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A note on ruminal *in situ* degradability and *in vitro* gas production of some West African grass species and multipurpose legume tree leaves

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ABSTRACT

Samples of two grass species (*Pennisetum purpureum, Trypsacum laxum*) and four multipurpose tree leaves (*Leucaena leucocephala, Calliandra calothyrsus, Sesbania sesban, Gliricidia sepium*) from the Western Highland of Cameroon were tested using nylon bag and *in vitro* gas production techniques. The two grasses were of similar chemical composition and degradation characteristics. *Leucaena leucocephala* and *Sesbania sesban* had the highest potential *in sacco* degradability and *Calliandra calothyrsus* the lowest. Although the *in vitro* fermentation failed to rank the browse species in the same order, there was a high positive correlation ($r^2 = 0.74$) between the 48 h nylon bag degradation and the 48 h gas production. The *in vitro* degradation of *Calliandra calothyrsus* was unexpectedly low as compared to the *in sacco* potential degradability of the plant.

KEY WORDS: legume tree leaves, grass, *in sacco* degradability, *in vitro* gas production, West Africa

INTRODUCTION

A more efficient utilisation of locally available feed resources is one of the best solutions to poor ruminant nutrition in Tropical Africa. *Pennisetum purpureum* otherwise known as elephant grass or napier grass is the most widely used grass

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species in West Africa and constitutes the basis of ruminant diet in many parts of the world. Like many other tropical grasses, *Pennisetum purpureum* is poor in nitrogen and its nutritive value decreases very rapidly with the stage of harvesting. That is why Guatemala grass also known as *Trypsacum laxum* was introduced some years ago with a claim of its higher biomass production and higher nutritive value. Recently, some multipurpose legume trees were introduced from the International Livestock Research Institute, Kenya in an attempt to improve the productivity of the West African Dwarf goat. Preliminary feeding trials have shown that most of these browses were accepted by the animal, however, a great deal of information is needed to ensure an efficient utilisation of these feed supplements. The objective of this study was to investigate the potential of the locally produced grass species (*Pennisetum purpureum* and *Trypsacum laxum*) and multipurpose legume tree leaves (*Leucaena leucocephala, Sesbania sesban, Gliricidia sepium* and *Calliandra calothyrsus*) as feed for ruminants in general and the West African Dwarf goat in particular.

MATERIAL AND METHODS

Sample collection

Samples of grass species (*P. purpureum* and *T. laxum*) and leaves of browse trees (*Leucaena leucocephala, Sesbania sesban, Gliricidia sepium* and *Calliandra calothyrsus*) used in this study were collected from the University of Dschang experimental farm. Dschang is located in the Western Highlands of Cameroon at 1400 m above sea level, between the 5th and 8th degree north of the equator. The climate is characterised by a long rainy season from mid-March to mid-November and a short dry season from mid-November to mid-March. The average daily temperature is about 25°C and relative humidity is 75-90%. Large amounts of plant material from tested species were harvested for the regular feeding of animals on station and sub-samples were collected from bulked material for each species. These were oven dried at 45°C for 48 h and stored in sealed plastic bags. All samples were analysed for total Kjedahl-N (AOAC, 1980), dry matter (105°C for 24 h) and ash (500°C over night). Neutral detergent fibre (NDF) analysis was carried out according to Van Soest and Wine (1967).

In situ dry matter degradation

Each sample was ground using a hammer mill to pass a 2.5-mm screen. Three grams samples were weighed into nylon bags of the type previously described by Ørskov et al. (1980) and analysis was carried out according to Mehrez and Ørskov

(1977) using three rumen-cannulated sheep. The sheep were fed twice a day (9 a.m. and 4 p.m.) on a general-purpose diet made of chopped hay and cubed grass. For each plant species, one bag per animal was collected after 4, 8, 16, 24, 48, 72 and 96 h of incubation, thoroughly washed under running tap water until water coming out of the bag was colourless, then oven dried at 60°C for 48 h and weighed. Washing losses were determined by soaking the nylon bag with tested feed in duplicate, in cold water for 24 h and then washed and dried as described above.

In vitro gas production

About 200 mg of 1 mm milled sample were weighed into calibrated glass syringes (100 ml) in duplicate for each plant species. The pistons were lubricated with vaseline to ease their movement and prevent gas escape. Hay was used as standard. All syringes were pre-warmed overnight at 40°C. The rumen liquor obtained from two rumen cannulated sheep under the same feed regimen described above, was strained using gauze and added to a buffer solution in a 1:2 v/v ratio (Menke and Staingass, 1988) and 30 ml of the mixture injected into each syringe. Blank syringes containing exclusively the rumen liquor/buffer solution were included at the beginning and the end of the series. The syringes were then incubated in a water bath at 38.5°C and readings were recorded after 3, 6, 12, 24, 72 and 96 h of incubation. If gas production exceeded 50 ml, the piston was moved back to the 30-ml position.

Data analysis

The DM nylon bag degradation and cumulative gas production data were fitted to the equation $P = a + b\,(1-e^{-ct})$ of Ørskov and McDonald (1979) using the NEWAY software (Chen, 1997). Data were subjected to a single factor analysis of variance (Microsoft Excel, Version 5.0 for PC) and the least significant difference used for mean separation when applicable (Gomez and Gomez, 1984).

RESULTS

Chemical analysis

The chemical analysis of tested materials is given in Table 1. There were great variations among the plant species for OM, NDF and washing losses (WL) and N content. There was no species pattern for WL. The highest WL values were obtained for *Gliricidia sepium* and *Leucaena leucocephala* (46.6 and 41.1%, respectively) and the lowest for *Trypsacum laxum* and *Calliandra calothyrsus* (19.5 and 21.4%, respectively) *Pennisetum purpureum* and *Sesbania sesban* had intermediate values. The nitrogen content of legume tree species varied from 3.6 for *S. sesban* to 5.3% for *Leucaena leucocephala*. Grass species had lower N values than browses but their N contents were fairly comparable, about 2.1%. For the browse leaves, ash content of *Gliricidia sepium* was the highest (10.45% DM) and *Calliandra calothyrsus* the lowest (5.73% DM). The grass species, however, had higher ash content as compared to browses. The NDF values for grasses were above 60% while those of browses vary from 23 for *S. sesban* to 44% for *Calliandra calothyrsus*.

TABLE 1

OM, ash , N, NDF content and washing losses (WL) of two Cameroonian grass species and four multipurpose legume trees, %

Forage	Organic matter	Ash	N	NDF	Washing losses
Grasses					
Pennisetum purpureum	87.92	12.07	2.06	64.42	29.90
Trypsacum laxum	89.17	10.83	2.12	68.29	19.52
Browses					
Calliandra calothyrsus	94.27	5.73	4.49	44.03	21.38
Leucaena leucocephala	91.60	8.40	5.29	24.88	41.14
Gliricidia sepium	92.24	7.76	3.95	33.28	46.59
Sesbania sesban	89.55	10.45	3.58	23.14	31.89

Rumen dry matter degradation

The results of nylon bag dry matter disappearance of grasses and legume tree leaves and their degradation characteristics are given in Table 2. There were significant ($P<0.05$) variations in the degradation characteristics of feeds, browse leaves especially. Except for *Calliandra calothyrsus*, the browses ranked significantly ($P<0.01$) higher than grasses for DM disappearance at each incubation time. The highest rate constant was obtained with *Leucaena leucocephala* ($P<0.01$). The grass species and *Gliricidia sepium* were comparable for their potential degradability, but these were significantly ($P<0.01$) lower than that of *Leucaena leucocephala* and *Sesbania sesban*. All samples except *Calliandra calothyrsus* had a lag phase and the highest ($P<0.05$) was that of *Sesbania* while *Trypsacum laxum* had the lowest.

TABLE 2

In situ degradability of two Cameroonian grass species and four multipurpose legume tree leaves and their degradation characteristics obtained by fitting data to the equation $p = a + b\ (1 - e^{-ct})$

	Disappearance at each incubation time, h						a + b[1]	L	c	RSD
Forage	8	16	24	48	72	96	%h $^{-1}$	%h $^{-1}$	%h^{-1}	
Grasses										
P. purpureum	31.6^{d}	38.9^{c}	46.1^{c}	59.9^{d}	62.4^{d}	62.8^{d}	64.9^{bc}	1.4^{b}	0.0395^{d}	1.37^{c}
T. laxum	30.2^{d}	34.7^{d}	44.2^{c}	57.4^{d}	60.8^{d}	63.9^{d}	66.8^{b}	0.4^{c}	0.0303^{e}	0.40^{c}
Browse										
C. calothyrsus	35.3^{c}	36.5^{cd}	39.0^{d}	45.4^{e}	47.1^{e}	50.8^{e}	57.8^{c}	0.0^{c}	0.0131^{f}	0.89^{c}
L. leucocephala	57.7^{a}	73.5^{a}	78.7^{a}	79.5^{b}	82.3^{b}	82.4^{b}	82.0^{a}	1.3^{b}	0.0967^{b}	2.14^{b}
G. sepium	58.0^{a}	66.5^{b}	70.4^{b}	70.5^{c}	71.8^{c}	74.0^{c}	72.4^{b}	1.3^{b}	0.0971^{a}	1.34^{c}
S. sesban	46.4^{b}	71.5^{a}	79.2^{a}	85.2^{a}	87.1^{a}	88.8^{a}	88.1^{a}	2.1^{a}	0.0771^{c}	3.99^{a}
LSD, 5%	1.6	5.2	3.7	2.4	4.9	3.4	8.0	0.5	0.00010	1.04
,1%	2.3	7.3	5.3	3.3	6.8	4.8	11.3	0.8	0.00015	1.46

[-1] a + b is the potential degradability, L the lag time, c the rate constant and RSD the residual standard deviation for fitting DM degradation to the exponential equation $p = a + b\ (1 - e^{-ct})$

$^{a, b, c, d, e, f}$ – $P<0.05$

In vitro gas production

Table 3 summarises the cumulative *in vitro* gas production and the fermentation characteristics of the tested feeds. The grass species produced significantly ($P<0.05$) more gas than the browse leaves. Significant ($P<0.05$) variations were observed among browse leaves for fermentation characteristics. The highest gas production values ($P<0.05$) for browses were obtained with *Sesbania* and *Gliricidia*, and the lowest with *Calliandra*. Rate constant (c value) was highest for *Gliricidia* and lowest for *Calliandra* and the two grasses ($P<0.05$). The lag phase was significantly ($P<0.05$) the highest for grass samples. No lag phase was recorded for browse samples except *Leucaena leucocephala* (Table 3).

DISCUSSION

Wide variations were observed in the chemical composition of the samples, especially among browse species. This confirms an earlier report by Duguna et al. (1994) that multipurpose tree leaves vary widely in their chemical composition. AbdulRazak (1995) reported similar results on *Gliricidia sepium* and *Leucaena leucocephala*. The crude protein content of *Calliandra calothyrsus* was in the range of values reported by Salawu et al. (1999).

There were significant differences among browse samples for their *in vitro* fermentation and *in sacco* incubation characteristics. This is in agreement with previous reports on tropical browses (Keir et al., 1997; Apori et al., 1998; Nherera et al., 1998; Maasdorp et al., 1999). From a recent study, Maardorp et al. (1999) reported that *Leucaena* had lowest and *Calliandra* the highest content of soluble phenolics and fibre bound proanthocyanidins that are responsible for depression effect on rumen degradability of browses. Although the samples were not analysed for phenolic content, the poor performance of *Calliandra calothyrsus* in both *in sacco* and *in vitro* could probably be related to its high content of soluble phenolics (Maasdorp et al., 1999). The detrimental effect of high tannin levels on the degradability of *Calliandra calothyrsus* has also been mentioned by Nherera et al. (1998). However, our results contrasted with Salawu et al. (1999) who have reported higher values of the *in situ* DM degradability (values ranging from 697 to 883 g/kg). Mean values obtained for *in sacco* and *in vitro* gas production for *Gliricidia sepium* are similar to those reported by Keir et al. (1997). *Leucaena leucocephala* in our study produced almost twice as much gas after 96 h as the leaves used by these authors, although the *in sacco* degradation characteristics of this browse plant were similar in both studies. The reason for this difference is not clear. Although *Leucaena leucocephala* had one of the highest potential degradability, its *in vitro* gas production was lower than that of all other plant species

TABLE 3

Cumulative *in vitro* gas production (ml / 200 mg DM) of two Cameroonian grass species and four multipurpose legume tree leaves after 6, 12, 24, 48, 72 and 96 h incubation and the characteristics of fermentation obtained by fitting of 96 h incubation period to the equation $p = a + b\,(1 - e^{-ct})$

	Gas produced after, h					a + b[1]	c	RSD	L
Forage	12	24	48	72	96	$\%h^{-1}$	$\%h^{-1}$		$\%h^{-1}$
Grasses									
P. purpureum	10.17^{d}	19.67^{b}	30.00^{a}	33.83^{a}	36.00^{a}	31.1^{a}	0.0315^{d}	0.69	1.3^{a}
T. laxum	10.08^{d}	20.08^{b}	29.08^{ab}	33.33^{ab}	36.17^{a}	37.9^{a}	0.0314^{d}	0.72	1.2^{a}
Browse									
C. calothyrsus	5.50^{e}	8.33^{c}	13.00^{d}	14.67^{d}	16.00^{d}	17.1^{e}	0.0275^{d}	0.26	0.0^{c}
L. leucocephala	13.17^{c}	20.67^{b}	26.33^{b}	27.83^{c}	29.00^{b}	28.8^{d}	0.0519^{b}	0.40	0.4^{b}
G. sepium	17.83^{a}	25.00^{a}	29.33^{ab}	30.33^{bc}	31.00^{bc}	30.7^{cd}	0.0714^{a}	0.32	0.0^{c}
S. sesban	14.17^{b}	22.17^{b}	29.00^{a}	31.67^{ab}	33.50^{ab}	33.6^{bc}	0.0415^{c}	0.36	0.0^{c}
LSD, 5%	1.77	2.70	3.32	3.30	3.02	4.1	0.0594	NS	0.5
,1%	2.50	3.81	4.68	4.65	4.23	5.7	0.0080	–	0.8

[-1] a + b is the potential degradability, c the rate constant, L the lag phase and RSD the residual standard deviation for fitting the mean gas production to the exponential equation $p = a + b\,(1 - e^{-ct})$

[a, b, c, d, e] – $P<0.05$

except *Calliandra calothyrsus*. This relative decrease in the degradability of *Leucaena leucocephala* is probably related to the mimosine content of the plant. Apori et al. (1998) stated that the detrimental effect of mimosine on rumen microbes is more likely to occur *in vitro* because it is a closed system. The analysis of *in sacco* degradation should therefore take into account the dilution effect of the rumen and the fact that some ruminants are equipped with microbes capable of digesting mimosine (Jabbar et al., 1997). Values of potential degradability and rate constant of dry matter loss for *Trypsacum laxum* and *Pennisetum pupuereum* were lower than those reported by Shem et al. (1995). This difference may be related to the difference of age of harvest of the samples used in the two experiments. In general, the chemical composition and degradability of plant species are affected by soil fertility, stage of growth or age, and processing. There was a high positive correlation ($r^2 = 0.74$) between 48 h gas production and 48 h *in sacco* degradability of the feed, suggesting that both methods were adequate to estimate degradability of the grass and browse species tested.

A positive relation between *in vitro*, *in sacco* degradation characteristics and voluntary feed intake has been shown by Ørskov et al. (1988) and Blummel and Ørskov (1993). This suggests that both the grass and browse species used in this study except *Calliandra calothyrsus*, have a good potential for small ruminants feeding at the beginning of the dry season.

CONCLUSION

The *in sacco* DM degradation and *in vitro* gas production of *Pennisetum pupuereum, Trypsacum laxum* have shown comparative potential as small ruminants feed. On the basis of the results, it can be concluded that the exotic Guatemala grass (*Trypsacum laxum*) failed to show better performance than the endogenous graminea species *Pennisetum purpureum* (elephant grass).

From their degradation and fermentation characteristics, the leaves of *Leucaena leucocephala, Gliricidia sepium* and *Sesbania sesban* have a good potential as supplement for ruminant feeding.

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STRESZCZENIE

Rozkład w żwaczu i produkcja gazu *in vitro* przy inkubacji niektórych wschodnio-afrykańskich gatunków traw i liści drzew motylkowych

Oznaczono rozkład w żwaczu prób dwóch gatunków traw (*Pennisetum purpureum* i *Trypsacum faxum*) oraz liści czterech drzew motylkowych (*Leucaena leucocephala*, *Calliandra calothyrsus*, *Sesbania sesban* i *Glicridia sepium*), pochodzących z wschodniej górzystej części Kamerunu, przy zastosowaniu woreczków nylonowych oraz produkcji gazu *in vitro*.

Skład chemiczny obydwóch traw i stopień degradacji były podobne. Potencjalny rozkład w żwaczu *Leucaena leucocephala* i *Sesbania sesban był najwyższy*, a *Calliandra calothyrsus* – najniższy. Mimo, że w badaniach *in vitro*, w przypadku liści drzew, wartości były uszeregowane w innej kolejności, to korelacja pomiędzy wynikami 48 godzinnej degradacji w żwaczu i 48 godzinnej produkcji gazu była wysoka ($r^2 = 0,74$). Rozkład *in vitro Calliandra calothyrsus* był nieoczekiwanie niski w porównaniu z potencjalnym rozkładem *in sacco*.