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Nutritional Values of Indigenous Browse and Herbaceous Legume Species for Ruminants in Ethiopia: A Meta-analysis

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Abstract

Browse species and herbaceous forage legumes play a crucial role in providing nutrients for livestock. Due to their high protein content and better digestibility compared to common tropical grasses, they have the potential to be used as protein-rich supplements for ruminants. Thus, proper utilization of these fodder sources in Ethiopia requires establishment of comprehensive data on their nutritional composition and performance response of ruminants to diets containing these feed resources. This quantitative review summarized nutritional value and the effects of including foliage from browse species and herbaceous forage legumes in the diets of ruminants. Herzing's Publish or Perish free software was used to search 134 papers published in Ethiopia from the web databases of Google Scholars, Scopus, and PubMed. The results demonstrate that although the nutritional values are largely variable, foliage of browse species and herbaceous forage legumes studied can be classified as nutrient-rich diets. Browse species and herbaceous forage legumes had crude protein content of 17.3±5.2%(5.2-32.4%) and 20.2±4.2% (9.1-30.1%), and *in vitro* organic matter digestibility of 59.3±11.7% (33.2-89.3%) and 54.7±9.8%(39.7-69.3%), respectively. Because of these nutritional advantages and moderate fiber (NDF, ADF, and ADL) concentration, supplementation of both fodder sources to low quality basal diets increased dry matter intake and weight gain of animals. The presence of large variation in their nutritional composition may provide an opportunity to screen species and varieties of high nutritional quality traits. Moreover, determination of optimum inclusion level is also essential for best performance.

Key words: forage legumes, browse species, ruminants

Introduction

Natural pastures and crop residues are the major sources of feeds for ruminants in Ethiopia (Mengistu et al., 2017). But, they have low nutritional value due to the high fiber content, low CP content and low digestibility (Feyisa et al., 2021). Supplementation using locally available browse species and cultivated forage legumes has been suggested to improve the livestock productivity. These fodder sources have high protein content and can be considered as affordable protein sources for ruminants (Feyisa et al., 2021; Franzel et al., 2014). However, a comprehensive dataset on the nutritional composition and performance response of ruminants to diets containing these feed resources need to be established for efficient utilization. This review summarized feeding value of browse species and herbaceous forage legumes using literature data.

Material and Methods

Two datasets were built on *in vitro* nutritional value (62 studies) and *in vivo* animal performance (72 studies) using literatures collected from web databases (Google Scholar, Scopus, and PubMed) using Herzing's Publish or Perish free software. The studies were heterogeneous in plant species and variety studied. Thus, categorizing the species into herbaceous forage legumes, multipurpose fodder tree species, and indigenous browse species was applied to overcome the likelihood of data extraction from few studies. Statistical outlier data in the boxplots were excluded and analyzed using summary statistics of SAS (Version-9.0). Only 25 *in vivo* studies that compared *ad libitum* basal diet feeding (control) against a control plus browse species and herbaceous forage legume supplements were analyzed.

Results and Discussion

Mean nutritional value of forage categories

Nutritional value of forage categories are presented in Table 1. Multipurpose fodder tree species had low ash content (8.3±2.3%) while the others contained comparable value (10.3±3.4-10.8±2.4%). The mean maximum and minimum CP of 22.4±4.5% and 17.3±5.2% were recorded for multipurpose fodder tree species and indigenous browse species, respectively, whereas herbaceous forage legumes had intermediate values. The lower CP content of herbaceous forage legumes compared to multipurpose fodder species was consistent with previous report in Ethiopia (Melaku et al., 2003). The main reason for the difference could be the sampling of only leaves, twigs, and fine stems of trees for the analysis (Castro-Montoya & Dickhoefer, 2020). In good agreement to current result, Papanastasis et al. (2008) reported high CP in cultivated woody legumes than indigenous browse species. The pooling of all both leguminous and non-legumes species could be reason for the relatively low CP value of indigenous browse species. But, all the analyzed species had a CP largely exceeding the minimum CP (7%) recommended for optimal rumen microbial activity (Van Soest, 1982). Herbaceous forage legumes tend to contain high fiber compared to the indigenous browse and multipurpose fodder tree species (Table 1). The maximum ADL concentration was recorded in the indigenous browse species. Their fiber concentration were not far from the criteria set for good quality roughages which are less than 40% and 31% NDF and ADF, respectively (Singh et al., 2012). Results of digestibility revealed high IVDMD (77.0±7.9%) in multipurpose fodder species, and their IVOMD relatively comparable. Despite the differences in chemical composition and digestibility, ME values were comparable among forage categories (8.1±1.2-8.9±1.4MJ/kg DM). The current results were lower than the 10.42-12.31MJ/kg DM reported for five forage legumes by Berhanu et al. (2019). Large variations seen within the forage categories can be explained by the species or cultivars difference, plant parts, phenological stage, environmental conditions, and management practices (Papanastasis et al., 2008).

Feed intake and weight gain performance

Description of the diets and animal performance results are given in Table 2. The basal diet used as control treatment had low CP (7.2±2.0%) and high NDF content (70.6±6.1%), while the forages studied for supplements had high CP (19.4±5.1%) and low NDF (43.9±12.2%). The current results of nutritional composition of basal diet were consistent with a previous report from the tropical region (Castro-Montoya and Dickhoefer, 2018). Another meta-analysis conducted on goats in the tropics reported higher CP (9.7%) and lower NDF (65%) in control diet, whereas their values of study forages were comparable to current findings (Kronqvist et al., 2021). Due to this substantial difference in nutritional composition, the supplementation of the basal diet increased daily DM, CP, and ME intake by 28.8%, 80.2%, and 48.3%, respectively. The large improvement observed in protein intake indicates the potential of the studied forages as a protein source supplement for ruminants. The inclusion of browse species and herbaceous forage legumes in low-quality basal diet can increase the CP concentration of the total diet. Thus, sufficient nitrogen supplied for rumen microbial activity with subsequent improvement in feed digestibility and energy efficiency (Tolera, 2007). However, the values varying largely between minimum and maximum, the supplementation of those study forages improved daily weight gain of the animals by 274.5%. The current results on feed intake and weight gain were corresponding to the better feed utilization efficiency and growth rate of goats fed foliage substituted grass-based basal diet (Kronqvist et al., 2021). The observed large variation in minimum and maximum values (Table 2) could be attributed to the difference in the type of study forage and basal diet, supplementation level and animal characteristics (species, age, initial weight etc.).

Conclusions

Despite the heterogeneity in data sources, plant species and experimental protocols, the mean nutrient concentrations, digestibility, ME values as well as the effects on feed intake and weight gain performance of the animals revealed the potential of these fodder sources for use as protein supplements for ruminants. The presence of large variations may provide an opportunity to screen for species and varieties of high nutritional quality. Moreover, determination of optimum inclusion level is vital to gain best performance.

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Table 1: Chemical composition, digestibility and metabolizable energy value of indigenous browse species, herbaceous forage legumes and multipurpose fodder tree species

Variables	Indigenous browse species			Herbaceous forage legumes			Multipurpose fodder species		
	N	Mean	Range	N	Mean	Range	N	Mean	Range
DM %	160	92.7±2.4	87.7-98.5	43	90.3±1.5	88.1-95.0	65	91.9±2.7	84.0-97.5
Ash %	223	10.3±3.4	2.0-18.5	73	10.8±2.4	3.8-15.1	73	8.3±2.3	4.3-13.7
CP %	314	17.3±5.2	5.2-32.4	82	20.2±4.2	9.1-30.1	90	22.4±4.5	8.9-33.6
NDF %	355	41.1±12.9	12.2-75.2	73	45.5±9.3	26.3-70.7	30	40.8±14.2	13.6-66.7
ADF %	310	28.0±9.9	8.5-52.7	88	33.6±7.3	19.3-55.0	85	28.9±10.7	9.3-48.8
ADL %	241	11.7±5.8	1.8-26.4	70	8.5±3.7	2.9-21.6	57	8.6±4.3	2.0-24.4
IVDMD %	166	61.9±11.8	34.9-88.9	8	64.7±2.7	60.3-67.0	32	77.0±7.9	60.6-87.4
IVOMD %	159	59.3±11.7	33.2-89.3	28	54.7±9.8	39.7-69.3	34	58.5±8.7	49.1-76.0
ME MJ/kg DM	144	8.4±1.5	5.3-12.4	33	8.1±1.2	5.9-10.2	40	8.9±1.4	7.4-11.4

n-number of records, DM-dry matter, CP-crude protein, NDF-neutral detergent fiber, ADF-acid detergent fiber, ADL-acid detergent lignin, IVDMD- in vitro dry matter digestibility, IVOMD- in vitro organic matter digestibility, ME- metabolizable energy

Table 2: Chemical composition of experimental diets and feed intake and weight gain performance of animals analysed from *in vivo* studies

Variables	Category	N	Mean	SD	Minimum	Maximum
CP content (%)	Basal diet	25	7.2	2.0	3.6	12.2
	Forage supplement	25	19.4	5.1	11.5	30.0
NDF content (%)	Basal diet	25	70.6	6.1	53.7	83.1
	Forage supplement	25	43.9	12.2	13.2	64.8
Supplementation level (g/day/head)		25	284.0	70.3	100	479.4
DM intake (g/day)	Control group	25	574.0	165.0	277.0	985.2
	Supplemented group	25	739.3	189.9	367.3	1221.3
CP intake (g/day)	Control group	24	47.9	18.9	16.5	99.9
	Supplemented group	24	86.3	30.8	42.0	180
NDF intake (g/day)	Control group	20	403.1	120	210.2	775.7
	Supplemented group	20	461.5	143.3	245.3	872.8
ME intake (MJ/day)	Control group	9	5.8	2.0	3.6	9.3
	Supplemented group	9	8.6	2.8	5.9	13.1
Weight gain (g/day)	Control group	22	10.6	23.8	-19.3	90.3
	Supplemented group	22	39.7	26.9	2.2	129.2

n-number of studies, DM-dry matter, CP-crude protein, NDF-neutral detergent fiber, ME- metabolizable energy, SD: standard deviation