Livestock Research for Rural Development 31 (4) 2019 Guide for preparation of papers LRRD Newsletter Citation of this paper

Chemical composition and digestibility of Acacia species provenances in Tigray, Northern Ethiopia

Kibrom Gebremeskel, Kinfe Mezgebe[1] and Adugna Gesesse[2]

Mekelle Agricultural Research Center, Mekelle, Tigray, Ethiopia
kienzmds@gmail.com
[1] Tigray Agricultural Research Institute, Mekelle, Tigray, Ethiopia
[2] North Region Office, World Vision Ethiopia, Mekelle, Tigray, Ethiopia

Abstract

A study was conducted at Mekelle Agricultural Research Center, Northern Ethiopia, with the objective of evaluating chemical composition, anti nutritional constituent and digestibility of *Acacia saligna* provenances. Leaf samples from 15 provenances of three Acacia species (*A. saligna*, *A. microbotrya* and *A. daphnifolia*) were collected during the wet season (late August). Conventional chemical analysis procedures and in vitro organic matter digestibility (IVOMD) were used to determine the nutritional and anti nutritional content of the Acacia provenances. Results showed that crude protein content was highest (28.3%) in Bulk of four enclosures and lowest (16.4%) in Mingenew. A range of 1.41% - 3.03% and 4.02%-9.45% values were recorded for fat and ash respectively. The fiber contents ranged from 28.3% to 37.1%, 22.6% to 36.2%, 2.34% and 4.96% for Neutral Detergent Fiber, Acid Detergent Fiber and Acid Detergent Lignin respectively. Digestibility was highest (73.6 %) in Tincurrin and lowest (62.9%) in Arrowsmith River. The highest tannin content was in Tincurrin while low in Bulk of four enclosures. The results of this study showed that the Acacia provenances in general contained high levels of nutrients and hence have potential as supplementary feed for ruminants in northern Ethiopia.

Keywords: *foliage, in vitro organic matter digestibility, ruminant, tannin*

Introduction

Legume browse species provide significant amount of biomass from leaves and pods for livestock production to meet the requirement during the critical periods of the year (Canbolat 2012; Kaya and Kamalak 2012). As mentioned in many studies (Muluken et al 2015, Bruh and Destalem 2015) the importance of these browse plants in the arid and semi-arid areas is well recognized throughout Ethiopia. The major value of foliage of browse species is as a source of protein. Forage of browse species is expected to be most useful during the dry season when most grasses and other herbaceous species dry off. The ability of most browses to remain green in the dry season is attributed to their deep roots that enable them to extract water and nutrients from deep in the soil profile. Moreover, leguminous browse species fix atmospheric nitrogen, and this increases soil fertility that can be utilized by the companion or subsequent crops grown in the area (Atta-Krah AN 1990), and also contributes to the increased CP content of the foliage of browse species.

Acacia species is a leguminous shrub which provides large amounts of fodder for ruminants in arid and semi-arid regions (Safinaz et al 2010). *A. saligna* is one of the introduced browse shrub or tree species, which is widely grown and evergreen in different agro-ecological zones of Tigray (Shumuye and Yayneshet 2011). *A. saligna* has reasonably large amount of crude protein (Moujahed et al 2000), which has the potential to supplement the predominantly poor quality fibrous feeds widely used by smallholder farmers. Like other tropical forages, *A. saligna* is deficient in energy and could be provided to ruminants with other energy sources (Safinaz et al 2010). Studies have indicated that leaves of Acacia species better performance in terms of dry matter intake, body weight gain, and digestibility (Shumuye and Yayneshet 2011). The economic value of these species to animal production will depend on when the nutrients are available (i.e. does foliage/seed/pod production match feed gap and the concentrations of essential nutrients and secondary or anti-nutritive compounds. A number of *Acacia saligna* provenances were selected from Australia for the purpose of comparing their relative adaptation to conditions in northern Ethiopia with the naturalized type. However, the nutritive value to livestock of these provenances is yet to be examined. Hence, the objective of this study was to determine chemical composition, in vitro organic matter digestibility (IVOMD) and tannin content of the Acacia species provenances foliage used to feed ruminants.

Materials and methods

The study was conducted at Mekelle Agricultural Research Center. The altitude of the study area is 1960 m.a.s.l. The mean annual temperature ranges from 15 to 16°C. The hottest month is May with a mean maximum temperature of 24.8°C and mean minimum temperature of 11.5°C. The coolest month is December characterized by maximum and minimum temperature of 24.5°C and 11.3°C, respectively. The rainy season is June to September. Most of the annual rainfall occurs during July and August and to some extent in June and September with a mean annual rain fall about 532 mm. Soil type of the experimental site is vertisol and soil texture is clay. Acacia species had been grown in a triplicates trial since planting in 2012.

Foliage sample collection and preparation

Leaf samples from each Acacia species (*A.saligna*, *A. microbotrya* and *A. daphnifolia*) fifteen provenances were collected for chemical composition analysis and *in vitro* Organic Matter Digestibility (IVOMD). Samples were collected by hand picking from randomly selected nine individual A. species trees of each provenance. All the provenances sampled were the same age. Foliage samples were taken at three heights (top, middle and bottom of sample trees of canopy) during the wet season (late August). For each provenance, leaves collected were thoroughly mixed and three composite samples were taken for laboratory analysis. A sub-sample of each composite sample was taken for laboratory analysis. The samples were air dried in a well-ventilated room until transported to the laboratory and further dried in an oven at 65°C for 72 hours. Samples were ground in a Wiley mill to pass through a 1 mm sieve (for chemical analysis). The samples were then placed in plastic bags, sealed and kept for further analysis.

Chemical composition analysis

Triplicate samples of each Acacia species provenances were taken for chemical composition analysis. Dry matter content of the different samples (foliage) was determined by oven drying the samples at 60°C for 48 hours. Total Nitrogen (N) was determined by the Kjeldahl method (AOAC 1990). Crude protein (CP) was calculated as N x 6.25. Ash was determined by complete burning the samples in a muffle furnace at 500°C overnight according to the procedure of AOAC (1990). The structural plant constituents, namely Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL), were determined using the detergent extraction method (Van Soest et al 1991). The fat content was estimated according to the procedure of AOAC (1990). Condensed tannin content was determined according to Burns (1971).

In vitro organic matter digestibility

In vitro Organic Matter digestibility (IVOMD) of foliage samples was determined by the method of Tilley and Terry (1963) as modified by Van Soest and Robertson (1985). About 0.5 g of the samples was incubated in 125 ml Erlenmeyer flasks containing rumen fluid-medium mixture for 48 hours in a water bath maintained at 39°C. After the first 48 hrs of incubation, 35 ml of pepsin solution was added to the flasks and again incubated for another 48 hrs in a 39°C water bath. Shaking flasks was done at 2, 4, and 6 hours after pepsin addition. Results of the chemical composition, tannin and in vitro organic matter digestibility (IVOMD) were subjected to the one way analysis of variance (ANOVA) using a general linear model (GLM) of SAS 9.3 (SAS Institute 2002). Tukey test at $p<0.05$ was used to compare the treatment means.

Results

All chemical constituents showed marked variation between provenances (Table 1). The highest content of CP was measured for Bulk of four enclosures while the least CP content was recorded for Mingenew. Ash content varied from a low of Tincurrin to a high of Arrowsmith River. Tincurrin has shown highest tannin content while bulk of four enclosures recorded the least. The highest NDF content was obtained from Palmer block while lowest from Bambun Rd (Table 2). Maximum NDF value was recorded for Palmer Block whereas minimum value was recorded for Bambun Rd. The highest content of ADF was measured for Mingnew while the least ADF content was recorded for Tincurrin. The least ADL content was recorded in Tincurrin whereas a maximum value was determined in Tall selection Adishehu enclosure, Palmer Block and Mingenew.

Table 1. Chemical composition (% in DM) and tannin content (g/kg DM) of leaf samples from Acacia species provenances

Species	Provenances	CP	Fat	OM	Ash	Tannin
A. saligna	Arrowsmith River	18.4^{i}	1.70^{b}	85.9^{l}	14.1^{a}	24.6^{h}
A. saligna	Flynn Drive	19.7^{h}	1.93^{ef}	89.7^{g}	10.3^{f}	32.9^{b}
A. microbotrya	Tincurrin	20.4^{g}	2.68^{b}	95.9^{a}	4.10^{l}	47.6^{a}
A. saligna	Bulk of four enclosures	28.3^{a}	1.41^{k}	90.2^{f}	9.83^{g}	9.15^{o}
A. saligna	Murchison River	24.3^{c}	1.57^{hij}	87.6^{j}	12.4^{c}	27.2^{f}
A. saligna	Bambun Rd	21.5^{f}	2.15^{d}	86.7^{k}	13.3^{b}	29.3^{d}
A. daphnifolia	Coorow	16.6^{j}	2.35^{c}	88.6^{i}	11.4^{d}	31.7^{c}
A. microbotrya	Stawell 2011	21.7^{ef}	3.03^{a}	87.7^{j}	11.3^{d}	19.2^{n}
A. saligna	Parkeyeering	21.3^{f}	1.94^{e}	89.2^{h}	10.8^{e}	22.5^{k}
A. saligna	Palmer Block	22.1^{e}	1.64^{hi}	90.7^{e}	9.30^{h}	31.5^{d}
A. saligna	Pruinescens	26.8^{b}	1.50^{ijk}	91.4^{cd}	8.60^{i}	20.9^{m}
A. saligna	Mingenew	16.4^{j}	1.44^{jk}	92.1^{b}	7.90^{k}	22.8^{j}
A. saligna	Lake Coolengup	22.0^{e}	2.40^{c}	90.2^{f}	9.80^{g}	22.0^{l}
A. saligna	Muntagin	22.9^{d}	1.55^{ijk}	91.2^{d}	8.80^{i}	26.7^{g}
A. salign	Tall selection Adishehu enclosure	26.9^{b}	1.78^{gf}	$91.7b^{c}$	8.30^{j}	22.9^{i}
	SEM	0.18	0.05	0.18	0.25	0.012
	p	<0.001	<0.001	<0.001	<0.001	<0.001

Table 2. Fiber fractions and digestibility (IVOMD) of the leaves of Acacia species provenances

Acacia species	Acacia provenances	% in DM			
		NDF	ADF	ADL	IVOMD
A. saligna	Arrowsmith River	30.5^{h}	26.1^{g}	3.44^{efg}	62.9^{h}
A. saligna	Flynn Drive	30.0^{hi}	26.4^{g}	3.79^{c}	66.0^{f}
A. microbotrya	Tincurrin	31.2^{g}	22.6^{j}	2.34^{h}	73.6^{a}
A. saligna	Bulk of four enclosures	29.9^{i}	24.5^{i}	3.39^{gf}	70.5^{b}
A. saligna	Murchison River	29.7^{i}	25.2^{h}	3.68^{cdef}	64.6^{g}
A. saligna	Bambun Rd	28.3^{j}	24.2^{i}	3.47^{defg}	63.5^{h}
A. daphnifolia	Coorow	32.4^{f}	28.4^{e}	4.18^{b}	64.7^{g}
A. microbotrya	Stawell 2011	31.0^{g}	26.4^{g}	3.73^{cd}	64.6^{g}
A. saligna	Parkeyeering	34.5^{c}	29.2^{d}	3.86^{c}	63.8^{hj}
A. saligna	Palmer Block	37.1^{a}	34.3^{b}	4.83^{a}	64.8^{g}
A. saligna	Pruinescens	32.3^{f}	27.2^{f}	3.34^{g}	68.5^{c}
A. saligna	Mingenew	36.2^{b}	36.2^{a}	4.74^{a}	67.4^{de}
A. saligna	Lake Coolengup	33.1^{e}	27.5^{f}	3.73^{cde}	66.7^{def}
A. saligna	Muntagin	33.7^{d}	30.3^{c}	4.41^{b}	66.5^{ef}
A. saligna	Tall selection Adishehu enclosure	36.8^{a}	33.3^{bc}	4.96^{a}	67.7^{cd}
	SEM	0.15	0.14	0.10	0.5
	p	<0.001	<0.001	<0.001	<0.001

Discussion

The values of CP content of Acacia species provenances reported here are comparable to those reported by (Abdulrazak et al 2000; Dynes et al 2002 and Alam et al 2007) for Acacia species which was between 13.1 and 25.6%. The difference in CP content among species can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil or to fix atmospheric nitrogen, which is the case for leguminous plants. The CP contents of these Acacia species were higher than the minimum of 7- 8% necessary to provide the minimum ammonia levels required by rumen micro-organisms to support optimum rumen activity (Norton 2003). The CP concentration above the threshold CP content (11-12%) is required for moderate level of ruminant production (ARC 1980) and a minimum of 15% CP is required for lactation and growth (Norton 1982). In addition, high protein in the forage should be aimed at as it will favorably enhance intake and digestibility. This indicates the Acacia species provenances under this study may be well utilized as a protein supplement to low quality feed such as grasses and crop residues due to a higher level of crude protein.

In the present study, NDF contents were greater than those reported by (Boufennara et al 2012) and (Gebeyew et al 2015) who reported that NDF value of Acacia species to range from 18.6% to 24.5%. This could be attributed to differences in species, agro-ecology, stage of maturity at harvest and harvesting season. NDF content above 55% was reported by Van Soest (1994) to limit appetite and digestibility. Singh and Oosting (1992) also categorized roughages with NDF content of 45-65% as a medium quality feed, while feeds with NDF below 45% as high quality feeds. Tree forages with a low NDF concentration (20–35%) are usually of great digestibility (Bakshi and Wadhwa 2004).

In this finding the ADF content was in range with the previous reports of (Boufennara et al 2012) who reported that ADF value of Acacia species to range from 9.2% to 26.7%. With the exception of some of the provenances like Muntagin, Tall selection Adishehu enclosure, Palmer block and coorow were higher than of those previous reports.

In vitro Organic Matter Digestibility (IVOMD) of Acacia provenances reported in this study was higher than the 56% to 66% reported earlier for tropical browse species (Sanon et al 2007). The higher digestibility values could be partially attributed to the higher CP content of the feeds while the lower digestibility records might be associated with higher proportion of NDF, ADF, and lignin (Moore and Jung 2001; Zewdu 2008). The data reported in this study indicate that the leaves from Acacia provenances have a good potential to supply highly digestible feeds for ruminants.

Condensed tannin content in this present study were higher than the reports of (Elseed et al 2002) who reported that Acacia species during early June but lower than the same Acacia species during late dry season. According to Waghorn et al (1994a) tannins levels in excess of 50 g/kg dry matter can lead to low palatability, reduce digestibility, lower intake, inhibit digestive enzymes and be toxic to rumen micro-organisms. Accordingly, tannin contents of the Acacia provenance leaves in this study were lower than this range.

Conclusions

- The results of this study suggest that Acacia provenances were superior in terms of chemical composition, In vitro organic matter digestibility and lower in tannin content.
- The provenances had high level of protein content, easy degradability and low tannin content which deserved them to be potential feed for ruminants.
- Acacia provenances like Murchison river, bulk of four enclosures, pruincense and tall selection Adishehu enclosure could be mainstreamed as live fences, fodder banks, alley farms and as sources of homegrown supplements to low quality crop residues, especially during the dry season and as biological treatment to soil and water conservation structures would be useful in securing the sustainable development of the area.

Acknowledgments

The authors would like to give their deep appreciation to NOW-WOTRO for provision of primary funding for this research; additional funds were provided by Tigray Agricultural Research Institute (TARI) and World Vision Australia (WVA). We also extend our gratitude to the laboratory staff of Ethiopian Public Health Institute (EPHE) and Hawassa University for analysing the foliage samples.

References

Abdulrazak S A, Fujiharaa T, Ondiekb J K and Ørskov E R 2000 Nutritive evaluation of some Acacia tree leaves from Kenya. Animal Feed Science and Technology 85, 89–98. https://www.omicsonline.org/open-access/review-on-the-nutritive-value-of-some-selected-acacia-species-for-livestock

AOAC 1990 Official methods of analysis, 15th Edition. Association of official analytical chemists, Washington, DC.12p. http://www.sciepub.com/reference/51747

ARC (Agricultural Research Council) 1980 The nutrient requirement of ruminant livestock. Common Wealth Agricultural Bureaux. Slough, England. UK. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=2016517

Atta-Krah A N 1990 Fodder trees and shrubs in tropical Africa: Importance, availability and pattern of utilization. Center for Agricultural and Rural Cooperation, Wageningen University, Netherlands, pp. 118-138. http://www.lrrd.org/lrrd20/6/areg20086.htm

Bakshi M P S, and Wadhwa M 2004 Evaluation of forest tree leaves of semi-hilly arid region as livestock feed. Asian-Australasian Journal of Animal Science, 17:777-783.

Boufennara S, Lopez S, Bousseboua H, Bodas R and Bouazza L 2012 Chemical composition and digestibility of some browse plant species collected from Algerian arid rangelands. Spanish Journal of Agricultural Research, 10(1): 88-98. http://www.lrrd.org/lrrd27/3/mayo27042.html

Bruh W and Destalem G 2015 Identification and determination of chemical composition of some potential browses as livestock fodder in the Central and North Western Zones of Tigray, Ethiopia. Journal of Livestock for Rural Development 27 (2) 2015. http://www.lrrd.org/

Burns R 1971 Method for estimation of tannin in grain sorghum. Agronomy Journal 63, 511-512.

Canbolat O 2012 Determination of potential nutritive value of exotic tree leaves in Turkey. Journal of the Faculty of Veterinary Medicine, Kafkas University, 18 (3), 419-423. http://vetdergi.kafkas.edu.tr/extdocs/2012_3/419-423.pdf

Dynes R A and Schlink A C 2002 Livestock potential of Australian species of Acacia. Conservation Science Western Australia Journal 4(3), 117-124. http://ritlee.co.za/wp-content/uploads/2017/03/livestock-potential-wattle.pdf

Fadel Elseed A M A, Amin A E Khadiga, Abdel Ati A, Sekine J, Hishinuma M and Hamana K 2002 Nutritive Evaluation of Some Fodder Tree Species during the Dry Season in Central Sudan. Asian-Australian. Journal of Animal. Science . Vol 15, No. 6 : 844-85. https://www.ajas.info/upload/pdf/15_132.pdf

Gebeyew K, Beriso K, Mohamed A, G/silassie G, Melaku S and Worku A 2015 Review on the nutritive value of some selected Acacia species for livestock production in dryland areas. Journal of Advances in Dairy Research 3, 139. https://www.omicsonline.org/open-access/review-on-the-nutritive-value-of-some-selected-acacia-species-for-livestock-production-in-dryland-areas-2329-888X-1000139.php?aid=57281

Kaya E and Kamalak A 2012 Potential nutritive value and condensed tannin contents of acorns from different oak species. Journal of the Faculty of Veterinary Medicine, Kafkas University, 18(6), 1061-1066. http://vetdergi.kafkas.edu.tr/extdocs/2012_6/1061-1066.pdf

Moore K J and Jung H J G 2001 Lignin and fiber digestion. Journal of Range Management 54, 420-430. https://journals.uair.arizona.edu/index.php/jrm/article/view/9640/9252

Moujahed N, Ben Salem H and Kayouli C 2005 Effects of frequency of polyethylene glycol and protein supplementation on intake and digestion of Acacia cyanophylla Lindl. foliage fed to sheep and goats. Small Ruminant Research 56, 65-73. https://scialert.net/fulltextmobile/?doi=ajas.2011.102.117

Moujahed N, Kayoulib C, Thewis A, Beckers Y and Rezgui S 2000 Effect of multinutrient blocks and polyethylene glycol 4000 supplies on intake and digestion by sheep fed Acacia cyanophylla Lindl. Foliage-based diets. Animal Feed Science and Technology 88, 219-238. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5432601/

Muluken G, Getachew A and Getinet A 2015 Chemical composition and in vitro organic matter digestibility of major indigenous fodder trees and shrubs in Northeastern drylands of Ethiopia. Journal of Livestock for Rural Development 27 (2) 2015. http://www.lrrd.org/lrrd27/2/girm27026.htm

Norton B W 1982 Differences between species in forage quality. In: Hacker JB (eds), Nutritional limits to animal production from pastures. Farnham Royal: Commonwealth Agricultural Bureaux. pp .89–110. https://scholar.sun.ac.za/bitstream/handle/10019.1/1347/mbatha_using_2006.pdf?sequence=4&isAllowed

Norton B W 2003 Studies of the nutrition of the Australian goat. Thesis (D. Agr. Sc), University of Melbourne. Available: http://worldat.org/oclc62538900

Ogunbosoye D O, Tona G O and Otukoya F K 2015 Evaluation of the nutritive value of selected browse plant species in the Southern Guinea savannah of Nigeria for feeding to ruminant animals. British Journal of Applied Science & Technology, 7(4): 386-395. https://www.researchgate.net/publication/276394920_

Olivares P J, Avilés N F, Albarrán P B, Castelán O O A and Rojas H S 2013 Use of three fodder trees in the feeding of goats in the subhumid tropics in Mexico. Tropical Animal Health Production 45, 821-828. http://era.ujat.mx/index.php/rera/article/download/300/652

Safinaz M S, Ahmed M H and Ibrahim M A 2010 Impact of feeding atriplex halimus and acacia saligna with different sources of energy on lambs performan. Egyptian Journal of Sheep Goat Science 5(1), 191-208.

Sanon H O, Kaboré-Zoungrana C and Ledin I 2007 Behaviour of goats, sheep and cattle and their selection of browse species on natural pasture in a Sahelian area. Journal of Dairy Science 67(1), 64–74. https://stud.epsilon.slu.se/2122/1/jonsson_h_110111.pdf

Shumuye B and Yayneshet T 2011 Effect of feeding treated *Acacia saligna* (Labill.) H.L. Wendl. leaves on growth performance and digestibility in goats. Journal of Dryland Agriculture 4(2), 341-347.

Singh G P and Oosting S J 1992 A model describing the energy value of straw. Indian Dairy man, 4: 322-327. https://www.omicsonline.org/open-access/chemical-composition-and-nutritive-value-of-oats-avena-sativa-grown-in-mixture-with-vetch-vicia-villosa-with-or-without-phosphorus-2155-9600-1000609.php?aid=91295

Tilley J M A and Terry R A 1963 A two-stage technique for the in vitro digestion of forage crops. Journal of British Grassland Society, 18: 104-111. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2494.1963.tb00335.x

Van Soest P J and Robertson J B 1985 Analysis of forage and fibrous foods. A laboratory manual for Animal Science. 613 Cernell University, Ithaca, New York, USA. https://www.worldcat.org/title/analysis-of-forages-and-fibrous-foods/oclc/223471931

Van Soest P J, Robertson J B and Lewis B A 1991 Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 74: 3587-3597. http://www.journalofdairyscience.org/article/S0022-0302(91)78551-2/pdf.

Waghorn G C, Shelton I D and McNabb W C 1994a Effects of condensed tannins in Lotus pedunculatus on its nutritive value for sheep. 1. Non-nitrogenous aspects. Journal of Agricultural Science 123, 99-107. https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/assay-and-digestion-of-14clabelled-condensed-tannins-in-the-gastrointestinal-tract-of-sheep/604C34234EF4F8D7C5176F61AE8BAEE2

Zewdu T 2008 Effect of plant density on morphological characteristics, dry matter production and chemical component of Napier grass (*Pennisetum purpureum* (L.) Schumach). East African Journal of Sciences, 2:55–61. http://213.55.85.90/bitstream/123456789/2617/1/Effect%20of%20Plant%20Density%20on%20Morphological%20Characteristics%%2C%20Yield%20and%20Chemical%20Composition%20c

Received 24 January 2019; Accepted 21 March 2019; Published 1 April 2019

Go to top