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Rumen Degradability of Dry Matter and Crude Protein of Diets Containing *Acacia Angustissima, Leucaena Trichandra* and *Calliandra Calothyrsus*

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Abstract:
Samples of browse legume diets Acacia angustissima (AA), Leucaena trichandra (LT) and Calliandra calothyrsus (CC) were evaluated for degradability using the nylon bag technique with three rumen-cannulated steers in order to determine dry matter (DM) and crude protein (CP) disappearance. The browse legumes were included in the diets at 30% and they were made isonitrogenous such that each diet contained 16% CP. A completely randomized design (CRD) was used in this trial. The nylon bags were sequentially added for 0, 12, 24, 48, 72 and 96 hours. The results showed that the A. angustissima diet had a significantly higher (P<0.05) effective degradability value (81.85%) for DM than the L. trichandra diet (73.15%) and C. calothyrsus (62.27%) diets at a k-value of 0.02. The effective degradability of CP of 56.5% for A. angustissima diet was significantly different (P<0.05) from L. trichandra (38.0 %) and C. calothyrsus (24.9%). Potential degradability of DM ranged from 61% (CC) to 82.4% (AA) while that for CP ranged from 25.2% (CC) to 57.12% (AA). The findings of this study showed that diets prepared using A. angustissima were more degradable than those from L. trichandra and C. calothyrsus possibly due to differences in tannin content. It is concluded that highly degradable diets can be formulated for small ruminants using browse legumes.

Keywords: *Degradability, dry matter, crude protein, nylon bag technique*

1. Introduction

A. angustissima (AA), *L. trichandra* (LT) and *C. calothyrsus* (CC) are browse legumes with potential to be used as protein supplements for small ruminants. Available data on the nutritional composition of the three legumes show that they are high in protein (more than 16%) as well as dry matter (88%) and hence can be used as supplements (Murungweni, 2000). Although the value of these browses as protein supplements has been investigated, there has been no assessment of their degradability at 30% substitution with cottonseed meal in goats. The value of a protein is based on the proportions of the protein that will be degraded in the rumen and that which will escape rumen fermentation and be digested post-ruminally (Aganga and Tshwenyane, 2003). This rumen degradable protein is what drives rumen microbial protein synthesis.

The ability of these browse legumes to be drought resistant, remain green and maintain a high crude protein value during the dry season (D'Mello, 1992) make them potential protein and energy supplements (Reed, Soller and Woodward, 1990). Aganga and Tshwenyane (2003) reported the use of leaves and twigs of trees as supplements to a wide range of forages and agricultural by-products in the diets of many ruminants in Botswana. Browse legumes provide high quality protein for utilization by rumen microbes to produce microbial protein. Microbial cells then pass to the post ruminal sites where they provide the major source of absorbed amino acids for the ruminant (D'Mello, 1992). In some cases, legumes provide by-pass proteins that are absorbed in the small intestines. According to Ahn, Robertson, Elliott, Gutteridge and Ford (1989) the microbial population in the rumen requires a minimum level of ammonia (70mgN/L) to support optimum activity and any lower values are associated with decreased microbial activity and indicate nitrogen deficiency hence feeds containing less than 8% crude protein are considered deficient. However, all browse legumes have crude protein content higher than this value.

Browse legumes contain tannins and this limits their use in feeding to ruminants (Bamualim et al., 1984; Barry et al., 1987; D'Mello, 1992). Pritchard, Stocks, O'Sullivan, Martin, Hurwood and O'Rourke (1988) showed that the feeding of polyethylene glycol (PEG) to

sheep fed *Acacia* markedly increased feed intake, weight gain and wool growth. The low quality of *Acacia* was therefore related to its high content of condensed tannins and their capacity to bind feed proteins and reduce degradability in the rumen as well as digestibility in the small intestines. In spite of the problems of tannins highlighted above, they have beneficial effects such as higher nitrogen retention in sheep and cattle leading to higher growth rates and milk yield when included in small quantities (4%) (D'Mello, 1992). The mechanism by which tannins benefit ruminants is by complexing with high quality dietary protein and reducing its degradability in the rumen hence providing by-pass protein, which is effectively digested in the small intestines (Reed, 1995).
The use of the nylon bag feed evaluation method developed by Ørskov and McDonald (1979) is an important tool in the measurement of the quality of ruminant feeds by ruminant nutritionists. The objective of this study therefore was to evaluate the degradation characteristics and effective degradability of the dry matter (DM) and crude protein (CP) contents of the browse legume diets.

2. Materials and Methods

2.1. Animals and Management

Three Friesian-Holstein steers fitted with rumen cannulae were fed on wheat straw basal diet, cottonseed meal and crushed maize before incubation of the bags. The steers' average weight was 500 ± 50kg. The diets were formulated as follows:

- Treatment 1: 53% Maize, 16% wheat straw and 30% *A. angustissima* and 1% cotton seed meal
- Treatment 2: 56% Maize, 12% wheat straw and 30% *L. trichandra* and 2% cotton seed meal
- Treatment 3: 57% Maize, 10% wheat straw and 30% *C. Calliandra* and 3% cotton seed meal

2.2. Design of Experiment and Measurement of Degradability

Rumen degradability was determined using the Nylon bag technique (Mehrez and Ørskov, 1977). Samples containing browse leaves, twigs and pods were collected from the International Centre for Research in Agroforestry, Domboshawa and air dried at the Department of Animal Science in Harare for a week and then milled through a 2mm screen. Five gram samples of each legume were placed into pre-weighed and marked nylon bags. The bags were incubated for 0; 12; 24; 48; 72; 96 hours using the sequential addition method. This method unlike the sequential removal method was chosen as it reduces disturbances to the already incubated bags. The experiment was done to determine the rumen degradation of DM and CP in a randomized complete block design with three replicates. Thus, each treatment had 3 bags by 6 incubation times by 3 steers. The incubation times were chosen such that they were representative of the low, medium and high feeding levels (Agricultural Food and Research Council, 1993). The bags were tied on corks and attached to rubber tubing. The other bags were then introduced through the rumen cannulae at the relevant times. All bags were removed at the same time and washed through using pressurized tap water to remove digesta. The bags were then stomachered to reduce microbial contamination from feed residues. The residues were then dried in an oven at 55ºC for 48 hours before weighing and nitrogen determination. The zero hour bags were not introduced into the rumen but underwent the same procedures as those removed from the rumen.

2.3. Measurements

DM and CP content were determined using the Kjeldahl method (AOAC, 1990). DM and CP losses were computed as the difference in weight between the pre-incubated and post-incubation samples and expressed as percent. Effective degradability (ED) of the examined nutrient components were calculated using the outflow rate of 0.02/hr, according to Ørskov et al. (1980) model.

2.4. Statistical Analysis

The DM and CP disappearance data were subjected to PROC NLIN procedure of SAS (1996) to derive the degradability constants. The degradability constants were fitted to the equation below and effective degradability was then calculated.

$P = a + bc / (c + k)$

Where P= Effective degradability at time t

- Rapidly soluble fraction;
- Amount that will degrade in time t;
- Fractional rate constant;
- k- Fractional outflow rate (2%/hr);

3. Results

The degradation of DM in the test browse legume diets differed significantly ($P < 0.05$) in their characteristics, disappearance rates and effective degradability after different incubation times as shown in Table 1. The immediately soluble fraction 'a' ranged from 24.12% in *C. calothyrsus* to 54.2% in *A. angustissima* legumes. The insoluble but rumen degradable fraction 'b' was least in *A. angustissima* 28.2%. This showed that its DM component was most readily soluble. A slow rate of degradation 'c' per hour of the rumen degradable fraction in *C. calothyrsus* (0.01) diets and *A. angustissima* (0.03) diets makes these diets potential sources of energy for rumen microbes. Figure 1 shows the fitted DM degradability curves of the diets. The potentially degradable fraction 'a + b' was significantly higher in *A. angustissima* ($P < 0.05$) than both *C. calothyrsus* and *L. trichandra* diets.

The CP degradation characteristics of the test diets are shown in Table 2. All parameters measured were significantly different (*P*<0.05). The readily soluble CP fraction 'a' was significantly more in *A. angustissima* legume with a value of 24.87% compared to 11.97% in *C. calothyrsus* diet. The rate of degradation 'c' of CP was fastest in *A. angustissima* while this was not significantly different between *L trichandra* and *C. calothyrsus* diets. At 48 hours CP disappearance for *A. angustissima* was significantly higher than the other two diets, a trend continued until 96hours. Figure 2 shows the fitted CP degradation curves of the test diets.

Diet	A/A	L /T	C/C	SEM
Degradation constant				
a (%)	54.20[a]	30.23[b]	24.12[c]	0.000
b (%)	28.20[a]	43.73[b]	36.88[c]	1.650
c (/hr)	0.03[a]	0.08[b]	0.01[c]	0.001
a+b (%)	82.40[a]	73.96[b]	61.00[c]	1.120
Effective degradability (%)	81.85[a]	73.15[b]	60.27[c]	0.080

Table 1: Rates and extent of rumen DM degradation of the browse legume diets
Significance level = 0.05

[a, b, c =] means within row with different superscripts are significantly different.
a-readily soluble fraction, b- insoluble fraction, c- rate of degradation of b per hour, a+b, potentially degradable fraction, SEM-standard error of mean. Effective degradability at 2% rumen fractional outflow rates.

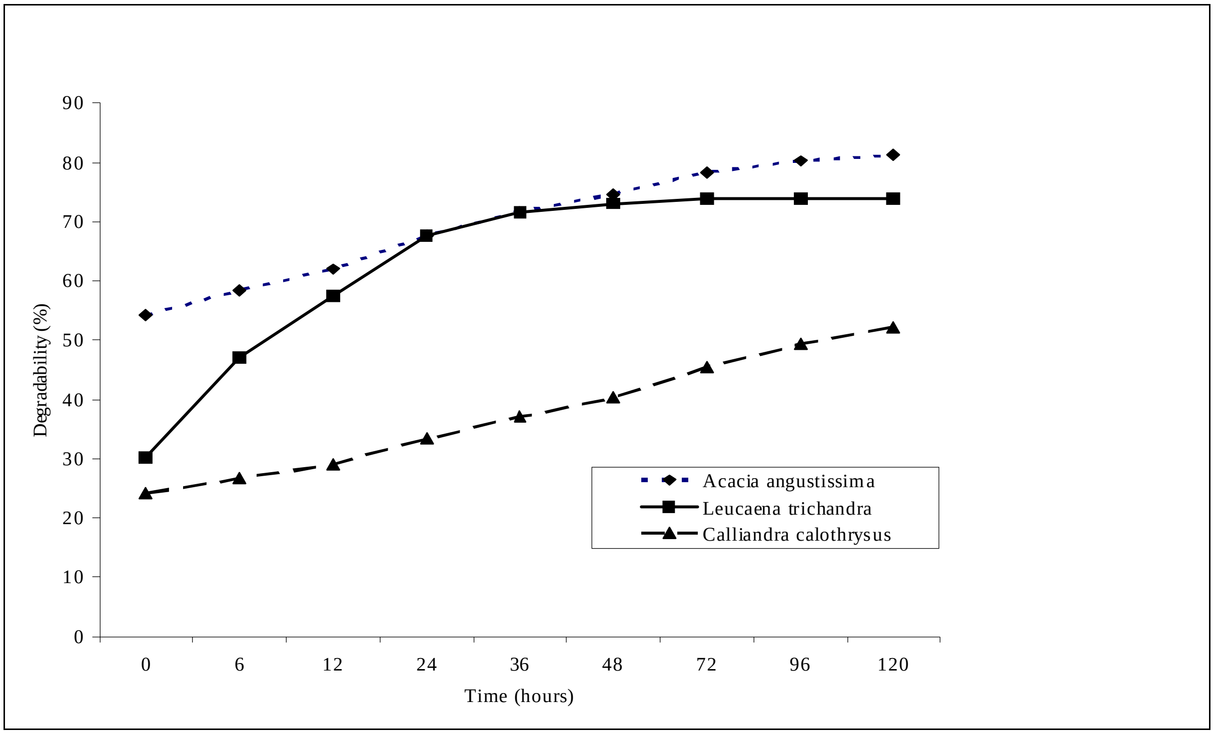

Figure 1: Fitted DM degradability curves for the browse legume diets

Diet	A/A	L /T	C/C	SEM
Degradation constant				
a (%)	24.87[a]	18.65[b]	11.97[c]	0.001
b (%)	32.25[a]	19.75[b]	13.23[c]	1.120
c (/hr)	0.05[a]	0.00[b]	0.02[c]	0.002
a+b (%)	57.12[a]	38.40[b]	25.20[c]	1.120
Effective degradability (%)	56.50[a]	38.01[b]	24.90[c]	0.480

Table 2: Rate and extent of rumen CP degradation of the browse legume diets
Significance level=0.05

[abc] = means within row with different superscripts are significantly different.
a-readily soluble fraction, b- insoluble fraction, c rate of degradation of b per hour, a+b, potentially degradable fraction, SEM-standard error of mean, *A/A- A. angustissima, L/T- L. trichandra, C/C- C. calothyrsus*

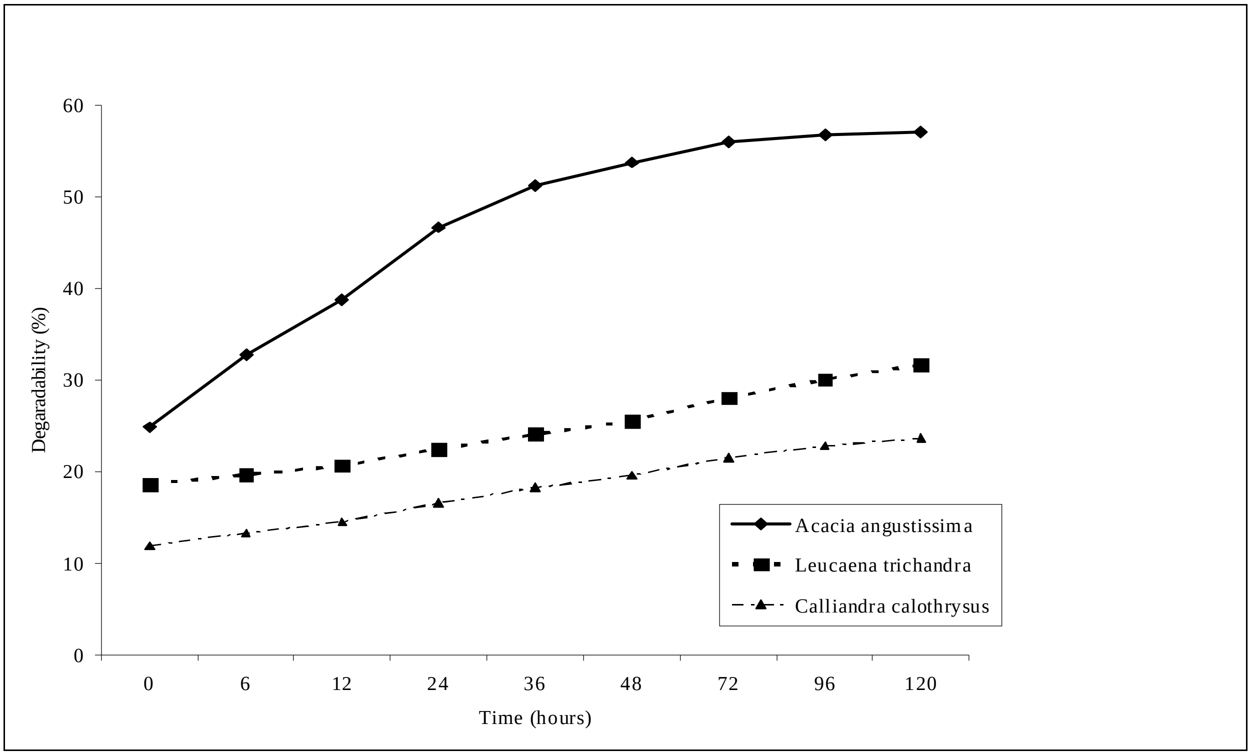

Figure 2: Fitted CP degradability curves for the browse legume diets

4. Discussion

Acacia angustissima had the highest immediately soluble fraction ‘a’ of DM showing that it has the potential for use as energy for microbial growth. Mupangwa, Ngongoni, Topps and Ndlovu (1997) observed effective degradability to decrease as the outflow rate increased. *Acacia angustissima* diet had the highest effective degradability when calculated using low outflow rates of 0.02. This is in agreement with Murungweni (2000) who observed that *A. angustissima* was more rumen degradable than *C. calothyrsus*. The disappearance of the DM contents of the diets by end of 48hours of incubation is generally considered to be equivalent to digestibility (Bhargava and Ørskov, 1987) and being the mean retention time of fibrous feeds was high. This information provides an insight into the level of rumen undegradable DM post 96 hours. The zero hour degradability could be misleading as some of the samples could have leaked during the washing of the bags instead of being degraded. This study showed that the prepared diets had DM disappearance values for 48hours, which rose above recommended 40-50%, (Preston, 1989).

The soluble DM contents of the diets indicate the potential of them being good sources of more nutrients for microbial growth (Djouvinov and Todorov, 1994), since Clark et al. (1992), Gomes et al. (1994) and Masama et al. (1997) reported a strong positive relationship between DM intake and microbial growth.

The effective degradability of CP followed a similar trend to that of dry matter although with lower values as previously reported by (Mgheni et al., 1996). The disappearance of the CP in all the diets increased with increasing incubation time. The release of energy should match the release of ammonia-N from dietary protein for effective microbial protein synthesis (Salter et al., 1979).

5. Conclusion

The diets showed potential as protein supplements and hence can be used to feed ruminants particularly during the dry season when feed is scarce and low in quality. *Acacia angustissima* diets were more degradable and hence are recommended to farmers at an inclusion level of 30% and can be considered when formulating strategies for feeding ruminants.

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