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Research Article

Biomass Yield and Chemical Composition of the Indigenous Browse Species in Gozamen District, Northwestern Ethiopia

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In many regions of Ethiopia, particularly in the study area, high-quality livestock feed is scarce, particularly during the dry season. Indigenous browse species could potentially offer alternative sources of feed, but their potential has not been fully exploited, owing to a lack of detailed information. Without detailed information on the nutritional value of indigenous browse species, it is difficult to assess their suitability as feed sources. This knowledge gap indicates that even if these plants are abundant, they may not be used effectively because their nutritional benefits are not well understood. The objective of the present study was to fill this gap by systematically evaluating the biomass yield and nutritional content of indigenous browse species. The mean biomass yields for various indigenous browse species varied significantly ($p < 0.05$) among species, with *Ficus thonningii* producing the highest, whereas the biomass yields of *Vernonia amygdalina* were the lowest. *Arundinaria* species exhibited the highest NDF content (68.5%), whereas *V. amygdalina* had the lowest NDF content (46.8%). The crude protein content varied significantly ($p < 0.05$) among the species, with *Acacia albida* having the highest (20.3%), whereas the crude protein content of *Carissa edulis* was the lowest (13.3%). Hence, the crude protein content of all indigenous browse species is sufficient to meet the maintenance needs of cattle, sheep, and goats because, as stated by Kearl and NRC, the crude protein levels required for maintenance in these animals range from 7% to 10%. The crude protein content of indigenous browse species is sufficient to meet the milk production requirements of sheep and goats because the crude protein levels required for milk production for these animals range from 12% to 16%. For lactating dairy cows and growing beef cattle, Kearl recommended CP values of 14%–18% and 12%–16% required, respectively. Therefore, indigenous livestock producers should incorporate these species into their production systems to enhance productivity. This approach can also help mitigate the high costs associated with concentrate feeds, which are typically expensive.

Keywords: biomass; browse species; nutritional composition; species composition

1. Introduction

Ethiopia holds the distinction of having the largest livestock population in Africa, leading the continent in terms of the number of livestock [1]. Although Ethiopia has the largest livestock population, the livestock industry remains underutilized owing to challenges such as insufficient feed, low genetic potential of indigenous animals, limited knowledge of husbandry practices, and high prevalence of diseases [2, 3]. Among these, a common and leading constraint is the lack of sufficient quality feed for sustainable livestock production in Ethiopia [4, 5]. Due to the scarcity of feed and poor nutrition, particularly during the dry season, livestock in the area lose their body condition, have low productivity, and have slow growth rates [6].

In Ethiopia, particularly in dry lowland areas, native or indigenous browsing and fodder tree species play crucial roles as sources of animal feed [7, 8]. These species are often well-adapted to harsh environmental conditions, where other types of vegetation may not thrive. The significance of these indigenous species in the diet of livestock is heightened by the scarcity of other feed resources, particularly during dry seasons when pasture availability is minimal [9]. They provide essential nutrients such as proteins and minerals, which are often lacking in other feed types. Nutritional support is vital for maintaining livestock productivity [7].

However, the production and nutritional composition of native browsing plant species are affected by continuing cropland expansion, charcoal production, the introduction of noxious weeds, climate change, deforestation, and soil erosion [10, 11]. Therefore, the weed removal, the introduction of improved fodder trees, and enclosing are required to increase the production and nutrient content of indigenous browse species [12].

In the Gozamen District of northwestern Ethiopia, livestock production plays a critical role in the livelihoods of rural communities, contributing significantly to food security, income generation, and cultural practices [13]. However, livestock productivity in this region is often constrained by inadequate and poor-quality feed resources [14], particularly during the dry season when the availability of conventional forage is limited. Indigenous browse species, which are naturally adapted to the local environment, represent potentially valuable but underutilized feed resources. These species can provide essential nutrients and biomass, especially during periods when other feed resources are scarce [7].

Despite their potential, there is limited scientific information on the biomass yield and chemical composition of these indigenous browse species in Gozamen District. More studies have been conducted on the biomass yield and nutritional composition of natural pastures [14], crop residues [15], Ethiopia's lowland arid and semiarid regions [16–20], and lowland to midland [21]. However, biomass production and nutrient composition of native woody and browsing species have not yet been investigated. The lack of data on the nutritional value and yield potential of indigenous browse species hinders their effective utilization in sustainable livestock feeding strategies. Consequently, local farmers often overlook these resources, relying instead on less sustainable or more expensive feed options, which exacerbates feed shortages and negatively affects livestock productivity. This problem is further compounded by a lack of understanding of how environmental factors, such as soil type, altitude, and climatic conditions, influence the productivity and nutritional quality of these browse species. Without this knowledge, it is challenging to develop management practices that optimize the use of indigenous browse species, ensuring their sustainable exploitation while maintaining the ecological balance of the region.

Therefore, there is a critical need to investigate the biomass yield and chemical composition of indigenous browse species in Gozamen District. Such research will provide the necessary data to evaluate their potential as reliable and sustainable feed resources, contributing to improved livestock production, better resource management, and enhanced food security in the region.

2. Materials and Methods

2.1. Description of the Study Area. The study was conducted in the Gozamen District, East Gojjam Zone, and northwestern highlands of Ethiopia. The zone is located between latitudes of 100°1 46‴ and 100°35′ 12″ N and longitudes of 370°23′ 45″ and 370°55′ 52‴ E. The district is located between 1200 m and 3510 m above sea level. The district receives an average of 1628 mm of rain each year, with up to 6 months of rainfall during the rainy season. The highest and lowest average temperatures were 25°C and 11°C, respectively. The district's farmers mostly practice agriculture, which is characterized by mixed crop–livestock production systems. The district is used to produce sheep, goats, cattle, and pack animals, including donkeys, horses, mules, chickens, and bees.

2.2. Sampling Procedures and Sample Size. The selection of research sites was guided by existing information about the study area. These preliminary data provide insights into the locations of indigenous browse species that might be found. To refine site selection, discussions were held with livestock officials and community elders. Their local knowledge and experience were valuable in identifying the most relevant areas where browse species were abundant. This consultation process ensured that the chosen research sites were representative of the area's browse species and aligned with the local understanding and management practices. At each selected site, two 100×100 m sampling blocks were demarcated. This large-scale sampling approach ensured that the collected vegetation samples were representative of the site's overall vegetation, capturing a broad view of the browse species present. Each 100×100 m sampling block was further divided into smaller units of 10×10 m plots [22]. This subdivision allows for a more detailed analysis of each block. By breaking down the large blocks into smaller plots, this study aimed to capture the variability in species composition and other ecological factors at a finer scale. Therefore, 36 (10×10 m) transects were selected to assess the species composition, height (measured using a tape meter), density (counted from each transect), biomass production, and nutrient content.

2.3. Identification of Browse Plant Species. The identification of plant species is crucial for managing rangeland or pasture land because it is used to assess the condition of pasture land and species composition, which affects dietary quality [23]. To facilitate identification, samples were collected and identified from August to October, when the plants were in the vegetative stages. The indigenous browse species in each transect were identified in the field, and those that were difficult to identify were transported to the national herbarium.

2.4. Plant Species Composition. In the study area, a plant species was identified with the aid of manuals by comparison with previously identified plants or specimens. The identified species and their relevant plant parts were collected and mounted in a press, coded, identified, and compared to the herbarium. In the study area, 26 species were grouped into 19 families, and all 26 species were classified as palatable or nonpalatable.

2.5. Estimation of Biomass Yield. The biomass yields of palatable browse trees and shrubs were determined using the following procedure: trunk diameter was measured at a height of 30 cm for shrubs and 120 cm for trees using a measuring tape meter. The leaf yield per year was determined using the algometric equation developed by Petmak as follows:

$$\begin{aligned} \mathbf{logw} &= \mathbf{2.24logDT - 1.50}\,(\text{Leaf yield of trees}),\\ \mathbf{Logw} &= \mathbf{2.62logDS - 2.45}\,(\text{Leaf yield of shrubs}),\\ \frac{\mathbf{DT}}{\mathrm{DS}} &= \mathbf{0.6360C}, \end{aligned} \tag{1}$$

where(i) **DT** is the trunk diameter (cm) at 120 cm above the ground, (ii) **DS** is the steam diameter (cm) at 30 cm above the ground, (iii) **C** is the circumference, and (iv) **w** is the leaf yield in kilograms.

2.6. Chemical Analysis of Indigenous Browse Species. To determine the nutrient composition of the indigenous browse species, samples were collected from the leaves of indigenous browse species. The major browse species in the study area were identified and prioritized by farmers based on their abundance and preference for livestock. Among the 26 identified species, the top 10 were selected for chemical analysis based on priority by farmers. Leaves of these species were collected from four randomly selected trees of each species, and a composite sample was prepared. The samples were weighed using an electronically sensitive balance before being placed in a paper bag with the appropriate label. The samples were ground in a Wiley mill to pass through a 1-mm sieve screen after being dried in an oven at 65°C for 72 h. The samples were delivered to the Agricultural Research Center for Nutritional Analysis. DM, ash, and CP content were determined from the feed samples using the AOAC method [24]. The method of Ref. [24] was used to analyze neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL).

2.7. Data Analysis. The data were analyzed using the general linear model procedure of SPSS (version 25). Significant differences between means were compared using the least significant difference (LSD). The following model was used for analysis:

$$Y_{ij} = \mu + A_i + E_{ij}, \tag{2}$$

where μ is the overall mean, Y_{ij} is the biomass yield of leaf, $A_i$is the type of browse species, and $E_{ij}$is the random error.

3. Results

3.1. Composition of Indigenous Browse Species. A comprehensive survey identified 26 indigenous browsing species in the study area. Of the total species, *A. albida* was identified as the most abundant species in the study area, followed by *Carissa spinarum*. In contrast, *Rumex nervosa* was the least abundant species in this study. The study also recorded a lower number of woody species (26) compared to other regions: 52 woody plants in the southern Gonder zone in northeast Ethiopia [25], 5 woody plants in Wonjeta St. Michael Church forest in northwestern Ethiopia [26], 32 woody plants in the moist mid-highlands of southern Ethiopia [27], and 44 woody plants in Chencha, Gamo Gofa, Ethiopia [28]. Of the 26 indigenous woody species identified, nonpalatable species were the most abundant, constituting 43.3% of the species, followed by less-palatable species (30.8%) and palatable species (26.9%) (Table 1).

3.2. Distribution of Height Class and Woody Species Density. This study identified five height classes for browsing plant species in the area: < 1, 1–2, 2–3, 3–4, and > 4 m (Table 2). The dominant plants were located within the 1- to 2-m height strata, which aligns with the browsing height preferred by the animals. This suggests that the height of the browsing plants significantly influences the area's attractiveness to browsing animals. In contrast, the least dominant plants were found in the 3- to 4-m height strata, which are inaccessible to browsing animals.

The mean height of woody species in the study area was 2.39 m, which is higher than the mean height of 1.4 m reported for woody species in the central highland regions of Vietnam [29]. The average density of woody species in the current study was 11,600 ha^{-1}. This is notably higher than densities reported in various other regions: 2622 ha^{-1} in the semiarid dry plains of Borana [30], 7950 ha^{-1} in natural forests [31], 5480 ha^{-1} in the semiarid rangeland of southern Ethiopia [29], 740 ha^{-1} in the central highland of Vietnam [29], and 311 ha^{-1} in the Wof Washa highland of Ethiopia [32].

3.3. Indigenous Browse Species Biomass Production. The biomass yields of the selected indigenous browse species are presented in Table 3. The dry matter yield of *Ficus thonningii* was the highest among the studied species. This was followed by *F. sur*, which had the highest biomass yield. In contrast, the *R. nervous* system had the lowest biomass yield. In terms of statistical significance, the biomass yield of *F. thonningii* was significantly higher ($p < 0.05$) than that of all other indigenous browse species listed in Table 3. *F. sur* also showed significantly greater biomass production ($p < 0.05$) compared to species such as *Acacia abyssinica*, *A. brevispica*, *C. edulis*, *R. nervous*, *Rosa abyssinica*, *Arundinaria* species, *A. albida*, *and V. amygdalina*. Conversely, the biomass production of *Arundinaria* species, *A. brevispica*, *C. edulis*, *R. nervous*, and *Ro. abyssinica* was significantly lower ($p < 0.05$) than that of *A. abyssinica*, *A. albida*, and *V. amygdalina*.

Comparative analysis of biomass yields revealed that the biomass yield of *F. thonningii* in this study was less than the 62.14 kg/plant reported in the Lalo Kile District of Kellem Wollega Zone, western Ethiopia [33]. Similarly, the biomass yield of *V. amygdalina* was lower than the 9.8 kg/plant reported for the same species in the same region [33], although it was higher than yields reported in Sidama, Ethiopia

Table 1: The species composition (%) of indigenous browse species in the study areas.

Family name	Scientific name (local name)	Palatability	Composition (%)
Fabaceae	*Acacia abyssinica* (Tikur girar)	Hp	6.00
Fabaceae	*Acacia lahail* (Girar)	HP	9.27
Fabaceae	*Acacia brevispica* (Cheba)	HP	1.44
Fabaceae	*Acacia albida* (Cheba)	HP	23.03
Acanthaceae	*Acanthus pubescens* (Koshahila)	NP	0.35
Poaceae	*Arundinaria species* (Kerkeha)	LP	3.50
Apocynaceae	*Carissa edulis* (Agam)	LP	1.20
Apocynaceae	*Carissa spinarum* (Agam)	LP	11.13
Rutaceae	*Clausena anisata* (Limich)	NB	0.56
Combretaceae	*Combretum molle* (Abalo)	NP	1.60
Boraginaceae	*Cordia africana* (Wanza)	LP	3.27
Euphorbiaceae	*Croten macrotachys* (Bisana)	NP	10.70
Cucurbitaceae	*Cucumis prophetarum* L. (Embuay)	NP	1.00
Ebenaceae	*Euclea racemosa murr.* (Dedeho)	NP	4.47
Moraceae	*Ficus species* (Warka)	NP	3.40
Moraceae	*Ficus sur* (Shola)	LP	0.37
Moraceae	*Ficus thonningii* (Chibeha)	HP	6.00
Celastraceae	*Maytenus species* (Atat)	LP	7.90
Arecaceae	*Phoenix reclinata* (Zenbaba)	NP	1.77
Oleaceae	*Olea Africa* (Weyra)	NP	0.18
Santalaceae	*Osyris quadripartita Dec.* (Keret)	LP	0.67
Rosaceae	*Rosa abyssinica* (Kega)	HP	0.18
Polygonaceae	*Rumex nervous* (Embuacho)	LP	0.16
Malvaceae	*Sida ovata Forssk.* (Chifirg)	NP	0.18
Asteraceae	*Vernonia amygdalina Del.* (Girawa)	HP	2.00
Asteraceae	*Veronina auriculifera Hiern.* (Gengerita)	NP	0.33
Total			100

Abbreviations: HP = highly palatable, LP = less palatable, and NP = nonpalatable.

Table 2: The percentage of heights class distribution and density of browse species.

	Height (m)	Height composition (%)
Vegetation attributes	0-1	18.73
	1-2	41.32
Class of browse species height	2-3	19.56
	3-4	7.16
	> 4	13.22
Average height (m)		2.39
Density of woody plants per hectare		11,600

Table 3: Average yield per plant of different browse species.

Scientific name	Local name	Biomass yield (kg/plant)	*p* value
Ficus thonningii	Chibeha	19.65 ± 0.22^{a}	
Ficus sur	Shola	12.60 ± 0.22^{b}	
Vernonia amygdalina Del.	Girawa	5.47 ± 0.22^{c}	
Acacia abyssinica	Tikur girar	3.77 ± 0.22^{d}	0.0001
Acacia albida	Cheba	2.78 ± 0.22^{d}	
Arundinaria species	Kerkeha	1.34 ± 0.22^{e}	
Rosa abyssinica	Kega	0.80 ± 0.22^{fe}	
Acacia brevispica	Cheba	0.19 ± 0.22^{e}	
Carissa edulis	Agam	0.18 ± 0.22^{f}	
Rumex nervous	Embuacho	0.16 ± 0.22^{f}	

Note: Means within the same column with different superscript letters differ significantly ($p < 0.05$) among species.

(1.3 kg/plant) [17], and Dhati Walal National Park, western Ethiopia (0.9 kg/plant) [34]. Additionally, the biomass yield of *F. sur* (12.6 kg/plant) was less than the 19.7 kg/plant reported in Lalo Kile District [33].

3.4. Nutritional Composition of Browse Species. Table 4 displays the nutritional composition of various browse species, including ash, crude protein (CP), NDF, ADF, and ADL. The overall average percentage of the nutritional composition of the native browse species was 8.0% ash, 16.4% CP, 56.7% NDF, 42.2% ADF, and 6.9% ADL. These values are comparable to those of potential browse species in the Guba Lafto District, north Wollo zone, which were 7.2% ash, 17.7% CP, 45.0% NDF, 34.1% ADF, and 8.2% ADL [35].

The protein content of native browsing species ranged from 13.3% (*C. edulis*) to 20.3% (*A. albida*). Crude protein was the highest in *A. albida*, while crude protein was the lowest in *C. edulis*. These values indicate a notable difference in the nutritional quality of these browsing species. The crude protein content of the native browse species exhibited significant variability ($p < 0.05$). Notably, *A. albida* had the highest crude protein levels among the species studied, significantly surpassing the protein contents of other indigenous browse species (Table 4). In contrast, the protein content of the various species (Table 4) was significantly lower ($p < 0.05$) than that of *A. abyssinica*. Additionally, *A. brevispica* demonstrated significantly higher crude protein levels ($P < 0.05$) than *V. amygdalina*, *Arundinaria species*, *F. sur*, *R. nervous*, *F. thonningii*, *R. abyssinica*, and *C. edulis*. Among these, *Arundinaria species*, *V. amygdalina*, *R. nervous*, and *F. thonningii* showed significantly higher protein contents compared to *Ro. abyssinica* and *C. edulis*.

The CP content of *A. brevispica* in this study was 17.6%, which is lower than the 19.8% reported previously [35]. For *C. edulis*, the CP content was higher, exceeding 9.9%, compared to the findings of [35]. The CP level of *F. thonningii* in this study was 15.0%, which is comparable to the 15.8% reported previously [36]. However, this was significantly lower than the 31.9% reported previously [37]. For *V. amygdalina*, the CP content was 16.2%, which is lower than the range of 23.4%–29.7% documented by [34, 37, 38]. Similarly, the CP content of *A. abyssinica* in this study was 18.4%, which is lower than the 24.4% reported previously [37].

At the study locations, all browse species examined had a CP content exceeding 7.2% [39], which is the minimum level required to meet the maintenance needs of ruminants [40]. For ruminant growth and lactation, a minimum CP requirement of 0.15 kg per kilogram of dry matter is necessary, while 0.07 kg per kilogram of dry matter is needed for proper rumen function [41].

The study revealed a significant difference ($p < 0.05$) in the ash content among the indigenous browsing species, which is consistent with the findings of Ref. [35]. Arundinaria species had significantly higher ash contents compared to other species such as *A. albida*, *A. abyssinica*, *F. sur*, *V. amygdalina*, *A. brevispica*, *R. nervous*, *F. thonningii*, *R. abyssinica*, *and C. edulis*. On the other hand, the ash contents of *F. sur*, *R. nervous*, and *C. edulis* were significantly higher than those of *V. amygdalina*, *A. brevispica*, *A. albida*, *F. thonningii*, and *R. abyssinica*. Specifically, *C. edulis* had an ash content of 7.8%, and *A. brevispica* had an ash content of 5.4%, which was lower than the 8.4% and 7.4% reported by Ref. [35] for these species. In addition, the ash contents of *F. thonningii*, *V. amygdalina*, and *A. abyssinica* in this study were lower than previously reported values of 14.8% (*F. thonningii*) [36, 37], 11.4% (*V. amygdalina*) [38], and 14.0% (*A. abyssinica*) [37].

The NDF content varied significantly among the indigenous browsing species. Arundinaria species had the highest NDF content (68.5%), followed by *R. abyssinica* (67.4%) and *R. nervous* (62.5%). Conversely, the lowest NDF levels were recorded for *A. albida* (47.8%) and *V. amygdalina* (46.8%). The NDF content for *A. brevispica* was 50.0%, and *C. edulis* had an NDF content of 51.8%. These values are similar to those reported by [13], where *A. brevispica* and *C. edulis* had NDF contents of 52.2% and 56.7%, respectively. In contrast, the NDF contents of *A. abyssinica* (55.3%), *V. amygdalina* (46.7%), and *F. thonningii* (54.4%) were higher than those previously reported for *A. abyssinica* (31.1%) [37], *V. amygdalina* (20.9%–45.9%), and *F. thonningii* (22.0%–44.7%) [36, 37].

The NDF content of native browsing species was lower than that of crop residues [15] and indigenous herbaceous species [14]. According to the classification system [42], roughage feeds are categorized based on NDF content into high, medium, and low quality, with thresholds of less than 45%, 45%–65%, and over 65% NDF, respectively. In this study, *Arundinaria* species and *R. abyssinica* were classified as low-quality feeds because their NDF content exceeded 65%. In contrast, *A. albida*, *A. abyssinica*, *A. brevispica*, *F. thonningii*, *F. sur*, *V. amygdalina*, *C. edulis*, and *R. nervous* fell into the medium-quality category.

This study revealed significant variability in the ADF content among different browse species. Arundinaria species exhibited the highest ADF content (58.1%), whereas *A. albida* had the lowest ADF content (31.3%). These findings align with the results reported in Ref. [35], where the ADF content in browse species ranged from 23.2% to 60.2% in the Guba Lafto District, north Wollo, Ethiopia. Furthermore, indigenous browsing species in northwest Ethiopia showed lower ADF contents than crop residues [15] and indigenous herbaceous species [14].

This study found that the concentration of ADL in indigenous browsing species varied between 5.22% and 9.89%. This range is lower than the 5.5%–11.0% reported [13]. Furthermore, the ADF and ADL levels in *F. thonningii*, *V. amygdalina*, and *A. abyssinica* differed from those reported in earlier studies in Refs. [34, 36, 38]. These variations in the lignin content highlight differences in the fiber composition of the browsing species studied.

4. Discussions

4.1. Composition of Indigenous Browse Species. The predominance of *A. albida* in the study area can be attributed to its adaptability to various environmental conditions such as

Table 4: Chemical composition (%) of different indigenous browse species in the study areas.

Browse species	Chemical composition of (%) different indigenous browse species						
	DM%	Ash%	OM%	CP%	NDF%	ADF%	ADL%
Arundinaria species	93[a]	18.99[a]	74.01[c]	15.33[d]	68.53[a]	58.06[a]	5.90[b]
Vernonia amygdalina	92[a]	5.43[d]	86.57[a]	16.24[b]	46.78[b]	40.86[b]	5.22[b]
Acacia brevispica	92[a]	5.35[d]	87.65[a]	17.60[c]	50.00[b]	36.56[b]	5.88[b]
Acacia albida	92[a]	5.43[d]	86.57[a]	20.25[a]	47.84[b]	31.28[c]	5.82[b]
Acacia abyssinica	93[a]	12.09[b]	80.10[b]	18.41[b]	55.32[b]	53.19[a]	9.69[a]
Carissa edulis	93[a]	7.78[c]	84.72[a]	13.27[f]	51.77[b]	37.63[c]	6.10[b]
Rumex nervous	92[a]	8.70[c]	83.30[a]	15.39[d]	62.46[a]	40.43[c]	9.89[a]
Ficus sur	93[a]	6.45[c]	86.55[a]	15.65[d]	52.41[b]	38.71[b]	5.93[b]
Ficus thonningii	92[a]	5.80[d]	88.20[a]	15.03[d]	54.38[b]	33.33[c]	5.55[b]
Rosa abyssinica	93[a]	5.38[d]	87.62[a]	14.72[f]	67.37[a]	51.61[a]	8.92[a]
Mean	92.5[a]	8.00[c]	84.53[a]	16.39[d]	56.69[b]	42.17[b]	6.90[b]

Abbreviations: ADF = acid detergent fiber, ADL = acid detergent lignin, CP = crude protein, DM = dry matter, NDF = neutral detergent fiber, and OM = organic matter.

soil type, water availability, and climate [43]. This adaptability likely provides *A. albida* with a competitive edge over other species, allowing it to thrive and dominate the area. Additionally, *A. albida* may possess traits such as a faster growth rate or more effective reproductive strategies that contribute to its higher population density [44]. Its resilience to grazing and possibly reduced palatability compared with other species might also play a role in its abundance [45]. The lower number of woody species in the study area (26) than in other regions could be due to factors such as location, altitude, rainfall, human impacts, and biotic and abiotic conditions [46].

The dominance of nonpalatable species (43.3%) among the indigenous woody species suggests that grazing pressure favors the proliferation of less desirable plants [47]. According to Refs. [48, 49], highly palatable species are likely to decrease under heavy grazing pressure, whereas less palatable or nonpalatable species are more likely to thrive and become more abundant. This trend is consistent with observations in other rangelands, such as those in the Allaidege areas of northern Ethiopia, where unpalatable plants dominate under similar conditions [50].

4.2. Distribution of Height Class and Woody Species Density. The dominance of plants within the 1- to 2-m height range suggests a favorable browsing environment for animals, which may increase the area's attractiveness for grazing and browsing. This height class aligns with the browsing behavior of many herbivores, indicating a correlation between the plant height and animal browsing preferences [51]. The observed variation in the density of woody species across different regions can be attributed to several factors. The higher density of woody species in the current study area compared to other regions might be influenced by local land use practices, such as the clearing of woody areas for construction and firewood, as well as by differences in edaphic and climatic conditions [52]. The discrepancy between the mean height of woody species in the current study and that reported for central highland regions of Vietnam could reflect ecological differences or varying browsing pressure. Similarly, the higher density of woody species in this study than in other regions highlights the impact of local factors on woody vegetation distribution and density [53]. Therefore, the results underscore the importance of plant height and density in influencing animal browsing behavior and suggest that land use and environmental conditions play significant roles in shaping the distribution of woody species.

4.3. Indigenous Browse Species Biomass Production. The observed differences in biomass yield among indigenous browse species can be attributed to several factors. *F. thonningii* demonstrated the highest biomass yield, which can be attributed to its ability to thrive under various environmental conditions, including nutrient-poor soils and limited water availability [54]. The robust growth of *F. thonningii* is likely due to its deep root system, efficient water use, and adaptability, all of which contribute to its high dry matter yield [55]. In contrast, the *R. nervous* system had the lowest biomass yield. Possible reasons for this include less efficient photosynthesis, lower water retention, and slower growth rates compared with other species. This lower yield may restrict its application in large-scale biomass production [56].

The variation in the biomass yield observed in different locations further underscores the influence of environmental factors. For instance, the biomass yields of *F. thonningii* and *F. sur* in this study were lower than those reported in the Lalo Kile District of the Kellem Wollega Zone [33]. Such discrepancies may be due to the variations in the soil quality, rainfall, and other environmental conditions specific to the study sites. Additionally, differences in species genetics, age, and human disturbance can affect biomass production [57].

4.4. Nutritional Composition of Browse Species. The observed differences in the protein contents of indigenous browse species can be attributed to their distinct biological characteristics. *A. albida*, a leguminous tree, benefits from its ability to fix atmospheric nitrogen through symbiotic relationships with Rhizobia bacteria in its root nodules [58]. This nitrogen fixation enhances nitrogen availability in the

soil, which in turn increases the crude protein content of the tissues [59]. In contrast, *C. edulis*, a nonleguminous shrub, does not engage in nitrogen fixation. Its protein content is therefore more dependent on the nitrogen levels present in the soil, which are generally lower than those in leguminous plants [59]. This explains why *A. albida* has a higher protein content than other indigenous browse species.

The significant variation in the crude protein content observed among the native browse species highlights the diverse nutritional profiles of these plants. *A. albida's* significantly higher ($p < 0.05$) protein content indicates its potential as a superior forage resource compared to other species. The lower protein levels found in various species relative to *A. abyssinica* suggest that *A. abyssinica* might offer more nutritional value in terms of protein compared to other species except *A. albida*. *A. brevispica's* higher protein content relative to several other species, including *V. amygdalina and F. sur*, emphasizes its nutritional advantage as well. The significant protein content observed in Arundinaria species, *V. amygdalina*, *R. nervous*, *and F. thonningii* compared with that in *R. abyssinica,* and *C. edulis* may reflect their potential utility as forage options, offering better nutritional benefits. These findings are consistent with those of previous studies [34, 35] that also reported significant differences in the protein content of browse species.

The observed variations in the crude protein content among the studies can be attributed to several factors. Differences in the plant parts analyzed [34, 35], harvest stage [60], and intrinsic species characteristics can significantly affect the nutrient content. Additionally, variations in the morphology of the same species [61] and differences in the lignin, cellulose, and hemicellulose levels [61, 62] may also contribute to these discrepancies. Notably, all native browsing species evaluated in this study had higher CP levels than herbaceous plants [14] and crop residues [15]. This indicates that native browsing species might be more suitable for sustainable livestock production, as they generally provide higher nutritional value.

All browse species at the study locations met the CP threshold of 7.2% and were potentially adequate to satisfy ruminant maintenance requirements. This CP level is crucial for fulfilling the nutritional needs of ruminants, particularly for growth, lactation, and rumen function [40]. Therefore, livestock producers should consider incorporating browsing plant species into their feeding strategies. This could help reduce reliance on concentrated feed and contribute to more sustainable livestock production practices.

The observed differences in ash content among the indigenous browsing species are consistent with previous studies [35] and highlight variability across species. The Arundinaria species demonstrated a higher ash content than most other species, which may indicate differences in mineral composition or soil uptake. Conversely, *F. sur*, *R. nervous*, and *C. edulis* had higher ash contents than several other species, suggesting that they may have accumulated more minerals. The discrepancies between the results of the current study and those of Ref. [35] for *C. edulis* and *A. brevispica* may be due to the variations in soil conditions, plant age, or other environmental factors that affect the ash content. Similarly, the lower ash content found in *F. thonningii*, *V. amygdalina*, and *A. abyssinica* compared with previous studies could be attributed to the differences in the geographical location and growth conditions [63]. Understanding these variations is important for evaluating mineral nutrition in ruminants and optimizing the use of these browse species in feeding strategies.

The observed variation in the NDF content among indigenous browsing species reflects differences in their fiber composition, which is a crucial factor influencing their nutritional quality [64]. The high NDF content in Arundinaria species, *R. abyssinica*, and *R. nervous* suggests that these species are more fibrous and may be less digestible compared to species with lower NDF levels such as *A. albida* and *V. amygdalina*. The lack of significant differences in the NDF content among certain species implies that, within specific groups, their fiber content is relatively uniform, which may similarly impact their palatability and digestibility.

A comparison with previous studies revealed discrepancies in the NDF values, particularly for *A. abyssinica*, *V. amygdalina*, and *F. thonningii*. The higher NDF content observed in this study than in earlier reports could be attributed to the differences in environmental conditions, growth stages, or sampling methods [36, 37]. Such variations highlight the importance of considering these factors when interpreting NDF values and their implications for nutritional assessment of browsing species. The lower NDF content observed in native browsing species than in crop residues [15] and native herbaceous species [14] suggests that native browses may generally have a more digestible fiber profile. The classification of Arundinaria species and *Ro. abyssinica* as low-quality feeds owing to their high NDF content indicates the potential limitations to their nutritional value for livestock. High NDF levels can reduce feed intake and negatively affect the productivity and health of animals [65].

On the other hand, the medium-quality classification for species such as *A. albida*, *A. abyssinica*, *A. brevispica*, *F. thonningii*, *F. sur*, *V. amygdalina*, *C. edulis*, *and R. nervous* implies that these species may offer a balance between the fiber content and digestibility. This categorization highlights their potential as more suitable forage options than low-quality feeds, because they are likely to be more palatable and less likely to hinder animal performance.

The variation in the ADF content among browse species highlights the differences in their fiber composition, which influences their digestibility and nutritional value. Arundinaria species with the highest ADF content were likely to be less digestible than *A. albida*, which had the lowest ADF content. This difference can affect the overall quality of forage, as higher ADF levels typically indicate more lignin and cellulose, making the forage less palatable and more difficult to digest [66]. The lower ADF content observed in native browsing species than in crop residues [14] and native herbaceous species [14] suggests that these browses may offer better digestibility and nutritional value to livestock. This is important for formulating balanced diets and

optimizing animal performance. The consistency of these findings with those of previous studies underscores the importance of considering ADF content when assessing forage quality and when making decisions regarding livestock feed.

Lignin content, as measured by ADL, plays a crucial role in determining the digestibility and nutritional value of forage. According to Ref. [67], lignin is a significant factor affecting feed intake, the rate of organic matter fermentation, microbial cell production, and fermentation product ratios. Higher lignin levels can reduce the digestibility of fibers, which affects the overall nutrient availability to animals. Reference [68] found that when the lignin concentration in feed exceeds 100 g/kg, the proportion of digested fibers is typically less than 60%, potentially leading to reduced feed intake and poorer nutritional outcomes. In this study, the lignin concentration in all indigenous browsing species was below 100 g/kg, suggesting that these species may not significantly hinder dry matter intake or affect animal production capacity. This indicated that indigenous browsing species could be a viable option for improving the quality of livestock feed, particularly in regions where tropical grass species and low-quality crop residues are prevalent. Thus, incorporating native browsing species into livestock diets could help address the nutritional deficiencies associated with poor-quality forage and residues.

5. Conclusions

The study of biomass yield in indigenous browse species aims to understand how native plants adapted to local conditions contribute to sustainable agricultural and ecological systems. These findings indicate that indigenous browse species in the study area exhibit a diverse range of biomass yields, with certain species demonstrating significantly higher productivity than the others. *F. thonningii* yielded the highest biomass, indicating its potential as a productive forage option. Conversely, *V. amygdalina* produced the lowest biomass yield among the studied species. The crude protein content in all indigenous browse species in the study area meets the maintenance needs of cattle, sheep, and goats, as the required levels for these animals are between 7% and 10%, according to Kearl and NRC. Additionally, these species provide adequate crude protein to support the milk production needs of sheep and goats, which require between 12% and 16%. For lactating dairy cows and growing beef cattle, the recommended crude protein levels are 14%–18% and 12%–16%, respectively. Therefore, it is crucial to feed livestock on native browsing species in order to enhance production, particularly during the dry season. Further research will be conducted on the antinutritional factors of all identified indigenous browse species.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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