Nig. J. Anim. Prod. 2003, 30(1):47-56 Nigerian Society for Animal Production


# Chemical composition and rumen degradation of diet combinations of cottonseed cake, dried brewer's grains and *Lablab purpureus* hay incubated in the rumen of fistulated N'dama steers in South-western Nigeria

*G. O. Tona [a], K. Agyemang [b], J. A. Adeneye [a] and J. A. Akinlade [c]

[a] *Animal Science Department, University of Ibadan, Ibadan, Nigeria.*
[b] *International Trypanotolerence Centre (ITC), Banjul, Gambia*
[c] *Ladoke Akintola University of Technology, Ogbomosho, Nigeria.*

## Abstract

*The chemical composition and dry matter (DM) and nitrogen (N) degradation characteristics of four diet combinations at four total digestible nutrients (TDN) levels of cottonseed cake (CSC), dried brewer's grains (DBG) and Lablab purpureus hay (LL) which were fed to ruminants in the humid zone of Ibadan, South-west Nigeria, were evaluated. The TDN levels used were 3.5, 4.5, 5.5 and 6.5 kg TDN. The CSC and DBG used are agro-industrial by-products which are used in feeding livestock while the LL is a leguminous plant which is not used much as human feed but is usually grown as forage legume for animal feeding. The completely randomized design with four treatments and three replicates was used. The experiment was carried out in Ibadan, South-western Nigeria during the wet season (June to July). The diets were high in crude protein contents so that they had high nutritional potential for ruminants feeding and productivity. The potential degradability (PD) of dry matter (DM) values ranged from 75.24 to 79.47 g/ 100g DM, while that for the nitrogen (N) degradability ranged between 88.36 and 94.30 g/100g N. The soluble fraction a value of DM degradation and the crude fibre (CF) content of the chemical composition of the diets were significantly correlated (r= 0.644; P= 0.007). The potential degradability (PD) values for both the DM and N degradabilities were not significantly (P>0.05) different among the four treatment diets combinations.*

**Keywords**: Chemical composition, degradation, N'dama steers, cotton seed cake, dried brewer's grains *Lablab purpureus*

## Introduction

McDonald *et al.* (1987) stated that the nutritional value of a feed could be evaluated in different ways, such as through carrying out a proximate chemical analysis and by *in vivo* and *in vitro* digestibility techniques. The nylon bag technique is an *in vitro* rumen digestibility technique involving the insertion of nylon bags into the rumen and monitoring the digestibility over specific time periods usually between 0 and 120 hours (Church, 1977). This technique was reported to be an inexpensive laboratory method (Kabuga and Darko, 1993). Preston and Leng (1987) outlined that there are two fractions from the degradation of dietary protein in the rumen, which are the rumen degradable protein (RDP) and the undegraded dietary protein (UDP). These authors mentioned that the nitrogen needs of the ruminant was partitioned into the nitrogen requirement of the rumen microbes and the amino acid requirement of the ruminant itself in the small intestine. DeBoer *et al.* (1987) carried

*Corresponding author, <email: Gopadoyin02@yahoo.com>

out studies on the estimation of rumen undegrable protein and observed that for the concentrates (such as soyabean meal), the rumen DM disappearance values were higher than the N disappearance values, at the zero hour incubation, while the reverse was the case for alfalfa hay. Fall-Toure and Michalet-Doreau (1995) worked on the comparative degradability of tropical browse plants and temperate forages. They also examined the relationship between *in situ* N degradability and detergent fibre N contents of these plants. They reported that the N degradability of browses was closely related to their acid detergent N contents. They further reported that the relationship could be used to predict the N content of browse plants which are often variable, and that such assessment has to be done on a larger number of species. In another study, the chemical composition and rumen degradation values of some multipurpose fodder trees and shrubs were used as standards for ranking the nutritive quality in an initial screening studies (Larbi *et al.*, 1998). They were ranked as high, medium and low quality. These authors also observed positive and significant correlation between crude protein content and the rates of DM and N degradation of the multipurpose trees and shrubs. Studies by Ganev *et al.* (1979) showed that the differences in the degradation of protein supplements could be attributed to the variations in their crude fibre contents. In another experiment, Lufadeju and Olorunju (1986) observed that the six agro-industrial by-products, namely: groundnut cake, cottonseed cake, palm kernel cake, dried brewer's grains wheat offal and rice bran, used as supplements in ruminant rations were degraded at different rates in the rumen. That the differences in the rates of degradation probably had effect on their utilization by the animal. They further reported that those agro-industrial by-products with long acid detergent fibre contents (groundnut cake and wheat offal) had higher DM and N degradability values.

This study was a pre-feeding analysis used for estimating the nutritive quality of the experimental diets at the four TDN levels before they were fed to lactating cows in another experiment. The objective of carrying out the study was to show the effect of the four dietary TDN levels on the DM and N degradation. To rank the diets based on their TDN levels and to observe the differences in their nutritive quality. A secondary objective was to determine the relationships between the chemical composition (DM, crude protein, and fibre components) and the constants of DM and N degradation of the diets.

## Materials and methods

### *The experimental site, animals and diets*

The study was carried out at the International Livestock Research Institute (ILRI) farm in Ibadan, Nigeria. The station is located between latitudes 6°10' and 9°10' North of the equator and longitudes 3° and 6° East of the Greenwich. The vegetation in this area is made up of derived guinea savanna and humid forest zone (Ezenwa, 1995) and mixed farming had been practised in the area for several decades.

Three fistulated N'dama (*Bos indicus*) steers were used to determine the DM and N degradation of four treatment diets T1 (3.5kg TDN), T2 (4.5kg TDN), T3 (5.5kg TDN) and T4 (6.5kg TDN), according to the procedures outlined by Orskov *et al.* (1980). The animals were housed individually under open sided sheds, away from each other to prevent fighting between them. They were tethered to iron poles with long strong ropes tied from their neck belts and these ropes allowed them to graze only the grass within the radii between them and each iron pole.

McDonald *et al.* (1987) stated that : Total digestible nutrients (TDN) (per 100kg) = kg digestible crude protein (CP) + kg digestible crude fibre (CF) + kg digestible nitrogen free extract (NFE) + 2.25 (kg digestible ether extract (EE)). Therefore the TDN levels of diets were estimated based on the proximate composition of the three feed ingredients used and their digestibilities being fitted into the above equation.

The TDN levels of the diet combinations used were obtained from the compounding of CSC, DBG and LL as shown in Table 1. The actual

amounts in kg weight of the three feed ingredients used in compounding the diets at the four treatment levels of TDN were obtained by estimation. The completely randomized design with four dietary treatments and three replicates (three steers) was used.

**Table 1** *Ingredient composition of experimental diets*

| Ingredients | Level of TDN (kg) | | | |
|---|---|---|---|---|
| | 3.5 | 4.5 | 5.5 | 6.5 |
| Cottonseed cake | 2.3 | 3.0 | 3.5 | 4.3 |
| Dried brewer's grains | 2.5 | 3.2 | 3.7 | 4.6 |
| *Lablab purpureus* hay | 1.3 | 1.6 | 1.9 | 2.3 |
| Total | 6.1 | 7.8 | 9.1 | 11.2 |
| Calculated TDN (kg TDN /cow/day) | 3.5 | 4.5 | 5.5 | 6.5 |

***In sacco* DM and N degradation**

The DM and N degradation were determined using the nylon bag technique (Mehrez and Orskov, 1977). 3g feed samples in triplicates for each of the four treatment diets T1, T2, T3 and T4 were weighed into nylon bags of pore size 41 microns (μm) and dimension 5cm x 10cm, made of polyamide (polymon, Switzerland). The bags were carefully inserted into the rumen of each steer and incubated for 6, 12, 24, 48, 72 and 96 hours. The 96-hour incubation sample bags were placed inside the rumen of the fistulated steers first on the first day of incubation at about 09.00 hours. The next day, at the same time (09.00 hours), the 72-hour samples were inserted into the rumen. These were followed by the 48, 24, 12 and lastly the 6-hour sample bags. In this system all the bags were withdrawn at the same time by the method of sequential addition as outlined by Osuji *et al.* (1993). All the bags inserted in the rumen had been initially clearly numbered to indicate the treatment, replicate and incubation withdrawal hours. After incubation, bags were rinsed with tap water until the water was clear and then oven-dried at 65°C for 48 hours. After drying, bags were allowed to air equilibrate to room temperature for about three hours in a dessicator before weighing to determine bag plus feed sample residue weights for DM determination. The various residual feed samples were then ground through a 1mm screen to be used for N determination.

***Chemical analysis***

Proximate composition of the pre and post-incubation feed samples were determined using the A.O.A.C. (1991) methods. Neutral detergent fibre and acid detergent fibre were determined using analytical procedures of Van Soest *et al.* (1991).

***Determination of DM and N degradability***

Degradation constants of DM and N were calculated using the non-linear model:

$Y = a + b (1 - e^{-ct})$ suggested by Orskov and McDonald (1979), where Y = degradation at time t, a = water soluble fraction, b = insoluble but degradable fraction, c = rate of degradation of b at time t and potential degradability (PD) = extent of degradation (a + b ) after time t. The effective degradability (ED) values were estimated electronically by the Orskov analysis (Orskov *et al.*,1980) using the equation: $ED = \mathbf{a} + [(\mathbf{b} \times \mathbf{c}) / (\mathbf{c} + k)]$: where, **a** = water soluble fraction, **b** = insoluble but degradable fraction, **c** = rate of degradation, k = rumen outflow rate.

***Statistical analysis***

*In situ* DM and N degradation were subjected to the analysis of variance (Gomez and Gomez, 1986) to determine significant differences in the various parameters analysed while the means were separated by the Duncan's multiple range test (SAS, 1987). Correlation analysis was carried out by the method of Little and Hills (1978), using the SAS (1987) package.

## Results

### *Chemical composition of diets*

The chemical composition of the diets incubated in the rumen of the fistulated N'dama steers are presented in Table 2. The DM contents of the diets were very high and similar ranging from 91.3 to 91.8 g/100g DM. The crude protein contents were also of close range, 27.2, 27.4 and 28.0 g/100g DM at the 3.5, 4.5 and 5.5kg TDN levels respectively but slightly higher (29.0 g/100g DM) at the 6.5 kg TDN level. Thus as the TDN levels of the diets increased, there were only slight increases in the crude protein contents

**Table 2** *Chemical composition (g/ 100g DM) of experimental diets*

| | Level of TDN (kg) | | | |
|---|---|---|---|---|
| Parameter | 3.5 | 4.5 | 5.5 | 6.5 |
| Dry matter | 91.3 | 91.5 | 91.7 | 91.8 |
| Crude protein | 27.2 | 27.4 | 28.0 | 29.0 |
| Ether extract | 4.6 | 5.8 | 5.6 | 4.6 |
| Crude fibre | 23.4 | 21.3 | 20.2 | 19.1 |
| Ash | 6.5 | 6.7 | 7.0 | 6.9 |
| Nitrogen free extract | 38.4 | 38.8 | 39.4 | 40.0 |
| Hemicellulose | 13.7 | 13.0 | 14.5 | 13.8 |
| Acid detergent fibre | 14.0 | 13.0 | 14.4 | 13.2 |
| Neutral detergent fibre | 27.7 | 26.0 | 28.9 | 27.0 |

### *In sacco dry matter degradation of experimental diets in N'Dama bulls*

The values obtained for **a**, the soluble fraction, and **b**, the degradable fraction, were not significantly different (P> 0.05) among the treatment groups (Table 3). These values also apparently decreased as the TDN values of the diets increased from T1 to T4, except for the T1 value for **b** (47.33g/100g DM) which was rather low. The **a** values ranged from 25.99 – 27.91g/100g DM for T4 to T1 respectively, while the **b** values were between 47.33 and 52.10 g/100g DM. The **c** values which are the rates of degradation of **b** were also similar (P> 0.05) and did not show any definite pattern but ranged between 0.026 $h^{-1}$ for T2 and 0.035 $h^{-1}$ for T4. The potential degradability (**a** + **b**) values increased from T1 (75.24) to T2 (79.47) g/100g DM and then decreased in the order (T2 ) > T3 (76.45) > T4 (73.36) g/100 g DM. The 48 hr degradation, that is, the dry matter disappearance values after 48 hours of incubation were not significantly different (P> 0.05) for the various diets. The values varied from 62.15 to 63.93 g /100g DM for diets T2 to T1 respectively. The effective degradabilities (ED) of dry matter of diets in the rumen at the outflow rate of k (0.03 $h^{-1}$) were not significantly different (P > 0.05) but ranged from 48.77 to 50.63 g/100g DM for T3 and T1 respectively. The results further showed that the **b** values were approximately twice the values of **a**. Consequently, the PD values, **a** + **b**, were apparently due largely to the values of **b** in this study.

**Table 3** *Effect of total digestible nutrients (TDN) level of the diets on dry matter (DM)degradation characteristics*

| Level of TDN (kg) | a | b | c | PD | 48 h | ED |
|---|---|---|---|---|---|---|
| 3.5 | 27.91 | 47.33 | 0.034 | 75.24 | 63.93 | 50.63 |
| 4.5 | 27.37 | 52.10 | 0.026 | 79.47 | 62.15 | 50.03 |
| 5.5 | 26.45 | 50.00 | 0.029 | 76.45 | 62.27 | 48.77 |
| 6.5 | 25.99 | 47.37 | 0.035 | 73.36 | 63.07 | 49.47 |
| SE ± | 0.55 | 1.88 | 0.004 | 1.75 | 1.42 | 0.75 |

Means in the columns without letters are not significantly different ($P > 0.05$).
a = soluble fraction (g / 100g DM), b = degradable fraction (g / 100g DM), c = rate of degradation (% $h^{-1}$), PD = potential degradability (g / 100g DM), 48h = 48 hr degradation (g/100g DM), ED = effective degradability (g / 100g DM).

***Correlation among constants of in situ dry matter (DM) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets***

Correlation between dry matter degradation constant **a** (soluble fraction of DM) and dry matter content of the diet was negative and non-significant. That between **a** value and crude protein content was negative and significant ($P < 0.05$), ($r = -0.615$, $P = 0.011$); between **a** and crude fibre content was positive and significant ($r = 0.559$; $P = 0.025$). Correlation coefficients between dry matter degradation constants **b, c**, PD and ED and DM, CP, CF, ADF and NDF contents of experimental diets were not significantly different, except that between **c** and DM which was highly significant (Table 4).

**Table 4** *Correlation among constants of in situ dry matter (DM) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets*

| | DM | CP | CF | ADF | NDF |
|---|---|---|---|---|---|
| **a** | - 0.345ns | - 0.615* | 0.559* | - 0.315ns | - 0.396ns |
| **b** | - 0.123ns | - 0.093ns | - 0.053ns | - 0.207ns | - 0.215ns |
| **c** | - 0.790** | 0.345ns | - 0.276ns | 0.081ns | - 0.159ns |
| PD | 0.012ns | - 0.297ns | 0.129ns | - 0.314ns | - 0.386ns |
| ED | - 0.421ns | - 0.067ns | 0.323ns | - 0.086ns | - 0.190ns |

* = significant at $P < 0.05$, ** = significant at $P < 0.01$, ns = not significant
a = soluble fraction (g / 100g DM), b = degradable fraction (g / 100g DM), c = rate of degradation of b ($h^{-1}$), PD = potential degradability (g / 100g DM), ED = effective degradability (g / 100g DM). DM = dry matter, CP = crude protein, CF = crude fibre, ADF = acid detergent fibre, NDF = neutral detergent fibre.

***In Sacco* nitrogen (N) degradation of experimental diets**

The degradation characteristics of N for the four experimental diets were significantly ($P < 0.05$) different among the four treatment levels, except for the values for PD of N degradation which did not differ ($P > 0.05$) among the treatments (Table 5). The **a** values which are the soluble fractions were similar ($P > 0.05$) for T1 (10.95), T2 (9.90) and T3 (11.11 g/100g N), but were significantly ($P < 0.05$) higher than for T4 (6.49 g/100g N). The **b** or degradable fractions of the nitrogen were significantly different ($P < 0.05$) and ranged between 77.24 and 86.39g/100g N for T3 and T4 respectively. The **c** values which are the rates of degradation of **b** at time t varied significantly ($P < 0.05$) between 0.020 and 0.033 $h^{-1}$ for T2 and T4 respectively. The potential degradability values, that is, the sum of **a** + **b**, did not differ ($P > 0.05$); they ranged from 88.36 to 94.30 g/100g N for T3 and T2 respectively (Table 5). The 48 h disappearance values for T1 and T2 (62.20 and 63.99) were similar ($P > 0.05$) but significantly ($P < 0.05$) lower than for T3 (68.92) and T4 (74.38 g /100g N). The effective degradability of N, at the rumen outflow rate (k) 0.03 $h^{-1}$ were similar ($P > 0.05$) for T1 and T2 both of which were significantly lower ($P < 0.05$) than the similar values for T3 and T4. The values were; 44.23, 45.73, 51.70 and 50.67 g/100g N, for T1- T4 respectively. It was observed that the **a** values or the soluble fraction of the N degraded were low, ranging between 6.49 (T4) and 11.11 g/100 g N (T3). The **b** or degradable fractions ranged between 77.24 (T3) and 86.39 g/100g N (T4) and were thus about 8 to 12 times higher than a values.

**Table 5** *Effect of total digestible nutrients (TDN) level of the diets on nitrogen (N) degradation characteristics*

| Level of TDN (kg) | a | b | c | PD | 48 h | ED |
|---|---|---|---|---|---|---|
| 3.5 | 10.95$^{a}$ | 80.59$^{ab}$ | 0.023$^{b}$ | 91.54 | 62.20$^{c}$ | 44.23$^{b}$ |
| 4.5 | 9.90$^{a}$ | 84.41$^{ab}$ | 0.020$^{b}$ | 94.30 | 63.99$^{c}$ | 45.73$^{b}$ |
| 5.5 | 11.11$^{a}$ | 77.24$^{b}$ | .027$^{ab}$ | 88.36 | 68.62$^{b}$ | 51.70$^{a}$ |
| 6.5 | 6.49$^{b}$ | 86.39$^{a}$ | 0.033$^{a}$ | 92.88 | 74.38$^{a}$ | 50.67$^{a}$ |
| SE ± | 0.56 | 1.76 | 0.002 | 1.89 | 0.65 | 0.46 |

Means followed by unlike letters in the same column are significantly different ($P < 0.05$). Means without letters are similar ($P > 0.05$).

a = soluble fraction (g / 100g N), b = degradable fraction (g / 100g N), c = rate of degradation of b ($h^{-1}$), PD = potential degradability (g / 100g N), 48h = 48hr degradation (g/100g N), ED = effective degradability (g / 100g N).

***Correlation among constants of in situ nitrogen (N) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets***

Relationships between nitrogen degradation constant **a** (soluble fraction) and DM, ADF and NDF contents of diets were negative and not significant. Correlation between **a** and CP of diets was negative and significant ($r = -0.645$; $P = 0.007$) and that between **a** and percent CF of diets was positive and significant ($r = 0.644$; $P = 0.007$; Table 6). Correlation between rate of N degradation, **c** and DM content of diets T1-T4 was positive and significant ($r = 0.512$; $P = 0.043$); that between **c** and CF percent of diets was negative and significant ($r = -0.532$; $P = 0.034$). The correlation between **c** and CP, ADF and NDF percent of diets were positive and non-significant. The relationship between ED of nitrogen degradation and percent CF of diets was also negative and highly significant

(r = - 0.778; P = 0.0004). Correlation between other nitrogen degradation constants b, PD, ED and the DM, CP, CF, ADF and NDF contents of T1- T4 were not significant.

**Table 6** *Correlation among constants of in situ nitrogen (N) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets*

| | DM | CP | CF | ADF | NDF |
|---|---|---|---|---|---|
| **a** | - 0.329ns | - 0.645** | 0.644** | - 0.297ns | - 0.415ns |
| **b** | - 0.128ns | - 0.0404ns | - 0.275ns | - 0.132ns | - 0.207ns |
| **c** | 0.512* | 0.303ns | - 0.532* | 0.109ns | 0.345ns |
| PD | 0.329ns | - 0.127ns | 0.024ns | - 0.005ns | - 0.019ns |
| ED | - 0.432ns | - 0.296ns | - 0.778** | - 0.186ns | - 0.076ns |

* = significant at P< 0.05, ** = significant at P< 0.01, ns = significant
a = soluble fraction (g / 100g N), b = degradable fraction (g / 100g N),
c = rate of degradation of b ($h^{-1}$), PD = potential degradability (g / 100g DM),
ED = effective degradability (g / 100g N).
DM = dry matter, CP = crude protein, CF = crude fibre, ADF = acid detergent fibre,
NDF = neutral detergent fibre.

## Discussion

### *Chemical composition of diets*

The high DM contents of the experimental diets helped to avoid spoilage of these concentrate diets (seed cakes) and the hay. The observed differences in the diets could be attributed to the fact that they were compounded to have different TDN values. The diets had high nutrient contents, and particularly the high crude protein content appeared to have high nutritional potential for the feeding of lactating cows used in the main feeding experiment. The high crude protein contents of the seed cakes and the forage legume hay used in compounding the experimental diets enhanced the overall nitrogen contents of these diets.

### *In sacco dry matter degradation of experimental diets in N'Dama bulls*

The values obtained for the **a** (soluble fraction) of the four treatment diets were not significantly (P> 0.05) different from each other. This might be due to the similarities in the chemical composition of the diets. The **a** values of 25.99 – 27.91% were slightly higher than the **a** value of 20.2% reported by Sibanda *et al.*(1993) for dry matter of cottonseed cake and **a** value of 19.6% obtained when cottonseed cake was incubated in combination with maize. The values obtained in the present study for **b**, 47.33 – 52.10%, **c**, 0.026 – 0.035 $h^{-1}$, PD (**a** + **b**), 73.36 – 79.47% and ED, 48.77 – 50.63% were also similar to the **b**, 53.4%, **a+b**, 73.6%, **c**, 0.0527 $h^{-1}$ and ED, 47.4% reported by Sibanda *et al* (1993). The **b** values obtained for DM degradation characteristics were about 1.8 to 1.9 times that of **a**. The high degradable portion **b** might be due to the fibrous nature of the feed ingredients cottonseed cake, dried brewer's grains and *Lablab purpureus* forage hay, which were insoluble but degradable in the rumen. The 48h dry matter disappearance values of 62.15 – 63.93% was in close agreement with the 48 h dry matter disappearance value of 62.3% reported for brewer's spent grains by Karikari *et al.* (1995).

### *Correlation among constants of in situ dry matter (DM) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets*

Generally, the observed negative and non-significant correlation between dry matter degradation constants **a**, **b**, **c**, PD and ED and the chemical composition CP, ADF and NDF were consistent with the findings of Larbi *et al.* (1997) who made similar observations in the dry matter degradation experiments undertaken during the dry season of the year. The only positive and significant correlation existed between the **a** (soluble fraction of DM degradation) and the CF content. There might

exist positive relationship between the crude fibre content of the diet and the proportion of the soluble nutrients available in the **a** fraction of DM degradation which probably was used for bacteria fermentation processes.

***In sacco nitrogen degradation of experimental diets incubated in the rumen of fistulated N'Dama bulls***

The N degradation characteristics obtained by Sibanda *et al.* (1993) when cottonseed cake alone was incubated, which were **a**, 9.8 %; **b**, 72.90%; PD (**a**+**b**), 82.7%; ED, 43.3% and **c**, 0.05 $h^{-1}$ were close to the values of nitrogen degradation characteristics of **a**, 6.49 – 11.11%; **b**, 77.24 – 86.39%; PD (**a**+**b**), 88.36 – 94.30%; ED, 44.23 – 51.70% and **c**, 0.020 – 0.033 $h^{-1}$ reported in the present study. The crude protein disappearance of 74.1% at 48h of incubation for brewer's spent grains concentrate reported by Karikari *et al.* (1995) was also in agreement with the 48h nitrogen disappearance value of 62.20 – 74.38% for the concentrate diets used in the present study. When the values for the N degradation constants **a** and **b** representing the soluble and the degradable portions of the treatment diets were compared, it was observed that the **b** values were about 8-12 times the **a** values. The high **b** proportions in the diet treatments was an indication that the nitrogen composition of the ingredients was not very soluble but highly degradable in the rumen. Preston and Leng (1987) explained that the nitrogen or protein portion of the diet (**a** + **b**) was degraded into peptides and amino acids by the bacterial proteases and peptidases. They further mentioned that during this lysis of protein in the rumen, the soluble protein was adsorbed rapidly onto the bacteria cell prior to lysis. The values of **c** (the rate of degradation of **b**) ranged 0.020 – 0.033 $h^{-1}$ in the present study and were lower than the **c** value of 0.05$h^{-1}$ reported by Sibanda *et al.* (1993) for nitrogen degradation of cottonseed cake alone. The difference in the observed c values for nitrogen degradation of the various diets might be due to the differences in the fibre contents of the degradable portion of these diets which caused different rates of degradation of the diets. Similarly, Preston and Leng (1987) mentioned that the rate of degradation of protein was affected by the presence of lipids or other water insoluble substances in the diet. They also stated that the lipids might reduce the surface area of the protein that was accessible to microbial proteases. Therefore, the slower rate of degradation of nitrogen in the experimental diets used in this study could be due to the presence of residual fat (as in the cottonseed cake used) or other water insoluble substances such as the fibrous portion of the diets.

***Correlation among constants of in situ nitrogen (N) degradation and chemical composition (DM, CP, CF, ADF and NDF) of experimental diets***

Larbi *et al.* (1997) reported negative and significant and also non-significant correlation among nitrogen degradation characteristics, **a**, **b**, **c** and PD and chemical composition components, CP, ADF and NDF as was observed in the present study. The rate of nitrogen degradation, **c**, was significantly correlated with CF. This was also similar to the findings of Larbi *et al.* (1997) who reported significant correlation between the rate of nitrogen degradation, **c** and the CP, NDF and ADF of the diet. Significant correlation between CF and N degradation constants **a**, **c** and ED reported in this study probably implied that there was a positive relationship between the crude fibre breakdown by rumen microbes and the nitrogen degradation process.

## Conclusion

There were non-significant ($P>0.05$) differences in the *in sacco* DM degradation characteristics of the experimental diets. The degradation characteristics of nitrogen for the diets were however significantly ($P<0.05$) different among the four dietary treatment levels. The potential degradability (DM) values ranged from 75.24 to 79.47g/100g DM, while that for the potential degradability (N) values ranged between 88.36 and 94.30

g /100g N. Significant correlation existed between the **a** (soluble fractions of DM and N degradation) and crude fibre content of chemical

composition. These probably implied that there were positive relationships between the crude fibre breakdown by rumen microbes and the DM and N degradation processes.

## Acknowledgement

We are indebted to the International Livestock Research Institute (ILRI), Ibadan, Nigeria, who funded this research work.

## References

**A.O.A.C.** 1991 Association of Official Analytical Chemists. *Official Methods of Analysis.* 16th ed., Washington, D.C., U.S.A.

**Church, D. C.** 1977. Digestive Physiology and Nutrition of Ruminants. Vol. 1; 2nd ed. O. B. Books, Corvallis, Oregon, U.S. A. Pg. 53 – 67.

**DeBoer, G., Murphy, J.J.and Kennelly, J.J.** 1987. Mobile nylon bag for estimating intestinal availability of rumen undegradable protein. *J. Dairy Sci.* 70: 977 - 982.

**Ezenwa, I. V.** 1995. Forage production potentials of herbaceous and tree legumes in mixtures with grasses in Oyo State, Nigeria. Ph. D. Thesis, Agronomy Dept., University of Ibadan, Ibadan.

**Fall-Toure, S.and Michalet-Doreau, B.** 1995. Nitrogen partition in cell structure of tropical browse plants compared with temperate forages: influence on their *in situ* degradation pattern. *Anim. Feed. Sci. Tech.* 51:65 - 72.

**Ganev, G., Orskov, E.R. and Smart, R.** 1979. The effect of roughage or concentrate feeding and rumen retention time on total degradation of protein in the rumen. *J. Agric. Sci. (Camb)* 93 : 651 – 656.

**Gomez, K.A. and Gomez, A.A.** 1986. Statistical Procedure for Agricultural Research. 2nd ed. John Wiley and sons Inc. U.S.A.

**Kabuga, J. D. and Darko, C. A.** 1993. *In sacco* degradation of dry matter and nitrogen in oven-dried and fresh tropical grasses and some relationships to *in vitro* dry matter digestibility. *Anim. Feed Sci. Tech.* 40:191 - 205.

**Karikari, P.K., Gyawu, P., Asare, K. and Yambillah, S.S.** 1995. The reproductive response of N'Dama cows to brewer's spent grains supplementation in a hot humid environment. *Trop. Agric. (Trinidad)* 72: 315 - 318.

**Larbi, A., Smith, J.W., Raji, A.M., Kurdi, I. O., Adekunle, I.O. and Ladipo, D.O.** 1997. Seasonal dynamics in dry matter degradation of browse in cattle, sheep and goats. *Small Ruminant Research* 25 : 129 - 140.

**Larbi, A., Smith, J.W., Kurdi, I. O., Adekunle, I. O., Raji, A. M. and Ladipo, D. O.** 1998. Chemical composition, rumen degradation, and gas production characteristics of some multipurpose fodder trees and shrubs during wet and dry seasons in the humid tropics. *Anim. Feed Sci. Tech* 72: 81 - 96.

**Little, T. M. and Hills, F. J.** (1978). *Agricultural Experimentation.* Design and Analysis. John Wiley and Sons, Inc., N. Y., U.S.A.

**Lufadeju, E. A. .and Olorunju, S. A. S.**1986. The ruminal degradation of some agro-industrial by-products. *J. Anim. Prod. Res.* 6 (2) :161 – 170.

**McDonald, P., Edwards, R.A. and Greenhalgh, J. P. D.** 1987 *Animal Nutrition*, 4th ed. Longman Scientific and Technical Company, England. Pp154 – 176.

**Mehrez, A.Z. and Orskov, E.R.** 1977. A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. *J. Agric. Sci. (camb)* 8: 645 - 650.

**Orskov, E.R., and McDonald, I.** 1979. Estimation of protein degradability in the rumen from incubation measurements, weighed according to rate of passage. *J. Agric. Sci. (cambridge)* 92 : 499 - 503.

**Orskov, E.R., Hovell, F.I., De, B. and Mould, F.** 1980. The use of the nylon bag technique in the evaluation of feedstuffs. *Trop. Anim. Prod.* 5 : 195 - 198.

**Osuji, P.O., Sibanda, S. and Nsahlai, I.V.** 1993. Supplementation of maize stover for Ethiopian Menz sheep: effects of cottonseed, noug or sunflower cake with or without maize on the intake, growth, apparent digestibility, nitrogen balance and excretion of purine derivatives. *Anim. Prod.* 57: 429 - 436.

**Preston, T.R. and Leng, R.A.** 1987. Matching ruminant production systems with available resources in the tropics. 1st ed. Penambul Books, Armidale, New South Wales, Australia. Pg. 21-36.

**SAS** 1987. Statistical Analytical Systems. SAS / STAT. User's guide. Version 6, 3rd. ed. Cary. North Carolina, U. S. A. Pg.943.

**Sibanda, S., Osuji, P.O.and Nsahlai, I.V.** 1993. The degradation of oilseed cakes and their effects on the intake and rumen degradability of maize stover given to Ethiopian Menz sheep. *Anim. Prod.* 57: 421 - 428.

**Van Soest, P. J., Robertson, J. B. and Lewis, B. A.** 1991. Methods for dietary fibre, neutral detergent fibre and nonstarch polysaccharides in relation to animal nutrition. *J. Dairy Sci.* 74 : 3583 – 3597.

*(Received 30 October 2000; Accepted 20 April 2002)*