Trop. Anim. Prod. Invest. 10 (1): 01-10 (2007)
ISSN: 1115-2540
http://animalsci.agric.ui.edu.ng/TAPI/index.php/tapijournal/index

ORIGINAL RESEARCH ARTICLE

Evaluation of the nutritive value of some selected forages in late dry and early rain seasons by white Fulani heifers in Ibadan, Nigeria

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ABSTRACT

The nutritive value of eleven tropical forages: Cynodon dactylon, Panicum maximum, Ipomea aquatica, Althernanathera dentata, Sarcolepis africana, Leucaena leucocephala, Centrosema molle, Echinochloa stagirina, Pennisetum purpureum, Setaria baratata and Panicum maximum regrowth selected by white Fulani heifers in two prominent seasons of the year in the tropics (early rain and late dry) were studied through analysis of their proximate composition, fibre fractions and in vitro digestibility. Results of the proximate analysis showed an increase in the crude protein (g/100g DM) from 7.37% in Panicum maximum to 27.39% for Leucaena leucocephala. Crude fibre value ranged between 12.87% for Leucaena leucocephala and 29.60% for Centrosema molle. Neutral detergent fibre, acid detergent fibre and acid detergent lignin was significant among the forages. A significantly highest gas volume was obtained in Ipomea aquatica and the gas production rate constant (c) was not significant in the late dry season. The estimated metabolisable energy (ME) (MJ.Kg^{-1}DM), organic matter digestibility (OMD %) and short chain fatty acid (SCFA) (µm) ranged from 10.15 (Setaria bartata) to 20.98 (Leucaena leucocephala), 43.65 (Sarcolepis Africana) to 53.28 (Leucaena leucocephala) and 0.31 (Athernanthera dentata) to 0.71 (Ipomea aquatica). Seasonality effect on insoluble but degradable fraction (b) was significant ranging from 11.00mL in Panicum maximum regrowth to 28.00mL in Centrosema molle. The dry matter degradability (%/200mg DM) showed that Ipomea aquatica had the highest dry matter degradability (83.50) and the lowest value was recorded for Panicum maximum (48.53). It is therefore concluded from this study that seasonality affect the nutritive value of different forages in the tropics. Therefore forages in the rain season can be preserved for use in the off season so as to stabilize ruminant production.

Keywords: seasonality, nutritive value, forages, *in vitro* digestibility

INTRODUCTION

The success of the livestock industry anywhere in the world depends greatly on feed quantity and quality (Bamikole and Babayemi, 2004). Inadequate nutrition is one of the factors that generally affect livestock productivity. Nigeria has a wide diversity of climatic zones from the humid forest zone of the south to the very dry Sahel region of the North and mountainous cool belt of the plateau in the middle belt region. Vast areas of the forest region lie under the blood sucking insects challenge; hence the production of ruminant animal species is somehow limited. Despite the naturally endowed vegetations; there are still inadequate feeds and feedstuff for livestock in Nigeria. Period of dry season is always a stressful circumstance for livestock; as the environment is characterized by insufficient feed, occasioned by scarce forage and fibrous standing hays. The negative effect of the period is obvious in the loss of weight, reduced milk production and high mortality of the animals. Grazing ruminants attempt to adapt to these adverse condition by increasing the time for which they graze each day and also by dispersing more widely. In the off season, the leaf of browse trees show potentials to augment depleted nutrients, being high in protein, vitamins and minerals but also contain anti nutrients (Babayemi, 2006). Leaf meal from browse plants is bulky and may have low shelf- life. The conventional seed protein sources such as groundnut and soyabeans are scarce and expensive. As part of the new technology in animal husbandry, improved pastures produced more dry matter of high nutritive value and lead to greater animal productivity but land available are used for arable crop production (Ademosun, 1976).

Grazed herbage is the cheapest feed source available for cattle and sheep (Gibb and Orr, 1997) and so maximizing its utilization can be obtained by determining the nutritive value of naturally selected herbage. An insight into the plant species and their dominance in the late dry and early rain parts of the season may be vital for livestock farmers to strategize in

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Table 1: Different forages grazed by White Fulani heifers in late dry and early rain seasons in sub-humid zone of Nigeria

	Sward composition		
Forbs	Grasses	Legume	Browse
Althananthera Dentata	*Cynodon dactylon*	*Centrosema molle*	*Leucaena Leucocephala*
	Echonochloa stagirina		
Ipomea Aquatica	*Panicum maximum*		
	P.maximum regrowth		
Sarcolepsis Africana	*Pennisetum purpureum*		
	Setaria bartata		

formulating feeding regimes to meeting the animal's nutrient requirement for the remaining part of the off-season. The aim of this study therefore was to assess the quality and the nutritive value of selected forage grazed by white Fulani heifers in the late dry and early rain season of the year using in vitro fermentation method.

MATERIALS AND METHODS

Preparation of samples

The forages were selected at the ranged land within the Teaching and Research Farm University of Ibadan. Representative samples of the forages were obtained from the same area. Representative sample of the forage consumed/selected by the heifers was harvested and taken for dry matter analysis. The harvested forage was oven dried at 65˚C for dry matter. Dried samples were milled to pass through a 1mm mesh sieve.

Forage selection

Eight yearling white Fulani heifers with mean weight of 113.8 kg (± 9.86) were observed for the types of forages they graze in the range. The observation period lasted for three month both in the late dry and early rain season. Representative samples of forages consumed were taken for proper identification at the Department of Botany, University of Ibadan.

Chemical analysis

Crude protein, crude fibre, ash and ether extract were determined according to AOAC (1990) and the protein content was determined using the micro kjeldah method (N × 6.25), while neutral detergent fibre, acid detergent fiber and lignin were determined as reported (Van Soest *et al*., 1991).

In vitro gas production

The rumen fluid was collected prior to the early morning feeding. The rumen fluid was collected through the suction method by mean of the hose from three West African Dwarf (WAD) goats under the same feeding regime. The fluid was collected into a thermos flask and taken to the laboratory. The fluid was then filtered through a four-layered cheese cloth into a warm flask and flushed with carbon dioxide (CO_2) gas and stirred using an automatic stirrer. The buffer solution prepared was the McDougall's buffer which consisted of sodium bicarbonate ($NaHC0_3$),sodium phosphate dibasic (Na_2HP0_4) potassium chloride (KCl), sodium chloride NaC1), Magnesium sulphate ($MgS0_4.7H_20$) and calcium chloride ($CaCl_2.H_20$).

Table 2: Chemical composition (g/100g) DM of selected forages by White Fulani heifers in late dry season

	Forages Selected							
Nutrient constituents	CD	PM	IA	AD	SA	CM	LL	SEM
Dry matter	29.33^{b}	25.57^{bc}	18.20^{d}	16.90^{d}	18.20^{d}	40.87^{a}	42.73^{a}	2.12
Crude protein	7.67^{d}	7.37^{d}	11.17^{cd}	20.50^{b}	20.77^{b}	14.20^{c}	27.39^{a}	1.87
Crude fibre	17.70^{bcd}	23.07^{abc}	13.03^{d}	26.37^{ab}	18.20^{bcd}	29.60^{a}	12.87^{d}	2.73
Ether extract	4.30^{ab}	3.95^{abc}	3.07^{abc}	2.57^{bc}	3.20^{abc}	3.53^{abc}	4.70^{a}	0.58
Ash	9.07^{b}	10.13^{b}	9.07^{b}	16.23^{a}	11.63^{b}	8.20^{b}	8.20^{b}	1.31
NFE	42.33^{ab}	48.63^{ab}	63.83^{a}	46.00^{ab}	43.67^{ab}	51.00^{ab}	46.70^{ab}	0.84
NDF	65.66^{b}	61.85^{bc}	36.63^{h}	47.27^{fg}	53.14^{e}	44.76^{g}	39.70^{h}	1.70
ADF	40.31^{abc}	39.72^{abc}	48.49^{ab}	46.40^{abc}	55.85^{a}	38.31^{abc}	28.65^{c}	5.79
ADL	3.54^{bc}	8.21^{ab}	10.97^{a}	0.81^{c}	8.21^{ab}	7.40^{ab}	10.28^{a}	1.45

a,b,c,d,e,f,g,h means at the same row with different superscripts differ significantly (P<0.05); CD: *Cynodon dactylon;* PM: *Panicum maximum;* IA: *Ipomea aquatic;* AD: *Althernanthera dentate;* SA: *Sarcolepsis Africana;* LL: *Leucaena leucocephala*; CM: *Centrosema mole;* NFE: Nitrogen free extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin

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Table 3: Chemical composition (g/100g) DM of selected forages by White Fulani heifers in early rain season

	Forages grazed				
Nutrient constituents	PMR	ES	PP	SB	SEM
Dry matter	29.20^{b}	22.33^{cd}	21.83^{cd}	22.67^{bcd}	2.12
Crude protein	11.50^{cd}	10.33^{cd}	13.47^{cd}	7.97^{d}	1.87
Crude fibre	19.43^{bcd}	14.70^{cd}	20.73^{bcd}	18.33^{bcd}	2.73
Ether extract	3.40^{abc}	4.47^{a}	3.40^{abc}	2.20^{c}	0.58
Ash	12.00^{b}	16.17^{a}	3.53^{c}	10.27^{b}	1.31
NFE	53.60^{ab}	36.57^{b}	61.27^{a}	61.37^{a}	0.84
NDF	86.76^{a}	51.36^{ef}	56.43^{de}	60.20^{cd}	1.70
ADF	44.53^{abc}	43.06^{abc}	39.84^{abc}	36.09^{bc}	5.79
ADL	6.19^{ab}	8.76^{a}	8.09^{ab}	8.99^{a}	1.45

a,b,c,d,e,f,g,h means on the same row with different superscript differ significantly (P<0.05); PMR: *Panicum maximum* regrowth; ES: *Echinochloa stagirina*; PP: *Pennisetum purpureum*; SB: *Setaria bartata*; NFE: Nitrogen free extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin

The buffer solution was freshly prepared and stored in a dark bottle. The reagents were dissolved in distilled water. The calcium chloride was added only after the other reagents were completely dissolved in solution. Prior to use, a volume was warmed at 39^0C and reduced with a stream of CO_2. The zero time (i.e. the time when injection of the rumen: buffer mixture was introduced into the syringes) was stated and the incubation was recorded. Level of the piston of the syringes and the time when the filling of the syringes with the rumen liquor/buffer mix was finished were recorded. The syringes were then incubated at 39-40˚C in an incubator. The blanks contained only 30mL of the rumen-buffer solution. The incubation lasted for 24 hours and gas production was recorded at three hour intervals. The gas produced was read by measuring the space formed between the top of the piston and the liquor in the syringe. The gas produced was recorded as the gas produced (in mL) at 24 hours. After every reading (every 3 hours), the content in the syringes was shaken properly to allow proper mixing of the substrate and the liquor.

Methane gas determination

Ten molar of sodium hydroxide was prepared and introduced into the syringe after the end of the 24 hours incubation. About 4ml of the 10M NaOH solution was introduced through the silicon rubber tube attached to the capillary attachment (needle) of the syringe after opening the steel clip. The NaOH introduced absorbed $C0_2$ gas contained in the syringe leaving methane gas in the syringe. When the NaOH solution was introduced into each of the syringe; the clip was immediately tightened back to prevent escape of CO_2 gas. They were shaken to allow proper mixing and absorption of the CO_2 gas. After all the CO_2 gas has been absorbed, the volume of methane gas in the syringes was recorded.

Determination dry matter degradability

At post incubation, the rumen liquor was expunge out of the syringes by pushing up the piston, clean water was introduced into the syringes to rinse the sample bag placed inside. The sample bags were thoroughly washed and carefully brought out of syringes by removing the piston end of the syringe. The washed bags were oven dried to a constant weight. The dried weight is recorded and percentage degradation was calculated.

Table 4: *In vitro* fermentation characteristics of selected forages by White Fulani heifers in late dry season

Forages	a	b	a+b	c	Y	t
C. dactylon	4.00^{ab}	22.00^{abc}	26.00^{ac}	0.06^{ab}	18.00^{ab}	11.00^{ab}
P. maximum	6.67^{ab}	22.00^{abc}	28.67^{c}	0.02^{ab}	15.00^{abc}	7.50^{b}
I. aquatic	8.00^{a}	17.00^{cde}	32.00^{c}	0.06^{ab}	22.00^{a}	12.00^{ab}
A. dentata	4.00^{ab}	14.00^{de}	15.33^{bc}	0.07^{ab}	13.00^{abc}	14.00^{a}
S. africana	3.33^{b}	12.00^{e}	13.33^{b}	0.05^{ab}	11.00^{bc}	16.50^{a}
L. leucocephala	6.00^{ab}	17.33^{bcd}	23.33^{abc}	0.03^{ab}	13.33^{abc}	11.00^{ab}
C. mole	3.00^{b}	28.00^{a}	26.66^{ac}	0.05^{ab}	7.00^{c}	7.50^{b}
SEM	1.31	2.04	0.66	0.02	2.84	1.76

a,b,c means on the same row with different superscript differ significantly (P<0.05).

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Calculation

The average of the volume of gas produced from the blanks was subtracted from the volume of gas produced from each sample. This gave the net gas produced (GP) for each sample. Graphs of the volume of gas produced every 3–hour's interval of the 3 replicate of each sample was plotted against the incubation time. From the graph, the degradation characteristics were estimate as defined in the equation: Y= a+b (1-e) (Orskov and McDonald, 1979)

Where Y= Degradability at time (t)

a = intercept (or initial gas produced)
b = potentially degradable fraction
c = rate of degradation of b
t = incubation time

The asymptote represent (a+b) of the potential degradability. The intercept of the curve is represented by a and given the DMD value at time (zero hour). The b value was calculated as the difference between the asymptote DMD and the intercept a i.e. (a+b) –a.

To calculate the rate of degradation the above equation was transformed

$Y = a+b\ (1-e^{-ct}) = a+b - be^{-ct}$

$Y = \frac{(a+b)}{-b} = e^{-ct}$

Note $Y^1 = e^{-ct}$

Take the natural logarithmic

Derivative of both sides

In Y'= -ct

Hence $C = \frac{Ln\ Y^1}{-t}$

To get good estimate of (c), Y was selected (i.e. DMD% at time) when the curve changed rapidly. The gas produced on incubation of 200mg feed DM after 24 hours of incubation together with the levels of other chemical constituents, was used to predict digestibility of organic matter determined *in vivo* and metabolisable energy.

ME (MJ/kg DM) = 2.20+0.136 GP + 0.57CP + 0.0029CF.

OMD (%) = 14.88 + 0.889 GP +0.45CP + 0.651 XA,

SCFA = 0.0239GP - 0.0601ml/200g DM

Where ME is the metabolisable energy:

OMD = organic matter Digestibility;

CP = crude protein in %

CF = Crude fibre in %

XA = Ash in % and

GP = the net gas production in ml from 200mg dry sample after 24 hour of incubation and after correction; for the day to day variation of rumen liquor using the Hohemheim standard.

The short chain fatty acids were also calculated.

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and significant difference occurred means were separated (Duncan 1955) using Statistical Analysis System (SAS) package.

RESULTS AND DISCUSSION

Table 1 shows the result of the different forages grazed by heifers in the seasons. Eleven forage species were identified. They comprised of forbs, grasses, browse and legume. The percentage sward composition ranged between 9.1% for legume and browse and 54.5% for grasses. The forbs identified were *Ipomea aquatic*, *Althernanthera dentata* and *Sarcolepis africana*. The grasses included *Cynodon dactylon*, *Echinochloa stagirina*,*Panicum maximum*, *Pennisetum purpureum* and the regrowth of *Panicum maximum*. The Legume species was *Centrosema molle* while the browse species was *Leucaena leucocephala.*

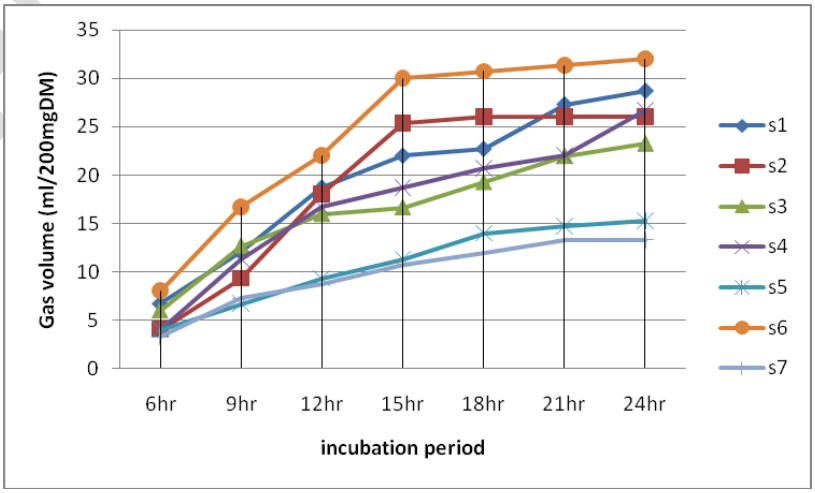

Figure 1: *in vitro* gas production of selected forages by white Fulani heifers in the late dry season.

S1: *Panicum maximum;* S2: *Cynodon dactylon;* S3: *Leucaena leucocephala;* S4: *Centrosema mole;* S5: *Althernanathera dentate;* S6: *Ipomea aquatic;* S7: *Sarcolepis Africana*

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Table 5: *In vitro* fermentation characteristics of forages selected by White Fulani heifers in early rain season

Forages	a	a+b	b	c	y	t
P. maximum r	6.00^{ab}	22.00^{abc}	11.00^{e}	0.09^{a}	15.00^{abc}	15.00^{a}
E. stagirina	6.00^{ab}	26.67^{ac}	25.00^{ab}	0.05^{ab}	14.67^{abc}	13.00^{ab}
P. purpureum	6.67^{ab}	26.67^{ac}	20.00^{bcd}	0.02^{ab}	12.00^{abc}	12.00^{ab}
S. bartata	5.33^{ab}	24.67^{abc}	15.00^{cde}	0.01^{b}	7.33^{bc}	16.50^{a}
SEM	1.31	0.66	2.04	2.02	2.84	1.76

a,b,c means on the same row with different superscript differ significantly (P<0.05).

The percentage selectivity for grasses, legume, forbs and browse respectively are 54.5, 9.1, 27.3 and 9.1%. Table 2 shows the result of the proximate composition and cell wall constituent (i.e. crude protein, dry matter, crude fibre, ash, nitrogen free extract, neutral detergent fibre, acids detergent fibre and lignin) of selected forages by heifers on the range land in late dry season of the year. The chemical composition of the forages differed (P<0.05) significantly. The dry matter ranged between 18.20 and 42.73 percent. The crude protein values ranged between 7.37 and 27.39%. The fibre fractions of the forages were high and significantly differed (P<0.05). The ether extract values ranged between 3.07 and 4.70% while values of nitrogen free extract ranged between 42.33 and 63.83%. The crude fibre values are between 17.70 and 29.60%.

Table 3 shows the result of the chemical composition of selected forages by white Fulani heifers in early rain season of the year. The chemical composition of the forages differed (P<0.05) significantly. Crude protein values ranged between 7.97 and 13.47 percent. Crude fibre values are between 14.70 and 20.73% while ether extract values ranged between 2.20 and 4.47%. The nitrogen free extract values ranged between 36.57 and 61.37%. The neutral detergent fibre values ranged between 51.36% and 86.76%. The lignin content of the forages are between 6.19 and 8.99%. The *in vitro* fermentation characteristics of selected forages by heifers in late dry season as shown in Table 4, indicate that the *in vitro* fermentation characteristics varied significantly (P<0.05) among the incubated feedstuffs/forages. Values for 'a' which is the initial gas is produced ranged between 3.00 and 8.00 (ml/200 mg DM). The values for 'y' which is the gas volume at the peak of fermentation ranged between 7.00 and 22.00 (ml/200mg DM). Figure 1 show the graph of in vitro gas production of selected forages by white Fulani heifers in late dry season. Initial gas produced at incubation 'a' was lowest for *Sarcolepis africana* (a=3.3ml) and highest for *Ipomea aquatica* (a=8.0ml). The final gas produced at 24th hours 'a+b' was lowest for *leucaena leucocephala* (a+b=13.3ml) and highest for *panicum maximum* (a+b=28.7ml). Shown in Table 5 are the results of *in vitro* fermentation characteristics of selected forages by heifers in early rain season.

The parameters a, b, a+b, c, y and t varied significantly (P<0.05) among the incubated forages. 'a' is the initial gas produced at incubation, 'b' is the fermentation of degradable fraction 'c' is the rate of gas production, a+b is the final gas produced at 24th hour, y is the peak of gas production and t is the corresponding time.

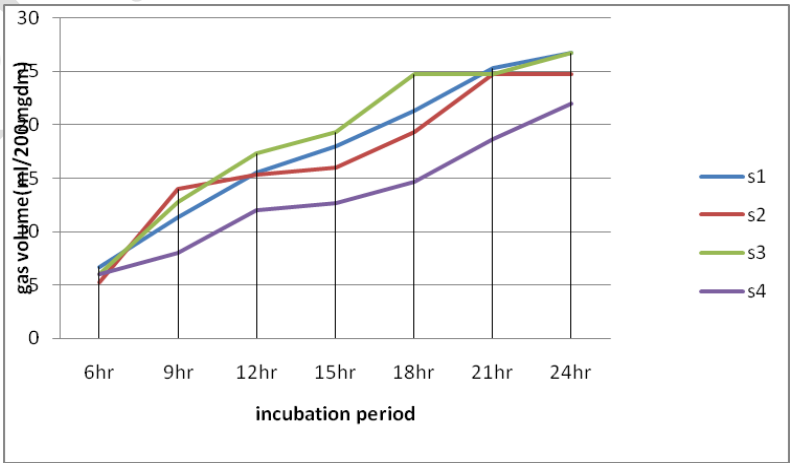

Figure 2: *In vitro* gas production of selected forages by white Fulani heifers in early rain season
S1: *Pennisetum purpureum;* S2: *Setaria bartata;* S3: *Echinochloa stagirina;* S4: *Panicum maximum*

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Table 6: *In vitro* fermentation parameters of selected forages by White Fulani heifers in late dry season

Forages	Metabolisable energy	Organic matter digestibility	Short chain fatty acid
C. dactylon	10.18^{b}	47.35	0.56^{ac}
P. maximum	10.38^{b}	51.61	0.63^{c}
I. aquatic	12.95^{bc}	54.13	0.71^{c}
S. Africana	15.91	43.65	0.26^{b}
C. Mole	13.99^{b}	50.32	0.58^{ac}
L. leucocephala	20.98^{a}	53.28	0.50^{bca}
A. dentate	16.01^{c}	48.30	0.31^{bc}
SEM	0.46	0.57	0.10

a,b,c, means on the same row with different superscripts differ significantly (P<0.05)

Shown in Figure 2 is the graph of *in vitro* gas production of selected forages by white Fulani heifers in the early rain seasons. *Echinochloa stagirina* and *pennisetum purpureum* produced the highest gas volume at 24th hours (a+b=26.7ml) while the lowest value was recorded for *panicum maximum* (a+b=22.0ml). Initial gas produced 'a' at incubation was lowest for *setaria bartata* (a=5.3ml) and highest for *pennisetum purpureum* (a=6.7ml). Presented in Table 6 are the results of *in vitro* parameters of forages selected in late dry season. The metabolisable energy (ME) in (MJ/kg) DM differed significantly among the forages. The ME values range between 10.18 and 20.98. Significant difference (P<0.05) also exist for short chain fatty acid among the selected forages, its values ranged between 0.26 and 0.71. No significant difference (P>0.05) exist for organic matter digestibility. Shown in Table 7 are the *in vitro* parameters of selected forages in early rain season by heifers. There is significant (P<0.05) difference among the forage samples. The metabolisable energy (ME) ranged between 10.15 and 13.56 (ME/kg DM).Organic matter digestibility values ranged between 47.08 and 53.76, Short chain fatty acid values is between 0.47 and 0.58.

Shown in Figure 3 is the result of dry matter degradability of selected forages by white Fulani heifers in late dry season. Values obtained ranged between 48.53 and 83.50 (%/200mg DM). There was significant difference (P<0.05) among the incubated forages. *Ipomea aquatica*, a forb record the highest dry matter degradation while *Panicum maximum* had the lowest dry matter degradation. Shown in Figure 4 is the result of dry matter degradability of forages selected in the early rain season by the heifers. Values obtained ranged between 50.80 and 80.13 (%/200mg DM). Significant (P<0.05) difference was observed among the incubated forages. *Echinochloa stagirina* had the highest degradation while *Setaria bartata* had the lowest dry matter degradation. Shown in Figure 5 is the methane gas production of forages selected in late dry season by heifers. The methane volume (ml/200kg DM) ranged between 7.33ml and 17.33. There was no significant difference (P>0.05) among the forages incubated. *Panicum maximum* recorded the highest methane volume (17.33ml) while *Sarcolepis africana* had the lowest volume.

Table 7: *In-vitro* fermentation parameters of selected forages by White Fulani heifers in early rain season

Forages	Metabolisable energy	Organic Matter Digestibility	Short Chain Fatty Acid
P. maximum r.	11.80^{b}	47.43	0.47^{abc}
E. stagirina	11.77^{b}	53.76	0.58^{ac}
P. purpureum	13.56^{a}	47.71	0.58^{ac}
S. bartata	10.15^{b}	47.08	0.53^{abc}
SEM	0.46	0.57	1.10

a,b,c means on the same row with different superscript differ significantly (P<0.05)

Shown in Figure 6, is the result methane gas production of selected forages in the early rain season. Values ranged between 9.33 and 16.37 (ml/200mg DM).

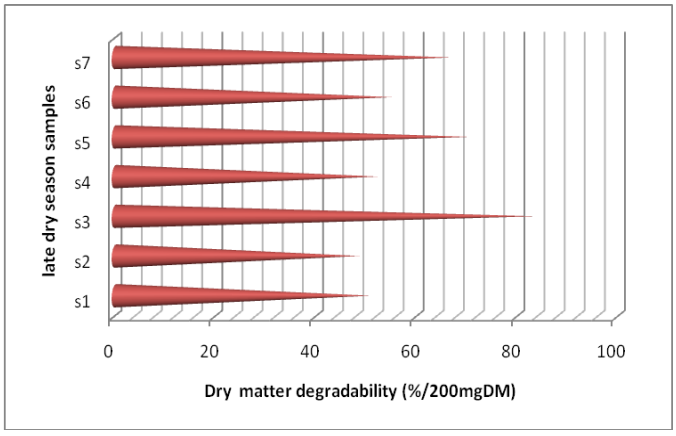

Figure 3: Dry matter degradability of selected forages by white Fulani heifers in late dry season
S1= *Cynodon dactylon;* S2= *Panicum maximum;* S3=*Ipomea aquatic;* S4= *Sarcolepis Africana;* S5= *Leucaena leucocephala;* S6= *Centrosema mole;* S7= *Althernanathera dentata*

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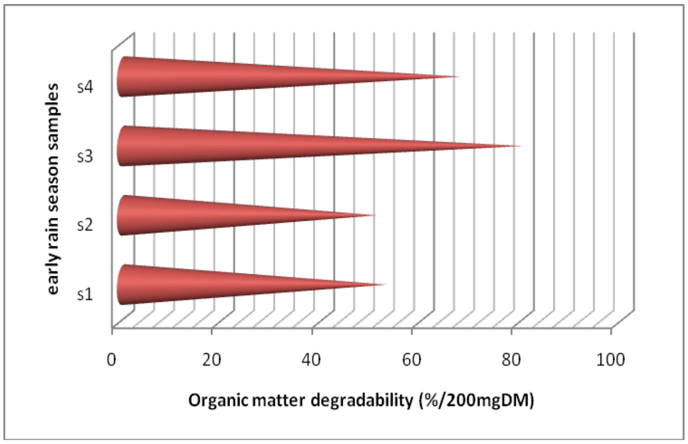

Figure 4: Dry matter degradability of selected forages by white Fulani heifers in early rain season
S1= *Panicum maximum* regrowth; S2= *Setaria bartata;* S3= *Echinochloa stagirina;* S4= *Pennisetum purpureum*

There was no significant difference (P>0.05) among the forages incubated. The forage specie that recorded the highest volume is *Setaria bartata* and *Pennisetum purpureum* recorded the lowest volume. There were more than one hundred plant species observed in the rangeland but eleven varieties composed of grasses, legumes and forbs were consistently grazed at one time or the other by the heifers. Most of the forages grazed by the heifers are available in south western of Nigeria (Aregheore and Yahaya, 2001). *Gliricidia sepium* and *Leucaena leucocephala* were available in both late dry and early rain season but the former was not observed to be browsed.

Grazing and browsing of forages by ruminants is a selective event (Philip, 1993) and selection of forage is aimed at obtaining plant component with the highest nutritive value and the presence of antinutritional factors or toxins also affect plant selection by ruminants especially cattle (Provenza,1995). The few different forage selected by the heifers as compared to large varieties of plant present on the range might be attributed to body size (Gordon and Illius, 1988) and level of production. Forbs were grazed all through the late dry season. Only two Legumes were observed to be consumed in the four month. Observation on the field shows that there is strong preference for *Panicum maximum* regrowth at the onset of early rain season and throughout the early rain season period. *Pennisetum purpureum* was available in both season under study but was not grazed until March. This might be due to maturation, high lignin content and drop in crude protein level (Areghore, 1996). All these observations corroborate the previous findings of (Omokaye, *et al.*, 2001), that selected browse plant during the dry season in the sub-humid Nigeria will include *Panicum maximum*, *Pennisetum purpureum*, some weeds and forbs (Aregheore, 2001). Succulent and palatability might be factors responsible for high choice of forbs in the dry season as the process of lignifications of grasses could have been high (Smith, 1992) around this time. In the month when most of the forage species were observed not to have been grazed by heifers, forage biomass quantity play a large role. This observation corroborated the findings of (Aregheore, 1996) that marked seasonal changes affect the quality and quantity of forage and that quantity of forage declines rapidly in the dry season.

From the result in Table 2 and 3, it was observed that Legume forage had the highest dry matter content. A trend also emerged from table 3, that Legume forage (*Leucaena leucocephala*) was grazed by the heifers all through the seasons. It can be inferred from this results that grazing animals select forage based on their nutritive value (Provenza, 1995). It was observed that forages grazed in the dry season were low in crude protein especially grasses. This corroborates the report of Smith (1992) that nutritional quality declines as the dry season advances, such that crude protein falls as low as 2% in the grassland and 6-7% in the sub-humid zone. Forbs were the choice forage selected by the heifers in the dry season. This might probably be due to availability and palatability as the result here showed high crude protein in value for forbs. According to Huhtanen *et al.* (2002), high protein content in forage enhanced feed intake.

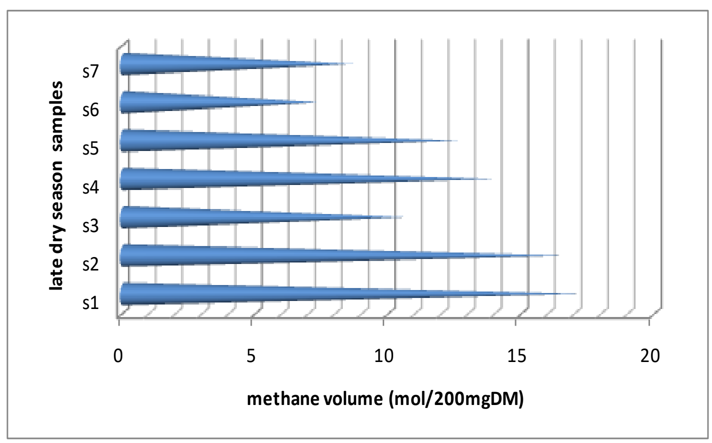

Figure 5: Methane gas production of selected forages by white Fulani heifers in late dry season.
S1= *Panicum maximum;* S2= *Cynolon dactylon;* S3= *Leucaena leucocephala;* S4= *Centrosema mole;* S5= *Ipomea aquatic;* S6= *Sarcolepis Africana;* S7= *Althernanathera dentate*

The fibre fractions of the forages were high and varied values were obtained for the selected forages. The fibre contents (NDF, ADF, and lignin) have implications on the digestibility of plants and this can be used to

determine the quality of forage. The neutral detergent fibre (NDF), which is a measure of the plants cell wall contents; is the chemical component of the feed that determines its rate of digestion. The NDF is always inversely related to the plants digestibility (Mc Donald *et al;* 1991). With increase in NDF, the lower the plant's digestible energy. In this study, the forage selected by heifers, with highest NDF value was *Panicum maximum* (86-76%). It is an early rain season sample, which accounted for the high percentage of NDF. Nuru (1996) reported that seasonal changes affect the quality and quantity of forage and that best quality forage are obtained in the raining season. The acid detergent fibre (ADF) consist mainly the lignin and cellulose. ADF values of the forages ranged between (28-55%).

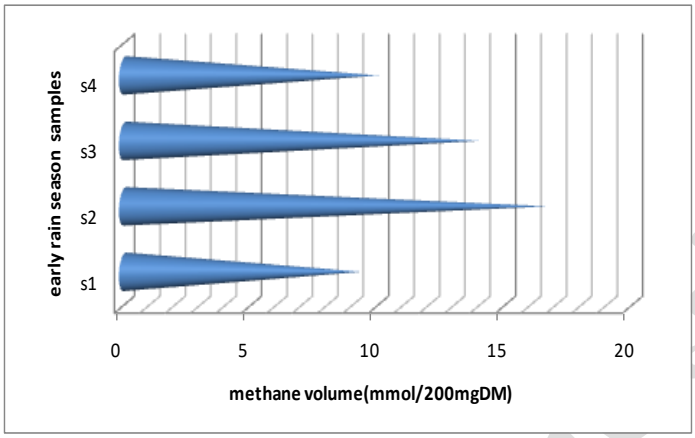

Figure 6: Methane gas production of selected forages by white Fulani heifers in early rain season
S1= *Pennisetum purpureum;* S2= *Setaria bartata;* S3= *Echinochloa stagirina;* S4= *Panicum maximum* regrowth

The ADF values according to Smith (1992) are highest in forages in the late dry season up to 60% ADF. The result of this study, shows that *Sarcolepis Africana,* a forage forbs has the highest ADF content (55.85) and it was a grazed by the heifers in late dry season. Lignin content of a plant is the most indigestible component of the fibre fraction and its amount will also influence the plant digestibility. The ADL contents varied among the selected forages. The highest ADL content of 10.97% was obtained for *Ipomea aquatica*, a forage forbs which was also selected by the heifers in the dry season. However *Althananthera dentata* had the least ADL content (0.81%). As such, the lower lignin content of *Althananthera dentata* comparison with other forage samples observed in this study may likely predispose *Althananthera dentata* to better digestibility to grazing animals than other forage samples. It should be noted that various factors affect chemical composition such as stage of growth, or maturity and species or variety and soil type. The potential gas production (a+b), gas production from the insoluble fraction (b), extent and rate of gas production (c), volume of gas produced (y) and time of production (t) at 24 hours incubation period were represented on tables 4 and 5.The initial value 'a' for all the forages ranged from 3.33 for *Sarcolepis africana* to 8.00 for *Ipomea aquatica* (both forbs). The value for absolute 'a' used ideally reflects the fermentable of the soluble fraction in this study. The absolute gas production was highest for *Ipomea aquatica*. The soluble fraction makes it easily attackable by rumen microorganism and leads to much gas production. Therefore, more rumen microorganism worked on *Ipomea aquatica* and this leads to highest gas production. The extent of gas production 'b' described the fermentation of the insoluble fraction.

The gas volume of *Panicum maximum* (early rain season sample) had the lowest value of 11.00 and was highest in *Centrosema mole.* The advantage of 'b' is for predicting feed intake; Blummel and Orskov (1993) found that the 'b' value could account for 88% for variance intake. The rate of gas production 'c' was highest for forage sample *Panicum maximum* (early rain season sample) and lowest for *Setaria bartata*. Groot *et al.* (1996) reported that carbohydrate fraction could be affected by kinetics of gas production. William (2000) indicated that the intake of feed is mostly explained by the rate of gas production which affects the rate of the feed digestion through the rumen fluid. Potential of gas production (ab) was highest in *Ipomea aquatica* (32.00) while the lowest was recorded for *Sarcolepis africana*. The high value of the potential extent of gas production recorded was due to abundant of carbohydrate fraction embedded in *Ipomea aquatica* which have a large population of lignified cell wall. Getachew *et al*. (1997) stated that it is well known that gas production is basically the result of fermentation of carbohydrate to volatile fatty acids (acetate, propionate and butyrate). Low (a+b) recorded in *Sarcolepis africana* was probably due to high protein content. Cone and Van Gelder (1999) reported that protein fermentation does not lead to much gas production. The volume of gas produced at time't', 'y' is the peak of gas production for each sample at each incubation period. The time of peak of gas production is highest in *Setaria bartata* and *Sarcolepis africana* and lowest in *Panicum maximum* and *Centrosema mole*. 'y' which is the volume of gas produced at time 't' is lowest in *Centrosema mole* and highest in *Ipomea aquatica*. However, there are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fibre feed sample preparation (Lowman *et*

al., 2002) and potency of the rumen liquor for incubation. It is possible to attain potential gas production of a feedstuff if the donor animal from which rumen liquor for incubation was collected got the nutrient requirement met. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrates (Blummel and Becker, 1997). Organic matter digestibility was highest in *Echinochloa stagirina* and least for *Sarcolepis africana*. Although gas production is a nutritionally waste product (Cone *et al.,* 1996) but it provides a useful basis from which metabolizable energy (ME), organic matter digestibility (OMD) and short chain fatty acids (SCFA) could be estimated. The values indicated that *Panicum maximum* selected by the heifers in the late dry season was least degraded while the highest was recorded for *Ipomea aquatica*, in late dry season. The degradability of a feedstuff and the fermentation pattern influence the daily dry matter intake, and this is of importance to high yielding cows. Fibre fractions that have the greatest impact on degradability are the cell wall constituent (Blummel and Becker; 1997) NDF, ADF and lignin. As the forage mature the cell wall content increase which leads to decrease degradation (Mould, 2003). *Panicum maximum*, in this study was a late dry season sample, it was the least degraded and this can be attributed to maturity. The reverse was seen in the same species of forage (*Panicum maximum*) which was selected in the early rain, the percentage degradation was higher (52.70%) Water soluble carbohydrate (WSC) content of the forage also contributes positively to degradation (Huhtanen *et al.,* 2002). The higher the WSC the higher the rate of degradation and the higher the percentage degraded. Forage sample with high water soluble carbohydrate will have high percentage degradation.

The methane gas production results indicated that *Panicum maximum* selected by the animals in the late dry season had the highest methane gas volume while *Sarcolepis africana*, also selected in the late dry season recorded the lowest methane gas volume. Methane gas is an important gas among gases produced by ruminant at fermentation and has been reported (Babayemi and Bamikole, 2006) to be an energy loss to the animal and when emitted it contribute to the destruction of ozone layers. Moreover, when the dry matter degradation occurs in the rumen by the action of microorganism, there is production of gas which mainly constitutes hydrogen, carbondioxide and methane.

CONCLUSION

This study validated earlier report that *in vitro* gas production technique can be used to evaluate the potential value of feedstuff. The selected forages by the heifers were all naturally selected (i.e. the animals grazed the forages willingly) and since animasl select feedstuff based on their nutritive component, these forages possess satisfactory nutritive value for consumption. Although, their availability throughout the seasons of the year varies, some are available throughout the year especially the forbs. These forages can be harvested when they are available and ensiled till the off season period when they can be fed out to avoid production fluctuation by the animals. The nutrient composition of the eleven selected forages observed in this study showed that they might be useful energy and protein supplement in ruminant feeding. However, more work may be required to determine anti-nutritional factors inherent in the proven forages before they can be recommended for use.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest concerning the submission of this manuscript for publication.

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