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Nutrient Content and Dry Matter Degradability of Acacia Species in Arid and Semi-Arid Land of Baringo County, Kenya

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Abstract

The inadequate grass-based feed sources in arid and semi-arid lands (ASALs) constraint livestock production. Acacia trees and shrubs form the dominant vegetation in parts of the ASAL of Sub-Saharan Africa where they offer solutions to feed shortage. The current study examined the nutrient content and dry matter degradability of Acacia species preferred by goats in Marigat Sub-county, Baringo County. The collected samples of Acacia spp. leaves were cleaned with water, air-dried in the shade for five days, thoroughly mixed and oven-dried at 60^{o}C for 24 hrs, then grounded and packed in air-tight polythene bags. The samples were analysed for proximate composition before 200 mg of the sample was subjected to in-vitro degradability. The data obtained was subjected to ANOVA. The dry matter (DM) for all the tree species ranged from 95.42% in A. mellifera to 97.21% in A. nilotica leaves and was not significantly different. The crude protein (CP) content was significantly high in A. Mellifera at 22.00% while the fibre content was significantly different with A. brevispica at 28.12%. The ash content was significantly high in A. senegal at 15.59%. The findings of in-vitro dry matter degradation (IVDMD) indicated that A. nilotica had highest gas production at 48 hours followed by A. senegal at 24 hours. The gas production at 48 hours for A. nilotica leaves was significantly different ($p<0.05$) from A. brevispica leaves. The study concludes that A. nilotica was highly degradable followed by A. tortilis with least degradable being A. brevispica. The study recommends A. tortilis and A. brevispica, be used as supplements for livestock feeds in the ASAL regions, and thereby alleviate nutrient scarcities and reduce livestock malnutrition. A. brevispica provides fodder continuously to the pastoralist and therefore it can be propagated as a climate mitigation measure and as an alternate feed for the livestock during droughts.

Keywords: *Acacia spp*, Browse Plants Species, Nutrient Content, *In-vitro* DM Degradability (IVDMD)

INTRODUCTION

During the dry season, the crop residues and natural pastures are the main feed resource for ruminants. Ruminant livestock production in the tropical region is low due to insufficient nutrients in feed in terms of energy and protein, therefore the livestock in arid and semi-arid lands (ASALs) subsists on a limited feed with low nutrient value (Melaku *et al.*, 2010). Further, Mphinyane *et al.* (2015) reported that the forage quality tends to reduce during the dry season, and specifically the decline is observed in grasses than in fodder trees. These feeds are low in crude protein content and digestibility resulting in low feed intake and sub-optimal production (Kaushalendra, 2011). Fodder trees and shrubs supply the bulk of nutrient requirements to goats and camels but form the supplementary diets for sheep and cattle (Abdalla *et al.,* 2014). In that end, goats appear to be selective in the types of the available browse species while cattle tend to prefer spineless, soft leave browses which are shorter (Aregawi *et al.,* 2008).

In the ASAL region of Sub – Saharan Africa, Acacia tree species are dominant and provide food, medicine and fodder (Abdulrazak *et al.,* 2000). This is observed in the native deciduous browse species that have higher nutrient content than mature grass. Further, there is a remarkable difference in the various parts of the browse species including leaves, pods, twigs and flowers and as observed by Aregawi *et al.,* (2008), the pods of *A. tortilis* and *D. cinerea* have served as an important feed source for goats.

Plants growing in harsh environments such as the ASAL contain secondary anti-nutritive compounds which are a survival aid with Acacia *spp* being reported to contain several secondary compounds that include; alkaloids, cyanides, tannins, fluoroacetate, oxalates, amines, saponin, and unidentified toxins (Tibbo, 2000). The presence and level of these toxins vary from species to species and plant part to plant part. *Acacias spp.* grow in diverse habitats (Tibbo, 2000) and its nutrient value for animal production depends on the nutrient availability, their concentrations and secondary compounds in foliage, seeds or pods (Tibbo, 2000). According to Ramírez *et al.,* (2000), tree foliage and shrubs are protein-rich fodder for livestock production.

Foliage from trees and shrubs are considered to be important for the nutrition of grazing and browsing animals when the quantity and quality of the pastures are low (Dynes & Schlink, 2002). According to Abdulrazak *et al.* (2000) tree fodder has higher crude protein, minerals and digestible nutrients than grass. Livestock utilizes the following parts of browse trees and shrubs; leaves, pods, twigs and flowers depending on the availability (Aregawi *et al.,* 2008). In particular, camels and goats depend on the *Acacia* trees for their nutrient source and thus these browse species are very important to the pastoralists.

When forages are less digestible due to the low metabolizable energy and high fibre content, then, theoretically the productivity of the grazing animals will be increased by an increased feed intake (Caton & Dhuyvetter, 1997). But when digestibility falls below 55%, the nutrient availability of the browse is low and insufficient and thereby leading to weight loss (Dynes & Schlink, 2002). Based on the foregoing literature, the study sought to examine the nutrient content and undertake a comparative analysis of the in-vitro dry matter degradability of the edible parts of the preferred *Acacia spp.*

MATERIALS AND METHODS

Study Site

The current study was carried out at Marigat Sub-county, Baringo County in Kenya. The area was selected due to its ASAL nature with the main vegetation and browse plants being *Acacia* species. The locations identified and visited included Chemeron, Ng’ambo, Parkera, and Sirinyo as was guided by the local pastoralists and the Egerton University staff. Marigat is 252 km northwest of Nairobi and about 50 km north of the Equator from Mogotio Trading Centre in Baringo County at 0°28´N. The area is 1062 m above sea level with average temperatures of 28°C. The annual average rainfall is 625 mm which mainly falls in the months of May to July and very little in October and November.

Research Design

The testing was done using 3 flocks totalling 900 goats from 3 different sites as identified by the local pastoralists in Marigat. The process involved the release of the goats to the field at 9.00 a.m. and then following them with the help of the local herdsman and the expert from Egerton University. This method allows goats to browse naturally in the field and recording browsing ophthalmologic observation data after every 5 minutes for a period of 160 minutes. Visible number of goats browsing on specific Acacia tree species was recorded. Further, the design preferred offers greater validity to the results of the statistical analysis. Once, the data had been collected, the researchers selectively choose the leaves of the different Acacia spp. trees for sampling and further analysis.

Data Collection

The edible plant parts from which the samples were obtained included leaves based on the browseability data of the goats. The samples from each of the Acacia species were then thoroughly mixed and air-dried in the shade for five days to form homogenous sample. Samples were further oven-dried at 65°C for 24 hours, ground using a laboratory mill to pass through a 1mm sieve, then packed in dry air-tight polythene bags and labelled. The ground samples were analysed for nutrient composition (crude protein, crude fibre, ether extract and ash contect) based on the Association of the Analytical Chemist (AOAC) (1990) methods.

Once the nutrient composition had been determined, two hundred (200) mg of each sample was put into 100 ml calibrated glass syringes in duplicate for the *In-vitro* dry matter digestibility (IVDMD) which was carried out at Egerton University, Animal Science Nutrition Laboratory. The *In-vitro* dry matter digestibility (IVDMD) was determined following the methods of Tilley & Terry (1963) and as modified by Menke & Steingas (1988) which involves incubating the samples in thermostatically controlled water circulating bath (Chibinga & Nambeye, 2016). The *In-vitro* dry matter digestibility (IVDMD) was carried out and the data on gas production was collected at 0, 3, 6, 9, 12, 24, 48, 72, 96 and 120 hours.

Data Analysis

The data from proximate analysis were standardized and entered into Microsoft Excel spreadsheet before being subjected to Analysis of variance (ANOVA). The gas production data were fitted to the exponential model of Ørskov and McDonald (1979) where $GP(t) = a+b(1-e^{-c(t-L)})$. ANOVA was carried out on nutrient composition (crude protein, dry matter, fibre content, ether and mineral content) using the general linear model (GLM) based on Genstat 14.0 software while SEM was used to analyse the results of IVDMD. The significant difference was separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Nutrient Composition

The results given in table 1 showed that the Acacia spp. leaves had no significant differences in the composition of dry matter ($p \geq 0.05$) and ether ($p \geq 0.05$). The DM content of *A. brevispica* was at 97.07% while *A. senegal* had the low at 94.91 % and compared favourably with the range reported by Abdulrazak *et al.* (2000). Other findings on dry matter content of Acacia spp. leaves have indicated that *A. brevispica had 89.1% while A. senegal had 88.4%.* Shenkute *et al.* (2012) observed that A. *mellifera* had 91.90%, Abdalla *et al*. (2014) reported that A. *seyal* had 93.70%, Dambe *et al*. (2015) reported 99.0% for A. *mellifera* and 98.4% for A. *nigrescens* and Mangara (2018) reported 93.1% content.

Table 1: Nutrient composition of *Acacia* species leaves (%)

Acacia spp.	Dry Matter	Ash	Crude Protein	Crude Fibre	Ether Extract
A. brevispica	97.07 [a]	7.01[b]	21.63[a]	28.12[a]	3.66 [a]
A. tortilis	96.85 [a]	10.73[b]	15.36[b]	18.68 [b]	4.89 [a]
A. nilotica	97.21 [a]	5.41[b]	14.40[b]	9.66[c]	5.21 [a]
A. Senegal	94.91 [a]	15.59[a]	16.59[b]	16.96 [b]	4.01 [a]
A. mellifera	95.42[a]	10.38[b]	22.00[a]	16.97[b]	4.88 [a]
F-Statistic	3.39	3.38*	3.37*	3.37*	3.40 [a]

Means in the column with different superscript are significantly different (p≤0.05).

The crude protein (CP) contents as shown in Table 1 were higher than the 7 – 8% DM required for rumen functioning (Van Soest, 1994). *Acacia Mellifera and Acacia brevispica* had significantly (p≤0.05) high CP% of 22.00% and 21.63% with *A. nilotica* having the lowest (14.40%) which agrees with the CP range of 13.4% to 21.3% reported (Abdulrazak *et al.,* 2000). These also agreed with the CP content range of 12.8% DM in *A. lahai* to 22.8% DM in *A. oerfota* (Melaku *et al.,* 20*10*). *A. tortilis*, *A. oerfota* A. *asak*, and *A. amara* contain more than 15% CP content level (Norton, 1982). A high CP content of foliages and pods (10.16% to 23.90% DM) would justify their use in supplementation of poor-quality natural pastures and crop residues (Osuga *et al.,* 2008).

The leaves had significant (p ≤ 0.05) differences in crude fibre as shown in table 1, with *A. brevispica* having a high crude fibre (CF) at 28.12%, while *A. nilotica* having a lower CF content *of* 9.66%. The results augur well with those of Ondiek *et al.* (2010), Shenkute *et al.* (2012), Rubanza *et al.* (2003), Mangara *et al.* (2017) and Mangara (2018). Other studies by Abdalla *et al.* (2014) reported 24.34% CF content in Acacia seyal, Dambe *et al.* (2015) reported 25.0% CF in A. *nigrescens.* In comparison, other leguminous tree species have higher CF content as indicated by *Dichrostachys cinereal* with 49.55% CF and *Bauhinia thonningii* with 55.21% CF (Mahwasane, 2018) while Shenkute *et al.* (2012) observed a CF content *of* 24.9% in *Celtics Africana* and 47.5% in *Arundinaria alpine* while Rubanza *et al.* (2003) reported low CF content of between 14.6% to 19.6% for *Dichrostachys spp. F. villosa, P. thonningii, Harrisonia spp.,* Mangara *et al.* (2017) observed a 20.2% CF content in *Balanite aegyptiaca* and 20.1% CF in *Combretum adenogonium* (Mangara *et al.*, 2017).

The leaves had significant (p ≤ 0.05) differences in Ash content as shown in Table 1, with *Acacia nilotica* having the lowest Ash content of 5.41% while *A. senegal* had the highest at 15.59%. This finding agrees with those of Rubanza *et al.* (2003), Mangara *et al.* (2017), Mangara (2018) while Abdalla *et al.*, (2014) reported 11.62% ash content in *A. seyal*. In other related studies, Giridhar *et al.* (2018) observed the A. *auriculiformis had* 0.80% ash content while Ondiek *et al.* (2010) reported higher ash content of 21.2% in *A. nilotica.* Within the leguminous plants, Mahwasane (2018) reported that *Dichrostachys cinereal* contained 5.18% ash while *Bauhinia thonningii* leaves contained 6.98% ash. Shenkute *et al.* (2012) reported that *Celtics africana* had 20.6% ash content with *Dichrostachys cinera* having 6.9% ash. Mangara *et al.* (2017) reported *12.3% ash in Balanite aegyptiaca.*

The ether extract (EE) in leaves as shown in Table 1 did not differ among plant species. The leaves had no significant differences in EE content (p ≥ 0.05) with *A. brevispica* had the lowest ether extracts of 3.66% with *A. nilotica* had the highest ether content (5.21%). The results mirror those of Rubanza *et al.* (2003), Mangara *et al.* (2017), Mangara (2018) while Giridhar *et al.* (2018) reported an ether of 5.59% in A. *auriculiformis.* In other study findings, Mangara *et al.* (2017) observed 28.7% in *Balanites aegyptiaca* while *Combretum* *adenogonium* had 4.76% EE, Mangara (2018) reported 6.25% to 12.3% EE in *B. aegyptiaca, C. adenogonium, S. birrea and Z. spina-christi.* Odedire and Babayemi (2008) reported that *Panicum maximum* and *Andropogon gayanus* grasses showed lower values of 7.00% EE compared to the leguminous trees. Giridhar *et al.* (2018) indicated that *Leucaena leucocephala* had 3.33% EE, while the following browse tree species which include *Melia dubia, Sesbania grandiflora, Dillenia* spp., *Moringa oleifera, Commiphora caudata* had values which ranged between 2.34% to 4.96% EE. This ether extract concentration for the study is comparatively lower when compared to other leguminous and non – leguminous browse species like *in Balanite aegyptiaca* (Mangara *et al.*, 2017).

In-vitro Gas Production (ml/200 mg DM)

The results from *In-vitro* gas production measured from 3 to 120 hours for the leaves of Acacia tree browses showed significant differences in gas production among the browses as shown in Table 2 above. The Initial gas production (A) and rates of gas production (C) differed ($p<0.05$) among the browses. At 24 hrs fermentation, the rate of gas production was highest in *A. nilotica* at 77.15% followed by *A. senegal*, *A. tortilis*, *A. mellifera* and lastly *A. brevispica* leaves at 30.91% gas production. At 48 hrs fermentation, *A. nilotica* was highest at 60.29% gas production followed by *A. mellifera,* then *A. senegal, A brevispica* and lastly *A. tortilis* at 25.81% gas production. The browse with highest gas production at 24 and 48 hrs was *A. nilotica* leaves (77.15 ml and 60.29 ml per 200 mg Dm, respectively. The actual gas production during fermentation (B) was highest in *A. nilotica* leaves with 36.74% gas production followed by *A. mellifera*, *A. brevispica*, *A. tortilis* and lastly *A. senegal* at 15.98%.

Table 2: *In-vitro* gas production (ml/200 mg DM) at 24 and 48 hrs and Fermentation Characteristics of Leaves of Preferred Acacia Species Browse

	Total Degradation (%)		Fermentation Characteristics					
Sample	24 hrs	48 hrs	A	B	A+B	C (%/H)	48 hr OMD%	RSD
A. brevispica	30.91^{a}	35.45^{ab}	2.97^{a}	25.86^{ab}	28.83^{ab}	0.011^{a}	52.45^{a}	5.81
A. tortilis	56.79^{ab}	25.81^{a}	2.93^{a}	18.37^{a}	21.30^{a}	0.089^{b}	43.21^{a}	20.76
A. senegal	57.95^{ab}	41.61^{bb}	8.56^{b}	15.98^{a}	24.54^{a}	0.025^{a}	57.87^{ab}	23.07
A. nilotica	77.15^{b}	60.29^{b}	4.15^{a}	36.74^{b}	40.89^{b}	0.060^{ab}	75.01^{b}	33.73
A. mellifera	52.40^{ab}	45.72^{ab}	2.40^{a}	27.98^{ab}	30.38^{ab}	0.015^{a}	61.96^{ab}	25.13
SEM	±16.50	±12.78	±2.52	±8.26	±7.46	±0.034	±11.77	

SEM: Standard error of the Means
A, B, C are constants in the equation (Ørskov & McDonld, 1979)
[a, b, c,] Means with the different superscript in a column are significantly different ($p<0.05$).
OMD: Organic Matter Digestibility (calculated from Menke and Steingass, 1988 formula
RSD: Residual Standard Deviation; A is initial gas produced; B is actual gas produced during DM degradation; A+B is the total gas produced during fermentation; $C\%H^{-1}$ is the rate of gas production per hour; OMD (%) = 18.53 + 0.9239(gas production at 48 hrs) + 0.0540* CP (Menke & Steingass, 1988)*

The total gas production (A+B) did not follow the same pattern, however, *A. nilotica* registering 40.98% followed by *A. mellifera*, *A. brevispica*, *A. senegal,* and the least *A. tortilis* with 21.3% gas production which disagreed with the results of Abdulrazak *et al.* (2000). Rate constant gas production (C) shows variations in the forage' degradability and digestibility potential, with *A. tortilis*, leaves showing the highest (0.089% h^{-1}) while *A. brevispica* leaves had the lowest (0.011% h^{-1}) which compares well with results reported by Abdulrazak *et al.* (2000).

The Residual Standard Deviation (RSD) showed variation with *A. brevispica* having the least at 5.81, followed by *A. tortilis*, *A. senegal*, *A. mellifera*, and lastly *A. nilotica* at 33.73. This shows that although *A. nilotica* leaves were highly degradable, the RSD was high. The low RSD for *A. brevispica* may be related to results registered during preference tests. The OMD% was high for *A. nilotica* (75.01%) followed by *A. mellifera*, *A. brevispica*, *A. senegal*, and the least was *A. tortilis* at 43.21%. All the *Acacia spps* had more than 50% OMD except for *A. tortilis* which may be attributed to the presence of anti-nutritional factors such as tannins, phenols and suppressant of digestion.

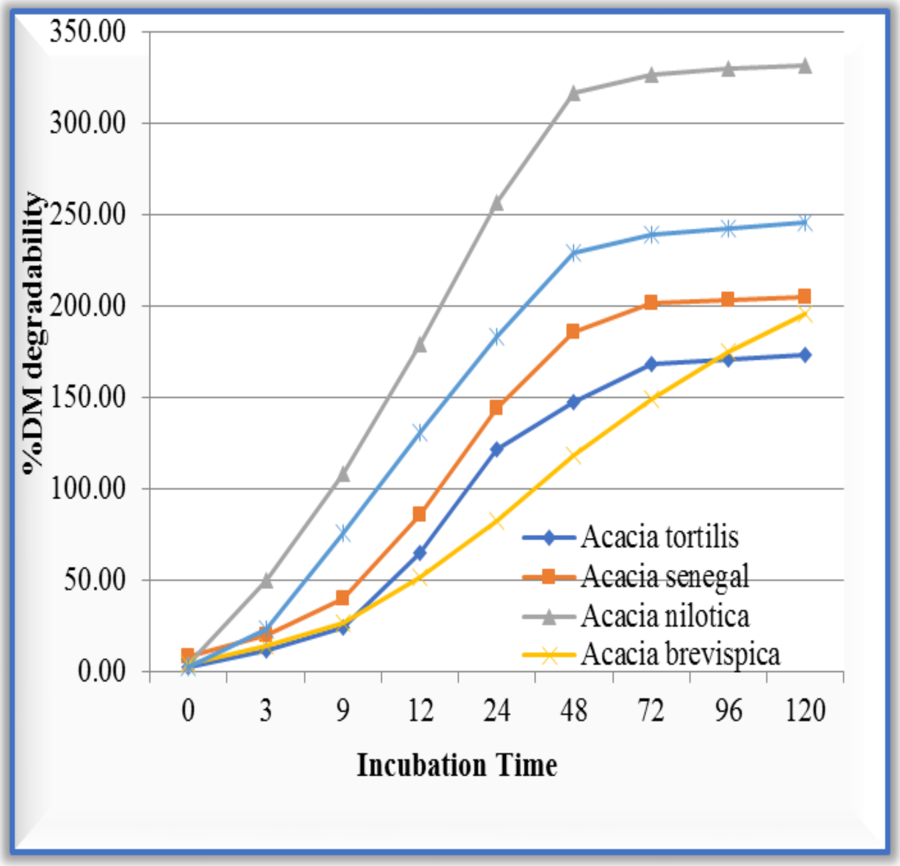

Figure 1: *In-vitro* Dry Matter Degradability of Leaves for Selected Acacia Species.

The results from *In-vitro* gas production (Figure 1) were measured from 3 to 120 hours showed significant differences in gas production with potential gas production (A) and rates of gas production (C) differing among the browses. Further, incubation time and the type of browse species significantly influenced the *In-vitro* gas production for the different browse species. Figure 1 shows the trends in fermentation of leaves for selected Acacia species with *A. nilotica* leaves showing highest degradation followed for *A. mellifera*, *A. senegal*, *A. tortilis*, and finally *A. brevispica*. However, *A. tortilis* registered the same degradability up to 9 hours, after which it became more degradable up to 96 hours.

Total gas production shows variation in the forage degradability rate constant with *A. tortilis* leaves showing the highest

(0.089%/h) and *A. brevispica* leaves the lowest (0.011%/h) which compares well with results reported by Abdulrazak *et al.* (2000). The mean gas production at 48 hours for *A. nilotica* leaves is significantly different ($p<0.05$) from *A. brevispica*, *A. senegal* leaves, *A. mellifera* which were similar. The browse with highest gas production at 24 and 48 hours was *A. nilotica* leaves (77.15 ml and 60.29 ml per 200 mg DM, respectively). The significance of browse feed source is determined by among other things, the nutritional content and therefore the browsing ruminants tend to avoid toxic materials. Alkaloids, phenolics, tannins and aromatics tend to alter palatability and intake of feeds irrespective of their nutritional value (Ngwa *et al.,* 2003). Thus, due to the marginal association between nutrient composition, intake and palatability, nutrient content analysis is an unreliable predictor of a feed source (Gwanzura *et al.,* 2011).

CONCLUSION AND RECOMMENDATION

The nutrient content of preferred *Acacia spp* browses had high dry matter content which indicates high amounts of nutrients that may be available to the animals. The result also showed crude proteins to be high in the leaves and pods and generally low in the barks except for *A. mellifera* and thus Acacia species are a good source of crude protein. The CP content of leaves and pods of all the species preferred can be good sources of proteins for feed supplementation in the ASALs where forages are of low nutrient content.

The IVDMD showed that the highly degradable/fermentation browse was *A. nilotica* and the least was *A. brevispica* although the RSD results for *A. brevispica* was lowest which indicates that most of the *A. brevispica* browse is degraded and hence the positive preference.

The crude fibre (CF) were high in the barks and this may be attributed to high lignin, cellulose and hemicelluloses deposits that formed over time. The CF for the leaves and pods were high indicating that Acacias can be a good source of energy to the browsers. As for ether extracts (EE), the results showed leaves of the Acacia spp. have higher CP content.

REFERENCES

Abdalla, M. S., Babiker, I. A., Idris, A. M. and Elkalifa, K. F. (2014). Potential Nutrient Composition of Acacia seyal Fruits as Fodder for Livestock in the Dry Lands in Sudan. *Development in Analytical Chemistry*, *1*, 25-30.

Abdulrazak, S. A., Fujihara, T., Ondiek, J. K. and Ørskov, E. R. (2000). Nutritive evaluation of some Acacia tree leaves from Kenya. *Animal Feed Science and Technology*, *85*(1-2), 89-98.

AOAC (1990). *Official Methods of Analysis*, 15th edn. Association of Official Analytical Chemists, Washington, DC

Aregawi, T., Melaku, S. and Nigatu, L. (2008). Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. *Livestock Research for Rural Development*, *20*(6), 86.

Caton, J. S. and Dhuyvetter, D. V. (1997). Influence of energy supplementation on grazing ruminants: requirements and responses. *Journal of Animal Science*, *75*(2), 533-542.

Chibinga, O. C. and Nambeye, E. (2016). Nutritive value of some selected indigenous livestock browse species in the drylands of Southern Province, Zambia. *International Journal of Applied and Pure Science and Agriculture*, *2*(1), 2394-5532.

Dambe, L. M., Mogotsi, K., Odubeng, M. and Kgosikoma, O. E. (2015). Nutritive value of some important indigenous livestock browse species in semi-arid mixed Mopane bushveld, Botswana. *Livestock Research for rural development*, *27*(10), 1-10.

Dynes, R. A. and Schlink, A. C. (2002). Livestock potential of Australian species of Acacia. *Conservation Science Western Australia*, *4*(3), 117-124

Giridhar, K. S., Prabhu, T. M., Singh, K. C., Nagabhushan, V., Thirumalesh, T., Rajeshwari, Y. B. and Umashankar, B. C. (2018). Nutritional potentialities of some tree leaves based on polyphenols and rumen in vitro gas production. *Veterinary World*, *11*(10), 1479.

Gwanzura, T., Ngambi, J.W. and Norris, D. (2011). Effects of Selected Legume Species and Forage Sorghum Hay Grown in Limpopo Province on Voluntary Intake and Relative Palatability Indices of Pedi Goats. *Asian Journal of Animal and Veterinary Advances, 6: 1249-1255.*

Kaushalendra, K. (2011). Evaluation of tannin degrading bacteria as probiotic in goats for better utilization of tree leaves.

Mahwasane, M. B. (2018). *Chemical composition, ruminal degradability and in vitro digestibility of dry matter and crude protein of dichrostachys cinerea and bauhinia thonningii leaves* (Doctoral dissertation).

Mangara, J. L. I. (2018). *Evaluation of the nutritive value of selected indigenous tree browses as feed for ruminant livestock in South Sudan* (Doctoral dissertation, Egerton University).

Mangara, J. L. I., Guliye, A. Y., Migwi, P. K. and Ondiek, J. O. (2017). Nutrient composition of selected indigenous tree browses in Central Equatoria State of the Republic of South Sudan. *Livestock Research for Rural Development*, *29*(4).

Melaku, S., Aregawi, T. and Nigatu, L. (2010). Chemical composition, in vitro dry matter digestibility and *in sacco* degradability of selected browse species used as animal feeds under semi-arid conditions in Northern Ethiopia. *Agroforestry Systems*, *80* (2), 173-184.

Menke, K. H. and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Anim Res Dev*. 28:7–55.

Mphinyane, W. N., Tacheba, G. and & Makore, J. (2015). Seasonal diet preference of cattle, sheep and goats grazing on the communal grazing rangeland in the Central District of Botswana. Afr. J. Agric. Res. Vol. 10(29), pp. 2791-2803

Ngwa, A. T., Nsahlai, I. V. and Bonsi, M. L. K. (2003). Feed intake and dietary preferences of sheep and goats offered hay and legume-tree pods in South Africa. Agrofor. Syst., 57: 29-37.

Norton, B. W. (1982). Differences between species in forage quality. In: Proceedings of international symposium held at St. Lucia, Queensland, Australia, 24–28 Sep 1981. Nutritional Limits to Animal Production from Pastures

Odedire, J. A. and Babayemi, O. J. (2008). Comparative studies on the yield and chemical composition of Panicum maximum and Andropogon gayanus as influenced by Tephrosia candida and Leucaena leucocephala. *Livestock Research for rural development*, *20*(2), 1-8.

Ondiek, J. O., Abdulrazak, S. A. and Njoka, E. N. (2010). Chemical and mineral composition, *in-vitro* gas production, *in-sacco* degradation of selected indigenous Kenyan browses. *Livestock Research for Rural Development*, *22*(2), 2010.

Osuga, I. M., Wambui, C. C., Abdulrazak, S. A., Ichinohe, T. and Fujihara, T. (2008): Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semi-arid area of Kenya. Animal Science Journal. Volume 79, pp. 582 – 589.

Ørskov, E. R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *The Journal of Agricultural Science*, *92*(2), 499-503.

Ramírez, R. G., Neira-Morales, R. R., Ledezma-Torres, R. A. and Garibaldi-González, C. A. (2000). Ruminal digestion characteristics and effective degradability of cell wall of browse species from northeastern Mexico. *Small Ruminant Research*, *36*(1), 49-55.

Rubanza, C. D. K., Shem, M. N., Otsyina, R., Ichinohe, T. and Fujihara, T. (2003). Nutritive evaluation of some browse tree legume foliages native to semi-arid areas in western Tanzania. *Asian-Australasian Journal of Animal Sciences*, *16*(10), 1429-1437.

Shenkute, B., Hassen, A., Assafa, T., Amen, N. and Ebro, A. (2012). Identification and nutritive vale of potential fodder trees and shrubs in the Mid Rift Valley of Ethiopia. Pakistan Agricultural Scientist's Forum.

Tibbo, M. (2000). Livestock production constraints in a M2-2 sub-agro ecological zone with special reference to goat production. In *The Opportunities and*

Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia from November (Vol. **10**, pp. 92-106).

Tilley, J. M. A. and Terry, D. R. (1963). A two-stage technique for the in vitro digestion of forage crops. *Grass and forage science*, ***18*** (2), 104-111.

Van Soest, P. J. (1994). Nutritional ecology of ruminants, 2nd eds. Cornell University Press, Ithaca and London.