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Nutritional Characterization of Selected Fodder Species in Abol and Lare Districts of Gambella Region, Ethiopia

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Abstract

In Ethiopia the commonly identified feed resource are natural pasture, crop residue, improved pasture and forages, agro-industrial by-products, other by-products like food and vegetable refusal, of which the first two contribute the largest share. This research was done with the objective of nutritional characterization of selected forage species in two districts of Gambella regional state Lare and Abol, Southwest Ethiopia. The study was done using a formal survey, focus group discussions and field observations followed by sample collection, chemical analysis and *In vitro* Dry Matter Digestibility (IVDMD) of selected grass and browse species. Purposive sampling was employed to select 90 Households (HHs) having livestock. Four grasses and 10 browses species were collected during November to December 2013 and their nutritive values were evaluated. The average Crude Protein (CP) was 11.51% for the grasses and 13.16% for the browses, respectively. The average neutral detergent fibre (NDF) content was 75.37% for grasses and 56.43% for browse species whereas the IVDMD of grasses and browses were 64.45% and 59.3%, respectively. The selected grasses and browse species were good potential as livestock feed in the area and is recommended if further analysis in more species and study sites in the area.

Keywords: Browse; Grass; Nutritive value; Digestibility

Introduction

Livestock feed resources in Ethiopia includes natural pasture, crop residue, improved pasture and forages, agro-industrial by-products, other by-products like food and vegetable refusal, of which the first two contribute the largest share [1]. Natural pastures are naturally occurring grasses, legumes, herbs, shrubs and tree foliage that are used as animal feed [2]. These natural pastures comprise the largest feed resources, the contribution of which is estimated at 80-85% in Ethiopia [3]. Grass and browse species of communal grazing lands of sub-Saharan Africa are important sources of feed for smallholder ruminant production systems [4]. Livestock grazing is the predominant form of land use in pastoral areas which receive less than 600-700 mm annual rainfall. Natural pastures are decreasing from time to time and gradually disappearing due to rapidly increasing human population and expansion of cropland [2]. Studies report that overgrazing might also have been the main factor for the decline in the composition and diversity of plant species over a long period of time [5,6].

As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers [7]. They play a significant role in arid areas where moisture is inadequate [8]. Pastoralists depend heavily on woody plants for multiple uses [9]. These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry periods. They have deep root systems enabling the extraction of water and nutrients from deep in the soil profile [10]. Most browse plants have high crude protein content, ranging from 10 to more than 25% on a dry matter basis [11]. This reliable protein resource can be used to develop a sustainable feeding system and increase livestock productivity [12].

Gambella region is endowed with diverse species of grasses and browses [13]. Gelayenew et al. [14] indicated in natural pasture was the dominant feed resources during the wet season. Crop residue and browse forage species play a significant role during the dry season. The major livestock production constraints in the study area were disease and parasite (67%) followed by feed shortage (50%) and water scarcity (46%).

This biodiversity is of a substantial potential to support local livestock production and serve as candidate source of germplasm for further research aimed at improving livestock production elsewhere in the country. This requires a systematic documentation of information on chemical characterization of common feed resources. Thus, the objective of this piece of work was to characterize some common fodder species in terms of their nutritive value.

Materials and Methods

Description of the study area

The study was carried out at Abol and Lare districts of the Gambella People's Regional State (GPNRS). Abol district is one of the districts in Anuak zone having a total land area of 3,118.79 km^2 where 20% of it is covered by forest. The total human population of the district is 10,590 with 2595 households. The district is found at an elevation of 400-600 masl bordered on the south by Abobo and on the west by Itang districts and on the north and east by Oromia Regional State [15].

Lare district is part of the Nuer zone which covers a total land area of 685.17 km^2 a human population size of 31,406 and 5,432 households. It is found at an elevation of 300-400 masl and bordering on south and east by Anuak zone, on west by Baro River, which separates Jikawo, and on north by Jikawo River which separates from south Sudan. The terrain in Lare consists of marshes and grasslands [15]. The study districts were an annual rainfall varying from 900 to 1,500 mm. The absolute maximum temperature occurs in mid-March and is about 45°C and the absolute minimum temperature occurs in December and is 10.3°C [13].

Study design

The study involved questionnaire surveys, field visits and observation, focus group discussions and key informant interviews with the main objectives of chemical characterization of selected/common fodder species.

Sampling procedures and determination of sample size

The districts were selected randomly from the low lands of Gambella from which three peasant associations (PAs) were also selected randomly from each of the districts. Those districts and PAs that have security problems were excluded. The sample size was determined according to Arsham [16] with the formula of $n=0.25/SE^2$, where SE=5.27% and at confidence interval of 5%. Accordingly, a total of ninety (90) households (HHs) were purposively selected, 30 from Abol and 60 from Lare districts distributed based on the principle of sample proportional size, were involved in the study. The sampling frame comprised only of those households with livestock.

Data Collection

Method of data collection

Closed and open ended questionnaires were prepared and used for data collection through field visits, group discussions and key informant interviews. During the assessment, discussions were held with pertinent experts and secondary data were collected from the Agriculture Office of the districts. In addition to the closed and open-ended questionnaires, informal discussions were held with a group of households in each of the PAs and with development agents working in the localities. Enumerators were recruited and trained to administer the pretested questionnaires. The researcher was also involved in supervising the processes and the actual data collection which extended from November to December 2013.

Sampling of feeds and preparation of samples

During the focus group discussions, the available feed resources were listed and common forages (grasses, and browses) were ranked according to animal preference and availability as livestock feed at each of the PAs in the districts. For plant identification, the common prioritized forage samples were collected from the study sites. Information on local name of plant, plant morphology and photographs of the plant samples were also taken during the field work to facilitate identification which was done at the Addis Ababa University's herbarium.

For chemical analysis of the browse species the sample was hand plucked with a mix of all edible parts(leaves, fine stems and pods) and a composite sample of three kilogram on fresh bases from ten and above plant was taken from each species when available along peasant associations (Pas) while for grass samples two quadrants (1 × 1 m) were made around river bank in PA that were river border when available and harvested at about 5 cm above the ground and after harvest other species of the forages were separated. Grass and browse samples of same species were pooled over the PAs and one sub-sample of 0.5 kg representing the specific species was taken for nutritional quality analysis. The materials analyzed included four grass and ten browse species.

Fresh samples with high moisture content were weighed with suspended beam balance and then partial sun dried to reduce the moisture content to a safe level for storage until it was brought to Holleta Research Center's animal nutrition laboratory for oven-drying at 135°C for 2 h and ground to pass through 1 mm sieve for chemical analysis and *in vitro* digestibility. The ground samples were kept in air-tight containers until used for analysis.

Chemical analyses of the feed sample

Chemical analyses and *in vitro* dry matter digestibility of collected forage samples were determined using standard analytical methods. Dry matter and ash contents of feed samples were determined according to the procedures of AOAC [17]. The organic matter (OM) content was obtained as 100 minus ash content of the sample. Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was calculated as N × 6.25 [17]. The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Van Soest et al. [18]. Hemicellulose was determined by subtracting ADF from NDF. The method of Tilley and Terry [19] as modified by Van Soest and Robertson [20] was used to determine *in vitro* DM digestibility (IVDMD). The analyses were done at Holetta Agricultural Research Center animal nutrition laboratory.

Data management and analysis

The collected data were organized, summarized and analysed with the help of Statistical Package for the Social Sciences [21]. Chemical composition and IVDMD of major browse and grass forages were determined using descriptive statistics.

Results

Available feed resources and their distribution overtime

As ranked during focus group discussions the predominant livestock feed resources in the area were grasses followed by browse plants (Table 1). Grasses are the most preferred feed resources by cattle in the area where as browses are the main feeds of goats and mostly used for cattle during dry period. These browse plants in addition to feed for livestock and food for human consumption they are also used for construction purpose, fire wood and traditional medicines. Crop residues (stovers of maize and sorghum) were also in the list of important feed resources in those areas which practice crop cultivation. Other important feed resources include 'Atela' the by product from local brewing beverages. However, in the area there was no practice of conserving feed resources (hay and silages), planting of improved forages, using of agro by-products and storing of crop residues.

Feed resources	Availability by percentage	Time of Availability
Grasses	100	May to October
Browse species	63.3	Year round
Crop residues	32.2	September
Others ('Atela')	3.3	At the time when available

Table 1: Feed resources and their time of availability listed in their rank of importance.

Seasonal variation in feed quality and quantity is one of the most important constraints that limit livestock productivity in the area. For instance, in the area feed shortage was occurring due to flood during rainy season and drought during dry period. Plenty of grasses are available for about six months starting from May to December (Table 1). The browse plants were evergreen and available year round but mainly browsed in the dry season at the time when the growth of grasses and other herbaceous plants is severely affected. Feeds were abundant during the rainy season in the district except in areas affected by flood.

Chemical composition and *in vitro* dry matter digestibility of selected grass and browse species

During the focus group discussions, the available feed resources were listed and common forages (grasses, and browses) were ranked according to animal preference and availability as livestock feed in the districts. The materials analysed included four grass and ten browse species and site of collection indicated (Table 2).

Scientific name	Vernacular name	Forage category		Site of collection	
		Grass	Browse	Abol	Lare
Pennistetum sp.	*Pon/Mono*	X	-	-	X
Pennisetum unssetm (Nees.) Benth	*Bor/Ubo*	X	-	-	X
Eustachys paspaloids (Vahl.)Lanza&Pahei	*Wath/Agada*	X	-	X	-
Cynodon sp.	*Moth/Teli*	X	-	X	-
Senna sp.	*Wak/Akano*	-	X	X	-
Combretum Molle	*Jijat*	-	X	X	-
Anogeissus leiocarpus (DC.) Guill. & Perr	*Math*	-	X	X	-
Gardenia volensii K. Schum.	*Gari*	-	X	X	-
Landolphia Buchannanii (Hall. f.)Stap. f.	*Yewafmeshila*	-	X	X	-
Grewia tenax (Forssk.) Fiori	*Pori*	-	X	-	X
Maerua angolensis DC	*Neti/Anido*	-	X	-	X
Ziziphus abyssinica	*Bow/Lang*	-	X	X	-
Tamarindus indica L.	*Roka/Kuat/Choa*	-	X	X	X
Medicago plymorpha L. *(shrub legume)*	-	-	X	X	-

Table 2: Common fodder species sampled for laboratory analysis and the sites of collection.

Chemical composition and *in vitro* dry matter digestibility of selected grass species

The chemical composition and *in vitro* dry matter digestibility (IVDMD) of selected grass species are shown in Table 3. The chemical composition showed wide variation among the four grass species. The DM content of *Pennistetum unssetum* (95.85%) was the highest in the grasses. Among the grass species, the ash content in *Pennistetum* sp. (14.58%) was the highest and the lowest was in the *Cynodon* sp. (8.04%). Crude protein (CP) content varied from 8.95% in *Cynodon* sp. to 14% in the *Pennistetum* sp. The average NDF content of the four grass species was 75.37 ± 2.20 with range of 72.45% in *E. paspaloids* to 77.79% in *Cynodon* sp. The ADF content of *Pennistetum* Sp. (54.99%) was the highest whereas the lowest was observed in *P. unssetum* (42.33%) with the average group value of 48.53 ± 5.33. The mean ADL percentage reported was 10.20 ± 3.22 with the range of 7.03% in *P. unssetum* and 12.99% in *Cynodon* sp. In case of hemicelluloses *Pennistetum* sp. (20. 70%) was the lowest but highest in *P. unssetum* (33.23%). The average IVDMD contents of the four grass species under the study were 64.40 ± 3.97 with the range of 69.08% in *P. unssetum* to 66.13% in *E. paspaloids.*

Grass species	DM	OM	Ash	CP	NDF	ADF	ADL	Hem.	IVDMD
Pennistetum sp.	95.79	85.42	14.58	14.00	75.69	54.99	12.96	20.70	60.22
Pennisetum unssetm	95.85	89.62	10.38	12.00	75.56	42.33	7.03	33.23	69.08
Eustachyspaspaloidsi	95.14	87.20	12.80	11.10	72.45	46.84	7.83	25.61	66.13
Cynodon sp.	94.42	91.69	8.04	8.95	77.79	49.97	12.99	27.82	62.17
	93.3	88.55	11.45	11.51	75.37	48.53	10.2	21.2	64.4
Mean ± SD	± 0.66	± 2.85	± 2.85	± 2.09	± 2.20	± 5.33	± 3.22	± 11.13	± 3.97

Table 3: Chemical composition and *in-vitro* organic matter digestibility of selected grass species from Abol and Lare districts of Gambella by percentages.

Chemical composition and *in vitro* dry matter digestibility (IVDMD) of selected browse species

The chemical composition and IVDMD of different browse species of the districts are shown in Table 4. There were differences in nutrient contents between the ten browse species. Among the browse species the average DM content was 93.53 ± 0.97 with the range of 92.13% in *G. volensii* to 94.99% in *C. molle*. In *M. plymorpha* L. the ash content (15%) was the highest but the OM (76.36%) and ADL (7.50%) contents were the lowest. The average CP content of the species were 13.16 ± 4.17 and ranged from 8.05% in *Z. abyssinica* to 19.66% and 19.91% in *Senna* sp. and *M. plymorpha* L., respectively. The average NDF content were 56.43 ± 13.48 with the range of 43.49% in *A. leiocarpus* to 87.01% in *G. tenax*. The average content of hemicelluloses was 18.95 ± 12.25 ranged from 10.39% in *C. molle* to 52.63% in *G. tenax*. The average ADF and ADL content of the browse plants were 37.49 ± 7.9 and 9.82 ± 1.12 and their ranges were 30.43% in *A. leiocarpus* to 56.38% in *G. volensii* for ADF and 7.50% in *M. plymorpha* L. to 11.67% in *G. volensii* for ADL, respectively. The averages IVDMD of the species were 59.30 ± 6.06 with the range of 50.98% in *C. molle* to 68.86% in *Senna sp.*

Browse species	DM	OM	Ash	CP	NDF	ADF	ADL	Hem.	IVDMD
Senna sp.	93.03	89.85	10.15	19.66	44.21	32.58	8.73	11.63	68.86
Combretum Molle	94.99	93.99	6.01	16.00	52.44	42.05	10.69	10.39	50.98
Anogeissus leiocarpus	93.13	92.04	7.96	11.17	43.49	30.43	10.34	13.06	63.34
Gardenia volensii.	92.13	91.93	8.07	10.68	73.22	56.38	11.67	16.84	63.57
Landolphia buchannanii.	93.77	90.44	9.56	13.99	52.40	32.19	9.94	20.21	64.56
Grewia tenax	93.60	90.54	9.46	9.26	87.01	34.38	10.06	52.63	59.43
Maerua angolensis	94.34	90.96	9.04	9.64	54.07	37.25	10.04	16.82	54.97
Ziziphus abyssinica	92.46	87.11	12.89	8.50	49.99	31.98	9.54	18.01	51.07
Tamarindus indica	94.84	92.10	8.06	12.77	55.79	43.26	9.70	12.53	55.1
Medicago polymorpha	92.89	76.36	15.00	19.91	51.70	34.36	7.50	17.33	61.12
	93.52	89.52	9.62	13.16	56.43	37.49	9.82	18.95	59.30
Mean ± SD	± 0.97	± 4.96	± 2.60	± 4.17	± 13.48	± 7.9	± 1.12	± 12.25	± 6.06

Table 4: Chemical composition and *in vitro* dry matter digestibility of selected browses from Abol and Lare districts, Gambella by percentages.

Discussion

Available feed resources and their distribution overtime

Feed resources available in the area were natural pastures which includes grasses and browse species. These feed resources were highly depending up on climate or seasons that agree with report of Mohamed-Saleem and Abate [22] and Gelayenew et al. [14]. Seasonal variations in feed quality and quantity is the main limitation to animal production and cause fluctuation in productivity throughout the year, particularly in the dry and flooding seasons during which feed is scant and poor in nutritive value which consistence with the report of Alemayehu and Sissay [1].

The use of browse plants in addition to feeds and food they have been used for different purposes that agrees with report of Gemedo-Dalle et al. [23] and Teshome et al. [9]. Being perennial plants, fodder plants are not susceptible to sudden climatic changes and continue to maintain their green leaves longer into the dry season and known to produce high quality fodder even during drought years when grasses and other annual forages are dry and long gone due to their deep root systems which agrees with report of Coppock [24] and Eshetu [8]. However, no farmers climb up fodder plants to lop down for their livestock except very few farmers when they face critical problems similar with the report of Yeshitila [25].

Chemical composition and *in vitro* dry matter digestibility of selected grass and browse species

The average dry matter for the samples analyzed was 95.30 for grasses and 93.52% for browses, respectively, which is similar to the one reported by Beyene et al. [26] in Assosa Zone where the figures were 94.86% and 95.4% for grass and browse, respectively. This small variation could be attributed to the different times at which plants were collected, differences in species of plants, stage of harvest as reported by Gworgwor et al. [27]. The average ash content of the samples was 11.45% and 9.62% for grass and browse, respectively. This result is in consistence with the result reported by Aster et al. [28], in Borana range land 12.23% for grasses and 8.34% for browse and similarly Beyene et al. [26] reported 13% for grasses and 9% for browse. Gworgwor et al. [27] argued that differences in the ash content of the forage plants might be attributed to differences in soils and species.

The average Crude Protein (CP) of the samples was 11.51% for the grasses and 13.16% for the browse, respectively. These values were above the critical value of 7.5% reported to be required for optimal rumen function [29]. The CP for the grasses was higher and for the browse lower than that reported by Aster et al. [28] the values was 8.22% for grasses and 15.18% for browse, respectively. The variation in CP content may be attributed to different stage of harvest and seasons [30]. However, the CP of the grasses is consistent with the result of Shenkute [31], who reported that the CP content for most of immature grasses ranged from 7.2-20.2% of DM, whereas for matured grasses ranged from 5.6-11.5% of DM. The relatively high CP values in the forage studied appeared satisfactory for animal production since they exceeded the minimum protein requirement of 10-12% [32] for ruminants. On the other hand Norton [33] has reported CP level required to support lactation and growth to be 15%. This indicates that supplementation is imperatives for highly productive animals.

The average NDF content of the samples was 75.37% for grasses and 56.43% for browse species, respectively. The NDF contents of the grasses lie above the critical value of 60% which was reported to result

in decreased voluntary feed intake, feed conversion efficiency and longer rumination time [34]. According to Singh and Oosting [35] if the roughage contains above 65% NDF, it is considered as poor quality feed. Moreover, Norton [33] indicated that the NDF content that ranged from 67% to 78% to be high enough to limit DM intake and digestibility, yet the study by Nyamangara and Ndlovu [36] with goats on natural vegetation with NDF contents of between 59% and 79%, indicates that this cell wall component in the foliage should be adequately degraded. Higher NDF in browse comparing with result of Aster et al. [28] 34.14% and Beyene et al. [26] 33.29 is attributed in the sampling procedures where fine stems and dry pod were included which have higher lignin contents than leaves and hence high NDF. This makes them less digestible.

The IVDMD of grasses and browses were 64.45% and 59.3%, respectively. Mugerwa et al. [37] has reported that the digestibility values greater than 65% indicate good nutritive value and values below these level results in reduced in take due to lowered digestibility. So the digestibility of the browse species was lower than the threshold level indicated. Since digestibility were affected by many factors, the lower digestibility of browse plants were attributed by lignification's of the high proportion of the fine stem and dry pod in the feed analysed. However, according to Youngquist et al. [38] the digestibility level needed for maintenance of cattle in the tropics is 45%.

Conclusion

The region as whole is endowed with diverse species of grasses and browse plants covering a vast area of land. During the main rainy season, availability of feed is not a problem in the area. However, feed shortage is prevalent during the dry period and times of flood affecting livestock production and productivity. At times of feed shortage, no practice of supplementing livestock by conserving feed resources (hay and silage) or improved forages or crop residues was observed. However, they move livestock around the riverbank during dry period and flat areas during flooding. From the results of this study, it has been observed that the browse and grass species evaluated have good potential as livestock feed.

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Authors Contribution

E.M., A.M. and G.A. conceived and designed the study; E.M. performed the experiments; A.M. analysed the data; E.M. and G.A. intensively involved in the data collection and wrote the paper.

Conflict of Interest

The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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