

**CHEMICAL COMPOSITION AND RUMEN DEGRADATION  
CHARACTERISTICS OF SIX *Calliandra calothyrsus* PROVENANCES**

**[COMPOSICIÓN QUÍMICA Y CARACTERÍSTICAS DE DEGRADACIÓN  
RUMINAL DE SEIS ACCESIONES DE *Calliandra calothyrsus*]**

J.N. Abia<sup>1</sup>, N.T. Ngongoni<sup>1</sup>, F. Gandiya<sup>1</sup>, L. Hove<sup>2</sup>, J.F. Mupangwa<sup>3</sup> and  
A. Sebata<sup>4\*</sup>

<sup>1</sup>Department of Animal Science, University of Zimbabwe,  
P.O. Box MP 167, Mt. Pleasant, Harare, Zimbabwe

<sup>2</sup>ICRAF, P.O. Box CY 594, Causeway, Harare, Zimbabwe

<sup>3</sup>Department of Agriculture, Bindura University of Science Education,  
P. Bag 1020, Bindura, Zimbabwe

<sup>4</sup>Department of Forest Resources & Wildlife Management,  
National University of Science & Technology,  
P. O. Box AC 939, Ascot, Bulawayo, Zimbabwe.

E-mail: allans20022002@yahoo.com

\*Corresponding author

**SUMMARY**

The chemical composition and rumen degradation characteristics of six *Calliandra calothyrsus* provenances were determined. The six provenances were selected on the basis of their good browse and seed production attributes under Zimbabwean conditions. The six provenances were: Oxford Forestry Institute (OFI) 9/89, OFI 10/91, OFI 11/91, OFI 12/91, OFI 23/91 and OFI 62/91. The nitrogen content of the provenances ranged from 27.15 to 32.51 g/kg DM with provenance 62/91 having the highest value while provenance 9/89 had the lowest value. The provenances differed in nitrogen content with 9/89, 10/91 and 23/91 being significantly different ( $P < 0.05$ ) from 12/91 and 62/91, while the acid detergent fibre and the neutral detergent fibre content showed significant differences between provenances 9/89, 62/91 and 11/91. The proanthocyanidins content of the provenances ranged from 29.3 g/kg DM to 56.0 g/kg DM with provenance 9/89 being significantly ( $P < 0.05$ ) different from the other provenances. The rumen dry matter degradability of the six *C. calothyrsus* provenances differed significantly ( $P < 0.05$ ) with provenances 9/89, 10/91, 12/91 and 62/91 having different quickly degradable fractions from provenances 11/91 and 23/91. The potential degradability ranged from 790.4 g/kg DM to 890.9 g/kg DM, with the rate of degradation varying from 0.002h<sup>-1</sup> in provenance 10/91 to 0.012h<sup>-1</sup> in provenance 12/91 while the effective degradability ranged from 250 to 411.1 g/kg (2% passage rate) and 203.3 to 308.4 g/kg (5% passage rate) and differed significantly. The nitrogen degradability of the six *C. calothyrsus* provenances also differed significantly ( $P <$

0.05). The quickly degradable fraction ranged from 195.8 g/kg N in provenance 62/91 to 235.0 g/kg N in provenance 23/91, while the potential degradability was between 782.2 g/kg N and 888.2 g/kg N. The rate of degradation varied from 0.005h<sup>-1</sup> in provenance 62/91 to 0.012h<sup>-1</sup> in provenance 10/91 with the effective degradability ranging from 195.6 to 399.3 g/kg (2% passage rate) and from 179.2 to 361.3 g/kg (5% passage rate). The six provenances had adequate nitrogen contents and were moderately degradable in the rumen suggesting that they were suitable for incorporation into ruminant diets as supplements to low quality forage. However, the high proanthocyanidin levels could affect their use by ruminants.

**Key words:** *Calliandra calothyrsus*, provenances, chemical composition, degradation

**RESUMEN**

Se estudió la composición química y degradación ruminal de seis accesiones de *Calliandra calothyrsus* que fueron seleccionada con base a sus atributos como forraje y producción de semilla en las condiciones de Zimbabwe. Las seis accesiones fueron: Oxford Forestry Institute (OFI) 9/89, OFI 10/91, OFI 11/91, OFI 12/91, OFI 23/91 y OFI 62/91. El contenido de N fluctuó de 27.2 a 32.5 g/Kg MS siendo la accesión 62/91 la de mayor contenido y la 9/89 la de menor valor. La fibra detergente ácida y neutra mostraron diferencias entre las accesiones 9/89, 62/91 y 11/91. El contenido de proantocianidina fluctuó de 29.3 a 56.0 g/kg MS siendo OFI 9/89 diferente ( $P < 0.05$ ). La degradación ruminal de 9/89, 10/91, 12/91 y 62/91 fue diferente en su fracción rápidamente degradable de

aquella obtenida con 11/91 y 23/91. La degradabilidad potencial fluctuó de 790.4 a 890.9 g/kg MS, con una tasa de degradación de 0.002h<sup>-1</sup> (OFI 10/91) a 0.012h<sup>-1</sup> (OFI 12/91), mientras que la degradabilidad efectiva fluctuó de 250 a 411.1 g/kg (2% tasa de pasaje) y de 203.3 a 308.4 g/kg (5% tasa de pasaje). La fracción rápidamente degradable del nitrógeno fluctuó de 195.8 g/kg N (OFI 62/91) a 235.0 g/kg N (OFI 23/91), mientras que la degradabilidad potencial varió de 782.2 g/kg N a 888.2 g/kg N. La tasa de degradación fluctuó de 0.005h<sup>-1</sup> (OFI 62/91) a 0.012h<sup>-1</sup> (OFI 10/91) con una degradabilidad efectiva de 195.6 a 399.3 (2% tasa de pasaje) y de 179.2 a 361.3 g/kg (5% tasa de pasaje). Las seis accesiones tuvieron contenidos adecuados de N y fueron moderadamente degradables en el rumen sugiriendo que son adecuadas para su incorporación como suplementos en la alimentación de rumiantes. Su alto contenido de proantocianidina podría limitar su uso.

**Palabras clave:** *Calliandra calothyrsus*, accesiones, composición química, degradación.

## INTRODUCTION

*Calliandra calothyrsus* (Meissn) is a shrub native to an extensive area of Central America, between 8-16°N in areas around Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama (Palmer and Schlink, 1992). In its native Central American habitat, it grows at altitudes from sea level to 1,860 m in areas where the annual precipitation ranges from 700 to 3,000 mm (Lowry and Macklin, 1989). The plant is not very drought tolerant although it is able to withstand dry periods (Palmer, Macqueen and Gutteridge, 1994). In humid climates, the tree is evergreen, whereas in areas with a long dry season it is semi-deciduous. Under severe drought conditions, the tree will die back but will generally recover after the onset of the rainy season. The common uses of *C. calothyrsus* include as firewood, animal fodder, for reforestation, soil stabilisation, soil improvement and minor secondary production (pulp and paper, honey and shellac, leaf meal) (Palmer, *et al.*, 1994). A number of provenances of *C. calothyrsus* have been evaluated and the Oxford Forestry Institute has made collections at over 40 sites from seven countries in Central America covering a large range of edaphic and climatic regimes (Macqueen, 1992).

*C. calothyrsus* (Meissn) is also currently being promoted by the Southern Africa Development Community- International Centre for Research in Agroforestry (SADC-ICRAF) as a fodder plant for livestock. In Zimbabwe fodder yields of between 2.3 and 4.3 tonnes of dry matter per hectare have been obtained with an average crude protein content of 176

g/kg DM (Dzowela, Hove, Topps and Mafongoya, 1995). In several experiments in Australia, *C. calothyrsus* has been shown to be highly palatable for both grazing and pen-fed animals (Palmer, *et al.*, 1994). Wiersum and Rika (1992) reported 22% crude protein, 30-70% fibre, 4-5% ash and 2-3% fat in dried leaves of *C. calothyrsus*. No toxic substances have been found but high concentrations of condensed tannins (up to 11%) have been reported (Ahn, Robertson, Elliott, Gutteridge and Ford, 1989). These levels may be responsible for the rather low (around 40%) *in sacco* degradabilities measured on oven-dried material in a number of experiments (Baggio and Hueveldop, 1984; Robertson, 1988). An advantage of the tannin is that it ensures protected (bypass) protein but high levels of tannin may reduce the digestibility of protein for livestock (Palmer, *et al.*, 1994). In feeding trials conducted in Indonesia with both goats and sheep, the *in vivo* estimates of digestibility were in the order of 60% (Mahyuddin, Little and Lowry, 1988). These data suggest that the nutritive value of *C. calothyrsus* is not yet fully understood, but the high digestibility of fresh material (60-80%) shows the potential of *C. calothyrsus* as a feed for browsing animals (Palmer and Schlink, 1992).

The objective of this study was to carry out a quantitative assessment of usable nutrients as well as to estimate the levels of condensed tannins (proanthocyanidins) in six provenances of *C. calothyrsus* selected on the basis of their good browse and seed production attributes under Zimbabwean conditions. The dry matter and nitrogen degradability was also estimated using the nylon bag technique.

## MATERIALS AND METHODS

### Chemical composition of six *Calliandra calothyrsus* provenances

#### *Source of C. calothyrsus provenances*

The leaf material of the six provenances was obtained from SADC-ICRAF research trial plots at Domboshava in Zimbabwe. The site is located 30 km north-east of Harare (17° 90' S, 31° 10' E) in Ecological Region 2b with an altitude of 1500m above sea level, a mean annual rainfall of 895 mm and mean annual temperature range of 15-20°C.

The six provenances were selected on the basis of their good browse and seed production under Zimbabwean conditions and these were Oxford Forestry Institute (OFI) 9/89 and OFI 10/91 (both originated in Guatemala), OFI 11/91 (originated in Nicaragua), OFI 12/91 and OFI 23/91 (both originated in Honduras) and OFI 62/91 (originated in Mexico). Leaves were harvested from three year old plants.

### Chemical analysis

Air-dried leaves were milled using a Willey mill through a 1 mm screen. Dry matter (DM) and organic matter (OM) were determined using the standard procedures (AOAC, 1990). The crude protein (CP) content was determined using the Kjeldahl procedure (AOAC, 1990) while the neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to the procedures of Goering and Van Soest (1970). Proanthocyanidins were estimated colorimetrically by the butanol-HCl method (Reed, Horvath, Allen and Van Soest, 1985).

### Statistical analysis

Analysis of variance was carried out to determine the differences among the provenances using the Proc GLM procedure of SAS (SAS, 1998). The model was,  $Y_{ijk} = \mu + P_i + e_{ijk}$ , where  $Y_{ijk}$  is the independent variable (e.g. nitrogen content),  $\mu$  is the overall mean,  $P_i$  is the fixed effect of the provenance and  $e_{ijk}$  is the random residual. A comparison of means was done using Tukey's studentized range test of SAS (1998).

### Rumen degradability of six *C. calothyrsus* provenances

#### Animals and Management

Three steers (Holstein x Mashona) weighing  $600 \pm 23$  kg each fitted with a rubber rumen cannula of 8.5 cm diameter, were used to determine the degradability profiles of the six *C. calothyrsus* provenances using the nylon bag technique (Mehrez and Ørskov, 1977; Bhargava and Ørskov, 1987). The steers were housed in individual pens and each given a basal diet of *Chloris gayana* cv. Katambora Rhodes grass hay supplemented with 2 kg of dry *C. calothyrsus*. The trial was carried out at Grasslands Research Station in Marondera which is 75 km east of Harare. The steers were fed for 14 days prior to the ruminal incubation of the nylon bags, to allow animal adaptation. Fresh water was always available from drinking troughs.

#### Incubation procedure

Air dried leaf material of the six provenances were milled through a 2mm screen and samples weighing approximately 3g placed in pre-weighed nylon bags of 9 x 13cm and pore size of 49 $\mu$ m (Polymon, Switzerland). The bags were incubated in the rumen of the three steers for periods of 0, 6, 12, 24, 48, 72, 96

and 120 hours. The incubation was carried out in two runs with 42 bags per steer per run. Six sample bags suspended on string were sequentially introduced into the rumen. All the sample bags were then removed at the same time at the end of the incubation period. After incubation the bags were washed under running cold tap water until the water was clear. The sample bags were then machine washed for 15 minutes. Microbes strongly attached to the residues were removed using a stomacher. The 0 hour measurement was obtained by soaking the bags in cold water for one hour. The bags were dried in an oven for 48 hours at 60 °C to constant weight to determine the dry matter content.

### Chemical analysis

The sample residues were analyzed for Kjeldahl-N according to standard procedures (AOAC, 1990).

### Statistical analysis

The non-linear model ( $P = a + b(1 - e^{-ct})$ ) (Ørskov and McDonald, 1979), where  $P$  is the dry matter or nitrogen degradation at time  $t$ ,  $a$  is the quickly degradable and soluble fraction (represented by the 0 hour samples),  $b$  is the slowly degradable fraction,  $c$  is the rate of degradation,  $t$  is the incubation time (hour) and  $e$  is the exponential constant, was used to describe the pattern of degradation of nitrogen and dry matter. The constants were fitted by an iterative least squares procedure (SAS, 1998). The effective degradability (ED) was calculated according to the model of Ørskov and McDonald (1979):  $ED = a + (bc / (c + k))$ , where  $k$  is the rumen fractional outflow rate: values of 0.02/hr and 0.05/hr for rumen outflow rate ( $k$ ) of supplement were assumed as they generally correspond to the passage rate of low and high producing ruminant animals.

Analysis of variance was carried out on the degradability and effective degradability data in a completely randomized block design using the General Linear Model Procedure (SAS 1998). The model was,  $Y_{ijk} = \mu + P_i + S_j + e_{ijk}$ , where  $Y_{ijk}$  is the observed dependent variable (DM or N degradation),  $\mu$  is the overall mean,  $P_i$  is the provenance effect,  $S_j$  is the steer effect and  $e_{ijk}$  is the random residual. A comparison of means was done using Tukey's studentized range test of SAS (1998).

## RESULTS

The chemical composition of six *C. calothyrsus* provenances are given in Table 1. The nitrogen content of the provenances ranged from 27.15 to 32.51 g/kg DM with provenance 62/91 having the highest value while provenance 9/89 had the lowest value. The provenances differed in nitrogen content with 9/89,

10/91 and 23/91 being significantly different ( $P < 0.05$ ) from 12/91 and 62/91, while the acid detergent fibre and the neutral detergent fibre content showed significant differences between provenances 9/89, 62/91 and 11/91. The proanthocyanidins content of the provenances ranged from 29.3 g/kg DM to 56.0 g/kg DM with provenance 9/89 being significantly ( $P < 0.05$ ) different from the other provenances.

### Dry matter degradability

The *in situ* dry matter degradability constants of six *C. calothyrsus* provenances are given in Table 2. The rumen dry matter degradability of the six *C. calothyrsus* provenances differed significantly ( $P < 0.05$ ) with provenances 9/89, 10/91, 12/91 and 62/91 having different quickly degradable fractions from provenances 11/91 and 23/91. The quickly degradable fraction ranged from 171 g/kg DM in provenance 11/91 to 238.3 g/kg DM in provenance 12/91. The potential degradability ranged from 790.4 g/kg DM to 890.9 g/kg DM. The rate of degradation varied from

0.002h<sup>-1</sup> in provenance 10/91 to 0.012h<sup>-1</sup> in provenance 12/91 while the effective degradability ranged from 250 to 411.1 g/kg (2% passage rate) and 203.3 to 308.4 g/kg (5% passage rate) and differed significantly ( $P < 0.05$ ).

### Nitrogen degradability

The *in situ* nitrogen degradability constants of the six *C. calothyrsus* provenances are given in Table 3. The nitrogen degradability of the six *C. calothyrsus* provenances differed significantly ( $P < 0.05$ ). The quickly degradable fraction ranged from 195.8 g/kg N in provenance 62/91 to 235.0 g/kg N in provenance 23/91, while the potential degradability was between 782.2 g/kg N for provenance 23/91 and 888.2 g/kg N for provenance 62/91. The rate of degradation varied from 0.005h<sup>-1</sup> in provenance 62/91 to 0.012h<sup>-1</sup> in provenance 10/91 with the effective degradability ranging from 195.6 to 399.3 g/kg (2% passage rate) and from 179.2 to 361.3 g/kg (5% passage rate).

Table 1. Chemical composition of six provenances of *Calliandra calothyrsus*

Provenance	DM (g)	g/kg DM						
		OM	N	ADF	NDF	ADIN	NDIN	PA
9/89	882.80	943.60	27.15 <sup>a</sup>	205 <sup>a</sup>	400 <sup>a</sup>	0.026 <sup>a</sup>	0.027 <sup>a</sup>	29.3 <sup>a</sup>
10/91	895.00	955.58	28.50 <sup>a</sup>	235 <sup>ab</sup>	410 <sup>a</sup>	0.024 <sup>a</sup>	0.032 <sup>b</sup>	46.2 <sup>b</sup>
11/91	878.55	940.18	29.64 <sup>ab</sup>	280 <sup>b</sup>	470 <sup>b</sup>	0.018 <sup>b</sup>	0.025 <sup>a</sup>	56.0 <sup>b</sup>
12/91	882.50	943.23	31.63 <sup>b</sup>	260 <sup>b</sup>	405 <sup>a</sup>	0.024 <sup>a</sup>	0.032 <sup>b</sup>	46.2 <sup>b</sup>
23/91	890.00	949.35	28.21 <sup>a</sup>	240 <sup>ab</sup>	465 <sup>b</sup>	0.021 <sup>b</sup>	0.025 <sup>a</sup>	54.1 <sup>b</sup>
62/91	883.60	944.45	32.51 <sup>b</sup>	200 <sup>a</sup>	405 <sup>a</sup>	0.026 <sup>a</sup>	0.028 <sup>a</sup>	50.7 <sup>b</sup>
s.e.	4.05	5.78	1.24	25.33	3.53	0.001	0.001	0.01

<sup>ab</sup>Means in the same column with different superscripts differed significantly ( $P < 0.05$ )

s.e. = standard error of the means, DM = dry matter, OM = organic matter, N = nitrogen, ADF = acid detergent fibre, NDF = neutral detergent fibre, ADIN = acid detergent insoluble nitrogen, NDIN = neutral detergent insoluble nitrogen, PA = proanthocyanidins

Table 2. Dry matter and effective rumen degradability (% of DM) of six *C. calothyrsus* provenances.

Constants	Provenances						s.e.
	9/89	10/91	11/91	12/91	23/91	62/91	
a	21.83 <sup>a</sup>	22.46 <sup>a</sup>	17.10 <sup>b</sup>	23.83 <sup>a</sup>	18.95 <sup>b</sup>	21.68 <sup>a</sup>	1.38
b	62.22 <sup>a</sup>	66.63 <sup>b</sup>	62.33 <sup>a</sup>	62.66 <sup>a</sup>	60.08 <sup>c</sup>	60.21 <sup>c</sup>	13.70
PD (a+b)	84.05	89.09	79.43	86.49	79.04	81.89	
c	0.003 <sup>a</sup>	0.002 <sup>a</sup>	0.010 <sup>b</sup>	0.012 <sup>b</sup>	0.010 <sup>b</sup>	0.003 <sup>a</sup>	0.0014
ED at							
k=0.02	41.11 <sup>a</sup>	37.88 <sup>a</sup>	nd	25.00 <sup>b</sup>	32.96 <sup>c</sup>	32.27 <sup>c</sup>	3.52
k=0.05	30.84 <sup>a</sup>	30.70 <sup>a</sup>	nd	20.33 <sup>b</sup>	28.87 <sup>c</sup>	26.29 <sup>c</sup>	2.21

<sup>ab</sup>Means in the same row with different superscripts differed significantly ( $P < 0.05$ )

nd = not determined, a = quickly degradable fraction (0 hr samples), b = slowly degradable fraction, c = rate of degradation, DM = dry matter, PD (a+b) = potential degradability, ED = effective degradability, k = rumen fractional outflow rate, s.e. = standard error of the means

Table 3. Nitrogen and effective degradability (% of N) of six *C. calothyrsus* provenances.

Constants	Provenances						s.e.
	9/89	10/91	11/91	12/91	23/91	62/91	
a	22.59 <sup>a</sup>	20.16 <sup>b</sup>	23.42 <sup>a</sup>	22.19 <sup>ab</sup>	23.50 <sup>a</sup>	19.58 <sup>b</sup>	1.13
b	61.41 <sup>a</sup>	64.35 <sup>a</sup>	nd	56.94 <sup>b</sup>	74.72 <sup>c</sup>	69.24 <sup>c</sup>	14.50
PD (a+b)	84.00	84.51	nd	79.13	78.22	88.82	
c	0.007 <sup>a</sup>	0.012 <sup>a</sup>	0.001 <sup>b</sup>	0.009 <sup>a</sup>	0.002 <sup>b</sup>	0.005 <sup>b</sup>	0.004
ED at							
k =0.02	39.93 <sup>a</sup>	30.85 <sup>b</sup>	nd	19.56 <sup>c</sup>	34.60 <sup>b</sup>	nd	7.81
k =0.05	29.33 <sup>a</sup>	26.83 <sup>a</sup>	nd	36.13 <sup>b</sup>	17.92 <sup>c</sup>	nd	6.13

<sup>ab</sup>Means in the same row with different superscripts differed significantly (P< 0.05)

nd = not determined, a = quickly degradable fraction (0 hour samples), b = slowly degradable fraction, c = rate of degradation, N = nitrogen, PD (a+b) = potential degradability, ED = effective degradability, k = rumen fractional outflow rate, s.e. = standard error of the means

## DISCUSSION

The nitrogen content of the air-dried leaves of the six provenances ranged from 27.2 g/kg DM to 32.8 g/kg DM. Values of 28 g/kg DM to 36 g/kg DM for leaves of *C. calothyrsus* provenances were reported by Perera, Perera and Gunesena (1996). Palmer and Ibrahim (1996) reported values of 49.4 g/kg DM to 64.96 g/kg DM while, Norton and Ahn (1997) obtained nitrogen levels of 27.7 g/kg DM (fresh leaves) and 24.4 g/kg DM (oven-dried leaves). The average nitrogen content reported by several authors is 36 g/kg DM (Ahn *et al.*, 1989; Kamatali, Teller, Vanbelle, Collignon and Foulon, 1992; Kaitho, Tamminga and Bruchem, 1993; Dzewela *et al.*, 1995; Perez-Maldonado and Norton, 1996; Salawu, Acamovic, Stewart and Maasdorp, 1997; Nherera, Ndlovu and Dzewela, 1998; Maasdorp, Muchenje and Titterton, 1999; Merkel, Pond, Burns and Fisher, 1999; Salawu, Acamovic, Stewart and Roothaert, 1999).

The nitrogen content of the six provenances was also above the minimal 12.8 g/kg DM considered to limit the intake of tropical forages (Minson, 1990), suggesting that the provenances will supply the required nitrogen to animals grazing poor quality native pasture during the dry season or stall fed animals on low quality cereal crop residues. The neutral detergent fibre content ranged from 400 g/kg DM to 470 g/kg DM, while the acid detergent fibre was between 200 g/kg DM and 280 g/kg DM. Norton and Ahn (1997) reported neutral detergent fibre contents of 302 g/kg DM (fresh leaves) and 395 g/kg DM (oven-dried leaves) with acid detergent fibre contents of 229 g/kg DM and 286 g/kg DM for fresh and oven dried leaves respectively. Mean neutral detergent fibre and acid detergent fibre contents of 418 g/kg DM and 235 g/kg DM respectively were reported by several authors (Ahn *et al.*, 1989; Kamatali *et al.*, 1992; Kaitho *et al.*, 1993; Dzewela *et al.*, 1995; Perez-

Maldonado and Norton, 1996; Salawu *et al.*, 1997; Nherera *et al.*, 1998; Maasdorp *et al.*, 1999; Merkel *et al.*, 1999; Salawu *et al.*, 1999). The proanthocyanidins content ranged from 29.3 g/kg DM for provenance 9/89 to 56.0 g/kg DM for provenance 11/91. Although provenance 9/89 had the lowest nitrogen content of 27.15 g/kg DM it also had a correspondingly low content of proanthocyanidins of 29.3 g/kg DM suggesting that it might be utilized by ruminants better than the other five provenances. Condensed tannin (proanthocyanidins) levels of between 15.4 and 47.1 g/kg DM have been reported by other workers (Ahn *et al.*, 1989; Perez-Maldonado and Norton, 1996).

The low effective nitrogen degradabilities of between 19.56% and 39.93% and 17.92% and 36.13% at rumen fractional outflow rates of 2% and 5% respectively are supported by the high concentrations of proanthocyanidins, which have been implicated in the low availability of nitrogen for ruminant use (Ahn *et al.*, 1989).

## CONCLUSION

It can be concluded from this study that the six provenances of *C. calothyrsus* had different nitrogen, neutral detergent fibre and acid detergent fibre contents. The high proanthocyanidins contents could impact negatively on availability of nitrogen for ruminant use.

## ACKNOWLEDGEMENTS

The authors would like to thank Grasslands Research Station for providing the experimental facilities and the animals. Assistance with research materials from the International Centre for Research in Agroforestry (ICRAF- Zimbabwe) is greatly appreciated. Financial support from the Belgian Administration Development Corporation (BADC) is acknowledged.

## REFERENCES

- Ahn, J.H., Robertson, B.M., Elliott, R., Gutteridge, R.C. and Ford, C.W. 1989. Quality assessment of tropical browse legumes: tannin content and protein degradation. *Animal Feed Science and Technology*. 27:147-156.
- A.O.A.C. (Association of Official Analytical Chemists) 1990. *Official Methods of Analysis*. 15<sup>th</sup> Edition. 2200 Wilson Boulevard, Arlington, Virginia 22201, USA.
- Baggio, A. and Heuvelod, J. 1984. Initial performance of *Calliandra calothyrsus* Meissn. in live fences for the production of biomass. *Agroforestry Systems*. 2:19-29.
- Bhargava, P.R. and Ørskov, E.R. 1987. (Eds). *Manual for the use of the nylon bag technique in the evaluation of feedstuffs*. The Rowett Research Institute, Aberdeen, UK: 1-20.
- Dzowela, B.H., Hove, L., Topps, J. H. and Mafongoya, P.L. 1995. Nutritional and anti-nutritional characters and rumen degradability of dry matter and nitrogen for some multipurpose tree species with potential for agroforestry in Zimbabwe. *Animal Feed Science and Technology*. 55:207-214.
- Goering, H. K. and Van Soest, P. J. 1970. Forage fibre analysis. *Agricultural handbook*, No. 379. United States Department of Agriculture: 4 – 6.
- Kaitho, R. J., Tamminga, S. and Bruchem, J. 1993. Rumen degradation and *in vivo* digestibility of dried *Calliandra calothyrsus* leaves. *Animal Feed Science and Technology* 43:19 – 30.
- Kamatani, P., Teller, E., Vanbelle, M., Collignon, G. and Foulon, M. 1992. *In situ* degradability of organic matter, crude protein and cell wall of various tree forages. *Animal Production* 55: 29 – 34.
- Lowry, J.B. and Macklin, W. 1989. *Calliandra calothyrsus* - an Indonesian favourite goes pan-tropic. NFT Highlights. 88-02. NFTA, Hawaii, USA.
- Maasdrop, B. V., Muchenje, V., Titterton, M. 1999. Palatability and effect on dairy cow milk yield of dried fodder from the forage trees *Acacia boliviana*, *Calliandra calothyrsus* and *Leucaena leucocephala*. *Animal Feed Science and Technology*. 77: 49 – 59.
- Macqueen, D.J. 1992. *Calliandra calothyrsus*: Implications of plant taxonomy, ecology and biology for seed collection. *Commonwealth Forestry Review*. 71: 20-34.
- Mahyuddin, P., Little, D.A. and Lowry, J.B. 1988. Drying treatment drastically affects feed evaluation and feed quality with certain tropical forage species. *Animal Feed Science and Technology*. 22: 69-78.
- Mehrez, A.Z. and Ørskov, E.R. 1977. A study of the artificial fibre bag technique for determining the degradability of feeds in the rumen. *Journal of Agricultural Science, Cambridge*. 88: 645- 650.
- Merkel, R. C., Pond, K. R., Burns, J. C., Fisher, D. S. 1999. Intake, digestibility and nitrogen utilization of three tropical tree legumes I. As sole feeds compared to *Asystasia intrusa* and *Brachiaria brizantha*. *Animal Feed Science and Technology* 82: 91 – 106.
- Minson, D.J. 1990. The chemical composition and nutritive value of tropical grasses. In: *Tropical Grasses*. Skerman, P.J and Riveros, F. (Eds), FAO, Rome, Italy:163-180.
- Nherera, F. V., Ndlovu, L. R. and Dzowela, B. H. 1998. Utilisation of *Leucaena diversifolia*, *Leucaena esculenta*, *Leucaena pallida* and *Calliandra calothyrsus* as nitrogen supplements for growing goats fed maize stover. *Animal Feed Science and Technology* 74:15 – 28.
- Norton, B.W. and Ahn, J.H. 1997. A comparison of fresh and dried *Calliandra calothyrsus* supplements for sheep given a basal diet of barley straw. *Journal of Agricultural Science, Cambridge*, 129: 485-494.
- Ørskov, E.R. and McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to the rate of passage. *Journal of Agricultural Science, Cambridge*. 92:499-503.
- Palmer, B. and Ibrahim, T. M. 1996. *Calliandra calothyrsus* forage for the tropics. A current assessment. In: *International workshop on the Genus Calliandra*. D.O. Evans (Eds) Borgor. Indonesia, Winrock International, Morrilton, USA: 183-194.

- Palmer, B., Macqueen, D.J. and Gutteridge R.C. 1994. *Calliandra calothyrsus* - a Multipurpose Tree Legume for Humid Locations. In Forage Legumes in Tropical Agriculture. R.C. Gutteridge and Shelton, H. M. (Eds). CSIRO Cunningham Laboratory 306 Carmody Rd, St Lucia Queensland 4067.
- Palmer, B. and Schlink, A.C. 1992. The effect of drying on the intake and rate of digestion of the shrub legume *Calliandra calothyrsus*. *Tropical Grasslands*. 26:89-93.
- Perera, A.N.F., Perera, E.R.K. and Gunesena, H.P.M. 1996. Nutritive value and degradation characteristics of *Calliandra calothyrsus* provenances. In: International Workshop on the Genus *Calliandra*. D. O. (Eds). Bogor, Indonesia, Winrock International, Morrilton, USA: 251-259.
- Perez-Maldonado, R. A. and Norton, B. W. 1996. The effects of condensed tannins from *Desmodium intortum* and *Calliandra calothyrsus* on protein and carbohydrate digestion in sheep and goats. *British Journal of Nutrition* 76: 515 – 533.
- Reed, J.D., Horvath, P.J., Allen, M.S and Van Soest, P.J. 1985. Gravimetric determination of soluble phenolics including tannins from leaves by precipitation with trivalent ytterbium. *Journal of Science, Food and Agriculture*. 36: 255-261.
- Robertson, B.M. 1988. The nutritive value of five browse legumes fed as supplements to goats offered as basal rice straw diet. Master of Agricultural Studies Thesis, The University of Queensland.
- Salawu, M. B., Acamovic, T., Stewart, C. S. and Roothaert, R. L. 1999. Composition and degradability of different fractions of *Calliandra* leaves, pods and seeds. *Animal Feed Science and Technology*. 77:181 – 199.
- Salawu, M. B., Acamovic, T., Stewart, C. S., Maasdorp, B. 1997. Assessment of the nutritive value of *Calliandra calothyrsus*: its chemical composition and the influence of tannins, piperolic acid and polyethylene glycol on *in vitro* organic matter digestibility. *Animal Feed Science and Technology* 69:207 – 217.
- SAS, 1998. Statistical Analysis System Institute Inc. SAS users guide: Statistics, Version, 3<sup>rd</sup> edition, SAS Institute Inc, Cary, NC,USA.
- Wiersum, K.F. and Rika, I.K. 1992. *Calliandra calothyrsus* Meissn. In: Plant Resources of Southeast Asia: 4 Forages. Westphal, E. and Jansen, P.C.M. (Eds), Pudoc Wageningen, Netherlands. 68-70.

*Submitted October 08, 2005 – Accepted April 07, 2006*  
*Revised received April 14, 2006*