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°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 Ramirez 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 content) 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 & Nambuye, 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 \( GP(t) = a + b(1 - e^{-ct}) \). 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≥ 0.05) and ether (p≥ 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.
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., 2010). 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 thomningii 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 thomningii 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...
**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 browse 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>
<thead>
<tr>
<th>Sample</th>
<th>Total Degradation (%)</th>
<th>Fermentation Characteristics</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>24 hrs</td>
<td>48 hrs</td>
</tr>
<tr>
<td><em>A. brevispica</em></td>
<td>30.91</td>
<td>35.45b</td>
</tr>
<tr>
<td><em>A. tortilis</em></td>
<td>56.79</td>
<td>25.81a</td>
</tr>
<tr>
<td><em>A. senegal</em></td>
<td>57.95</td>
<td>41.61b</td>
</tr>
<tr>
<td><em>A. nilotica</em></td>
<td>77.15</td>
<td>60.29b</td>
</tr>
<tr>
<td><em>A. mellifera</em></td>
<td>52.40</td>
<td>45.72b</td>
</tr>
<tr>
<td><strong>SEM</strong></td>
<td>±16.50</td>
<td>±12.78</td>
</tr>
</tbody>
</table>

SEM: Standard error of the Means

| A, B, C are constants in the equation (Örskov & McDonld, 1979)
| **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 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* spp had more than 50% OMD except for *A. tortilis* which may be attributed to the presence of antinutritional factors such as tannins, phenols and suppressant of digestion.

![Figure 1: In-vitro Dry Matter Degradability of Leaves for Selected Acacia Species.](image)

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


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).
