Journal of Animal and Feed Sciences, 12, 2003, 341–349

Evaluation of the nutritive value of the browse species *Gliricidia sepium* (Jacq). Walp, *Leucaena leucocephala* (Lam.) de Wit. and *Cajanus cajan* (L.) Millsp from Nigeria

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(Received 1 July 2002; revised version 18 February 2003; accepted 4 April 2003)

ABSTRACT

The nutritive value of the leaves of three leguminous browse species (*Gliricidia sepium*, *Leucaena leucocephala* and *Cajanus cajan*) harvested from Nigeria was determined. *In vitro* gas production from incubation with rumen fluid, including the effect of polyethylene glycol (PEG) on gas production was used. Species had a significant effect on *in vitro* gas production with *G. sepium* producing the highest volume of gas. The addition of PEG caused a significant increase in the volume of gas produced by all three browse species ($P<0.01$), indicating that they all contain phenolic compounds which could have anti-nutritive properties. Measurements of *in sacco* DM degradability showed that 24 h rumen DM degradability for *G. sepium*, *L. leucocephala* and *C. cajan* is 62.86, 55.25 and 55.63%, respectively. *G. sepium* had statistically higher DM degradability ($P<0.01$). The results suggest that, among the compared species, *G. sepium* has the highest nutritive value and that *L. leucocephala* and *C. cajan* are of similar value.

KEY WORDS: browse, *in vitro* gas production, DM degradability, nutritive value, *G. sepium*, *L. leucocephala*, *C. cajan*

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INTRODUCTION

Maximum rumen fermentation rates are attained when all factors required by the rumen micro-organisms are available (mainly energy and nitrogen (N)). Low quality (high fibre and/or low N) roughage-based diets (hay and crop residues) are characterized by low intake and resulting in low animal growth rate. Supplements are required to correct these deficiencies. Most forage tree legumes have an N content higher than 1.3% (Norton, 1994) and supplementation of roughages alleviated N deficiency (Bonsi et al., 1995). The amount of foliage needed to provide effective supplementation varies with the quality of the basal diets, the rate of fermentation of the foliages (Umunna et al., 1995) and the level of animal production expected (Norton, 1994).

However, the potential uses of tree leaves as supplements to ruminants is often limited by the presence of anti-nutritional factors that might affect the availability of nutrients and feed intake (Norton, 1994; Bonsi et al., 1995). There have been several studies aimed at inactivating phenolic compounds in browse using polyethylene glycol (PEG). Increases in *in vitro* and *in vivo* digestibility of tannin rich feeds by the addition of PEG has been reported (Kumar and Vaithiyanathan, 1990).

The most important tree legumes in Nigeria are *Leucaena leucocephala* (Lam.) de Wit, *Gliricidia sepium* (Jacq). Walp and *Cajanus cajan* (L.) Millsp. These species have great potential as sources of rumen degradable nutrients for ruminants and are suitable as year round feed because of their drought resistance, persistence, vigorous growth, re-growth and relative high intakes (Reynolds and Atta-Krah, 1986). The nutrient content of these species has been studied previously (Adejumo, 1984; Odeyinka and Ademosun, 1993).

According to Ørskov (2000), feed evaluation is important to farmers in deciding which feeds to buy and for livestock planners to assess prospective production levels, to plan for food import and export strategies. *In vitro* methods for laboratory estimations and feed ruminal degradation are important tools for ruminant nutritionists. The *in vitro* gas test is extensively used for the estimation of *in vivo* digestibility and metabolizable energy for ruminants (Menke et al., 1979; Menke and Steingass, 1988). The gas test is of increasing interest because of the possibility of estimating the extent and rate of degradation in one sample by time series measurement of the accumulating gas volume (Blummel and ∅rskov, 1993).

The objectives of the study were to determine the nutritive value of the three browse species common to Nigeria using *in vitro* gas production and nylon bag degradability methods and to detect the presence or absence of anti-nutrients in the feed samples.

MATERIAL AND METHODS

Leaf material from the leguminous browse plants *G. sepium*, *L. leucocephala* and *C. cajan* were harvested in June 2000 at the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife in South Western Nigeria (coordinates 70° 28 N and 4° 33 E at an altitude of 240 m above sea level). The samples were oven dried at 70°C for 24 h and milled through either a 2.5 mm screen (for nylon bag degradability estimation) or a 1 mm screen (for *in vitro* gas production measurements).

In vitro gas production was measured using the method described by Blummel and Ørskov (1993) by incubating 200 mg of the forage samples with 30 ml buffer and rumen fluid and recording the volume of gas produced over time. Measurements were made after 3, 6, 10, 24, 48, 72 and 96 h of incubation. Analysis was carried out in triplicate in the presence and absence of 200 mg PEG, molecular weight 4000 (Sigma-Aldrich Company Ltd, Poole, Dorset, UK). The gas syringes were incubated by suspension from a rack fitted above a water bath. The rumen fluid was taken from two sheep, fitted with permanent rumen cannulae, receiving a diet of dried grass pellets and hay.

Estimations of rumen degradability were made using the nylon bag technique described by ∅rskov et al. (1980). The nylon bags used were 8 cm x 14 cm, 40 to 60 micron pore size (IFRU, The Macaulay Institute, Aberdeen, UK). Duplicate samples were incubated in 2 sheep receiving the same diet as above. The following incubation times were used: 4, 8, 16, 24, 48, 72, and 96 h.

The results of the experiments were analysed using “Fitcurve” macro (Chen, X.B., 1995. IFRU, The Macaulay Institute, Aberdeen, UK) for Microsoft Excel. The program is a utility for processing data of feed degradability or *in vitro* gas production. It fits the data to the exponential equation $p=a+b(1-e^{-ct})$ adapted by Ørskov and McDonald (1979). For degradability characteristics, p is the percentage degraded at time t, a is the intercept of the line at time zero (or the soluble fraction), b is the insoluble but degradable fraction, therefore a+b is the potential degradability and c is the rate of degradation of b. While this equation was originally developed for protein supplements in which the intercept was also an approximate expression of solubility, this is not the case for trees and shrubs due to the occurrence of a lag phase or a period in which there is no net disappearance of the insoluble but fermentable substrate (∅rskov and Ryle, 1990). Accordingly, A is solubility and small particle loss, B is the insoluble but fermentable fraction (B=(a+b)–A). For *in vitro* gas production, the data is fitted to the same equation, p is the volume of gas produced at time t, a is the intercept of the line at time zero, b is the potential gas production and c is the rate constant (∅rskov and Ryle, 1990).

The nitrogen (N) content of the tree leaves was determined by an automated Dumas combustion procedure (Pella and Colombo, 1973) using a Carlo Erba NA

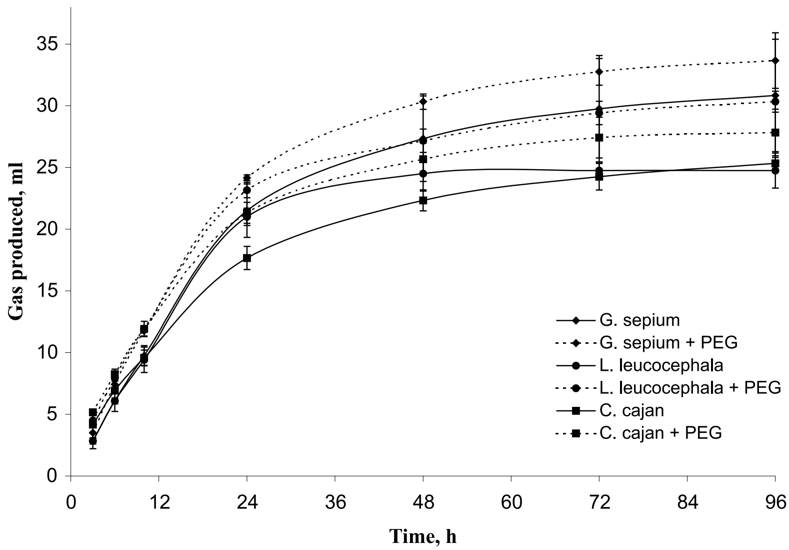

Figure 1. *In vitro* gas production by leaves of the browse species from Nigeria with or without PEG

1500 Elemental Analyser (Carlo Erba Instruments, Milan, Italy). The crude protein content was calculated by multiplying the total nitrogen value by 6.25.

The results were subjected to statistical analysis using GENSTAT 5 Release 4.1 software package. Analysis of variance was done to detect differences between treatments. Variations in each dependent variable were partitioned into 2 components: variations attributable to known (experimental factors and their interactions) and unknown (random error) components. Differences between treatments were analysed using means across replications. Least significant difference (LSD) test was used to compare treatment means.

RESULTS AND DISCUSSION

Figure 1 shows the gas produced over time with and without PEG for *G. sepium*, *L. leucocephala* and *C. cajan*, respectively. Table 1 summarises the gas production characteristics of the three browse species. Species had significant effect on gas production ($P<0.005$), with *G. sepium* producing the highest volume of gas and no significant difference in gas production between *L. leucocephala* and *C. cajan* (Table 2).

There was no increase in gas production by *L. leucocephala* after 48 h, which might be due to the reduction of cellulolytic activities by *L. leucocephala in vitro*. Digestibility *in vitro* is reportedly lowered by the reduction of the acti-

TABLE 1

In vitro gas production characteristics of the leaves of the browse species as described by $p = a + b\,(1-e^{-ct})$ (∅rskov and McDonald, 1979)

Species	a	b	c	RSD
G. sepium	-0.866	32.20	0.0444	0.865
G. sepium + PEG	-0.782	34.80	0.0479	0.767
L. leucocephala	-1.244	26.03	0.0630	1.585
L. leucocephala + PEG	-0.246	30.39	0.0548	0.747
C. cajan	0.390	24.78	0.0485	0.431
C. cajan + PEG	0.246	27.62	0.0576	0.432

a - intercept of line at time zero, b - potential gas production, c - rate of gas production

TABLE 2

In vitro gas production of the leaves of the browse species from Nigeria

Specie	Time, h						
	3	6	12	24	48	72	96
Gliricidia	2.84^{a}	6.09^{a}	9.76^{a}	21.52^{a}	27.36^{a}	29.78^{a}	30.86^{a}
Leucaena	2.84^{a}	6.09^{a}	9.76^{a}	21.02^{a}	24.52^{ab}	24.77^{b}	24.78^{b}
Cajanus	4.17^{b}	6.92^{b}	9.58^{a}	17.66^{b}	22.33^{b}	24.25^{b}	25.33^{b}
s.e.d	0.38	0.42	0.65	0.89	1.24	1.43	1.62

means with different superscripts along the same column are statistically different ($P<0.05$)

TABLE 3

Effect of PEG on *in vitro* gas production of the browse species from Nigeria

Time, h	Specie	Without PEG	With PEG	s.ed
3	*Gliricidia*	2.84^{a}	3.50^{b}	0.309
	Leucaena	2.84^{a}	4.50^{b}	
	Cajanus	4.17^{a}	5.17^{b}	
6	*Gliricidia*	6.09^{a}	7.92^{b}	0.345
	Leucaena	6.09^{a}	7.92^{b}	
	Cajanus	6.92^{a}	8.25^{b}	
12	*Gliricidia*	9.76^{a}	11.74^{b}	0.530
	Leucaena	9.76^{a}	11.74^{b}	
	Cajanus	9.58^{a}	11.92^{b}	
24	*Gliricidia*	21.52^{a}	24.15^{b}	0.726
	Leucaena	21.02^{a}	23.17^{b}	
	Cajanus	17.66^{a}	21.34^{b}	
48	*Gliricidia*	27.36^{a}	30.32^{b}	1.011
	Leucaena	24.52^{a}	27.17^{b}	
	Cajanus	22.33^{a}	25.67^{b}	
72	*Gliricidia*	29.78^{a}	32.73^{b}	1.167
	Leucaena	24.77^{a}	29.42^{b}	
	Cajanus	24.25^{a}	27.59^{b}	
96	*Gliricidia*	30.86^{a}	33.65^{b}	1.327
	Leucaena	24.78^{a}	30.34^{b}	
	Cajanus	25.33^{a}	27.84^{b}	

means with different superscripts for the same hour across the rows are significantly different ($P<0.01$)

TABLE 4

Degradation characteristics of the browse species from Nigeria as described by $p = a + b\ (1-e^{-ct})$ (Ørskov and McDonald, 1979)

Species	a	b	c	RSD	A	B	(A+B)
G. sepium	10.7	58.3	0.095	4.260	29.3	39.7	69.0
L. leucocephala	17.6	46.9	0.068	1.687	21.1	43.4	64.5
C. cajan	7.2	56.8	0.075	1.612	19.0	45.0	64.0

a - solubility and small particle loss, b - insoluble but fermentable fraction, c - rate of degradation of b, A - washing loss (%), B - degradation of water insoluble fraction (%), A+B - potential degradability (%)

TABLE 5

In sacco degradability of leaf samples from browse species from Nigeria

Species	Time, h						
	4	8	16	24	48	72	96
Gliricidia	31.41[a]	36.41[a]	60.86[a]	62.86[a]	64.70[a]	69.00[a]	69.08[a]
RSD	0.80	2.18	0.83	0.47	0.42	0.41	1.79
Leucaena	30.10[a]	34.67[a]	50.03[b]	55.25[b]	63.31[a]	63.36[b]	64.50[b]
RSD	0.37	1.24	1.38	2.29	0.20	0.12	0.28
Cajanus	23.28[b]	30.28[a]	47.63[b]	55.63[b]	62.09[a]	63.25[b]	64.02[b]
RSD	0.25	0.83	2.13	2.40	0.46	0.68	0.07

means with different superscripts in the same column are statistically different

vity of cellulolytic bacteria by mimosine and as such, *in vitro* digestibility of *L. leucocephala* is often underestimated by between 2 and 7% (Odeyinka and Ademosun, 1993).

The addition of PEG had significant effect on the volume of gas produced by all three browse species ($P<0.01$) (Figure 1) (Table 3). The higher volume of gas produced as a result of addition of PEG indicates the presence of phenolic compounds in the browse species (Tolera et al., 1997). Of the three species, *L. leucocephala* gave the greatest response to PEG followed by *G. sepium* and then *C. cajan*. The high response to PEG for *L. leucocephala* indicates that it contains a considerable amount of phenolic compounds. This is supported by the available literature; it is known that *L. leucocephala* and *G. sepium* contain condensed tannins (polyphenolic compounds) (D'Mello, 1992) and *C. cajan* contains phenolic acids (Nahar et al., 1990).

G. sepium had statistically higher potential DM degradability than *L. leucocephala* and *C. cajan* ($P<0.01$). Although not significant, *C. cajan* had the lowest potential degradability (Tables 4 and 5).

The ranking order of the species for potential degradability (a+b) is the same as that for the *in vitro* gas production. The correlation between 48 h DM degradability and 48 h *in vitro* gas production of the browse species was strong, ($R^2 = 0.805$, $y = 0.561x - 5.985$) although it was stronger at 96 h ($R^2 = 0.901$, $y = 1.249x - 51.105$).

Previous studies have shown a positive relationship between *in sacco* degradability and both voluntary intake and *in vivo* digestibility (Blummel and Ørskov, 1993; Kibon and Ørskov, 1993). The positive and significant correlation between *in sacco* degradability and *in vitro* gas data suggests that either method could be used to estimate nutritive value of such feeds (see also Blummel and ∅rskov, 1993).

The crude protein content of *G. sepium* was 24.56% of DM, *L. leucocephala* was 24.44% and *C. cajan* was 24.12%. The only significant difference in protein content was between *G. sepium* and *C. cajan* (P>0.05).

CONCLUSIONS

G. sepium, *L. leucocephala* and *C. cajan* from Nigeria are at least 64% degradable, they contain more than 24% crude protein and are useful as animal feeds. They are particularly useful as supplements to poor quality, low nitrogen crop residues. The results of the studies on *in vitro* gas production show that all three species contain some phenolic compounds, which may have anti-nutritive properties. According to their nutritive value estimated by these two methods, *G. sepium* has the highest value. *L. leucocephala* and *C. cajan* are of similar value.

ACKNOWLEDGEMENT

S.M. Odeyinka would like to thank the Stapledon Memorial Trust for sponsoring her stay at the Macaulay Institute to carry out this work. We thank Prof. Iain Gordon of the Macaulay Institute for his help in preparing the manuscript.

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STRESZCZENIE

Wartość pokarmowa liści młodych pędów i gałązek krzewów *Gliricidia sepium* (Jacq). Walp, *Leucaena leucocephala* (Lam.) de Wit. i *Cajanus cajan* (L.) Millsp z Nigerii

Oznaczono wartość pokarmową liści młodych pędów trzech gatunków strączkowych (*Gliricidia sepium* (Jacq). Walp, *Leucaena leucocephala* (Lam.) de Wit. i *Cajanus cajan* (L.) Millsp) pochodzących z Nigerii, stosując metodę *in vitro* oznaczenia produkcji gazu podczas ich inkubacji z płynem żwaczowym i uwzględniając wpływ glikolu polietylenowego (PEG) na produkcję gazu. Stwierdzono istotny wpływ gatunku roślin na produkcję gazu; największy był dla *G. sepium*. Dodatek PEG istotnie zwiększał objętość wytwarzanego gazu przez wszystkie trzy gatunki krzewów ($P<0,01$), co wskazuje, że wszystkie one zawierają składniki fenolowe, które mogą mieć antyodżywcze właściwości. Rozkład suchej masy (s.m.), oznaczony metodą *in sacco*, po 24 godz. wynosił 62,86; 55,25 i 55,63%, odpowiednio, dla *G. sepium*, *L. leucocephala* i *C. Cajan*. Rozkład s.m. *G. sepium* był istotnie ($P<0,01$) większy niż pozostałych gatunków.
Otrzymane wyniki wskazują, że wartość pokarmowa *G. sepium* była najwyższa, pozostałych gatunków podobna.