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Effects of Season and Agro Ecology on the Nutritional Quality of Browse Species for the Dromedary Camels (Camelus Dromedarius) in Borana Plateau, Southern Ethiopia

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Abstract

The nutritional value of browsing species is being affected, camel movement is being disrupted, and camel feed resources appear to be being substantially degraded by climate change and its variations. This study explores the effects of season and location on the composition of nutrients and in vitro dry matter digestibility of the main browse species utilized as camel feed. Using an ANOVA model. Lannea rivae had an average DM content of 87.23% while Acacia brevispica had a range of 95.58%. There are no statistically significant variations (p>0.05) in the ash content of browsing species, which ranges from 2.56% in Acacia mellifera to 18.66% in Grewia evolute. The CP content of Lannea rivae in Maerua triphylla ranged from 6.19% to 27.24%. During the wet season, there is a statistically significant difference (p<0.05). On the other hand, Grewia evolute's CP contents varied from 24.56% to 10.44%, showing a significant difference (p<0.05). The results showed that Acacia etabaica had an NDF content that ranged from 25.63% to 72.10% Lannea rivae. Lannea rivae had the greatest ADF content (30.53%), and Grewia tembensis had the lowest (8.20%), with the difference being statistically significant (p<0.05). Grewia villosa in Lannea rivae had an ADL content that ranged from 2.82% to 15.86%. There is a statistically significant difference (p<0.05) during the dry season. During the wet season, the NDF concentration of Maerua triphylla in Boscia mossambicensis varied from 38.33% to 62.43%. The lowest ADF content was found in Acacia etabaica (22.47%), while the highest was found in Boscia mossambicensis (42.56%). The distinction is statistically significant (p<0.001). Grewia evolute contained 2.82% to 15.86% Acacia tortilis ADL. During the dry season, Dichrostachys cinerea had the lowest cellulose concentration (3.68%), whereas Euphorbia nubica had the greatest (18.77%). The study's conclusions indicate that the location is irrelevant. NDF, ADF, and ADL fiber fractions and chemical composition (DM, Ash, and CP) did not differ substantially (P<0. 05). The effects of location and season on the chemical and fiber compositions and nutritional value of browse species for dromedary camels (Camelus dromedarius) are clarified by this study. To identify other variables that affect the nutritional composition of browsing species, more investigation is required.

Keywords: *Browse Species, Season, Nutritional Quality, Agro Ecology, Dromedary Camels*

1. Introduction

Climate change has increased the frequency and severity of lowland droughts, leaving people without access to enough food and water (Ikanya, 2022). Camels are now being raised as a coping strategy for the unpredictable effects of climate change. Camels depend on a wide range of preferred browsing species, however it is unknown what nutrients these species provide (Hassen et al., 2022). The production of camels is mostly influenced by the quantity and quality of available feed (Ziblim, 2020). Because it accounts for almost 70% of the cost of animal production, the feed industry is crucial to all livestock economically (Demissie, 2020). Both high-quality, easily digestible diets and low-quality, fibrous feeds are suitable for camels. However, successful animal production cannot be maintained throughout the season because to intrinsic nutritional deficiencies, low digestibility, animals' limited intake capacity for such bulky meals, and low-quality natural pastures (Hassen et al., 2022).

In both the dry and rainy seasons, trees and bushes were important sources of food for camels, and browsing was the most common method of intake (Kandie et al., 2020). Camels and goats are particularly dependent on low-nutrient plants found in deserts and other semi-arid environments (Hassen et al., 2022). In particular, during the dry season, when readily available fodder tree leaves are used as camel feeds, fodder trees are a useful source of nourishment for camels (Ogunbosoye et al., 2015). The amount and quality of food available for animals in the Borana Pletua are insufficient due to the climate's prolonged dry season and limited rainy season (Derara and Bekuma, 2021). The nutritional value of a feed, on the other hand, refers to the quantity of nutrients that an animal can utilize (Beigh et al., 2020). A diet's level of usable nutrients is a sign of its better nutritional worth. As a result, the bulk of the livestock feed industry is currently concentrating on developing rations that are nutritionally balanced while adhering to cost-cutting standards (Dambe et al., 2015).

The vast natural feed production system, on the other hand, has an impact on animal desire, accessibility, and availability (Abdullah et al., 2017). Camels graze and browse an extensive variety of unidentified forages (Ikanya et al., 2022). It is suggested that differences in the availability and quality of various browser species are brought on by seasonality in rainfall distribution, which affects plant growth and development (Abebe et al., 2013). As a result, a number of variables, such as plant species, nutritional value, physical surroundings, plant environment, and animal behavior, affect camel plant preference (Khashkheli et al., 2022). Variations in the nutritional value of browse species are not properly captured in the research region, and neither are the effects of season or location on nutritive value.

In addition to that, earlier research on camels in different parts of the country focused on issues including breed characterization, reproductive physiology, milk and meat production, and camel illnesses. Understanding the dynamics of season and location effects on the nutritional composition of preferred browsing species is becoming more and more important in the modern environment of the Borana plateau, where climate variability has a significant impact on camel resources. It is now more important than ever to carefully examine the effects of seasons and location on the available browsing feed resources in terms of nutritional content because camels have historically been the domestic animal that receives the least attention in all areas, particularly camel feed nutrition. Therefore, the purpose of this study was to determine how the season and geographic location affected the nutritional makeup and in vitro dry matter digestibility of the main browse species fed to camels in the Borana Plateau.

2. Material And Methods

The study area's description

The research was carried out in three different areas of Southern Ethiopia's Borana Zone (Fig. 1), which correspond to the three agro-ecological classifications: hot lowland (Gamojji) Elwaye Goba, cool highland (Badda) Buya, and semi-arid (Badda Dare) Dharito. The area is classified according to annual and monthly mean temperature and rainfall, seasonal changes in rainfall, and native vegetation type. Elwaye Golba is at latitude 04°95.72', longitude 037'80.91', and elevation 1116m. The Buya has an elevation of 1695m and is located at 05° 13.29' latitude and 038°04.32' longitude. With an elevation of 1650m, the Dharito is located at 05°11.04' latitude and 038°27.46' longitude. In the study areas, rainfall is bimodal, with a mean annual rainfall of 500 mm and significant inter-annual variability (Angassa and Oba, 2007). The main rainy season (March to May) is responsible for 70% of total annual rainfall, while the short rainy season (September to November) is responsible for 30%. The average annual temperature is 24°C, with minimum and maximum temperatures of 17°C and 28°C, respectively (Megersa et al,.2014).

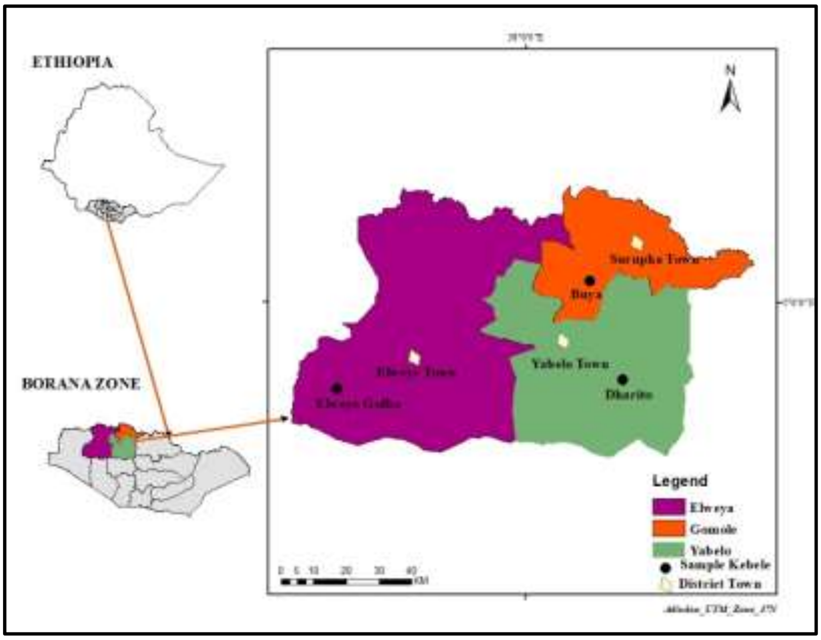

Figure 1: Map of study areas.

Identification of Camel browsing species

Perennial trees, bushes, and dwarf shrubs, which comprise a significant component of camel diets year-round, are among the browse species present in the study area. In the course of the household survey, a list of species that browse camels was created. A focus group with camel herders found the most popular tree and shrub species are accessible during both the dry and wet seasons. Finally, 18 browse plants were selected that camels could consume in the study locations during both the dry and wet seasons. The choice of collected browse species (Table 1) is determined by local availability, contributions to camel feeding, and camel preference, according to FGDs and key informants. The scientific and common names were derived from the identification of the flora of southern Ethiopian rangeland by Gemedo et al. (2005).

Table 1: The scientific and common names of the browsing species, as well as edible specifications, have been identified

Botanical name	Local name	Botanical name	Edible parts
Euphorbia nubica	Aannoo	Euphorbia nubica	Stems/leaf
Acacia etabaica	Alqabeessa	Acacia etabaica	leaf
Balanites aegyptiaca	Badana	Balanites aegyptiaca	leaf
Rhus ruspolii	Daboobessa	Rhus ruspolii	leaf
Acacia tortilis	Dhaddacha	Acacia tortilis	leaf
Grewia tembensis	Dheka	Grewia tembensis	leaf
Acalypha fruticose	Dhirrii	Acalypha fruticose	leaf
Maerua triphylla	Dhumaso	Maerua triphylla	leaf
Acacia brevispica	Hammareessa	Acacia brevispica	leaf/fruits
Commiphora Africana	Hammeessa	Commiphora Africana	leaf
Lannea rivae	Handaraka	Lannea rivae	leaf
Grewia evolute	Harooressa	Grewia evolute	leaf
Dichrostachys cinereal	Jirime	Dichrostachys cinereal	leaf
Grewia villosa	Ogomdii	Grewia villosa	leaf/fruits
Boscia mossambicensis	Qalqalcha	Boscia mossambicensis	leaf
Acacia mellifera	Saphansa guaracha	Acacia mellifera	leaf
Dalbergia microphylla	Wolchaamala	Dalbergia microphylla	leaf
Acacia goetzei	Burra	Acacia goetzei	leaf

Sample Collection and Preparation

Enumerators who had been hired and trained to collect the browsing species did so. Buya, Dharito, and Elwaye Golba were the three kebeles that were chosen expressly. To gather the sample, 12 20m*20m (400 m2) plots were placed at 200 m intervals along the transect line (Fekade et al., 2020). Ten plants from the chosen browsing species were examined for edible, nutritious sections. Based on their location, samples of the same feed type were pooled. A fresh sample of a browse species was dried in an oven at

105°C for 16 hours. The dried materials were crushed through a 1 mm Wiley filter to assess the chemical composition and in vitro dry matter digestibility (IVDMD).

The chemical composition of browse species was determined.
The typical laboratory nutritional studies were carried out by the Ethiopian Institute of Agricultural Research (EIAR), Holetta Research Center, and Animal Feeds and Nutrition Research Laboratory. Leaf samples from different browsing species were examined using AOAC (2005) standard techniques to determine the amounts of dry matter (DM; 105°C for 16 hours); organic matter (percent OM; 100% crude ash); and crude protein (CP; N x 6.25). Sequentially determining neutral detergent fiber (NDF) and acid detergent fiber (ADF) was done using the Van Soest et al. (1991) method. The NDF and ADF measurements take residual ash into account. When cellulose was dissolved in H2SO4, lignin (ADL) was created (Van Soest and Robertson 1985). By deducting the percent NDF from the percent ADF, hemicellulose (percent HC) was computed (Yisehak and Janssens, 2013). McDonald et al. (2002) computed the amount of energy that can be metabolized (ME, MJ/kg) based on the in vitro organic matter digestibility as ME = 0.16 x percent OMD.

In vitro dry matter digestibility and metabolizable energy determination
The in vitro dry matter digestibility (DMD) and organic matter digestibility (OMD) of the meals were evaluated using the Tilley and Terry (1963) two-stage in vitro method. A milled sample weighing 0.5 g was placed in a test tube with a 1 mm sieve. The material was combined in the tube with 50 mL of buffer solution and 10 mL of rumen liquor (AAC 1990). The mixture was shaken often during the 48-hour incubation period at 39°C. The supernatant was decanted after centrifuging the tubes. For the purpose of breaking down the protein, the residue was incubated for 48 hours at 39°C in a 60 mL solution of pepsin and hydrochloric acid. Centrifugation, filtration, residual drying, and ash were the subsequent processes. Two blanks (rumen liquor mixed with buffer only) and two standards with known digestibility were included (Yisehak and Janssens, 2013) to make up for the indigestible DM in the rumen liquor and to check that the system was functioning effectively. The formula for determining the amount of digestible organic matter (DOM) was 0.95* IVDMD (percent) - 2. ME (MJ/kg DM) = DOM (g/kg DM) x 18.5 x 0.81; the differences in hemicellulose and cellulose content were calculated as NDF-ADF and ADF-ADL, respectively.

Statistical analysis
Variance analysis (ANOVA) was performed using the SAS (2010) for Windows general linear model (GLM) technique. The differences in the chemical composition and nutritional content of browse species food were examined using the ANOVA model statement to account for the effects of season and location. Using the season, location, and interaction effects as separate components, a one-way ANOVA approach was utilized to determine the variance component. Model: $Yijk = \mu + FSi + Sj + (S * FS)\, ij + eijk$. Where Yijk is a measurement of feed chemical composition in ith feed species at jth season; μ is the fixed effects of feed chemical composition in ith feed species at jth season; FSi is effects of feed species; Sj is fixed effects of season; (S*FS) ij is interaction effects of season and feed species; and eijk is residual. All results were presented as means ± standard error of means (means ± SE).

3. Results And Discussions
Seasonal and species effects on the chemical composition of selected browse species
Table 2 shows the influence of species and seasons on chemical composition using the mean and standard error of the mean. The average DM contents of the browse species ranged from 87.23% ±0.01% for Lannea rivae to 95.58% ±12.96% for Acacia brevispica, with no statistically significant differences between any of them. Grewia evolute has an ash content of 18.66% ±1.96% compared to Acacia mellifera's 2.56% ± 2.66%. The CP content of Lannea rivae in Maerua triphylla ranged from 6.19% ±0.28% to 27.24% ±0.38%. There is a statistically significant difference ($p < 0.001$) during the wet season. During the dry season, DM concentrations of browsing species varied from 78.02% ± 0.87% in Acacia brevispica to 92.05% ± 0.33% in Grewia villosa (Table 1). Statistically speaking, there is a difference between the species ($p < 0.001$). Between 5.89% ± 0.30% in Acacia mellifera and 21.71% ± 0.82% in Acacia brevispica, the ash level of the browsing species varies. In Grewia evolute, Acacia brevispica's CP content ranged from 24.56% ± 3.04% to 10.44% ± 1.32%. During the wet season, there is a substantial difference ($p<0.001$). However, it was discovered that DM, ASH, and CP were lower during wet seasons, which is consistent with Geng et al (2020), who observed that, for tree/shrub species, these values were 91.98%, 12.80%, and 21.88%, respectively. Ziblim (2020) hypothesizes that condensed tannins may have played a role in the browsing species' reduced CP concentration. Contrarily, the chemical composition values in the present study are contrasted with those of Habte et al. (2021), who found that the ranges of the dry matter (DM) content, ash content, and crude protein (CP) content were 89.7-92, 20.4-11.9%, and 25.1-22.2%, respectively. Therefore, browse species that

have year-round nutritional values equivalent to one another have the potential to generate a feed of higher quality. When comparing other browsing species, animals may account for minor variations in the availability of nutrients. Similar conclusions were reached by other studies, which observed that certain nutrient concentrations existed when the levels were lower than the requirements of the animal.

Furthermore, changes in the fiber feed percentage and organic matter contents may be the reason behind the variance in the chemical composition of Borana rangeland browse species, according to Habte et al. (2021), who supported these findings. According to (Derara and Bekuma, 2021), the CP content of natural pasture in West Shawa, Ethiopia, ranged from 10.10% to 20.10%, and the variation in nutrient levels was brought on by forage species and agro-ecologies with diverse soil fertility. The dry forage and roughage studied by Alemayehu et al. (20216) had a CP content that was lower than the animal requirement, showing that the microbiological demand can rarely be reached without the addition of protein-rich foods. Additionally, the high CP content suggests that species may be able to supplement low-quality diets with protein. The most important quality indicator in animal feeding, according to Keba et al. (2013), is CP content, hence it is important to pay special attention when assessing whether or not the CP value (6 to 8%) is considered adequate for the majority of domestic animal maintenance. According to our research, the information is suitable for the camel to consume given the time of year and geographical references. We arrived to the conclusion that camels may be able to meet their needs because our research shows that some browsing animals have CP levels that are higher than what is required. The camels' physical condition remained constant during our sample collection in either season.

Table 2: The effects of season and species on proximate chemical composition (% DM) (DM, dry matter; OM, organic matter; ASH, total ash; and CP, crude protein)

Seasons	Browsing species	%Mean± standard error of mean			
		DM	**Ash**	**OM**	**CP**
Dry Season	Euphorbia nubica	89.29±0.49	3.18±0.67	96.82±0.67	9.13±0.47
	Acacia etabaica	91.16±0.38	5.74±1.62	94.26±1.62	15.67±1.39
	Balanites aegyptiaca	91.15±0.37	3.97±0.79	96.03±0.79	18.91±0.06
	Rhus ruspolii	90.41±0.30	17.00±1.36	83.00±1.36	9.95±1.25
	Acacia tortilis	88.42±0.43	6.15±0.86	93.85±0.86	18.36±1.43
	Grewia tembensis	94.22±0.19	9.62±1.83	90.38±1.83	13.81±0.37
	Acalypha fruticosa	91.45±1.01	3.74±1.11	96.26±1.11	15.96±4.14
	Maerua triphylla	93.52±0.62	17.30±0.52	82.70±0.52	27.24±1.49
	Acacia brevispica	95.58±0.87	10.59±0.82	89.41±0.82	23.91±3.04
	Commiphora africana	89.81±0.36	14.56±1.74	85.44±1.74	9.05±0.93
	Lannea rivae	87.23±0.52	14.59±2.81	85.41±2.81	6.19±1.01
	Grewia evolute	95.64±0.19	18.66±1.53	81.34±1.53	8.74±1.32
	Dichrostachys cinerea	88.25±1.14	16.14±1.36	83.86±1.36	11.30±3.11
	Grewia villosa	94.64±0.33	12.51±1.36	87.49±1.36	10.92±0.98
	Boscia mossambicensis	94.52±0.57	14.98±1.72	85.02±1.72	19.12±0.72
	Acacia mellifera	92.24±0.37	2.56±0.30	97.44±0.30	19.55±1.55
	Dalbergia microphylla	92.89±0.40	12.11±0.65	87.89±0.65	17.10±0.37
	Acacia goetzei	89.44±0.10	15.74±2.63	84.26±2.63	12.81±1.87
Rainy Season	Euphorbia nubica	92.66±0.93	9.42±0.31	90.58±0.31	12.77±0.99
	Acacia etabaica	91.18±0.17	8.04±0.29	91.96±0.29	14.76±1.21
	Balanites aegyptiaca	92.61±0.64	7.56±0.62	92.44±0.62	17.20±0.38
	Rhus ruspolii	91.02±0.31	9.98±0.31	90.02±0.31	11.42±0.38
	Acacia tortilis	91.32±0.21	6.88±0.10	93.12±0.10	11.20±0.38
	Grewia tembensis	90.75±0.13	11.55±1.35	88.45±1.35	18.42±0.38
	Acalypha fruticosa	91.73±0.24	13.04±0.53	86.96±0.53	13.64±0.38
	Maerua triphylla	91.20±0.22	13.64±0.73	86.36±0.73	20.62±0.38
	Acacia brevispica	78.02±12.96	21.71±14.15	77.90±14.54	24.56±3.03
	Commiphora africana	91.01±0.57	12.16±2.21	87.84±2.21	15.04±2.75
	Lannea rivae	89.99±0.01	8.50±1.49	91.50±1.49	11.75±0.28
	Grewia evolute	91.28±0.23	9.19±1.96	90.81±1.96	10.44±0.32
	Dichrostachys cinerea	91.04±0.13	7.08±2.01	92.92±2.01	14.44±2.64
	Grewia villosa	92.05±0.90	11.43±0.07	88.57±0.07	17.19±0.58
	Boscia mossambicensis	91.61±0.37	10.01±2.33	89.99±2.33	16.23±0.31
	Acacia mellifera	91.14±0.28	5.89±2.66	94.11±2.66	19.49±2.27

Dalbergia microphylla	90.88±0.24	6.48±0.33	93.52±0.33	15.13±2.82
Acacia goetzei	91.74±0.12	8.68±0.00	91.33±0.00	17.75±0.17

ab; *Means with different superscripts in the same column are significantly different (p < .05) , DM, dry matter; ASH, total ash; CP, crude protein.*

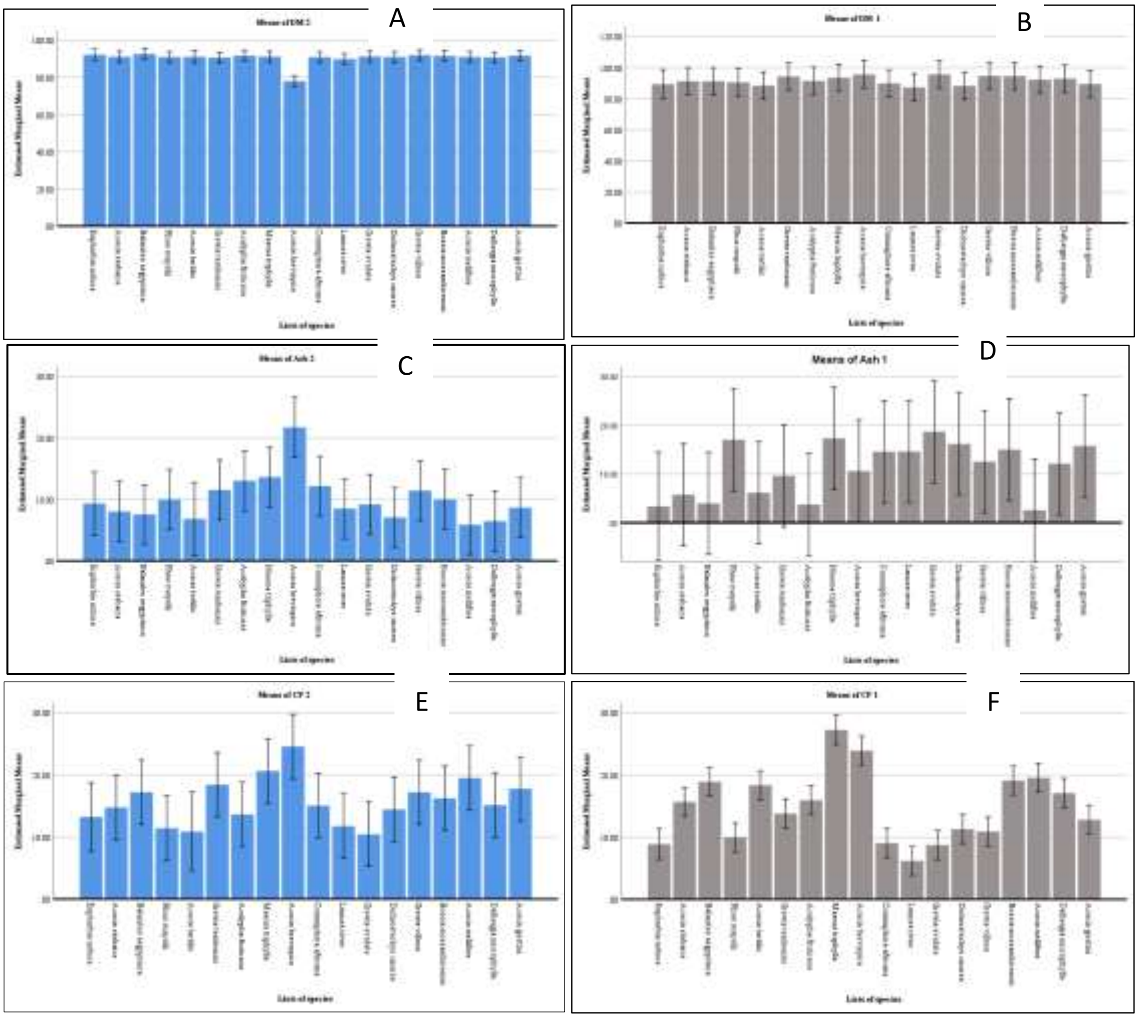

Figure 2: A, B, C, D, E, and F, Effect of species and season on proximate chemical composition (% DM) (DM, dry matter; ASH, total ash; and CP, crude protein)

Seasonal and species effects on fiber fractions of Borana lowland browse species

This study's NDF concentrations also revealed that there were variations in Acacia etabaica, ranging from 25.63% ±3.24% to 72.10% ±3.90% Lannea rivae. Grewia tembensis had the lowest ADF concentration, 8.20% ±0.20%, whereas Lannea rivae had the highest, 30.53% ±0.17%, a statistically significant difference (p<0.001). The dry season shows a significant difference (p <0.001). The cellulose content of Acacia goetzei in Euphorbia nubica ranged from 3.05% ±2.82% to 18.77% ±0.31%. The hemicellulose content of Acacia etabaica fluctuated between 11.26% ±4.18% and 56.99% ±2.58% during the dry season. During the wet season, the NDF concentration of Maerua triphylla in Boscia mossambicensis varied from 38.33% ± 2.66% to 62.43% ± 2.20%. Acacia etabaica had the lowest ADF content during the wet season (22.47% 0.75%), whereas Boscia mossambicensis had the highest (42.56% ± 0.41%). A statistically significant difference exists (p <0.001). Between 2.82% ± 1.96% and 15.86% ± 0.26% in Grewia evolute, Acacia tortilis' ADL content was found. There is a substantial difference during the dry season (p 0.001). Euphorbia nubica had the highest cellulose concentration (18.77% ± 0.31%) and Dichrostachys cinerea had the lowest (3.68% ± 0.83%) during the dry season. The hemicellulose concentration of browse species varied from 11.26% ± 4.18% for Acacia mellifera to 48.29% ± 2.31% for Maerua triphylla during the dry season. In the dry season, the hemicellulose content of browse species ranged from 11.26% ± 4.18% for Acacia mellifera to 48.29% ± 2.31% for Maerua triphylla, while in the wet season, it ranged from 15.51% ± 3.11% for Dalbergia microphylla to 27.49% ± 2.02% for Rhus ruspolii. In this investigation, it was discovered that the acid detergent fiber was the least easily digested fiber present in hay or other roughage. Forages with higher ADF levels have lower digestible energy levels than forages with lower ADF levels, suggesting that as ADF levels rise, so do digestible energy levels. Hence, it is suggested that fiber fractions (NDF and ADF) are the main factor limiting fodder intake and digestibility due to rumen fullness and have a significant impact on rumination. This result is in line with that of Andualem and Hundessa (2022), who found that during the rainy season, plant species had the highest levels of fiber fractions (NDF, ADF, and ADL), whereas browse species had the lowest levels. These three molecules are referred to as structural carbohydrates because they give the plant support as it grows and give it structure. Grewia tembensis (8.20%) and Acacia Etabaica (22.47%) had the lowest ADF, while Lannea rivae (30.53%) and Bosecia mossambiensis (42.56%) had the highest. However, the importance of including NDF in feeds cannot be overstated. An accurate representation of the overall fiber content of feedstuffs is thought to be NDF. Improved camel feeding methods are required, per Hassen et al. (2022), to boost camel productivity in areas where the NDF level is higher than the threshold value of 60%. The quality and digestibility of the fodder are significantly influenced by neutral detergent fiber. The average NDF value consequently showed wide ranges. The high content of NDF affects feed intake because of its composition, which improves feed intake. Animals are more inclined to take diets with high digestibility, and the relationship between digestibility and fiber concentration is inverse. NDF, ADF, ADL, cellulose, and hemicellulose levels differ greatly depending on the plant component, harvesting circumstances, time of year, and location. The chemical composition of browsing feeds varies significantly, according to Gebremariam and Belay (2021), and this variation may be influenced by the kind of soil, plant species, plant variety, plant proportion, and plant itself. The chemical composition of specific camel feed varies seasonally, with lower NDF and ADF during the dry season. According to research by Khaskheli et al. (2019), slight variances among browsing species may be caused by changes in the environment. Animals' access to forage depends greatly on seasonal variations, especially during the months when plant development is poor. In addition, the seasonal impact can explain the structural variations between the dry and rainy seasons (Sagala et al. 2020). The parameters had a big effect on the chemical makeup, flavor, and nutrient quality of the supplied feeds. Digestibility is frequently influenced by the quantity of ADF in the substrate, and most species demonstrated greater DM digestibility in wet conditions compared to dry conditions (Ravhuhali et al., 2022).

Table 3: The effects of season and species on fiber fraction composition (% DM) (neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin, cellulose, and hemicellulose of browse species)

Seasons	Browsing species	% Mean± standard error of mean NDF	Seasons ADF	Browsing species ADL	% Mean± standard error of mean Cellulose	Seasons Hemicellulose
Dry Season	Euphorbia nubica	44.42±2.48	29.08 ± 0.20^{ab}	10.31±0.32	18.77±0.31	15.34±1.74
	Acacia etabaica	25.63 ± 3.24^{a}	14.36±1.19	7.58±2.24	6.78±0.26	11.26±4.18
	Balanites aegyptiaca	30.52 ± 1.06^{a}	14.45±0.38	5.54 ± 1.70^{ab}	8.91±1.14	16.07±2.08
	Rhus ruspolii	58.16 ± 4.74^{a}	16.07±3.08	10.49±0.53	5.58±0.60	42.09±2.72
	Acacia tortilis	36.11±1.88	15.23±0.20	11.28±3.27	3.95±2.01	20.89±2.10
	Grewia tembensis	55.80 ± 1.61^{a}	8.20±0.20	3.25 ± 3.74^{ab}	4.95±2.23	47.60±4.01
	Acalypha fruticosa	39.69±3.36	20.16 ± 1.53^{a}	7.85±0.35	12.31±2.81	19.53±1.81
	Maerua triphylla	62.21 ± 4.21^{ab}	13.92±1.66	2.23 ± 0.65^{ab}	11.69±1.02	48.29±2.31
	Acacia brevispica	40.68±3.04	12.89±3.56	6.85 ± 6.60^{a}	6.04±2.41	27.78±1.47
	Commiphora africana	63.82 ± 3.21^{ab}	23.71 ± 1.26^{ab}	12.80 ± 0.69^{ab}	10.91±2.48	40.11±1.12
	Lannea rivae	72.10 ± 3.90^{ab}	30.53 ± 0.17^{ab}	15.86 ± 0.26^{ab}	14.67±1.93	41.57±3.51

	Grewia evolute	67.64±1.37^{ab}	10.65±0.20	2.99±0.85	7.66±1.56	56.99±2.58
	Dichrostachys cinerea	50.63±5.13	17.66±2.82	13.98±0.84^{a}	3.68±0.83	32.97±3.06
	Grewia villosa	64.59±2.18^{ab}	14.56±0.20	2.82±1.96^{ab}	11.74±0.48	50.03±4.07
	Boscia mossambicensis	54.04±5.10^{a}	20.65±0.20	6.18±0.70^{a}	14.47±0.11	33.39±2.43
	Acacia mellifera	30.72±2.31^{a}	13.68±1.25	5.71±1.72	7.96±0.25	17.04±2.04
	Dalbergia microphylla	53.79±7.93	21.67±5.06ab	11.16±0.91	10.51±0.57	32.12±1.82
	Acacia goetzei	51.48±0.31	14.62±3.38	11.57±1.14	3.05±2.82	36.86±3.98
Rainy Season	Euphorbia nubica	46.81±1.51	26.41±0.29	5.12±0.29	21.29±0.15	20.40±2.50
	Acacia etabaica	41.04±4.91	22.47±0.75	10.15±0.60^{a}	12.32±1.06	18.57±2.05
	Balanites aegyptiaca	43.94±3.11	25.33±1.03	9.07±0.12	16.26±1.77	18.61±1.02
	Rhus ruspolii	56.94±3.68^{a}	29.45±1.03	8.51±0.68	20.93±3.60	27.49±2.02
	Acacia tortilis	40.42±3.69	23.17±1.91	15.66±0.12^{a}	7.34±3.26	17.42±1.68
	Grewia tembensis	42.57±2.71	24.78±1.82	11.54±1.62^{a}	13.25±3.76	17.79±1.69
	Acalypha fruticosa	39.85±4.84	23.54±3.86	8.56±1.10	14.98±1.65	16.31±1.92
	Maerua triphylla	38.33±2.66	23.56±0.79	7.69±0.43	15.87±1.62	14.77±3.14
	Acacia brevispica	39.77±3.67	23.96±2.29	14.75±0.13^{a}	9.20±10.05	15.82±1.25
	Commiphora africana	49.51±1.99^{a}	25.97±2.09	8.81±0.40	17.16±1.02	23.54±2.05
	Lannea rivae	50.96±3.41^{a}	29.62±0.13	8.15±1.81	21.47±0.43	21.34±4.03
	Grewia evolute	55.69±2.73^{a}	30.49±1.57a	10.17±0.17	20.32±0.84	25.20±1.49
	Dichrostachys cinerea	51.09±4.06	26.78±1.01	12.77±1.53^{a}	14.02±3.40	24.31±3.02
	Grewia villosa	49.13±4.70	25.83±1.29	9.76±0.81	16.07±1.98	23.29±2.31
	Boscia mossambicensis	62.43±2.20^{ab}	42.56±0.41^{ab}	6.50±0.30	36.06±0.72	19.87±5.13
	Acacia mellifera	45.23±2.58	25.12±0.65	9.32±0.60	15.79±2.03	20.12±3.56
	Dalbergia microphylla	41.59±1.71	26.08±0.71	9.31±0.15	16.77±5.53	15.51±3.11
	Acacia goetzei	49.03±2.85	28.49±1.80	6.51±1.32	21.98±4.51	20.54±3.07

***ab;** Means with different superscripts in the same column are significantly different ($p < .05$)*

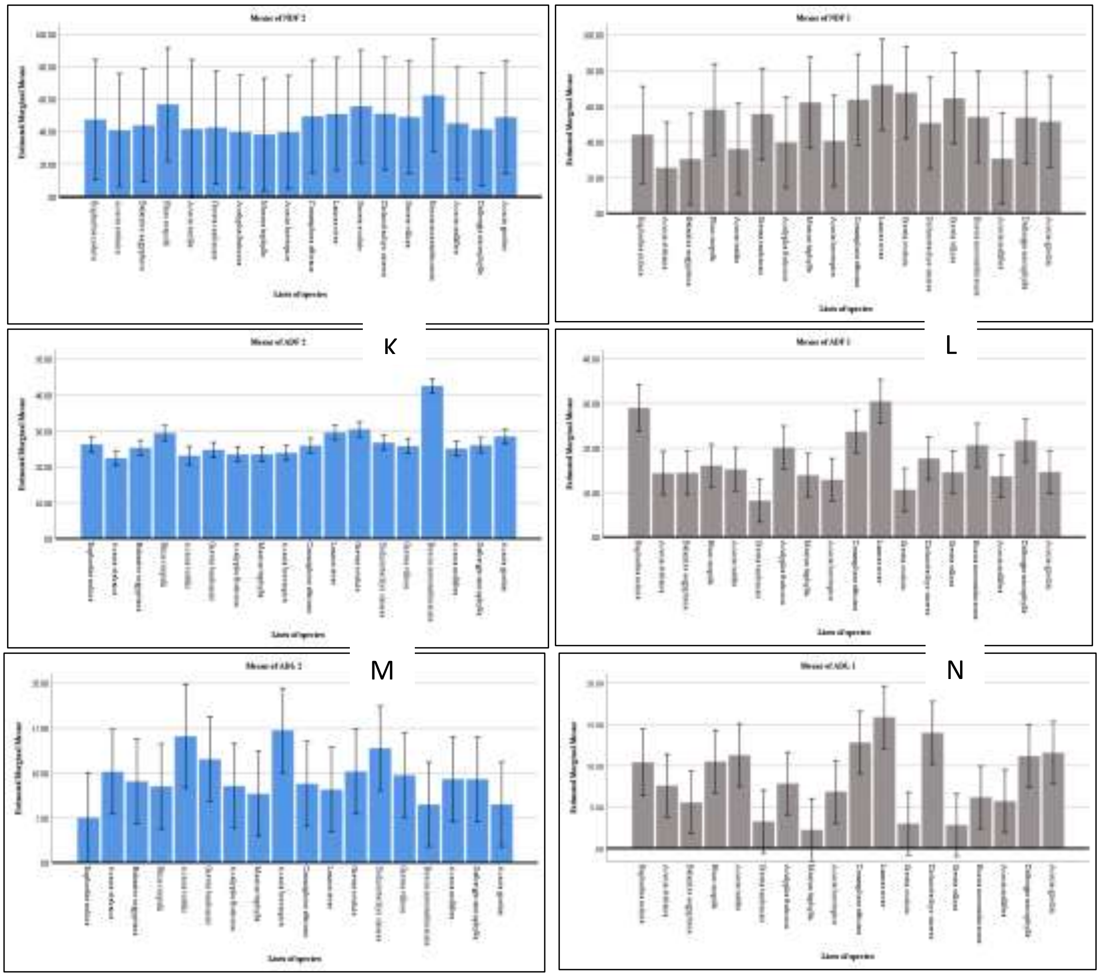

Figure 3: I, J, K, L, M, and N show the effect of species and season on the fiber fraction composition (% DM) (neutral detergent fiber (NDF), acid detergent fiber (ADF) of some browse species.

Seasonal and species effects on the in vitro digestibility and ME content of browsing species

The IVDMD, IVOMD, and ME values were evaluated in this study and compared across species and seasons (Table 4). With values of 73.84% ±0.90% and 68.01% ±0.51%, respectively, Maerua triphylla had the highest in vitro dry matter digestibility (IVDMD) content throughout the dry and wet seasons. The two species with the lowest percentages were Lannea rivae (44.02% ±3.62%) and Grewia evolute (38.36% ±0.51%). During the dry season, Lannea rivae had a mean IVODMD concentration of 34.28%± 3.85% while Maerua triphylla had a mean IVODMD concentration of 65.96% ±0.96%. From Grewia 28.25% ±0.54%, Balanites aegyptiaca 48.68% ± 0.54% develops. The variation is significant statistically ($p< 0.001$). For Lannea rivae, the metabolizable energy (ME) content ranged from 5.14% ±0.58% to 9.88% 0.14% throughout the dry season. For Maerua triphylla, it was 9.88%± 0.14%. Maerua triphylla and Grewia evolute had the highest and lowest metabolizable energy (ME) contents during the wet season, respectively, with 9.56% ±0.09% and 4.52% ±0.09%. The MEs of the investigated browsing species differed greatly ($P <0.001$). Ashes produced by browsing species had an inverse relationship with the proportions of OM, IVDMD, and ME (Table 5). The connection between OM, NDF, ADF, and ADL and the CP content of browsing species was, nevertheless, negative. The levels of ADL, IVDMD, and ME were inversely correlated with the NDF concentration in the browsing species. Additionally, it was found that the IVDMD and ME contents correlated negatively with the ADL content.

Table 4: Seasonal and species on (IVDMD, % DM; IVOMD, % DM); and metabolizable energy (ME, MJ/kg DM) of browsing species

Seasons	Species	% Mean± standard error of mean		
		IVDMD	**IVOMD**	**ME(DM)**
Dry season	Euphorbia nubica	58.62±1.69	49.78±1.80	7.46±0.27
	Acacia etabaica	57.53±0.33	48.63±0.35	7.29±0.05
	Balanites aegyptiaca	63.19±1.46	54.64±1.55	8.19±0.23
	Rhus ruspolii	60.86±2.71	52.17±2.88	7.82±0.43

	Acacia tortilis	60.26±1.19	51.52±1.26	7.72±0.19
	Grewia tembensis	63.72±2.41	55.20±2.56	8.27±0.38
	Acalypha fruticose	58.34±4.29	49.49±4.56	7.42±0.68
	Maerua triphylla	73.84±0.90^{ab}	65.96±0.96	9.88±0.14
	Acacia brevispica	66.94±2.41	58.63±2.56	8.79±0.38
	Commiphora Africana	54.79±1.09	45.72±1.16	6.85±0.17
	Lannea rivae	44.02±3.62	34.28±3.85	5.14±0.58
	Grewia evolute	57.68±2.85	48.79±3.02	7.31±0.45
	Dichrostachys cinerea	52.77±3.55	43.57±3.77	6.53±0.56
	Grewia villosa	55.78±1.46	46.77±1.55	7.01±0.23
	Boscia mossambicensis	67.43±0.65	59.15±0.69	8.86±0.10
	Acacia mellifera	66.22±1.54	57.86±1.63	8.67±0.24
	Dalbergia microphylla	56.85±0.97	47.90±1.03	7.18±0.15
	Acacia goetzei	56.64±1.63	47.30±1.57	7.09±0.23
Rainy season	Euphorbia nubica	56.58±0.51	47.61±0.54	7.62±0.09
	Acacia etabaica	49.58±0.51	40.18±0.54	6.43±0.09
	Balanites aegyptiaca	57.58±0.51	48.68±0.54	7.79±0.09
	Rhus ruspolii	42.82±0.51	32.99±0.54	5.28±0.09
	Acacia tortilis	56.90±0.51	47.95±0.54	7.67±0.09
	Grewia tembensis	49.81±0.51	40.42±0.54	6.47±0.09
	Acalypha fruticose	48.63±0.51	39.17±0.54	6.27±0.09
	Maerua triphylla	68.01±0.51	59.76±0.54	9.56±0.09
	Acacia brevispica	63.87±9.85	51.59±14.23	9.32±1.22
	Commiphora Africana	56.31±7.37	47.33±7.83	7.57±1.25
	Lannea rivae	48.64±0.51	39.18±0.54	6.27±0.09
	Grewia evolute	38.36±0.51	28.25±0.54	4.52±0.09
	Dichrostachys cinerea	45.25±0.51	35.57±0.54	5.69±0.09
	Grewia villosa	46.81±0.51	37.23±0.54	5.96±0.09
	Boscia mossambicensis	49.81±0.51	40.42±0.54	6.47±0.09
	Acacia mellifera	55.81±0.51	46.79±0.54	7.49±0.09
	Dalbergia microphylla	39.81±0.51	29.79±0.54	4.77±0.09
	Acacia goetzei	55.64±0.33	46.61±0.35	7.46±0.09

in vitro dry matter digestibility (IVDMD); in vitro organic matter digestibility (IVOMD); metabolizable energy (ME)

The effect of location and season on the chemical and fiber fraction composition of browse species

The browse species in the research locations' chemical and fiber fraction compositions. There were no statistically significant differences in chemical composition (DM, Ash, CP) or fiber fractions (NDF, ADF, and ADL) across species and regions ($P<0.05$) (Figs. 4 and 5). The DM contents of the browsing species as shown in (Fig. 4) show no appreciable variation ($p<0.05$). Despite variations in rainfall during our sampling causing the ash concentration in Dharito and Buya to be higher during the dry season, the ash concentration in Elwaye Golba is higher than the dry season value. There was no statistically significant difference between the three sites, despite the fact that CP concentrations were somewhat higher in Dharito during the dry season. There was almost any difference between the locations in NDF, ADF, and ADL during the dry and wet seasons. The content of neutral detergent fiber (NDF) in browse was higher at Dharito during the dry season. The findings demonstrated that throughout the wet season, there was little fluctuation in NDF levels between the three sites (Fig. 5). Elwaye Golba showed slightly higher values than Dharito and Buya, who had slightly lower ADF concentrations. ADL concentration did not significantly differ between the examined areas, but it was higher in Elwaye Golba during the wet season. The study's findings are consistent with widespread reports of regional, seasonal, and species-level variation in browsing species quality. The nutritional value of the browse species found at the location and during the season (Ash, CP, ADF, ADL, and ME) was investigated in this study (Comole et al., 2021). The nutritional profile or chemical composition of rangeland species varies from location to location, according to Sasoil (2022), due to natural variations based on genetic polymorphisms. Fiber composition is significantly influenced by soil variables.

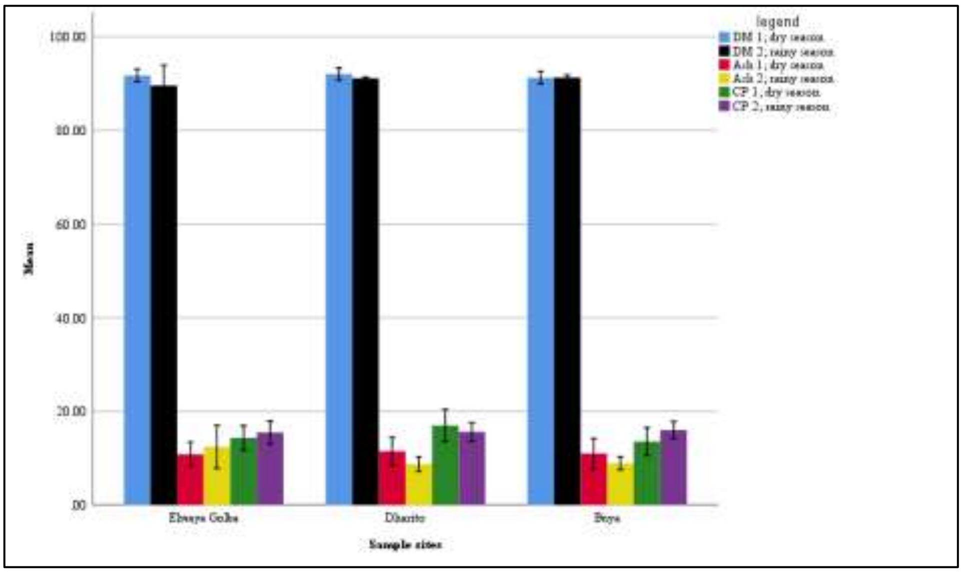

Figure 4: Seasonal and location effects on the chemical composition of browse species in the study sites (DM, dry matter; ASH, total ash; and CP, crude protein).

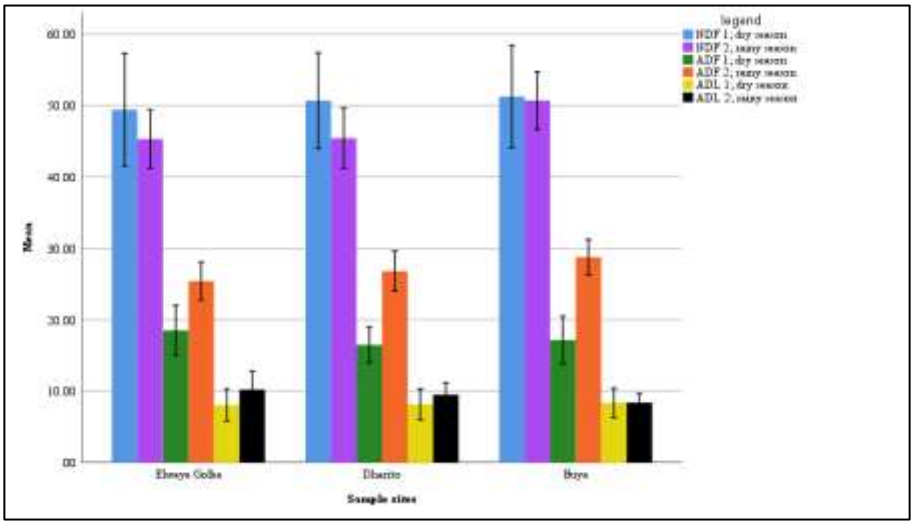

Figure 5: The effects of season and location on the fiber fraction composition (neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) of browse species in the study sites.

4. Conclusion

The greatest fiber fractions of NDF, ADF, and ADL were found during the dry season, but the DM, ASH, and CP contents of the browsing species decreased throughout the rainy season. On the other hand, the amounts of NDF, ADF, ADL, cellulose, and hemicellulose were barely affected by location. Our findings agree with previous recommendations for environmental enhancements. Seasonal variations in the chemical composition of a particular camel feed result in reduced NDF and ADF levels. More investigation is needed to establish the link between nutritional value and other factors in animal tests in order to verify the feeding quality of the browsing species.

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Conflicts of interest

The author declares that there is no conflict of interest

Availability of data and materials

The datasets collected and analyzed during the current investigation are accessible from the corresponding author upon reasonable request.

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Ethics approval and consent to participate

Not applicable

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