
Ruminal degradability of mixtures of *Panicum maximum* and four forage legume hays in N'dama steer

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Abstract

This study was conducted to evaluate rumen degradability of *Panicum maximum* (*Panicum*) and *Labiab purpurens* (*lablab*), *Stylosanthes guianensis* (*styro*), *Centrosema pubescens* (*centro*) and *Aeschynomene histrix* (*histrix*) harvested from the paddock consisting of grass and herbaceous legumes. Mixtures of *P. maximum* (1.8g) and each of these legumes (1.2g) were weighed together and incubated in a cannulated steer. Rumen degradability of the *Panicum* and legume mixtures were studied at 0, 6, 12, 24, 48 and 72 hours using the equation $P = a + b(1 - e^{-ct})$. Average dry matter (DM) and crude protein (CP) of the herbaceous legumes were 37.83% DM and 19.86% CP, respectively. The soluble fraction, *a* of the DM degradation ranged from 23.34 to 31.43%, rumen degradable fraction, *b* ranged from 39.46 to 44.43% DM, disappearance rate of substrates *c* was highest in *lablab* (12.4%h⁻¹) and *styro* (10.2%h⁻¹). Protein degradation characteristics varied significantly ($P < 0.05$) among the treatments. Higher *b* Potential degradability PD and Effective degradability ED, fractions were observed in the sole legumes and grass legumes combinations than the sole grass. This study revealed that hay consisting of grass and legume mixtures was better degraded in terms of DM, CP and fiber fractions in the rumen compared to sole grass hay and this could translate to enhance performance of livestock when fed these mixtures.

Keyword: Degradability, Grass, Herbaceous legumes, *Panicum maximum*.

Introduction

Ruminant animals depend on forage to meet their dietary requirements for growth, maintenance and reproduction. The role of these forages in filling their bulk and supply nutrients to ruminants has been reported (Onwuka *et al.*,

1996). However, forage nutritive values fluctuate with seasons and the dry season is the most limiting in terms of nutrient supply to grazing ruminants and stall-fed animals. This scarcity and fluctuating quantity and quality of year round feed supply is one of the constraints limiting ruminant

livestock production in the tropical areas of Sub-sahara Africa. The uneven distribution of annual rainfall in most part of the tropics is responsible for the seasonal forage supply. This scarcity results to inadequate feed provision especially during the 5-7 months of dry season (Lamidi *et al.*, 1997) leading to low productivity in these animals (Steele, 1996).

Natural pastures are usually fibrous and devoid of essential nutrients required for increased rumen microbial fermentation which could improve the performance of ruminant livestock. Adegbola (1985) reported that ruminant animals can not meet their maintenance needs on grass alone, therefore, the use of improved pasture particularly those base on high yielding tropical legumes has been advocated as one of the ways of achieving year round quality forage (Makembe and Ndlovu, 1996). Herbaceous legumes contain high crude protein (15-30% DM), minerals and vitamins (Norton and Poppi, 1995) and have been identified as potential supplement for ruminant on grass based diet. Since protein is usually the most limiting nutrient in tropical diets, the use of legumes in livestock production system for ruminants has increased. Herbaceous legumes can be grazed, harvested and freshly fed to animals, or stored as hay or silage (Harricharan *et al.*, 1988). A sustainable way of improving the feeding value of poor quality pastures is through supplementation with forage legumes (Ajayi *et al.*, 2008).

Several assessments of the nutritive value of tropical forages through the *in sacco* method have been carried out by researchers. These include tree legumes like *Ficus capensis* (Smith

et al., 1995), *Milletia thonning* and *Albizia lebbek* (Larbi *et al.*, 1996). Grasses such as *Panicum maximum* and *Pennisetum purpureum* (Mgheni *et al.*, 1996) and herbaceous legumes like *Pueraria phaseoloides* and *Neonotonia wightii* (Mgheni *et al.*, 1996), *Macroptilium lathyroids*, *Centrosema tubescens*, *Leucaena leucocephala*, *Macroptilium atropurpureum* (Odeyinka *et al.*, 2004). Assessment of some crop residues and Agricultural by products (Smith *et al.*, 1989).

Information on rumen degradability characteristic of grass and legume forages used for livestock feeding is scanty. This study was designed to determine the dry matter, crude protein and fiber fraction degradability of *Panicum maximum* and four forage legume hays in N'Dama steer.

Materials and Methods

Study Area

This study was carried out at the Dairy unit of the Institute of Agricultural Research and Training, Ibadan, Nigeria (Latitude 7°15-7°30N and Longitude 3°45-4°E) between March and October in 2004 and 2005. The area has a humid climate, the mean annual rainfall during the experimental period were 805mm and 1350mm for 2004 and 2005, respectively. The mean monthly temperature was 31°C for each year.

Forage sampling and preservation

The *Panicum maximum* and each of the forage legumes were harvested manually at four weeks interval for six months (May-October). Three quadrants were thrown at random and sample in it collected. The grass and legumes were cut with

sharp-knife at 5cm above ground level. Sub-sample of each harvest was oven dried at 105°C. The dried sub-samples were pooled together and milled using 1mm sieve with Thompson hammer mill for proximate analysis and mineral assay. The grass and legumes were spread out and sun-dried for six to seven hours daily on the field on sunny days and allowed to aerate inside the farm house when it rained. Turning over of the forage during drying was done thrice daily; moisture content determination was done in the laboratory until the value was reduced to 20%.

Animal Management

An N'dama steer weighing 250 kg liveweight and which was fitted with permanent rumen cannula was used to study the degradation characteristics of the forage mixtures, sole legumes and grass. The steer was allowed an adjustment period of two weeks during which prophylactic treatments consisting of antibiotic, vitamin and anti-helminthes injections were administration at 1m/10kg body weight. The steer was fed 10kg of *P. maximum* and 2kg of concentrate consisting of 14% in crude protein (CP) and 2,700 kcal in metabolizable energy. Clean water was given every morning.

The pen was cleaned every morning and wood shavings spread on the floor as bedding.

Ruminal Degradation of Forages

Approximately 3g consisting of 1.8g of *P. maximum* and 1.2g of each legume were weighed together into the nylon bags and incubated in the rumen of the steer. Approximately 3g sample of each of the *P. maximum*, Histris, Centro, Stylo and Lablab was weighed into the nylon bags

which measured 5.5cm x 13.0cm in size with pore size of 41 microns. The Dacron bags containing the samples were incubated randomly in duplicates in the rumen of the steer for 6, 12, 24, 36, 48, 72 and 96 hours (Orskov *et al.*, 1983 and Orskov *et al.*, 1988). The experiment was conducted three times because of the constraint in the use of fistulated animal. There were six replicates per treatment. Bags were withdrawn by method of sequential addition (Osuji *et al.*, 1993).

The bags were then washed in cold running water until the rinsed water became clear. The samples obtained were oven dried at 105°C. Washing losses were determined by weighing 3g of each sample in the nylon bags in triplicate and soaked in warm water in a water bath at 37°C for one hour. The samples were washed and oven dried at 105°C. The exponential equation $PD = a + b(1 - e^{-ct})$ (Orskov and McDonald, 1979) was used to describe the samples.

PD is the potential degradability of the substrate, *a* represents immediately soluble fraction of nutrient, *b* is insoluble but rumen degradable fraction, *c* is the rate of degradation of *b* at time *t*. *ED* is effective degradation calculated from the curve (Orskov *et al.*, 1980) and considering a rate of passage of 3% h⁻¹.

Chemical Analysis

Dried and ground samples of forages before and after incubation were analyzed for dry matter, crude protein, NDF, ADF, ADL, ether extract and ash determinations according to AOAC (1990) methods. Samples were analyzed in duplicates. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL)

were determined according to Van Soest and Robertson (1985) methods.

Statistical Analysis

Data obtained were analyzed by ANOVA and significant differences between means were compared using Duncan (Duncan 1955) multiple range test with the aid of SAS/STAT program (SAS, 1988).

Results and Discussion

The values of proximate composition of *P. maximum* and forage legumes differed significantly ($P < 0.05$) (Table 1). Among the legumes, Histrix had the highest value of DM (42.02%) and was lowest in ash content (1.82%). Lablab CP and ash content values were highest (23.29% and 3.96%, respectively) compared to the other legumes. Panicum had the least DM (28.29%), CP (7.63%) and Ether extract (EE) (4.71%). Centro had the highest value of EE (9.30%). The CP content of Lablab, Centro and Histrix obtained in this study are comparable to 21.08 %, 18.97 % and 20.13 % for Lablab, Centro and Histrix respectively (Nworgu and Ajayi, 2005, Babayemi *et al.*, 2006). Higher CP

was observed in Stylo compared to 12.10% reported (Bamikole *et al.*, 2004). The CP of Panicum obtained is similar to 8.50% cited by Arigbede *et al.*, (2005).

The DM degradability value of the soluble fraction, *a*, differed ($P < 0.05$) among the treatments (Table 2). The value obtained ranged from 21.19% in Panicum and Centro mixture to 27.22% in Panicum and Lablab mixture. Among the legumes, *b* ranged from 39.46% in Lablab to 44.43% in Histrix. The potential degradability (PD) ranged from 66.77% in Histrix to 71.59% in Stylo. Panicum had the least of values of degradation characteristics recorded. The values of *a* (21.19% - 31.43%) for DM degradation was higher than value of 2.1 - 26.2% reported (Odeyinka *et al.*, 2004) for tropical seeds. The *b* fraction represents the diet that potentially may escape rumen degradation but absorbed in the rumen (NRC, 1985). The *b* values obtained in this study are comparable with 7.12 - 11.5% reported (Odeyinka *et al.*, 2004). The lower *b* values obtained are an indication of the fibrous nature of the feedstuffs incubated. The rates of degradation, *c* values obtained (2.9 - 12.4%/h) are lower than values cited by Ajayi *et al.* (2007)

Table 1: Proximate composition (%) of *P. maximum* with four Krug legumes

Forage	Dry matter	Crude protein	NDF	ADF	ADL	Ash	EE	NFE
<i>Lablab purpureus</i>	36.41 ^a	23.29 ^a	64.28 ^a	39.14 ^a	9.67 ^a	3.96 ^a	8.51 ^a	17.22 ^a
<i>Aeschynomene histrix</i>	42.02 ^b	21.40 ^b	50.66 ^b	28.52 ^b	6.20 ^b	1.52 ^b	7.68 ^b	16.90 ^b
<i>Centrosema pubescens</i>	38.74 ^c	16.71 ^b	55.06 ^b	29.87 ^b	8.81 ^b	3.40 ^b	9.30 ^b	24.33 ^b
<i>Stylosanthes guianensis</i>	34.16 ^d	18.05 ^c	61.80 ^b	31.46 ^b	7.71 ^c	2.87 ^b	7.90 ^b	27.88 ^b
<i>Panicum maximum</i>	28.29 ^e	7.63 ^c	57.35 ^c	27.40 ^c	8.14 ^c	1.84 ^c	5.78 ^c	41.67 ^c
SEM	1.82	1.16	3.24	1.44		0.66	0.34	2.04

^{abc} - Means in the same column with different superscripts differ significantly ($P < 0.05$). NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, EE = Ether extract, NFE = Nitrogen free extract, SEM = standard error of the mean.

Table 2: Dry matter degradability characteristics (%) of *P. maximum* and mixtures of *P. maximum* and four forage legumes

Forage	Degradation characteristics (%)				
	a	b	c (h ⁻¹)	PD	ED
Panicum/Stylo mixture	24.16 ^a	42.25 ^{ab}	0.068 ^c	66.41 ^b	35.0 ^c
Panicum/Histrix mixture	25.17 ^{ab}	41.46 ^{ab}	0.041 ^{ab}	66.63 ^b	34.0 ^c
Panicum/Centro mixture	27.22 ^a	43.48 ^a	0.058 ^b	70.70 ^a	41.5 ^b
Panicum/Lablab mixture	21.19 ^a	39.11 ^b	0.094 ^c	60.30 ^c	32.0 ^d
<i>Panicum maximum</i>	25.24 ^{ab}	30.79 ^c	0.029 ^a	56.03 ^c	30.0 ^d
<i>Aeschynomene histrix</i>	22.34 ^a	44.43 ^a	0.071 ^c	66.77 ^b	42.0 ^{ab}
<i>Stylosanthes grahamensis</i>	29.07 ^{ab}	42.52 ^{ab}	0.102 ^d	71.59 ^a	44.5 ^{ab}
<i>Lablab purpureus</i>	31.43 ^b	39.46 ^b	0.124 ^d	70.89 ^a	50.5 ^a
<i>Centrosema pubescens</i>	28.48 ^{ab}	43.07 ^a	0.064 ^c	71.55 ^a	40.0 ^{ab}
SEM	0.92	0.55	0.03	0.87	3.02

^{abc} = Means in the same column with different superscripts differ significantly (P<0.05)

a = Soluble fraction, b = Insoluble but degradable fraction.

c = rate of degradation of b, PD = Potential degradability,

ED = Effective degradability. SEM = standard error of the mean.

for grass/legume mixture and sole legume and grass. The *PD* values of 56.03 - 71.59% obtained in this study were higher than values reported (Ajayi *et al.*, 2007). The variation could be as a result of the population of rumen microbes in the steer during the study since similar harvesting age was used for the forages incubated. The values of effective degradation (*ED*) obtained was within the range of 36.0 - 44.5% cited by Ajayi *et al.*, (2007). The CP degradability values differed significantly (P<0.05) among the treatments (Table 3). Panicum and Centro mixture had the highest degradation characteristics among the grass/legume mixtures considered in this study. Among the sole legumes, Lablab was highest in *b* (51.11%), *c* (21.0% h⁻¹) and *PD* (63.95%). Similarity (P>0.05) existed in the *ED* of the sole legumes. Panicum had the least values recorded for degradation characteristics of the forages. The higher rate of

degradation observed in the legumes was due to the lower fiber contents and high digestible nature of the legumes. The *PD* values of 47.62 - 63.95 % were lower than 76.8 - 82.4% reported by Bamikole *et al.*, (2004). There were no significant differences (P>0.05) in the *ED* values for the mixtures and sole legume. Among the legumes, the *ED* value ranges from 48.2% in Centro to 49.5% in Stylo. The highest *ED* value in the mixture was observed in Panicum and Centro mixture (41.5%) while sole Panicum had the least *ED* value. The *ED* of protein is an estimate of the total amount of nitrogen captured and utilized by the rumen microbiota for growth and synthesis of microbial protein (AFRC, 1993).

The degradation characteristics of neutral detergent fibre (NDF) of *P. maximum* with four herbaceous legumes differed significantly (P<0.05) among the treatments. (Table 4). Panicum and Histrix mixture gave the highest

Table 3: Protein degradability characteristics (%) of *P. maximum* and mixtures of *P. maximum* and four forage legumes

Forage	Degradation characteristics (%)				
	a	b	c (h ⁻¹)	PD	ED
Panicum/Stylo mixture	13.24 ^c	47.15 ^b	0.070 ^b	60.39 ^b	40.0 ^b
Panicum/Histrix mixture	12.72 ^b	44.96 ^{ab}	0.062 ^b	57.68 ^c	39.5 ^b
Panicum/Lablab mixture	12.96 ^{bc}	46.29 ^b	0.067 ^b	59.25 ^c	40.0 ^b
Panicum/Centro mixture	13.38 ^c	48.86 ^c	0.074 ^{bc}	62.24 ^{ab}	41.5 ^b
<i>Panicum maximum</i>	7.76 ^a	39.86 ^a	0.040 ^a	47.62 ^d	36.0 ^a
<i>Aeschynomene histrix</i>	12.72 ^b	48.86 ^c	0.131 ^c	61.58 ^{ab}	48.5 ^c
<i>Stylosanthes guianensis</i>	13.72 ^b	49.52 ^{cd}	0.184 ^c	62.99 ^a	49.5 ^c
<i>Lablab purpureus</i>	12.84 ^b	51.11 ^d	0.210 ^d	63.95 ^a	48.2 ^c
<i>Centrosema pubescens</i>	13.38 ^c	48.092 ^c	0.160 ^c	62.30 ^{ab}	48.2 ^c
SEM	0.34	1.08	0.15	1.85	0.78

^{abcd} = Means in the same column with different superscripts differ significantly (P<0.05)
a = Soluble fraction, b = Insoluble but degradable fraction,
c = rate of degradation of b, PD = Potential degradability,
ED = Effective degradability. SEM = standard error of the mean.

Table 4: Neutral detergent fibre characteristics (%) of *P. maximum* and mixtures of *P. maximum* and four forage legumes

Forage	Degradation characteristics (%)				
	a	b	c (h ⁻¹)	PD	ED
Panicum/Stylo mixture	24.16 ^a	38.56 ^b	0.082 ^{bc}	62.72 ^{ab}	52.50 ^a
Panicum/Centro mixture	25.17 ^{abc}	39.74 ^{ab}	0.065 ^{ab}	64.91 ^{ab}	55.50 ^{ab}
Panicum/Histrix mixture	27.22 ^c	41.80 ^{ab}	0.072 ^b	69.02 ^c	54.00 ^{ab}
Panicum/Lablab mixture	21.19 ^a	39.64 ^{ab}	0.041 ^a	60.83 ^a	57.00 ^c
<i>Panicum maximum</i>	25.24 ^{abc}	37.85 ^b	0.060 ^{ab}	63.09 ^{ab}	53.00 ^a
<i>Aeschynomene histrix</i>	29.07 ^{cd}	44.48 ^a	0.085 ^{bc}	73.55 ^c	58.50 ^c
<i>Stylosanthes guianensis</i>	22.34 ^a	42.60 ^{ab}	0.091 ^c	64.94 ^{ab}	58.60 ^c
<i>Lablab purpureus</i>	31.43 ^d	46.18 ^a	0.101 ^d	77.61 ^d	60.44 ^d
<i>Centrosema pubescens</i>	28.48 ^{cd}	40.81 ^{ab}	0.093 ^c	69.29 ^b	55.78 ^{ab}
SEM	0.92	1.94	0.01	2.65	1.53

^{abc} = Means in the same column with different superscripts differ significantly (P<0.05)
a = Soluble fraction, b = Insoluble but degradable fraction,
c = rate of degradation of b, PD = Potential degradability,
ED = Effective degradability. SEM = standard error of the mean.

Table 5: Acid detergent fibre characteristics (%) of *P. maximum* and mixtures of *P. maximum* and four forage legumes

Forage	Degradation characteristics (%)				
	a	b	c (h ⁻¹)	PD	ED
Panicum/Stylo mixture	22.07 ^{cd}	44.51 ^{bc}	0.050 ^b	66.58 ^{ab}	54.0 ^c
Panicum/Centro mixture	24.94 ^c	45.57 ^{bc}	0.043 ^a	70.51 ^d	56.0 ^c
Panicum/Histrix mixture	20.40 ^{bc}	43.82 ^b	0.057 ^b	64.22 ^{ab}	51.5 ^b
Panicum/Lablab mixture	16.74 ^a	43.77 ^b	0.073 ^{bc}	60.51 ^a	48.5 ^{ab}
<i>Panicum maximum</i>	22.11 ^{cd}	40.30 ^a	0.041 ^a	62.41 ^a	42.0 ^a
<i>Aeschynomene histrix</i>	23.30 ^{cd}	46.46 ^c	0.107 ^c	69.76 ^c	58.0 ^d
<i>Syloanthus guianensis</i>	19.59 ^b	48.65 ^d	0.114 ^d	68.23 ^c	55.5 ^c
<i>Lablab purpureus</i>	18.59 ^{ab}	47.28 ^{cd}	0.116 ^d	77.87 ^{ab}	51.0 ^b
<i>Centrosema pubescens</i>	20.79 ^c	46.05 ^c	0.102 ^c	66.84 ^{ab}	58.0 ^d
SEM	0.61	1.50	0.02	2.04	1.12

^{abc} - Means in the same column with different superscripts differ significantly (P<0.05)
a = Soluble fraction, b = Insoluble but degradable fraction,
c = rate of degradation of b, PD = Potential degradability,
ED = Effective degradability. SEM = standard error of the mean.

values in all degradation characteristics except for the ED value. Similarly, among the legumes, Histrix had the highest values in *b* (44.48%), *c* (8.5% h⁻¹), PD (73.55%) and ED (95.50%) when compared to other legumes. Panicum was lowest in all degradability characteristic values. The observed variations in the degradability characteristics of acid detergent fiber (ADF) values differed significantly (P<0.05) among the treatments (Table 5) with Panicum and legume mixtures having higher degradability characteristics values than the sole Panicum. Among the legumes, the soluble fraction, *a* ranged from 18.59% in Lablab to 23.30% in Histrix while *b* fraction ranged from 46.05% in Centro to 48.65% in Stylo.

The values of degradability characteristics of acid detergent lignin (ADL) of *P. maximum*

and legumes differed significantly (P<0.05) among the treatments (Table 6). Panicum and Histrix mixture had higher degradability values in *a* (24.72%), *b* (44.37%) and PD (69.09%) whereas mixture of Panicum and Lablab showed higher values in *c* (8.3% h⁻¹) and ED (48.50%). The low crude fibre values recorded for the legume compared to that of Panicum reflected in the higher degradability of NDF, ADF and ADL. Comparable high values of *b*, PD and ED obtained for the mixtures and sole legumes could be attributed to the short cutting interval of four weeks. This cutting interval had produced forage of high digestibility and minimal lignified tissue.

Conclusion

The high nutrient profile of *Lablab purpureus*, *Aeschynomene histrix*, *Centrosema pubescens*

Table 6: Acid detergent lignin (%) characteristics of *P. maximum* and mixtures of *P. maximum* and four forage legumes

Forage	Degradation characteristics (%)				
	a	b	c (h ⁻¹)	PD	ED
Panicum/Stylo mixture	24.33 ^a	43.26 ^{ab}	0.053 ^b	67.59 ^{ab}	45.50 ^{ab}
Panicum/Centro mixture	22.06 ^a	42.80 ^{ab}	0.064 ^{ab}	64.86 ^{ab}	47.00 ^b
Panicum/Histrix mixture	24.72 ^d	44.37 ^b	0.079 ^b	69.09 ^b	44.00 ^{ab}
Panicum/L. ablab mixture	22.88 ^b	43.08 ^{ab}	0.083 ^{ab}	65.96 ^{ab}	48.50 ^b
<i>Panicum maximum</i>	18.93 ^{ab}	40.09 ^a	0.072 ^a	59.02 ^a	41.50 ^a
<i>Aeschynomene histrix</i>	18.51 ^{ab}	47.46 ^c	0.092 ^b	65.74 ^b	57.50 ^{ad}
<i>Stylosanthes guianensis</i>	23.54 ^c	46.70 ^{bc}	0.098 ^c	70.24 ^c	59.00 ^d
<i>Lablab purpureus</i>	17.72 ^a	46.28 ^{bc}	0.112 ^{ab}	64.00 ^{ab}	58.00 ^d
<i>Centrosema pubescens</i>	16.27 ^a	45.52 ^b	0.106 ^a	61.79 ^a	51.50 ^c
SEM	1.55	0.86	0.02	3.50	2.00

^{abc} = Means in the same column with different superscripts differ significantly (P<0.05)

a = Soluble fraction, b = Insoluble but degradable fraction,

c = rate of degradation of b, PD = Potential degradability,

ED = Effective degradability, SEM = standard error of the mean.

and *Stylosanthes guianensis* is an indication that they would support livestock production. The high rate of disappearance of these forage legumes from the rumen shows that they should not be fed solely to ruminants. The degradability constants observed to be high in DM, CP, NDF, ADF, and ADL for Panicum and legume mixtures over the sole Panicum revealed the importance of grass and legume combination in the diet of ruminant livestock.

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