CHEMICAL COMPOSITION AND RUMINAL DEGRADABILITY OF COWPEA AND SILVERLEAF DESMODIUM FORAGE LEGUMES HARVESTED AT DIFFERENT STAGES OF MATURITY

[COMPOSICIÓN QUÍMICA Y DEGRADABILIDAD RUMINAL DE FORRAJE DE FRIJOL VIGNA Y DESMODIUM COSECHADOS A DIFERENTES ETAPAS DE MADUREZ]

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SUMMARY

The chemical composition and ruminal degradability of dry matter (DM) and nitrogen (N) of Cowpea and Silverleaf desmodium harvested at various stages of maturity was determined. *In sacco* degradability of protein and DM of the two legumes were determined using four mature Hereford x Nkone rumen-cannulated steers. The crude protein (CP), total ash, neutral detergent fibre (NDF), acid detergent fibre (ADF) and phosphorus contents of the Cowpea were influenced ($P < 0.01$) by interactions between the stage of maturity and plant part. The total ash content ranged from 72 g/kg DM in stems to 143 g/kg DM in the leaf. The CP and ash contents of the two legume samples were higher ($P < 0.01$) in the leaves than in the stems. The CP content of Silverleaf desmodium increased ($P < 0.01$) from pre-anthesis to post-anthesis. The NDF and ADF increased with maturity ($P < 0.05$). The DM effective digestibility (ED) values were not affected by the stage of maturity. All the N degradation rate constants for the two herbaceous legumes were not affected ($P > 0.05$) by stage of maturity. These legumes are high in protein, total ash and phosphorus. However, increasing maturity resulted in a depression in rumen DM and CP *in sacco* degradability in the forages.

Key words: Cowpea, Silverleaf desmodium, stage of maturity, chemical composition, degradability.

RESUMEN

Se estudió la composición química y degradabilidad ruminal de la material seca (MS) y nitrógeno (N) del forraje de Vigna y Desmodium cosechado en varias etapas de madurez. La degradabilidad ruminal (*in sacco*) se estimó en cuatro novillos Hereford x Nkone. La proteína cruda (PC), ceniza, fibra detergente neutro (FDN) y ácida (FDA), así como el contenido de fósforo fueron influenciados en la vigna (P<0.01) por la interacción entre madurez y sección de la planta. La ceniza varió de 72 g/kg MS en los tallos a 143 g/kg MS en las hojas. La PC y la ceniza de las dos leguminosas fue más alta en en las hojas que en los tallos (P<0.01). La PC en el desmodium incrementó (P<0.01) de la fase previa a la posterior a la floración (P<0.01). El contenido de FDN y FDA se incrementó con la madurez (P<0.05). La degradabilidad efectiva no fue afectada por la madurez. Los parámetros de degradación del N no fueron afectados por la madurez (P>0.05). Estas leguminosas tienen un alto contenido de PC, ceniza y fósforo. Sin embargo, con la madurez se observa una disminución de la degradabilidad ruminal de la MS y PC (*in sacco*) de estos forrajes.

Palabras clave: Vigna, desmodium, edad, madurez, degradabilidad.

INTRODUCTION

The importance of tropical forage legumes (Topps, 1992) and browse legumes (Le Houerou, 1980) as sources of valuable protein for ruminant animal production in the tropics has been acknowledged (Norton, 1982). Forage and browse legumes provide protein, vitamins and mineral elements, which are lacking in mature natural grassland pastures, especially during the dry season (Skerman *et al*., 1988). The high protein content of these legumes suggests that they have high potential for use as protein supplements in ruminant feeding. Protein supplementation from these sources could enhance carbohydrate fermentation (Molina Alcade *etal*., 1996) in animals on low quality roughages. In Zimbabwe, the use of forage and browse legumes as alternative protein sources is currently being examined. The effect of harvesting stage of

forage legumes on dry matter (DM), crude protein (CP), neutral and acid detergent fibres (NDF and ADF) is still to be investigated. In addition, some nutritional characteristics, that is, chemical composition, voluntary intake, degradability and digestibility of legumes need to be evaluated using ruminant animals at different stages of production. There is need for an adequate understanding of the nutrient availability, both in the rumen and post-ruminally, from these forage and browse tree legumes in order to properly balance their use in ruminant nutrition. The changes in chemical composition and degradability of DM and protein at different stages of maturity in these legumes has not been investigated. The objectives of the present study were to determine the chemical composition and ruminal degradability of dry matter (DM) and nitrogen (N) of herbaceous forage legumes, *Vigna unguiculata* (L.) Walp (Cowpea) and *Desmodium uncinatum* (Silverleaf desmodium) harvested at various stages of maturity.

MATERIALS AND METHODS

Forages

The Cowpea and Silverleaf desmodium herbaceous legumes, which are grown successfully in Zimbabwe, were grown at Henderson Research Station (17^o15'S and 31^o58'E). The Cowpea was grown in both the 1994/95 and 1995/96 cropping seasons. During the 1994/95 rain season, an area of about 3.0 ha was ploughed and disced for sowing the Cowpea and Silverleaf desmodium legumes. Pure stands of the forage legumes were sown with the first rains between 24th November and 22nd December, 1994 on red clay soils. Each of the legumes was sown on about 0.7 ha. The inter-row and intra-row spacing for the Cowpea was 45 x 45 cm at a seeding rate of 40 kg/ha. Silverleaf desmodium was banded in rows at the rate of 2.0 kg/ha, at an inter-row spacing of 45 cm (Skerman *et al.*, 1988). Single super phosphate (SSP) (18.5% P_2O_5) fertiliser was applied at the rate of 100 kg/ha at planting. Weeding was done using hand hoes.

At sampling, a 0.5 m^2 quadrant was placed at random and four replicates per cutting were obtained. All the plants, which were enclosed in the quadrant, were cut, at approximately 10 cm above the ground. Samples of the forage legumes were harvested once a month in February, March and April (representing the pre-anthesis, anthesis and post-anthesis stages of maturity) and separated into leaf and stem. The Cowpea was harvested when about 75 per cent of the pods had ripened, while Silverleaf desmodium was harvested in April after flowering. The forages were sun-dried in the fields and pods for Cowpea removed by hand. The hays were later milled in a hammer mill to pass through a 25 mm screen. The milled hays were stored in hesian bags.

Rumen degradability studies

Animals and feeding

Four mature Hereford x Nkone crossbred steers (mean weight of about 550 ± 0.5 kg), fitted with rumen cannulae of 8 cm internal diameter (Pigott Maskew (Pvt) Ltd., Bulawayo, Zimbabwe), were used to determine the degradability profiles of dry matter and nitrogen of the Cowpea and Silverleaf desmodium samples.

The animals were dosed with a broad spectrum anthelmintic (Systamex, CAPS Veterinary (Pvt) Ltd, Harare, Zimbabwe) prior to the commencement of the experiment. The animals were housed in individual pens with concrete floors. The steers were fed 8 kg/day of a 3:1 mixture of maize (3 parts) and cottonseed meal (1 part) and star grass (*Cynodon nlemfuensis*) hay *ad libitum*, starting 21 days prior to the commencement of the incubation of bags. Clean drinking water was always available in buckets.

Rumen in sacco incubation of the samples

The nylon bag technique (Mehrez and Ørskov, 1977) was used. Duplicate dacron bags (Lockertex, Warrington, UK) of an effective size of 9 cm x 14 cm and pore size of 40 to 45 μm containing approximately 5.0 grams each of air dried sample, milled through a 3 mm screen, were used per animal. The bags were attached, about 2 cm below the top using plastic bands, to flexible vinyl plastic tubes, about 40 cm long and of 6 mm outer diameter, and then suspended in the rumen of the cannulated animals for incubations of 0, 6, 12, 24, 48, 72, 96 and 120 hours. The bags were inserted before the morning feeding time. After each incubation time, the bags were removed from the rumen and washed in a washing machine. The duplicate zero hour bags per sample were washed without incubation in the rumen. The washed bags were dried in a forced air oven at 60^OC for 48 hours, allowed to cool, and then weighed. Nutrient degradation was calculated by the difference between the amount in original sample and in the degraded residues.

Chemical analysis

The samples of the forages were milled through a 2 mm screen and the residues after incubation were analysed in duplicate for dry matter (DM) by drying in a forced air oven at 60^oC for 48 hours according to the Associations of Official Analytical Chemists (AOAC) (1990) procedures. Analysis for crude protein (CP) (N x 6.25) of the dry hay samples was done using the macro-Kjeldahl procedure. Ash was determined by burning samples overnight at 500^oC using a muffle

furnace as outlined in AOAC (1990) procedures. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined using the method of Goering and van Soest (1970). Phosphorus was determined by reacting the feed samples with orthophosphate ion and ammonium molybdate to form a phosphomolybdate compound, which was reduced to molybdenum blue using 1-amino-2-naphthol-4-sulfonic acid. The colour intensity was read at 400 nm (Spectromic 20, Bausch and Lomb, Pvt., Ltd).

Data and statistical analysis

The *in sacco* degradability of dry matter and protein at various incubation times for each sample was described using the mathematical model of Ørskov and McDonald (1979) or McDonald (1981), respectively.

$D = a + b(1-e^{ct})$ (Ørskov and McDonald, 1979)
$D = a + b(1-e^{-c(t-tl)})$ (McDonald (1981)

Where:
D = degradation of DM or N after time t;
a = soluble (rapidly degradable) fraction;
b = insoluble but potentially degradable fraction; c = the fractional rate constant for degradation of the 'b' fraction;
a + b = potentially degradable fraction;
t = time of incubation;
tl = time lag

Effective degradability (P) of dry matter and nitrogen was calculated using outflow rates of 0.02 and 0.05 per hour according to the Ørskov and McDonald (1979) model:

$P = a + [bc/c + k]$

Where:
P = effective degradability, and
a, b and c = constants as described in Equations 1 and 2, and
k= rumen fractional outflow rate constant.

The degradability data were analyzed using the computer programme NEWAY (X.B. Chen, Rowett Research Institute, Aberdeen, UK) for estimation of degradation constants (a, b, a+b and c). Effective degradability (ED) was calculated by adjusting for rumen fractional outflow rates (k) of 0.02 and 0.05 per hour according to Ørskov and McDonald, (1979).

Analysis of variance (ANOVA) was carried out using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS) (1991). The effects of stage of maturity on chemical composition variables were determined. The model used was:

$Y_{ijk} = \mu + P_i + M_j + (P \times M)_{ij} + e_{ijk}$

where Y_{ijk} is the dependent variable, for example, crude protein, ash, NDF, and ADF μ is the overall mean; P_i = plant part (leaf or stem) (i = 1, 2); M_j = stage of maturity (pre-anthesis, anthesis and post-anthesis) (j = 1, 2, 3); $(P \times M)_{ij}$ the interaction of stage of maturity and plant part, e_{ijk} the random residual error.

The model used for the degradation values to determine the effects of the stage of maturity of sampling of the legumes on degradation values were determined using the following model:

$Y_{ijk} = \mu + A_i + M_j + (A \times M)_{ij} + e_{ijk}$

Where:
Y_{ijk} = DM or N degradation constants, a, b and c or digestibility of the DM and N;
μ = overall mean;
A_i = fixed effect of animal;
M_j = stage of maturity effect;
$(A \times M)_{ij}$ = interaction between animal and stage of maturity;
e_{ijk} = random residual error.

RESULTS

Chemical composition

The CP, total ash, NDF, ADF and phosphorus contents were significantly influenced ($P < 0.01$) by interactions between the stage of maturity and plant part (Table 1). The total ash and CP content of the leaves at all stages of harvesting were higher ($P < 0.01$) than for the stems. The CP content ranged from 89.2 to 209 g/kg DM with leaves containing almost double the amount that was in the stems. The CP content increased up to flowering and then declined with maturation. The total ash content ranged from 72 g/kg DM in stems to 143 g/kg DM in the leaf. The NDF and ADF values of the stems harvested from pre-anthesis to post-anthesis were consistently higher ($P < 0.01$) than in the leaves. Significant differences ($P < 0.01$) were recorded for phosphorus content in the (leaf and stem) samples harvested at the three stages of growth.

The total ash content of Silverleaf desmodium was significantly decreased ($P < 0.05$) as the plant matured (Table 2). The CP and ash contents of the two legume samples were higher ($P < 0.01$) in the leaves than the stem. The CP content of Silverleaf desmodium leaves significantly increased ($P < 0.01$) from pre-anthesis to post-anthesis.

DM and Nitrogen degradability of the forages

The dry matter and nitrogen degradability constants, a, b, a + b, and c and the potential degradability (a+b) of the forages are summarized in Tables 3 and 4 and illustrated in Figures 1 to 4. Within each legume species, all the degradability constants, for DM and N, were not affected ($P > 0.05$) across the stages of maturity for the two legumes (Tables 3 and 4) but the potential degradability (a+b) values for cowpea tended to decrease from pre-anthesis to post-anthesis. The ED values of cowpea and Silverleaf desmodium were not affected by the stage of maturity of the legumes.

All the nitrogen degradation rate constants for the two herbaceous legumes were not affected ($P > 0.05$) by stage of maturity of the forage (Tables 3 and 4). The potentially degradable (a+b) fraction and the estimated ED values tended to decline with maturity in Silverleaf desmodium.

Table 1. Chemical composition, g/kg dry matter (DM) of *Vigna unguiculata* (L.), Walp (Cowpea) plant parts (leaf and stem) harvested at pre-anthesis, anthesis and post-anthesis stages of growth.

Stage of maturity	Plant Part (PP)	[1]DM (g/kg)	Ash	[2]CP	[3]NDF	[4]ADF	[5]P
Pre-anthesis	Leaf	902	139	202	288	190	5.25
	Stem	907	118	87.0	550	414	3.34
Anthesis	Leaf	910	130	181	462	195	3.90
	Stem	912	85.4	115	537	290	2.09
Post-anthesis	Leaf	893	142	165	310	215	2.35
	Stem	912	80.1	118	588	301	1.34
[6]SEM		17.7	3.97	3.74	56.4	13.6	0.465
Significance	Stage	NS	**	*	*	**	**
	PP	NS	**	**	**	**	**
	Stage x PP	NS	**	**	**	**	NS

[1]DM = dry matter, [2]CP = crude protein, [3]NDF = neutral detergent fibre, [4]ADF = acid detergent fibre, [5]P = phosphorus, [6]SEM = standard error of the means; For comparisons within a column, * = $P < 0.05$, ** = $P < 0.01$; NS = non significant ($P > 0.05$)

Table 2. Chemical composition, g/kg dry matter (DM), of *Desmodium uncinatum* (Silverleaf desmodium) plant parts, leaves and stems, harvested at pre-anthesis, anthesis and post-anthesis stages of growth.

Stage of maturity	Plant Part (PP)	DM	Ash	[1]CP	[2]NDF	[3]ADF
Pre-anthesis	Leaf	923	99.6	150	426	307
	Stem	917	86.7	106	591	471
Anthesis	Leaf	926	93.7	237	396	286
	Stem	932	74.8	142	619	507
Post-anthesis	Leaf	952	81.6	246	398	276
	Stem	944	63.3	86.4	609	513
[4]SED		9.4	1.91	6.3	-	-
Significance	Stage	NS	**	*	-	-
	PP	NS	**	**	-	-
	Stage x PP	NS	**	NS	-	-

[1]CP = crude protein, [2]NDF = neutral detergent fibre, [3]ADF = acid detergent fibre. [4]SED = standard error of difference; For comparisons within a column, * = $P < 0.05$, ** = $P < 0.01$; NS = non significant ($P > 0.05$).

Table 3. Dry matter (DM) and Nitrogen rumen degradability constants and calculated effective degradability (ED) (at outflow rates of p = 0.02 and 0.05) of *Vigna unguiculata* (L.) Walp. (Cowpea) harvested at different stages of maturity.

		Degradability constants				Effective degradability	
Component	Stage	[1]a	[2]b	a+b	[3]c	p = 0.02	**p = 0.05**
Dry matter							
	Pre-anthesis	29.7	38.4	68.1	0.0905	59.5	52.8
	Anthesis	31.7	35.3	67.0	0.0505	56.6	49.1
	Post-anthesis	31.8	36.3	68.1	0.0497	57.6	49.9
	SEM	1.84	3.86	5.29	0.0324	7.10	7.27
	Significance	NS	NS	NS	NS	NS	NS
Nitrogen	Pre-anthesis	32.2	35.3	67.5	0.178	59.4	53.9
	Anthesis	32.1	33.5	69.0	0.057	53.7	47.3
	Post-anthesis	32.3	41.1	73.0	0.418	62.7	53.9
	SEM	3.42	3.95		0.116	4.65	4.84
	Significance	NS	NS	NS	NS	NS	NS

[1]a = soluble fraction; [2]b = slowly degradable fraction; a+b = potentially degradable fraction; [3]c = degradation rate constant; SEM = standard error of means; For within column comparisons, NS = non-significant ($P > 0.05$)

Table 4. Dry matter (DM) degradability constants and calculated effective degradability (ED) of *Desmodium uncinatum* Silverleaf desmodium) (at outflow rates of p = 0.02 and 0.05) harvested at different stages of maturity.

		Degradability constants				Effective degradability	
Component	Stage	[1]a	[2]b	[3]a+b	[4]c	p = 0.02	p = 0.05
Dry matter	Pre-anthesis	28.7	41.1	69.8	0.047	52.8	44.4
	Anthesis	28.7	40.4	69.1	0.031	49.0	41.1
	Post-anthesis	27.2	38.2	65.4	0.055	54.0	46.1
	SED	1.18	4.12	4.93	0.035	3.30	3.61
	Significance	NS	NS	NS	NS	NS	NS
Nitrogen	Pre-anthesis	33.8	41.4	76.0	0.035	61.1	51.8
	Anthesis	31.1	41.4	67.7	0.066	61.2	53.0
	Post-anthesis	31.6	34.1	65.7	0.062	56.6	49.8
	SEM	2.80	5.06		0.0205	3.77	2.82
	Significance	NS	NS	NS	NS	NS	NS

[1]a = soluble fraction; [2]b = slowly degradable fraction; [3]a+b = potentially degradable fraction; [4]c = degradation rate constant; SED = standard error of difference; For within column comparisons, NS = non-significant ($P > 0.05$).
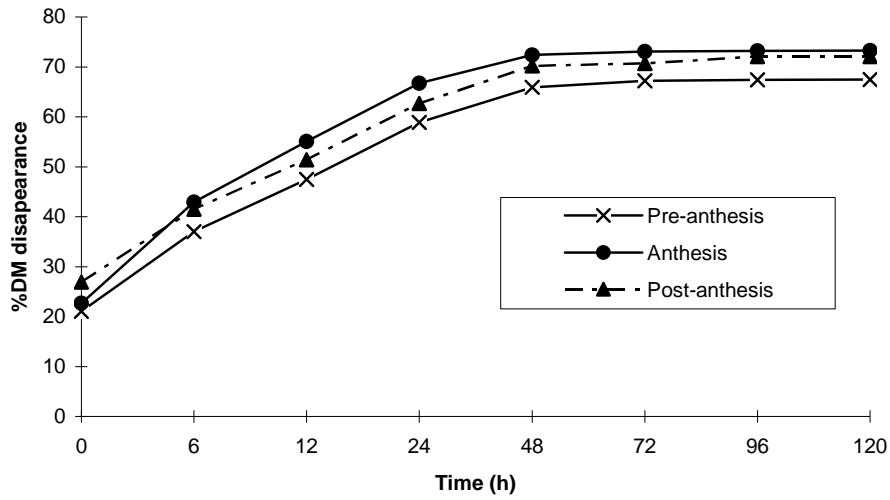
Figure 1. *In sacco* dry matter degradability (% disappearance) of Cowpea harvested at pre-anthesis, anthesis and post-anthesis stages of maturity
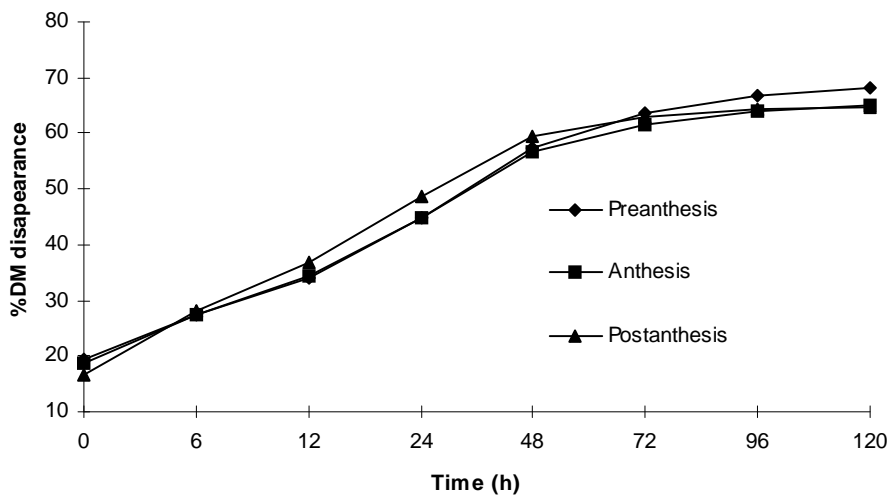

Figure 2. *In sacco* dry matter degradability (% disappearance) of Silverleaf desmodium harvested at pre-anthesis, anthesis and post-anthesis stages of maturity
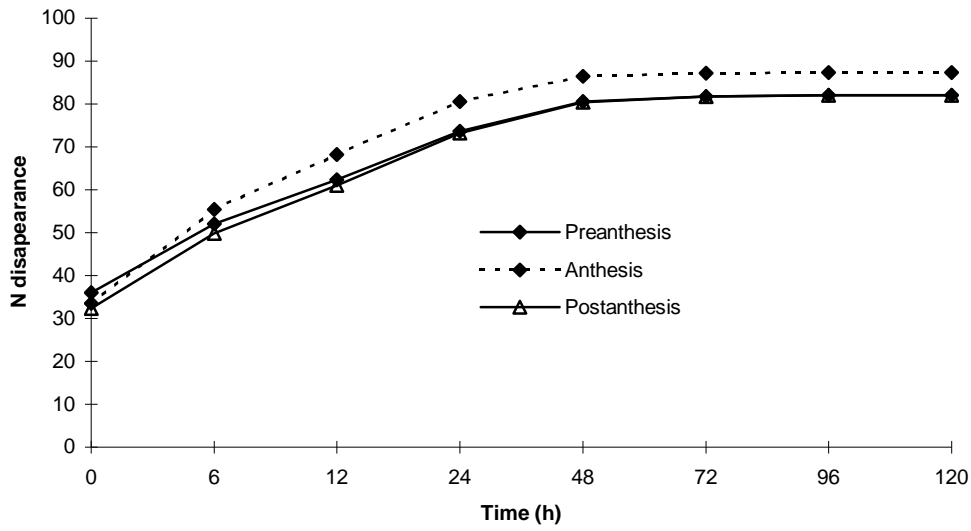
Figure 3. *In sacco* nitrogen degradability (% disappearance) of Cowpea harvested at pre-anthesis, anthesis and post-anthesis stages of maturity.
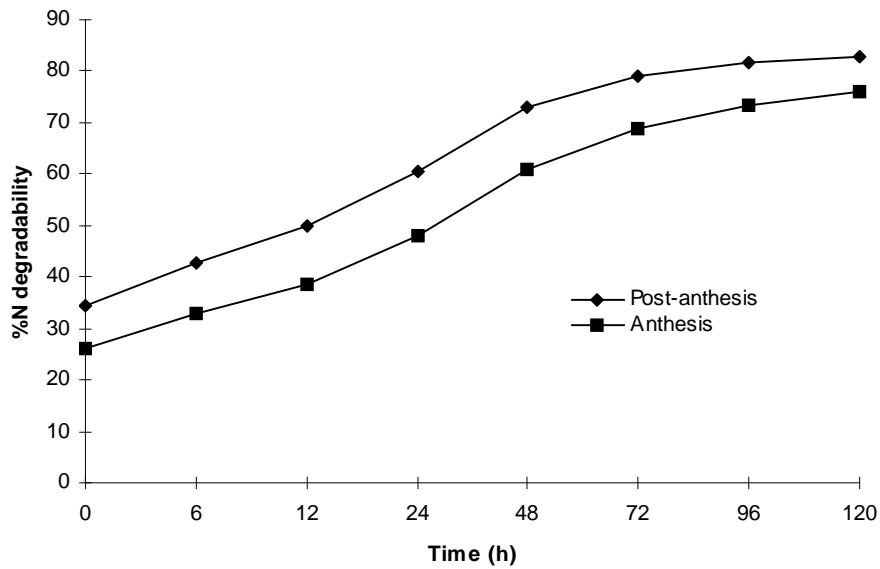

Figure 4. *In sacco* nitrogen degradability (% disappearance) of Silverleaf desmodium harvested at anthesis and post-anthesis stages of maturity.

DISCUSSION

The chemical composition of Cowpea and Silverleaf desmodium clearly showed that there are species differences in the CP content of the legumes. The high CP levels, up to post-flowering stages in the legume samples indicates that the plants were still growing vegetatively. The CP content in the leaf of the two herbaceous legumes was in excess of recommended minimum requirements for lactation (120 g/kg DM) and growth (113 g/kg DM) in ruminants (ARC, 1984). The CP content for the Cowpea stems ranged from 89 to 110 g/kg DM and for the whole sample, the range was from 136 to 168 g/kg DM, still enough to meet both lactation and growth requirements of ruminant livestock (ARC, 1984). These were within the range of values reported by other authors (Skerman *et al.*, 1988; Topps and Oliver, 1993; Matizha *et al.,* 1997) but lower than those reported by Neil *et al.* (1992) for 150 different Cowpea cultivars used in breeding trials at Summer Grain Institute of Potchefstroom, South Africa. The concentrations of CP in this are still high enough for these legumes to be used as protein supplements to mature natural grasses, which are frequently deficient in protein (Minson, 1988).

The high levels of CP in the Cowpea with increasing maturation was comparable to the findings of Demarquilly and Carriage (1974) for clover, which maintained its chemical composition almost constant during the growth period, as long as the leaves were green and active. In Cowpea, a high CP content was reported to be maintained in the hay and silage form (Bogdan, 1977). The high protein content and its maintenance with maturity may be associated with the continuous supply of nitrogen available from rhizobial fixation. The variation between legume species in the plant protein content also probably reflects the effectiveness of rhizobial nitrogen fixation under different environmental conditions (Norton, 1982). The differences in the protein content of the legumes may be related to the different proportions and composition of leaf and stem fractions of the plant. Leafiness in pasture plants is commonly associated with forage quality because there is usually a positive correlation between leaf percentage in a given plant species and protein and mineral composition (Norton, 1982). The CP levels in the stem are still relatively high in Cowpea and Silverleaf desmodium and this could provide valuable protein to the animal.

Since Cowpea appears to be a high quality feed resource for animal production, improvements in meat and milk production could be realised if Cowpea hay is used as a supplementary feed to poor quality hay.

The total ash content of Cowpea leaf material was almost double that of the stems. The values obtained for stems are above those published by Norton and Poppi (1995) for ash (89 - 119 g/kg DM) and phosphorus (1.8 - 4.2 g/kg DM). Both the ash and phosphorus in Cowpea declined with maturation. The phosphorus levels obtained in this study are higher than the recommended minimum requirements of 1.8 to 3.2 g/kg DM for ruminant animals (ARC, 1984).

The depression in the ruminal degradability of both DM and N with increasing stage of maturity could be explained by increases in the indigestible fraction of forages. Blade, Vandersall and Erdman (1993) reported that the stages of maturity affect both degradability and digestion and are associated with an increase in the indigestible fraction of the forage, neutral detergent fibre (NDF) and an increase in the lignification of the NDF. The observed decrease in degradability with maturity for the legumes may be compared with results reported by other workers (Vik-Mo, 1989; Blade *et al.,* 1993; Hadjipanayiotou *et al.*, 1996). Blade *et al.* (1993) found that the potentially degradable protein did not vary between forage legumes but decreased with maturity. This shift in forage protein degradation with maturity in the legumes should be taken into consideration when formulating ruminant animal diets using these legumes to meet the requirements for rumen degradable and undegradable protein (Hadjipanayiotou *et al.*, 1996).

The high protein content and fragility of legume cell walls, especially that of young vegetative material, results in high DM and N degradation at early stages of growth. Tropical legumes have leaves with low cell wall contents and high proportions of readily digestible thin-walled non-lignified mesophyll tissue, which results in greater degradation (Norton and Poppi, 1995).

Cowpea and Silverleaf desmodium showed a high potential (a+b) degradability, indicating that they might need to stay in the rumen for a longer time (Molina-Alcaide *et al.,* 1996) or correspondingly the rate constant values must be high. This high c value indicates higher nutritive value of the herbaceous legumes, but providing a low intestinal availability of undegraded dietary nitrogen (UDN). The ED of DM and N in the herbaceous legumes calculated at an outflow rate of 2% per hour indicates that substantial amounts of the DM and N were degraded in the rumen, thus providing rumen degradable nitrogen (RDN) and organic matter for microbial protein synthesis. The herbaceous legumes provided a large amount of RDN that could be used for microbial protein synthesis. The high degradability in the rumen could be due to a combined action of both proteolytic and cellulolytic enzymes in the rumen (Molina-Alcaide *et al.*, 1996), which are able to solubilize more protein than can be solubilized by enzymatic action in the intestine.

Silverleaf desmodium have been reported to contain tannins (Baloyi *et al.,* 2001). Numerous authors have attributed the low crude protein degradability in tropical forage legumes to the presence of tannins (Kumar and Singh, 1984; Ahn *et al.,* 1989; Kumar and Vaithiyanathan, 1990). Tannins are known to decrease protein degradability by complexing with feed protein and have a capability to reduce the activities of rumen microbes and to interact with proteins and carbohydrates (Makkar *et al.*, 1988; Reed, 1995 Salawu *et al.*, 1997). They could also inactivate proteolytic enzymes by binding to them, which would decrease protein degradability (Mueller-Harvey and McAllan, 1992; Makkar, 1993).

The effective nitrogen degradability at a passage rate of 0.02 is within the range of 32 and 80 per cent reported by Mgheni *et al.* (1993) for some tropical herbaceous legumes (*Desmodium intortum, D. uncinatum, Neanotonia wightii, Pueraria phaseoloides* and *Leucaena leucocephala).*

When the degradation data for N were fitted to the simple exponential model of ∅rskov and McDonald (1979), the presence of a lag time at the beginning of degradation had a great influence on the a, b and c values obtained. If a lag time exists, as was seen with these samples, and is not taken into account in the model, the asymptote is overestimated and the rate of degradation is underestimated (Stensig *et al.*, 1994). Dhanoa (1988) recommended simultaneous estimation of the lag and degradation parameters in order to obtain objective and more satisfactory estimates of the parameters. With increasing lag time, a greater proportion of the feed is assumed to have left the rumen before degradation begins and this introduces errors in calculating the effective degradability value.

Stensig *et al*. (1994) concluded that if estimates for the rate of degradation of NDF *in sacco* should be used directly, it is very important that the models to be used should deal with lag time. The same authors further indicated that if an exact curve description is not obtained by the degradation model not including the lag time (∅rskov and McDonald, 1979), then differences between feeds should be evaluated only on ED calculated with a certain rate of passage. These estimates are more robust and less dependent on exact curve fitting.

CONCLUSION

The Cowpea and Silverleaf desmodium are high in protein, total ash and phosphorus. These high nutritive value levels could suggest that harvesting these forages and feeding them to animals could increase the efficiency of utilization of poor quality basal diets of mature pasture. Increasing maturity resulted in a large depression in rumen DM and CP *in sacco* degradability in the forages. The shift in CP degradability with stage of maturity suggests that fixed values for CP degradability, as is used for conventional feedstuffs, could be inappropriate for such a dynamic feed attribute in the new protein evaluation system.

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.

ARC, 1984. The Nutrient requirements of Ruminant Livestock, Supplement No. 1. Report of the Protein Group of the Agricultural Research Council Working Party on Nutrient Requirements of Ruminants. CAB, Farnham Royal, UK.

AOAC. 1990. Official Methods of Analysis (15th Edition) Associations of Analytical Chemists. Washington DC, USA.

Baloyi, J.J., Ngongoni, N.T., Topps, J.H., Acamovic, T. and Hamudikuwanda, H. 2001. Condensed tannins and saponins of *Vigna unguiculata* (L.) Walp. (Cowpea), *Desmodium uncinatum* (Silverleaf desmodium) and *Stylosanthes guanensis* (Oxley fine stem stylo) and *Stylosanthes scabra* (Fitzroy). Tropical Animal Health and Production 33: 57-66

Blade, A.T. Vandersall J.H. and Erdman, R.E. 1993. Effect of stage of maturity of alfalfa and orchard grass on in situ dry matter and crude protein degradability and amino acid composition. Animal Feed Science and Technology 44: 29-43.

Bogdan, A.V., 1977. Tropical Pasture and Fodder Plants (Grasses and Legumes). Longman, London, UK.

Demarquilly, C. and Jarrige, R., 1974. The comparative nutritive value of grasses and legumes. In: Quality of herbage. Proceeding of the 5th General meeting of European Grasslands Fed., Uppsala, Sweden 28: 33–41.

Dhanoa, M.S., 1988. On the analysis of dacron bag data or low degradability feeds. Grass and Forage Science 43: 441 – 443.

Goering, H.K. and van Soest, P.J., 1970. Forage fibre analysis. Agricultural handbook, No. 379. United States Department of Agriculture, USA.

Hadjipanayiotou, M., Antoniou, I., Theodoridou, M and Photiou, A. 1996. *In situ* degradability of forages cut at different stages of growth. Livestock Production Science 45: 49 – 53.

Kumar, R. and Singh, M. 1984. Tannins, their adverse role in ruminant nutrition. Journal of Agricultural and Food Chemistry 32: 447 – 453.

Kumar, R. and Vaithiyanathan, S., 1990. Occurrence, nutritional significance and effect on animal productivity of tannins in tree leaves. Animal Feed Science and Technology 30: 21-38.

Le Houeroun, H.N. 1980. Browse in miombo woodland. Proceedings of the International Symposium on Browse in Africa. The current knowledge. ILCA., Addis Ababa, Ethiopia, 8-12 April, 1980.

Makkar, H.P.S., 1993. Antinutritional factors in foods for livestock. In: M. Gill, E. Owen, G.E. Pollott and T.L.J. Lawrence (Eds). Animal Production in Developing Countries. Occasional Publication No. 16. British Society of Animal Production, UK.

Makkar, H.P.S., Dawra, R.K. and Singh, B., 1988. Determination of both tannin and protein in tannin-protein complex. Journal of Agricultural and Food Chemistry 36: 523-525.

Matizha, W., Ngongoni, N.T. and Topps, J.H., 1997. Effects of supplementing veld hay with tropical legumes *Desmodium uncinatum, Stylosanthes guianensis* and *Macroptilium atropurpureum* on intake, digestibility, outflow rates, nitrogen retention and live weight gain in lambs. Animal Feed Science and Technology 69: 187-193.

McDonald, I., 1981. A revised model for estimation of protein in the rumen. Journal of Agriculture Science (Cambridge) 96: 251 - 252.

Mehrez, A.Z. and Ørskov, E. R. 1977. A study of the artificial fibre bag technique for the determining the digestibility of feeds in the rumen. Journal of Agricultural Science(Cambridge) 88: 645 – 657.

Mgheni, D.M., Hvelplund, T. and Wesbjerg, M.R., 1993. Rumen degradability of dry matter and protein in tropical grass and legume forages and their protein values expressed in the AAT-PBV protein evaluation system. Second Biennial Conference of the African Feed Resource Network (AFRNET), 6 -10 December, 1993. Harare. Zimbabwe.

Minson, D.J., 1988. The chemical composition and nutritive value of tropical legumes. In: *Tropical Forage Legumes, FAO Plant Production and Protection Series*, No. 2, Food and Agricultural Organisation of the United Nations, Rome. pp 185-193.

Molina-Alcaide, E., Weisbjerg, M.R. and Hvelplund, T., 1996. Degradation characteristics of shrubs and the effect of supplementation with urea or protein on microbial production using continuous culture system. Journal of Animal Physiology and Animal Nutrition 75: 121-132.

Mueller-Harvey, I. and McAllan, A.B. 1992. Tannins: Their role biochemistry and Nutritional properties. In: Advances in Plant Cell Biochemistry and Biotechnology 1: 152 – 217.

Neil, F.J., Siebrits, F.K and Hayes, J.P. 1992. Studies on the nutritive value of cowpea (*Vigna unguiculata*). South African Journal of Animal Science 22: 157 -160.

Norton, B.W., 1982. The nutritive value of tree legumes. In. Gutteridge, R.C., Shelton, H.M. (Eds), Forage Tree Legumes in Tropical Agriculture. CAB International, Wallingford, UK, pp 192-201.

Norton, B.W. and Poppi, D.P., 1995. Composition and Nutritional Attributes of Pasture Legumes. In: J.P.F. D'Mello and Devendra, C. (Eds.) Tropical Legumes in Animal Nutrition, Commonwealth Agricultural Bureau, International, Wallingford, UK. pp 23 – 47.

Ørskov E.R. and MacDonald, 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.

Reed, J.D., 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. Journal of Animal Science 73: 1516 - 1528.

Salawu, M.B., Acamovic, T., Sterwart C.S., Hovell, F. D. deB and McKay I., 1997. Assessment of the nutritive value of *Calliandria caolthyrsus*: *in sacco* degradation and *in vitro* gas production in the presence of Quebracho tannins with or without browse plus. Animal Feed Science and Technology 69: 219-232.

Statistical Analysis Systems (SAS), 1991. Statistical Analysis Systems, SAS User's Guide. Version 6.08. SAS Institute Inc. Cary, North Carolina, USA.

Sheldrick, R.D., Thompson, D.J. and Newman, G., 1987. Legumes for milk and meat. Chalcombe Publications, Bucks, UK.

Skerman, P.J., Cameron, D.G. and Riveros, F., 1988. Tropical Forage Legumes, FAO Plant Production and Protection Series, No. 2. Food and Agricultural Organisation of the United Nations, Rome.

Stensig, T., Weisbjerg, M.R. and Hvelplund, T., 1994. Estimation of ruminal digestibility of NDF from in sacco degradation and rumen fractional outflow rate. Acta Agriculture Scandinavia, Section. A,. Animal Science 44: 96 - 109.

Topps, J.H., 1992. Potential composition and use of legume shrubs and trees as fodders for livestock in the tropics. Journal of Agricultural Science (Cambridge). 118: 1-8.

Topps, J.H. and Oliver, J., 1993. Animal Foods of Central Africa. Technical Handbook No. 2. Harare, Zimbabwe.

Vik-Mo, L., 1989. Degradability of forages i*n sacco*. 2 Silages of grasses and red clover at two cutting times, with formic acid and without additive. Acta Agriculture Scandinavia 39: 53.