowledge of MPBs foraging value and laboratory result.

## MATERIALS AND METHODS

### Descriptions of the study area

The study was conducted in the highlands of Awi zone, Amhara National Regional State (ANRS) and lowlands of Metekel zone, Benishangul-Gumiz Regional State, north western Ethiopia. Awi zone is located within 10° 31'46" to 11°16' 0" North latitude and 36°30' 0" to 36°93'0" East longtiude and lies at an altitude range of 700 - 3100 meters above sea level with an average altitude of 2300 m.a.s.l. The average annual rainfall is 1750 mm while the average monthly temperature ranges from 17°C to 27°C (AZARDO, 2016). Metekel Zone is located in lower altitude and has warmer agro-ecology. It is located within

10°47'33" to 11°24'26" North latitude and 35°24'40" to 36°38'43" East longitude, with altitude range of 550 to 2500 meters above sea level. The average temperature ranges between 20 -25°C. During the hottest months (January to May), the temperature range between 28–34°C. The annual rainfall ranges from 500 to 1800 mm (MZARDO, 2016).

**Method of data and sample collection**

To identify predominant and most preferred browse species, a total of 60 (30 from each agro-ecology) experienced and knowledgeable farmers in the development and utilization of indigenous MPB species were purposely selected to conform discussion groups, identifying the benefits they recognize and their desire in the respective agro-ecology which included: high biomass, soft and succulent in texture, high intake and good live-weight gain in ruminant animals like cattle, goats and sheep. During group discussion, commonly agreed criteria were set for evaluating/scoring the MPB species with farmers. Thus, after commonly agreed criteria were determined during the group discussion, all farmers scored each species, an exercise undertaken on an individual basis. Scoring was done on a scale from 1 (poorly preferred) to 4 (highly preferred). Finally, samples of the MPB species were collected from each agro-ecology for laboratory analysis. Samples were randomly harvested from 10-15 plants of each browse species, collected from three *kebeles* (Peasant association) for each agro-ecology.

**Laboratory analysis**

Triplicate browse samples collected were air dried under shade and chopped to approximately 1 cm pieces and allowed to be dried at 55ºC for 72 hours in forced draft oven. The dried samples were then ground separately to pass through 1mm screen of a Willey mill. The dried and ground samples were kept in airtight plastic bags prior to analysis. Feed samples were analyzed for DM, ash and CP contents according to AOAC (1990). Total nitrogen (N) content of the feed samples was determined using micro-kjeldahl method. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson (1985). *In vitro* DM digestibility (IVDMD) was determined by the two-stage *in vitro* method of Tilley and Terry (1963). Samples weighing 0.5 g were incubated for 48 hours with rumen fluid and buffer followed by another 48 hour digestion with pepsin and HCl. The residues were oven dried overnight at 105ºC to determine IVDMD.

**Statistical analysis**

The scores of preference rating were treated as quantities measured on a continuous scale (Kuntashula and Mafongoya, 2005). Analysis of variance was carried out on chemical composition and IVDMD within agro-ecologies using General Linear Model procedure of Statistical Analysis System (SAS, 2008) for each agro-ecology due to the difference in the types of available MPB species. Spearman rank correlation analysis and their levels of significance were determined between farmers' assessment of MPB species feed value score with laboratory results of chemical composition and IVDMD.

## RESULTS

**Most preferred indigenous browse species in north western Ethiopia**

It was observed that farmers had preference for browse species based on the criteria they set. From the total identified 46 indigenous MPB species, the top 16, eight species from each agro-ecology, which were prioritized and frequently used with their vernacular name are presented on Table 1.

**Evaluation criteria and their rank**

Farmers' selection criteria and rank used to evaluate MPBs in north western Ethiopia are shown in Table 2. The purpose of ranking browse selection criteria was to establish what farmers give more emphases/ priority when selecting and rating indigenous MPBs. Species evaluation was based on plant characteristics of the various species and the perceived animal preference. This includes availability (easy to grow on wide range of soil types, dominant), biomass yield (amount of browsed leaves and twigs per tree), foraging value (improves intake, performance and health of animals), growth and re-growth ability (growth rate after establishment; re-growth potential after frequent pruning or looping, the ability to replenish leaves after leaf shedding), multi-functionality of the plant species (use for different purposes like fuel wood, fence, shade tree, timber, poles and other constructions, farm utensil, medicinal value, bee forage) and the animal preference which is the palatability of the browse species. According to the respondents, availability, feed value and biomass yield were the top three ranked criteria for evaluating MPB species in the highland, respectively. On the other hand, in the lowland, availability, feed value and palatability were the most important criteria for ranking the MPB species, respectively. In both agro-ecologies, multi-functionality ranked last.

**Table 1. The most preferred browse species by agro-ecology in northwestern Ethiopia.**

| Agr-ecology | Species | Vernacular name in three languages | | |
|---|---|---|---|---|
| | | Amharic | Agewugna | Gumuz |
| Highland | *Acacia seyal* | Girar | Tsatsi | |
| | *Apodytes dimidiate* | Dong | Zindi | |
| | *Albizia gummifera* | Sesa | Kantsini | |
| | *Erythrina Abyssinica* | Korch | Buri | |
| | *Ficus thonningii* | Chebeha | Tsiwawi | |
| | *Rothmannia urcelliformis* | Simerero | Chumlikiliki | |
| | *Vepris nobilis* | Sila/Atesa | Gimibilitigni | |
| | *Vernonia amygdalina* | Girawa | Khokhitsi | |
| Lowland | *Acacia seyal* | Grar | Tsatsi | Asandiya |
| | *Albizia malacophylla* | Sendel | Safili | Ansisiwa |
| | *Cordia africana* | Wanza | Bugitsi | Banja |
| | *Ficus sycomorus* | Bamba | Abari | Fiqua |
| | *Lonchocarpus laxiflorus* | Zanezena | Zunzuni | Beewa |
| | *Piliostigma thonninigii* | Yekola wanza | Ambri | Micha |
| | *Pterocarpus lucens* | - | Chari | Chaya |
| | *Steteospermum kanthianum* | Zana | zani | Odanjuwa |

**Farmers' scoring of indigenous multipurpose browse species**

Comparative evaluations of MPBs on the stated criteria by the local farmers are shown in Table 3. The result indicates that the most dominant browse species which had the highest score, in the highland was *A. gummifera* followed by *A. seyal.* About 93.3% of farmers gave *A. gummifera* a maximum of four score for its availability (Table 3). In the lowland, *F. sycomorus* and *P. thonningii* had the higher score followed by *P. lucens* for their availability. More than 85.6%, 82.2% and 54.4% of farmers gave *F. sycomorus*, *P. thonningii* and *P. lucens* a maximum of four score for their availability, respectively. *E. abyssinica* and *A. malacophylla* had the lowest score for availability in the highland and lowland, respectively.

**Table 2. Farmers' selection criteria and rank used to evaluate indigenous multipurpose browse species in north western Ethiopia (n=30).**

| Evaluation criteria | Agro-ecology | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Highland | | | | | | | | Lowland | | | | | | | |
| | No. of farmers | | | | | | | | No. of farmers | | | | | | | |
| | 1st | 2nd | 3rd | 4th | 5th | 6th | Index | Rank | 1st | 2nd | 3rd | 4th | 5th | 6th | Index | Rank |
| Biomass yield | 1 | 19 | | 10 | | | 0.21 | 3 | | | 8 | | 16 | 6 | 0.11 | 5 |
| Availability | 15 | 1 | 7 | 7 | | | 0.23 | 1 | 20 | 4 | | 6 | | | 0.25 | 1 |
| Feed value | 7 | 10 | 6 | 7 | | | 0.22 | 2 | 4 | 20 | 6 | | | | 0.23 | 2 |
| Multi-functionality | | | | | 7 | 23 | 0.07 | 6 | | | | 4 | 6 | 20 | 0.07 | 6 |
| Growth and re-growth | | | | 1 | 22 | 7 | 0.09 | 5 | | 6 | | 12 | 8 | 4 | 0.14 | 4 |
| Palatability | 7 | | 17 | 5 | 1 | | 0.2 | 4 | 6 | | 16 | 8 | | | 0.2 | 3 |

Index = [(6 × number of responses for 1st rank) + (5 × number of responses for 2nd rank) + (4 x number of respondents of the 3rd rank) + (3 x number of respondents of the 4th rank) + (2 x number of respondents of the 5th rank) + (1 x number of respondents of the 6th rank)] divided by (6 × total responses for 1st rank) + (5 × total responses for 2nd rank) + (4 x total responses for 3rd rank) + (3 x total responses for 4th rank) +( 2 x total responses for 5th rank) + (1 x total responses for 6th rank); n= number of respondents

**Table 3. Farmers' scoring of indigenous multi-purpose browses species by evaluation criteria and agro-ecology in northwestern Ethiopia.**

| Species/location | Evaluation criteria | | | | | | |
|---|---|---|---|---|---|---|---|
| | availability | Biomass yield | Feed value | Multi - functionality | Growth potential | Palatability | Over all mean |
| **High land** | | | | | | | |
| *Acacia seyal* | 3.1$^{b}$ | 1.4$^{f}$ | 2.2$^{d}$ | 2.1$^{e}$ | 2.7$^{cd}$ | 1.5$^{f}$ | 2.2$^{g}$ |
| *Albizia gummifera* | 3.9$^{a}$ | 3.4$^{b}$ | 1.9$^{e}$ | 3.8$^{a}$ | 2.5$^{de}$ | 3.8$^{a}$ | 3.3$^{b}$ |
| *Apodytes dimidiata* | 2.7$^{c}$ | 3.1$^{c}$ | 2.1$^{de}$ | 3.1$^{b}$ | 2.3$^{e}$ | 2.2$^{d}$ | 2.6$^{e}$ |
| *Erythrina abyssinica* | 1.2$^{f}$ | 3.8$^{a}$ | 2.3$^{d}$ | 2.9$^{c}$ | 2.4$^{e}$ | 3.3$^{b}$ | 2.7$^{e}$ |
| *Ficus thonningii* | 2.7$^{c}$ | 3.9$^{a}$ | 3.6$^{b}$ | 2.1$^{e}$ | 3.8$^{a}$ | 3.8$^{a}$ | 3.1$^{c}$ |
| *Rothmannia urcelliformis* | 2.2$^{d}$ | 1.9$^{d}$ | 2.9$^{c}$ | 2.5$^{d}$ | 3.2$^{b}$ | 1.9$^{d}$ | 2.4$^{f}$ |
| *Vepris nobilis* | 1.7$^{e}$ | 3.3$^{bc}$ | 3.6$^{b}$ | 3.8$^{a}$ | 2.8$^{c}$ | 2.8$^{c}$ | 3.0$^{d}$ |
| *Vernonia amygdalina* | 2.8$^{c}$ | 2.7$^{d}$ | 3.9$^{a}$ | 3.0$^{c}$ | 3.7$^{a}$ | 3.9$^{a}$ | 3.4$^{a}$ |
| SEM | 1.0 | 1.0 | 0.8 | 0.7 | 0.8 | 1 | 0.02 |
| **Low land** | | | | | | | |
| *Acacia seyal* | 2.3$^{e}$ | 1.8$^{f}$ | 1.5$^{ef}$ | 2.3$^{e}$ | 2.9$^{c}$ | 2.7$^{d}$ | 2.2$^{f}$ |
| *Albizia malacophylla* | 2.1$^{f}$ | 3.9$^{a}$ | 1.7$^{e}$ | 2.6$^{d}$ | 2.1$^{f}$ | 3.4$^{b}$ | 2.6$^{d}$ |
| *Cordia africana* | 2.7$^{d}$ | 2.8$^{c}$ | 2.9$^{c}$ | 3.9$^{a}$ | 3.9$^{a}$ | 1.2$^{f}$ | 2.9$^{c}$ |
| *Ficus sycomorus* | 3.9$^{a}$ | 2.3$^{d}$ | 1.2$^{f}$ | 2.2$^{ef}$ | 3.1$^{b}$ | 3.1$^{c}$ | 2.6$^{d}$ |
| *Lonchocarpus laxiflorus* | 2.5$^{de}$ | 2.0$^{e}$ | 2.7$^{c}$ | 2.0$^{f}$ | 2.1$^{e}$ | 3.8$^{a}$ | 2.5$^{e}$ |
| *Piliostigma thonningii* | 3.8$^{a}$ | 3.8$^{a}$ | 3.9$^{a}$ | 2.9$^{c}$ | 3.0$^{bc}$ | 3.9$^{a}$ | 3.6$^{a}$ |
| *Pterocarpus lucens* | 3.5$^{b}$ | 3.3$^{b}$ | 3.3$^{b}$ | 3.6$^{b}$ | 3.9$^{a}$ | 1.9$^{e}$ | 3.3$^{b}$ |
| *Steteospermum kanthianum* | 3.1$^{c}$ | 3.8$^{a}$ | 2.3$^{d}$ | 2.1$^{f}$ | 2.5$^{d}$ | 3.3$^{bc}$ | 2.8$^{c}$ |
| SEM | 0.03 | 0.03 | 0.04 | 0.03 | 0.02 | 0.04 | 0.01 |

$^{a, b, c, d}$ = Means in a column and within agro-ecology with different superscripts are significant at P < 0.05; SEM = standard error of mean

Notes: The number of farmers scoring each species on each criterion was 30. Rating of 1 = poor, 2= moderate 3= good, and 4= very good

According to the farmers scoring, *F. thonningii* and *E. abyssinica* were given the highest (P < 0.05) mean score for biomass yield in the highland, whereas in the lowland agro-ecology, *A. malacophylla*, *P. thonninigii* and *S. kanthianum* scored higher and were different (P < 0.05) from the other MPBs. In both agro-ecologies, *A. seyal* was scored lowest by the respondent farmers for its biomass yield as compared to other MPB species (Table 3).

Regarding the feed value of the browse species, respondent farmers indicated that *V. amygdalina* followed by *V. nobilis* and *F. thonninigii* were highly preferred, scored and were significantly different (P < 0.05) from the rest of MPBs for their feed value in the highland. In the lowland, *P. thonninigii* followed by *P. lucens* were the most preferred and scored highest (P < 0.05) MPBs for their feed value. Majority (93.3%) of the farmers gave the highest (scored 4) preference rate for *P. thonninigii* for its feed value. MPBs with lowest preference for feed value were *A. dimidiata* and *A. gummifera* in the highland and *A.seyal*, *A. malacophylla* and *F. sycomorus* in the lowland.

According to the preference score of the farmers in the highland, for their multiple functions, *A. gummifera* and *V. nobilis* followed by *A. dimidiate* had the highest (P < 0.05) mean score, while *F. thonningii* and *A. seyal* had the lowest score. In the lowland, *C. africana* had the highest score followed by *P. lucens* for their multi-functionality, whereas *L. laxiflorus* and *S. kanthianum* were given the lowest mean score.

*F. thonningii* and *V. amygdalina* were given the highest mean (P < 0.05) score for fast growth rate during establishment and re-growth potential after pruning from the rest of the MPBs in the highland agro-ecology. In the lowland, farmers gave higher (P < 0.05) score for *C. africana* and *P. lucens* followed by *F. syncromos* than the other multipurpose browse trees. *A. dimidiate* and *E. abyssinica* in the highland and *A. malacophylla* in the lowland were the lowest scored browse species by the respondent farmers in their growth and re-growth ability (Table 3).

Among the most preferred browse species in the highland, *A. gummifera*, *F. thonninigii* and *V. amygdalina* had the highest mean score and were different (P < 0.05) from the rest of the preferred

MPB species for their palatability. In the lowland, *L. laxiflorus* and *P. thonninigii* followed by *A. malacophylla* had higher ($P < 0.05$) mean score compared to the rest of the MPB species for their palatability. Respondent farmers gave to *A. seyal* and *C. africana* the lowest mean score in animal preference in the highland and lowland agro-ecologies, respectively.

Generally, the overall mean score value indicates that *V. amygdalina* and *P. thonninigii* had higher ($P < 0.05$) mean score compared to the rest of the browse species in the highland and lowland agro-ecologies, respectively. Whereas *A. seyal* has lower ($P < 0.05$) mean score in all evaluation criteria compared to other MPB species in both agro-ecologies.

**Chemical composition of the selected browse species**

Chemical composition and IVDMD of the browse species in the highland and lowlands of north western Ethiopia are presented in Table 4. The crude protein (CP) contents of MPB species for the highland and lowlands ranged from 145 to 319 g/kg DM and from 144 to 193 g/kg DM, respectively. In the highland, the highest CP content was recorded for *V. amygdalina* followed by *E. abyssinica* and the lowest was recorded in *A. dimidiate* which had similar value with *A. gummifera*. In the lowland, *A. malacophylla* had the highest CP content followed by *P. thonningii.*

The NDF and ADF content of MPBs ranged from 226 to 497.5 and from 185 to 282 g/kg DM in that order for the highland. In the lowland, the NDF content varied from 383 to 539.8 g/kg DM and the ADF content from 235 to 384 g/kg DM. *A. gummifera* has the highest and *V. amygdalina* has the lowest in both NDF and ADF contents in the highland agro-ecology. Whereas, *A. malacophylla* and *C. africana* had the highest NDF and ADF content in the lowland, respectively.

In the highland, the acid detergent lignin (ADL) content of MPB species ranged between 48 and 123 g/kg DM. *R. urcelliformis* contained the lowest, whereas *A. gummifera* had the highest ADL content. The ADL content of MPB species in the lowland varied from 73 to 137 g/kg DM. The lowest ADL content was found in *P. lucens* and the highest was in *C. africana*.

**Table 4. Chemical composition and *in vitro* dry matter digestibility of the leaves of major browse species by agro-ecology in northwestern Ethiopia.**

| Species/Agro-ecology | Chemical composition (g/kg for DM and g/kg DM for others) | | | | | | |
|---|---|---|---|---|---|---|---|
| | DM | Ash | CP | NDF | ADF | ADL | IVDMD |
| **Highland** | | | | | | | |
| *Acacia seyal* | 928$^{ab}$ | 97$^{d}$ | 184$^{cd}$ | 356$^{bc}$ | 187$^{d}$ | 54$^{d}$ | 557$^{de}$ |
| *Albizia gummifera* | 931$^{a}$ | 124$^{c}$ | 174$^{de}$ | 498$^{a}$ | 282$^{a}$ | 123$^{a}$ | 486$^{f}$ |
| *Apodytes dimidiata* | 920$^{abc}$ | 153$^{b}$ | 145$^{e}$ | 364$^{bc}$ | 195$^{d}$ | 78$^{b}$ | 571$^{de}$ |
| *Erythrina abyssinica* | 928$^{ab}$ | 176$^{a}$ | 254$^{b}$ | 375$^{b}$ | 254$^{b}$ | 60$^{cd}$ | 586$^{cd}$ |
| *Ficus thonningii* | 901$^{d}$ | 143$^{b}$ | 185$^{cd}$ | 329$^{c}$ | 235$^{bc}$ | 69$^{bc}$ | 545$^{e}$ |
| *Rothmannia urcelliformis* | 918$^{bc}$ | 122$^{c}$ | 200$^{cd}$ | 270$^{d}$ | 205$^{d}$ | 48$^{d}$ | 695$^{a}$ |
| *Vepris nobilis* | 924$^{abc}$ | 155$^{b}$ | 212$^{c}$ | 380$^{b}$ | 231$^{c}$ | 76$^{b}$ | 626$^{b}$ |
| *Vernonia amygdalina* | 913$^{d}$ | 173$^{a}$ | 319$^{a}$ | 226$^{e}$ | 185$^{d}$ | 65$^{bc}$ | 620$^{bc}$ |
| Mean ±SEM | 921±0. 2 | 142±0. 5 | 208±1 | 352±1. 6 | 220±0. 7 | 72±0.4 | 583±1.3 |
| **Lowland** | | | | | | | |
| *Acacia seyal* | 968$^{a}$ | 253$^{a}$ | 154$^{b}$ | 473$^{bc}$ | 264$^{cd}$ | 99$^{cd}$ | 545$^{ab}$ |
| *Albizia malacophylla* | 922$^{cd}$ | 182$^{b}$ | 193$^{a}$ | 540$^{a}$ | 252$^{d}$ | 97$^{cd}$ | 435$^{c}$ |
| *Cordia africana* | 909$^{d}$ | 116$^{c}$ | 159$^{b}$ | 480$^{bc}$ | 384$^{a}$ | 137$^{a}$ | 442$^{c}$ |
| *Ficus sycomorus* | 915$^{cd}$ | 111$^{c}$ | 162$^{b}$ | 412$^{d}$ | 293$^{c}$ | 85$^{cd}$ | 532$^{b}$ |
| *Lonchocarpus laxiflorus* | 944$^{b}$ | 185$^{b}$ | 162$^{b}$ | 511$^{ab}$ | 356$^{ab}$ | 100$^{cd}$ | 556$^{ab}$ |
| *Piliostigma thonningii* | 903$^{d}$ | 99.6$^{c}$ | 177$^{ab}$ | 456$^{bc}$ | 266$^{cd}$ | 108$^{bc}$ | 553$^{ab}$ |
| *Pterocarpus lucens* | 959$^{a}$ | 189$^{b}$ | 162$^{b}$ | 383$^{d}$ | 235$^{d}$ | 73$^{d}$ | 577$^{ab}$ |
| *Steteospermum kanthianum* | 925$^{c}$ | 209$^{b}$ | 144$^{b}$ | 466$^{c}$ | 344$^{b}$ | 92$^{cd}$ | 590$^{a}$ |
| Mean ±SEM | 931±0.5 | 168±1.1 | 164±0.4 | 465±1.1 | 299±1.1 | 101±0.5 | 529±1.2 |

$^{a, b, c, d}$= means within a column not bearing a common superscript differ significantly within agro-ecology; DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin; IVDMD = *in vitro* DM digestibility; SEM= standard error of mean

The IVDMD of MPB species in the highland ranged between 486 and 692 g/kg DM. *R. urcelliformis* had the highest IVDMD, whereas *A. gummifera* had the lowest in IVDMD. In the lowland, the IVDMD of MPB species ranged from 435 to 590.2 g/kg DM. The lowest IVDMD was found in *A. malacophylla* and *C. africana*.

**Correlation analysis**

The results of correlation analysis between chemical composition and IVDMD with farmers' feed value score are presented in Table 5.

**Table 5. Correlations of farmers' feed value score with laboratory indicators of nutritive value by agro-ecology.**

| Agro-ecology | Laboratory parameters | | | | |
|---|---|---|---|---|---|
| | CP | NDF | ADF | ADL | IVDMD |
| Highland | 0.83* | -0.57 | -0.41 | -0.41 | 0.74* |
| Lowland | 0.22 | -0.19 | 0.02 | 0.36 | 0.36 |

CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin; IVDMD = in vitro DM digestibility; * Significant at $P < 0.05$.

In the highland, the CP content and IVDMD of MPBs were positively correlated ($P < 0.05$) with farmers' feed value score. As farmers' scoring for feed value increases, there was an increasing trend in CP content and IVDMD of MPBs. In the lowland, the laboratory indicators (the CP content and IVDMD) were positively correlated but not significant ($P > 0.05$) with the farmers' assessment of feed value score.

**Complementarities between indigenous knowledge and laboratory assessment**

Farmers' feed value score and their corresponding nutrient composition values of both agro-ecologies of the MPBs are presented in Figure 1 and 2. In the highland, except *A. gummifera* and *E. abyssinica*, farmers were able to differentiate effectively MPBs that had high and low protein content using their indigenous knowledge of feed value (Figure 2). However, this trend was not consistent in the lowland. Farmers were not able to differentiate the MPB species that had high and low crude protein content using their indigenous knowledge, except *P. thonningii*. As it is shown in Figure 2, the association of farmers' ranking with CP of MPB species was unable to discriminate individual MPB species and did not support the complementarities of the two knowledge systems.

## DISCUSSION

**Farmers' preference criteria, rank and scoring of multipurpose browse species**

In this study, farmers prefer and evaluate indigenous MPB species using plant characteristics, feed value

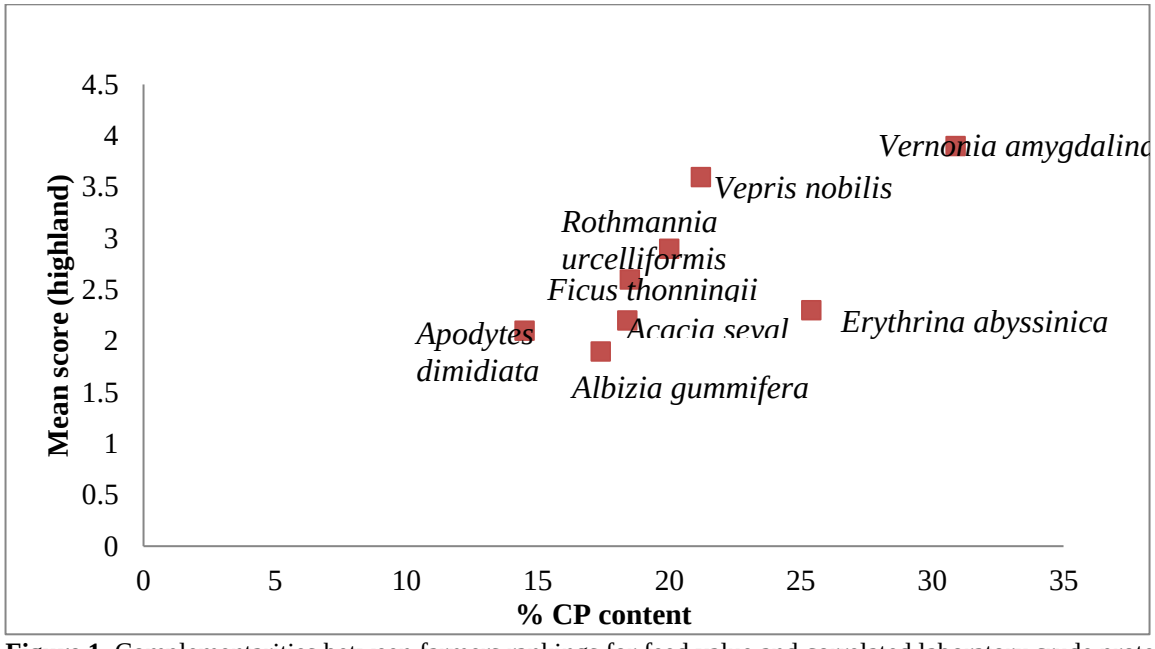


**Figure 1.** Complementarities between farmers rankings for feed value and correlated laboratory crude protein contents of multipurpose browse species in the highlands of northwestern Ethiopia.

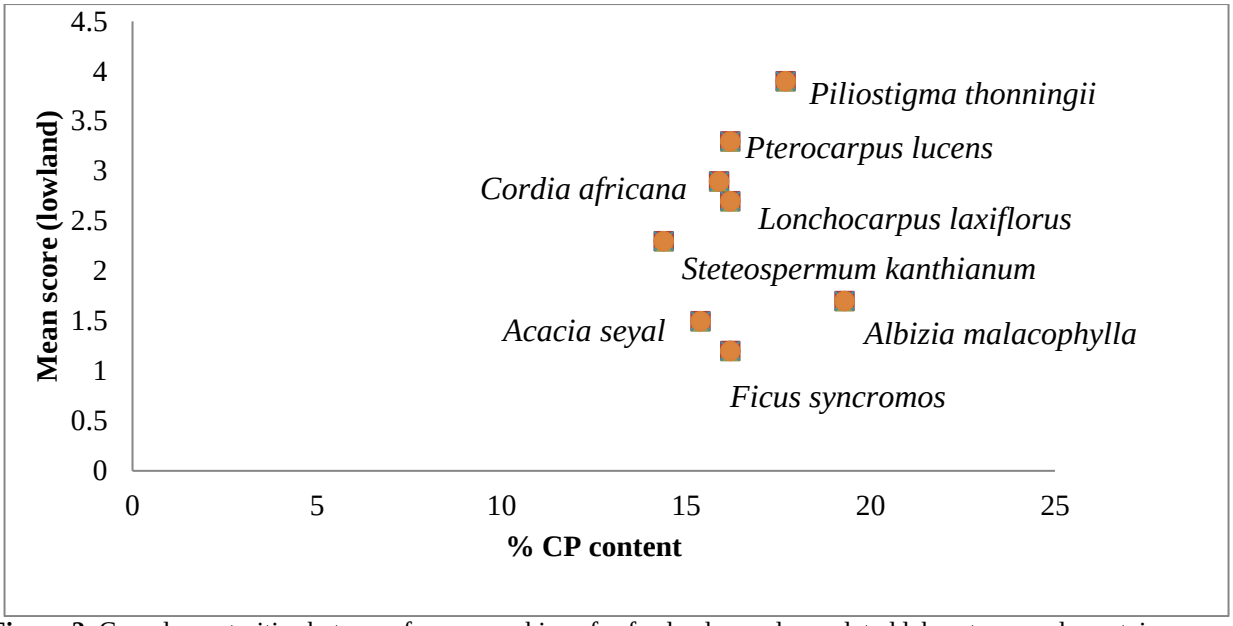


**Figure 2.** Complementarities between farmers rankings for feed value and correlated laboratory crude protein contents of multipurpose browse species in the lowlands of northwestern Ethiopia

and their multiple uses, which suggest farmers' preference criteria for MPB species are complex (Abebe *et al.,* 2008). Similar with this study, Sunita (2012) reported that fodder trees were ranked based on palatability, propagation easiness, growth rate and competition with agricultural crops. The evaluation of browse species by local farmers based on different decisive factors are supported by other studies (Rusten and Gold, 1991; Thapa *et al.,* 1997; Thorne *et al.,* 1999; Roothhaert and Franzel, 2001; Evelyne, 2007) who indicated that farmers evaluate browse species based on their palatability and foraging value (improves intake, performance and health of animals).

In both agro-ecologies, availability during the dry season and the ability of the browse species to satisfy the nutrient requirement of animals at different physiological state (feed value) were the first ranked criteria used by farmers for evaluating the MPB species. This could indicate feed shortage in terms of quantity is the main limiting factor in livestock production in the study area. Moreover, the high importance given to the feed function of the browse species as a major preference criterion suggests prevalence of feed shortage with regard to quality in both study agro-ecologies. Alemayhu (2006) reported that feed shortage is more aggravated during the dry season in both highlands and lowlands of the country. Similarly, Upreti and Devkota (2017) and Begashaw (2018) reported that farmers prefer and select important fodder trees based on availability during the dry season in Nepal and in Alicho-wriro District, Siltie Zone, respectively. In the highland farmers ranked third for biomass yield followed by palatability, whereas in the lowland the ranking is the vice versa. This might be due to the higher abundance of the available browse species in the lowland than the highland. In general, the importance of the browse species is highly dependent on their availability. Farmers in the study area reported that there are browse species having good quality according to their perception, but those species are rarely available. The reasons for scarcity of those species, as mentioned by the respondents and group discussants, were over browsing, grazing during the dry season, lopping and deforestation. During the interview and field observation we realized that the abundance of a single browse species was relatively higher in lowland than the highland. This might be due to the shrinkage of communal grazing lands in the highland due to high population growth and more land is demanded for crop production and deforestation.

In the highland, farmers' criteria rated *A. gummifera* as the most preferred multipurpose browse species. Azene (2007) reported that this specie has multiple uses including firewood, timber (general purpose), utensils (mortars, water troughs), medicine (roots, bark), fodder (leaves), bee forage, shade, ornament, nitrogen fixation and soil conservation. Also, a high farmer preference for *V. amygdalina* was shown for their feed value, growth and re-growth ability and palatability. This is a multipurpose rapid regenerating tree (Swee *et al.,* 2010) reported with high (24.4%) CP content (Ayenalem and Taye, 2008) which could serve as protein supplement to pasture grazing animals. A higher score was given to *F. thonningii* on biomass yield and growth and re-growth ability probably due to its fast growth rates, easy propagation

and ever greenness (Mulubrhan *et al.*, 2011). This was in agreement with the studies of Abebe *et al.* (2008) who also reported *F. thonningii* preferred by farmers in the highlands of Ethiopia for the same traits. Moreover, this specie has been reported as palatable to all species of livestock and with high biomass yield Mulubrhan *et al.* (2011).

While majority of the farmers reported *P. thonningii* as a highly preferred browse species for feed value and palatability in lowland, *F. syncromos* and *A. malacophylla* were superior for availability and biomass yield, respectively, which can be in part explained because *F. syncromos* is among the dominant browse tree in this area. On the other hand, *A. malacophylla* and *C. africana* were rated first in their multi-functionality. Both are used by local people for timber production and other construction materials and provide an opportunity to enhance household incomes. This was in agreement with the reports of Abebe *et al.* (2008) and Azene (2007) concerning the multiple uses of *C. africana* in different parts of Ethiopia. The lowest score given to *A. malacophylla* for growth and re-growth ability might be due to low availability of this browse tree in the lowland. In both agro-ecologies, *A. seyal* was rated poorly on any of the six criteria, probably due to their presence of thorns. In contrast Abebe *et al.* (2008) reported that farmers rated highest for *A. seyal* in its availability and feed value in the highlands of Ethiopia. However, the farmers' evaluation technique for a particular tree attribute was consistent regardless of the difference in agro-ecology of the two locations.

**Laboratory evaluation of the browse species**

The CP values of the browse species analyzed were within the ranges of several reports in Ethiopia (Ahmed *et al.*, 2017; Kibrom, 2016; Kassahun *et al.*, 2016). All the browse species have a CP concentration above the threshold CP content (11-12%) required for moderate level of ruminant production (ARC, 1980). Therefore, they could serve as potential protein supplements to enhance the intake and utilization of crop residues in ruminant diets. This shows that there are in fact possibilities of improving feed resource base from local resources available in both agro-ecologies which were preferred by farmers for their multiple uses. This finding is consistent with the reports of Abebe *et al.* (2008) in the highlands of Ethiopia. Regarding NDF content, *except A. malacophylla* and *L. laxiflorus* in the lowland, all have < 55%, the level reported by Van Soest and Robertson (1985) as limiting appetite and digestibility. On the other hand, all the browse species in both agro-`ecologies had ADF content < 40% which are believed to have high quality feed (Kellems and Church, 1998). Also, except *A. gummifera* and *C. africana* in highland and lowland, respectively, the ADL content was < 10% the limit to affect feed intake (Reed *et al.*, 1986). Nevertheless, chemical composition alone is an inadequate indicator of nutritive value since the availability of nutrients from browse species is variable and their digestibility could also be affected due to anti-nutritional factors (Norton, 1994). Hence, additional information on the secondary plant compounds along with animal performance trials of these MPBs is needed if a comprehensive assessment of their nutritive value is to be made.

**Relationship between farmers' feed value score and laboratory assessment**

The correlation analysis between farmers' feed value score and laboratory results (CP content and IVDMD) of MPB species in the highland showed strong association between farmers' indigenous knowledge on feed value and laboratory results. In particular, farmers were capable of differentiating MPB species that had high CP content and were able to select high quality fodder for supplementing their livestock through their indigenous knowledge. This is in agreement with the study by Thorne *et al.* (1999) and Sunita (2012) in Nepal and Abebe *et al.* (2008) in Ethiopia, who reported significant complementarities between farmers' assessment of feed value and laboratory results. However, in the lowland no significant correlation was found, probably because the study area has been mainly devoted to crop production and had less observable experience on the effects of the browse species in the performance of animals. Previous studies have shown variable correlation between farmers' knowledge and laboratory assessments (Thapa *et al.*, 1997). In the highland, even though the relationship was not significant, NDF, ADF and ADL content and farmers' feed value score were negatively correlated. This indicates that the farmers' indigenous knowledge to differentiate the browse species that had high and low fiber content confirmed the complementarities of the two knowledge systems. However, in the lowland, except NDF content, the farmers feed value score and ADF and ADL content of the browse species did not show a trend, which could confirm the complementarities of the two knowledge systems. This finding is consistent with the study of Abebe *et al.* (2008) who reported similar results in Sidama and Lay Armachiho district, Ethiopia.

## CONCLUSION

The result indicated that farmers used multiple criteria for evaluating browse species and there is no one single species that has all the preferred characteristics. Among the evaluating criteria, they gave more emphasis for availability of the browse

species and their feed value. In the highland, there was an association between farmers' preference score for feed value with crude protein and *in vitro* digestibility of the browse species and in the lowland not. Most importantly, the comparative advantage and the farmers' priority of the MPBs among their multiple uses should be investigated since the future development and efficient utilization of these browse species would rely up on the local peoples' farming objective. The latter, is vital to efficiently utilize indigenous multipurpose browse species and to tackle feed shortage in the study area.

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**Compliance with ethical standards.** The authors confirm that the research was carried out and managed in accordance with ethical standards.

**Data availability.** Data are available with the corresponding author (almazayenew@yahoo.com) upon reasonable request.

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