



## CRUDE PROTEIN DEGRADABILITY (*in sacco*) OF UNTREATED AND TREATED NAPIER GRASS (*Pennisetum puerperium*) SILAGES

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### ABSTRACT

The study was carried out to determine crude protein rumen degradability of differently ensiled Napier grass, and the nylon-bag procedure was used. Napier grass harvested at 16 weeks after planting was allowed to wilt for a day before ensiling. There were four treatments thus; T<sub>1</sub>=untreated/plain, T<sub>2</sub>=treated with 4% urea, T<sub>3</sub>=treated with 4% molasses and T<sub>4</sub>=treated with 2% molasses and 2% urea. Two White Fulani bulls (weighing 285kg and 292kg), fitted with rumen cannula were used. The incubation periods were 6, 12, 24, 48, 72 and 96 hours. Representative samples of each feed material were obtained and shed-dried, ground using pestle and mortar and sieved through a 1mm sieve. Four grams each of the representative samples were weighed into the nylon bags and incubated in the rumen. The samples were prepared in triplicate for every feed material, for each animal. The results of the CP disappearance of the silages showed that T<sub>2</sub> (4% urea treated Napier grass) had the highest rumen degradability in the earlier incubation times (22.61% after 6 hours and 28.61% after 12 hours). At 24 hours to 96 hours of incubation, T<sub>3</sub> (4% molasses treated Napier grass) recorded the highest degradability (41.05%, 52.89%, 61.19% and 68.44% for 24, 48, 72 and 96 hours respectively). For CP kinetics of the silages, T<sub>2</sub> had the highest soluble fraction 'a' (15.09%), T<sub>3</sub> had the highest insoluble but potentially degradable fraction 'b' (60.11%) and potential degradability 'a+b' (75.11%). Outflow rate of degradation per hour 'c' was highest in T<sub>2</sub> (0.091). The treated Napier grass silages have shown to have better crude protein degradability than that of the untreated/plain silage. Feeding these silages to ruminants is therefore recommended as they have recorded adequate crude protein degradability in the rumen, particularly the 4% molasses treated silage.

**Keywords:** Napier grass, silage, molasses, urea, degradability, crude protein

### INTRODUCTION

Animal production is a very important sector of the economy of any nation and is crucial in ensuring food security (Bamaiyi, 2013). Production of livestock therefore remains a priority and efforts to increase productivity by reducing problems of production must continue (Umar *et al.*, 2020). The development of the Nigerian animal production industry is of serious importance from the socioeconomic and public health point of view (Bamaiyi, 2013). Livestock production is an important tool in the economy of developing countries (Hyelda, 2017). Feed cost constitutes the single largest expenditure of livestock enterprise and accounts for approximately 60 % of total cost of production (Jagadeesh *et al.*, 2017). The majority of ruminant animals in tropical Africa are raised on natural pastures which drop rapidly in quality (Amole *et al.*, 2021). In tropical environments, dry seasons pose a major nutritional constraint on ruminant livestock production (Rambau *et al.*, 2022). Climate seasonality affects yield and nutritive value over the year, concentrating forage production in the months with greater rainfall and higher temperatures (Ferreira *et al.*, 2014). Thornton (2010) noted that poor nutrition is one of the major production constraints in smallholder



systems, particularly in Africa. In order to sustain the animals and ensure better productivity, there is need to explore the available natural pasture for silage and hay making such that the animals could be adequately fed during the dry season (Lawal-Adebowale, 2012).

Napier grass (*Pennisetum purpureum*) is a native grass grown and commonly used as a silage crop in tropical climates due to its high quality and yield (Bureenok *et al.*, 2012). Napier grass is native to Sub-Saharan Africa from where it is believed to have been distributed to other tropical and subtropical regions around the world (Negawo, *et al.*, 2017). It is considered one of the most important tropical forages because of its high potential for biomass production, easy adaptation to diverse ecosystems and good acceptance by the animals (Ferreira *et al.*, 2014). It has been grown in almost all tropical and subtropical regions of the globe due to its high potential for forage accumulation, nutritive value, acceptability by different animal species, vigor and persistence (Pereira *et al.*, 2021). It is widely used to feed herds in the forms of pasture and especially as silage, because of its high soluble carbohydrate content that favors good fermentation (Patrizi *et al.*, 2004).

Ensilage is the method of forage conservation based on conversion of water-soluble carbohydrates in organic acids by the activity of lactic acid bacteria, which reduces the pH and preserve the fresh forage. The ensiling process show advantages such as conservation of large quantities of forage in short time and forage conservation is less weather dependent. (de Oliveira *et al.*, 2016). Ensiling tropical grasses has gained importance due to the high productivity of these forages, which favors the reduction of the cost of feeding ruminants compared to traditional crops like corn and sorghum (Ribeiro-Junior *et al.*, 2014). Generally, ensiling is considered as an efficient process of preserving forage with high moisture content in sufficiently good quantity (Rambau *et al.*, 2022). Effective ensilage can reduce the cost of feeding ruminants and ensure a steady supply of quality feed (Pirmohammadi *et al.*, 2006). This study was conducted to determine the *in sacco* crude protein degradability and degradability kinetics of differently ensiled Napier grass.

## **MATERIALS AND METHODS**

### **Study Site**

The research was conducted at the teaching and research farm of the Federal College of Education Yola, Adamawa state. It lies within the Guinea Savannah Zone of Nigeria within latitude 09.11° North and longitude 12.28°. It has a tropical climate made up of dry and rainy seasons. The rainy season commences in April and ends late October while the dry season starts in October and ends in April. It has an annual rainfall of 800-1500mm. The ambient temperature ranges from 25 - 44°C (Adebayo *et al.*, 2020).

### **Experimental Animals**

Two (2) White Fulani (Bunaji) bulls, weighing 285 and 292kg and fitted with rumen cannula were used for the study. The experimental animals were fed a diet of Napier grass hay, maize bran and cottonseed cake throughout the experimental period. Water and mineral salt lick were given *ad-libitum*.

### **Ensiling Napier Grass**

Harvested Napier grass (at 16 weeks after planting) was allowed to wilt for a day before ensiling. The treated and untreated/plain Napier grass were preserved in black, air-tight polythene sheets, covered with sacks for two months.

T<sub>1</sub> = Ensiled Napier grass (untreated)

T<sub>2</sub> = Ensiled Napier grass (treated with 4% urea)

T<sub>3</sub> = Ensiled Napier grass (treated with 4% molasses)

T<sub>4</sub> = Ensiled Napier grass (treated with 2% molasses and 2% urea)



DM=dry matter, CP=crude protein, CF=crude fat, EE=ether extract, NFE=nitrogen free extract

### Preparation of Feed Samples for Incubation

Representative samples of each feed material were obtained and shed-dried, ground using pestle and mortar and sieved through a 1mm sieve. Four (4) grams each of the representative samples were weighed into the nylon bags and incubated in the rumen at varying specified time intervals. The samples were prepared in triplicate for every feed material, for each animal.

### Incubation in the Rumen

The representative samples were incubated in the rumen at 6, 12, 24, 48, 72 and 96 hours. Each bag was pushed slowly into the rumen through the cannula. A small nylon string was attached to each bag, which was used in withdrawing each bag from the rumen after incubation. The cannula was tightened and the bags left in the rumen for each specified period.

### Withdrawal of Bags from Rumen, Washing and Drying

At the end of each incubation period, each bag was withdrawn and was washed immediately under a running tap water until clear water comes out from the bags. The residual feed samples in the bags were dried at 60°C for 48 hours in an oven. The oven dried residues were weighed again and the difference in weight of each bag recorded.

**Table 1:** Proximate composition of Harvested Napier Grass (16 WAP) and Silages

Trts	DM	CP	CF	EE	Ash	NFE
16 WAP	27.55	8.36	37.77	1.52	9.64	42.71
T <sub>1</sub>	48.02	9.18	37.44	2.57	9.98	40.83
T <sub>2</sub>	46.59	10.35	34.52	2.06	9.71	43.36
T <sub>3</sub>	48.11	9.98	36.18	3.32	10.24	40.28
T <sub>4</sub>	46.82	10.24	36.91	1.91	10.18	40.76

**Table 2:** Average Crude Protein (%DM) of the Silage Residues After Degradability

Samples	Rep	Incubation Period (Hours)							CPBD
		0	6	12	24	48	72	96	
T <sub>1</sub>	6	7.77	7.13	6.71	5.65	4.65	4.03	3.46	9.01
T <sub>2</sub>	6	8.63	7.87	7.26	6.05	4.95	4.25	3.55	10.16
T <sub>3</sub>	6	8.32	7.65	7.18	5.77	4.61	3.81	3.10	9.80
T <sub>4</sub>	6	8.55	7.89	7.42	5.98	4.87	4.11	3.41	10.05

CPBD= crude protein before degradability

### The Washing Loss (Solubility)

The washing loss for each feed material was determined when four grams of each sample was placed into the nylon bag, soaked in warm water (37°C) for one hour and washed under tap water till the water obtained from the bag was very clear. This was done in triplicate for every feed material. The samples were then dried at 60°C for 48 hours in an oven. The oven dried samples were weighed again and the difference in weight of each bag recorded.

### Data Analysis

The NEWAY EXCEL, a utility for processing data from feed degradability was used to compute the data obtained. The crude protein degradability of each sample were calculated from the disappearance of crude protein from the bags after incubation and washing, according to the equation by Ørskov and McDonald (1979).

$$P = a + b(1 - e^{-ct})$$



Where:

P = cumulative amount degraded at time 't'

a = fraction of feed material that is rapidly soluble in the rumen (%)

b = potentially degradable fraction in the rumen (%)

c = rate of degradation (%/hour)

t = time (hours)

The ruminal outflow rate (effective degradability) was calculated using the Ørskov and McDonald (1979) equation;

$$P = \frac{a+bc}{c+k}$$

Where;

P = percent disappearance in the rumen at time 't'

a, b and c = constants from the equation;  $P = a + b(1 - e^{-ct})$  describing the degradation

k = fractional outflow/passage rate

### Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using JMP Statistical Analysis System software (2013). Differences among treatment means were determined using Duncan's Multiple Range Test of the same statistical package at  $P < 0.05$ .

The statistical model used for data generated was:

$$Y_{ij} = \mu + K_i + e_{ij}$$

Where:

$Y_{ij}$  = observation of the  $i^{th}$  of the treatment

$\mu$  = overall mean

$K_i$  =  $i^{th}$  effect of the treatment

$e_{ij}$  = random error

## RESULTS

### *In sacco* Crude Protein Disappearance (%) of the Silages

The results of the *in sacco* crude protein disappearance (%) of the silages are presented in Table 3. The crude protein washing loss (0 hour) for the silages ( $T_1$  to  $T_4$ ) were 14.72, 15.09, 15.03 and 14.90% respectively. Treatment two ( $T_2$ ) had the highest level of rumen degradation at 0 hour (15.09%), 6 hours (22.61%) and 12 hours (28.61%) and  $T_3$  had the highest level of rumen degradation at 24 hours (41.05%), 48 hours (52.89%), 72 hours (61.19%) and 96 hours (68.44%). All the silages had above 50% degradability after 48 hours of incubation in the rumen except for  $T_1$ , which was 48.35%. The level of crude protein disappearance was increased with increase in incubation time. There were significant ( $p < 0.05$ ) differences between all the silages in all the different incubation times.

**Table 3:** *In sacco* Crude Protein Disappearance (%) of the Silages

Feed material	Incubation period (Hours)						
	0	6	12	24	48	72	96
$T_1$	14.72 <sup>c</sup>	20.79 <sup>d</sup>	25.49 <sup>d</sup>	37.36 <sup>c</sup>	48.35 <sup>d</sup>	55.34 <sup>d</sup>	61.53 <sup>d</sup>
$T_2$	15.09 <sup>a</sup>	22.61 <sup>a</sup>	28.61 <sup>a</sup>	40.48 <sup>b</sup>	51.25 <sup>c</sup>	58.14 <sup>c</sup>	65.13 <sup>c</sup>
$T_3$	15.03 <sup>a</sup>	21.91 <sup>b</sup>	26.70 <sup>b</sup>	41.05 <sup>a</sup>	52.89 <sup>a</sup>	61.19 <sup>a</sup>	68.44 <sup>a</sup>
$T_4$	14.90 <sup>b</sup>	21.46 <sup>c</sup>	26.14 <sup>c</sup>	40.57 <sup>b</sup>	51.67 <sup>b</sup>	59.03 <sup>b</sup>	66.10 <sup>b</sup>
CV	0.30	0.38	0.29	0.28	0.14	0.14	0.13
LOS	*	*	*	*	*	*	*

Means with different superscript in the same row differ significantly ( $p < 0.05$ )

CV = Coefficient of variation, LOS = Level of significance, \* = Significantly different ( $p < 0.05$ )

### ***In sacco* Crude Protein Degradability Kinetics of the Silages**

The *in sacco* crude protein degradability kinetics (degradability constants and effective degradability at three rumen fractional outflow rates) of the silages are presented in Table 4. For the crude protein kinetics of the silages, T<sub>2</sub> had the highest soluble fraction (*a*) of 15.09%, followed by T<sub>3</sub>, T<sub>4</sub> and T<sub>1</sub> (15.00, 14.90 and 14.72% respectively), and there were significant ( $p < 0.05$ ) differences between the four silages. Treatment three (T<sub>3</sub>) had the highest insoluble but potentially degradable fraction (*b*) of 60.11% and also the highest potential ruminal degradability (*a+b*) of 75.11%. The '*b*' and '*a+b*' for the other treatments were 52.46% and 67.18% (T<sub>1</sub>), 55.06% and 70.15% (T<sub>2</sub>) and 56.25% and 71.15% (T<sub>4</sub>). There were significant ( $p < 0.05$ ) differences between the silages for both '*b*' and '*a+b*'. Outflow rate of degradation per hour (*c*) was highest at T<sub>2</sub> (0.091) and lowest at T<sub>1</sub> and T<sub>3</sub> (0.022) and there were no significant ( $p > 0.05$ ) differences between the silages. There was a reduction in the rumen outflow rate per hour (*k*) in the sequence of 1%, 3% and 5%. That is, effective degradability was highest at  $k=0.01$  (50.63%, 53.60%, 55.87% and 53.90% for T<sub>1</sub> to T<sub>4</sub> respectively) and lowest at  $k=0.05$  (30.33%, 32.97%, 32.63% and 32.00% T<sub>1</sub> to T<sub>4</sub> respectively) in all the four silages. There were significant ( $p < 0.05$ ) differences between the silages at all the different outflow rates calculated. The effective degradability was highest in T<sub>3</sub> at 1% and 3% outflow rates while T<sub>2</sub> had the highest effective degradability at 5% outflow rate.

**Table 4:** *In sacco* Crude Protein Degradation Kinetics of the Silages

Feed Material	Degradability constants (%)				ED (%) at different outflow rates		
	<i>a</i>	<i>b</i>	<i>c</i>	<i>a+b</i>	$k=0.01$	$k=0.03$	$k=0.05$
T <sub>1</sub>	14.72 <sup>d</sup>	52.46 <sup>d</sup>	0.022	67.18 <sup>d</sup>	50.63 <sup>d</sup>	36.60 <sup>d</sup>	30.33 <sup>d</sup>
T <sub>2</sub>	15.09 <sup>a</sup>	55.06 <sup>c</sup>	0.091	70.15 <sup>c</sup>	53.60 <sup>c</sup>	39.37 <sup>b</sup>	32.97 <sup>a</sup>
T <sub>3</sub>	15.00 <sup>b</sup>	60.11 <sup>a</sup>	0.022	75.11 <sup>a</sup>	55.87 <sup>a</sup>	39.77 <sup>a</sup>	32.63 <sup>b</sup>
T <sub>4</sub>	14.90 <sup>c</sup>	56.25 <sup>b</sup>	0.023	71.15 <sup>b</sup>	53.90 <sup>b</sup>	38.80 <sup>c</sup>	32.00 <sup>c</sup>
CV	0.26	0.42	1.15	0.32	0.18	0.16	0.12
LOS	*	*	ns	*	*	*	*

Means with different superscript in the same row differ significantly ( $p < 0.05$ )

CV = Coefficient of variation, LOS = Level of significance

\* = Significantly different ( $p < 0.05$ ), ns = Not significantly different ( $p > 0.05$ )

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

*c* = Outflow rate of degradation per hour, *a+b* = Potential degradability

*k* = Rumen outflow rate per hour, ED = Effective degradability

## **DISCUSSION**

### **Actual Crude Protein Disappearance**

The results of the *in sacco* rumen degradability for crude protein indicated that the crude protein content of the silages is one of the factors that determined the level of crude protein ruminal degradation. In comparison to what were recorded in this study, Jagadeesh *et al.* (2017) reported lower crude protein disappearance at 6 hours (18.86%) and 24 hours (46.67%) of incubation when hybrid Napier grass harvested at 60 days was degraded in the rumen. Ferreira *et al.* (2015) reported similar crude protein washing loss (16.54%) for untreated Napier grass silage but lower crude protein washing loss (9.23 to 12.20%) for treated Napier grass silages when compared to the crude protein washing loss (14.72 to 15.09%) recorded in this study. Ferreira *et al.* (2015) further reported higher crude protein disappearance at 6 hours (22.82 to 28.26%) and slightly lower crude protein disappearance at 24, 48 and 96 hours (31.47 to 36.87%, 42.17 to 49.09% and 52.18 to 64.82% respectively) when compared to the corresponding crude protein disappearance of the silages in this study.





In this study, the treated silages had a higher crude protein disappearance in the rumen than the untreated silage, which might be due to the superior nutrient composition of the treated silages. This agrees with Rambau *et al.* (2022) who opined that the higher crude protein contents and higher degradability of additives increased the degradability of Napier grass silages as a result of an increase in microbial degradation in the rumen. It also tallies with the findings of Gomes *et al.* (2015) who reported that highly soluble and digestible sugars and starch from the additives contributed to increased nutrient disappearance in the rumen. Additionally, the findings of this study collaborate with that of Mtengeti *et al.* (2014), Ferreira *et al.* (2015) and Rambau *et al.* (2022), who reported an increase in crude protein degradability when additives were used in ensiling Napier grass than when Napier grass was ensiled untreated. Rambau *et al.* (2016) opined that an increase in disappearance could be as a result of an increase in crude protein and a decrease in acid detergent lignin of feed materials. This tallies with the findings in this study in which ensiling Napier grass with molasses and urea helped in increasing the crude protein of the silages (9.98 to 10.35% for the treated silages and 9.18% for the untreated silage).

### **Crude Protein Degradability Kinetics**

The crude protein soluble fractions (*a*) of the silages in this study (14.72 to 15.09%) are within 11.40 to 18.66% reported by Ferreira *et al.* (2015) but lower than 35.12 to 37.01% reported by Ferreira *et al.* (2014) and higher than 7.4 to 13.7% reported by Rambau *et al.* (2022) when untreated and treated Napier grass silages were degraded in the rumen. Ribeiro-Junior *et al.* (2014) reported similar crude protein soluble fraction (14.8%) when Gamba grass silage was degraded in the rumen but Negrao *et al.* (2014) reported higher crude protein soluble fractions (36.50 to 45.89%) when Bracharia grass silages were degraded in the rumen. The crude protein insoluble but potentially degradable fractions (*b*) of the silages in this study (52.46 to 60.11%) are within 42.03 to 62.61% reported by Ferreira *et al.* (2015) but lower than 56.9 to 69.2% reported by Rambau *et al.* (2022) and higher than 46.67 to 48.30% reported by Ferreira *et al.* (2014) when differently ensiled Napier grass were degraded in the rumen. Bonelli *et al.* (2013) reported 46.69 to 48.53% as the potentially degradable fractions of Guinea grass silages, and these figures are lower than 52.46 to 60.11% recorded in this study. The crude protein outflow rate of degradation per hour (*c*) of the silages in this study (0.022 to 0.091 %/hour) are higher than 0.014 to 0.030 %/hour (Ferreira *et al.*, 2015) and 0.002 to 0.004%/hour (Rambau *et al.*, 2022) but the values 0.029 to 0.036 %/hour reported by Ferreira *et al.* (2014) are within 0.022 to 0.091 %/hour recorded in this study. The crude protein potential degradability (*a+b*) recorded for the silages in this study (67.18 to 75.11%) are within 64.9 to 82.9% and 54.1 to 81.27% reported by Rambau *et al.* (2022) and Ferreira *et al.* (2015) respectively but lower than 83.33 to 84.29% reported by Ferreira *et al.* (2014).

The crude protein effective degradability at 5% ( $k=0.05$ ) for the silages in this study (32.00 to 32.97%) are lower than 48.29 to 49.89% (Ferreira *et al.*, 2014) but higher than 26.7 to 32.0 (Ferreira *et al.*, 2015) and fall within 31.3 to 44.9% (Rambau *et al.*, 2022) for differently ensiled Napier grass, degraded in the rumen. It was observed in this study that the crude protein effective degradability decreased with increase in the rate of passage per hour from 1% to 5% ( $k=0.01$  to  $k=0.05$ ) and this collaborates with the report of Chanjula *et al.* (2003), Ferreira *et al.* (2015), Jancik *et al.* (2009) and Li *et al.* (2023) who recorded a decrease in the rumen outflow rate per hour when the rate of passage per hour was increased. The findings of this study also collaborate with Ørskov and McDonald (1979) who reported that with higher outflow rates, less is degraded.



## CONCLUSION AND RECOMMENDATION

All the silages were well degraded in the rumen. However, the crude protein degradability of the treated Napier grass silages were better than that of the untreated/plain silage. Feeding these silages to ruminants is therefore recommended as the silages had shown adequate crude protein degradability in the rumen. Particularly, the 4% molasses treated Napier grass silage was better than the other silages in terms of actual degradability and degradability kinetics.

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