CORRELATION COEFFICIENT (*r*) BETWEEN CHEMICAL COMPOSITION AND *IN VITRO* GAS PRODUCTION AND FERMENTATION CHARACTERISTICS OF SOME SELECTED *FICUS* SPECIES

***A.A. NJIDDA[1], I. K. AL-HABIB[2] AND B BELLO**

[1]Department of Animal Science, University of Abuja, P.M.B. 117, Abuja, Nigeria; [2]Department of Animal Science, Bayero University, P.M.B. 3011, Kano State, Nigeria; [3]College of Agriculture and Animal Science, P.M.B. 2134, Ahmadu Bello University Zaria, Mando, Kaduna; *Corresponding author's e-mail: ahmednjidda7@gmail.com

ABSTRACT

In vitro gas production and fermentation of five *ficus* species was determined using the *in vitro* gas production technique. The result showed that all ficus species leaves studied have high dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) acid detergent lignin (ADL) and low total condensed tannin and phenolics. The values for the fermentation characteristics was generally low for all the *Ficus* species. The results showed that *Ficus damarensis* at all incubation times except 12 h had the highest cumulative gas production. The correlation coefficient (*r*) showed positive relationship between CP and gas production and fermentation characteristics except for 96 h and T values. ADL is positively correlated and highly significant at 24, 48 and 72 h incubation period and insoluble but degradable fraction (b) and potential gas production. Phenolics is negatively correlated and highly significant at 3 and 6 h incubation period. It can be concluded that chemical composition and *in vitro* digestibility can be considered useful indicators for evaluating the nutritive value of forages.

INTRODUCTION

The most reliable means of determining the quality of forage is considered to be animal output (Larbi *et al.*, 1998). However, only few *in vivo* studies have been carried out with browse species in Nigeria. The efforts and cost involved, and the difficulty in collecting sufficient quantities of uniform forages has made feeding trials using browses difficult. Most studies on the nutritive value of these species have been limited to chemical composition (Larbi *et al.*, 1998; Njidda, 2011). Not until recently, the *in vitro* gas production (Menke and Steingas, 1998) methods have been shown to be simple and efficient for evaluating nutritive value of fodder trees and shrubs (Nsahlai *et al.*, 1994). On the other hand, Menke *et al.* (1979) and Menke and Steingass (1988) developed the *in vitro* gas production technique to evaluate the nutritive value of forages and estimate the rate and extent of DM degradation indirectly using the gas production (CO_2) during fermentation.

More recently researchers have been investigating the relationship between fermentation kinetics of forages obtained by *in vitro* gas production technique (Blummel and Ørskov, 1993). The objective was to determine the relationships between chemical composition and gas production; and *in vitro* fermentation characteristics.

MATERIALS AND METHODS

In vitro study

Rumen fluid was collected at 07:00hr. The donor was a bull fed a total mixed ration comprised of grass and maize silage and concentrate (i. e corn, wheat offal, perm kernel cake, groundnut cake, soybean meal and dried brewers grain) and 40% Gamba grass (*Andropogun gayanus*). The incubation procedure was as reported by (Menke and Steingass, 1988). The 120 ml calibrated syringes fitted with silicon tube at the mouth were used while the incubation was in three batch incubation. The incubation temperature was maintained at 39 ± 1 °C. Buffer was used and kept in the incubator for warming. About 200 mg of the feed sample (substrate) was measured and introduced into the syringe after removing the plunger. The rumen liquor was strained through a four layer cheese cloth. Rumen liquor and buffer were mixed together (1:4, v/v) as inoculums, all under continuous flushing with streams of CO_2. Using 120 ml capacity syringe, 30 ml of inoculums was dispensed into the substrate through the silicon tube. The plunger was pushed upward by pushing the inoculums to the tip of the syringe. Thereafter, the silicon was tightened with a metal clip. The gas production was measured from the calibrated syringe at 3, 6, 12, 24, 48, 72 and 96 hour. The gas production parameter was calculated using the equations of Ørskov and McDonald (1979): $G=a + b(1-e^{-ct})$; Where: G = is the gas production (ml) at time t; a = is the gas production from the immediately soluble fraction (ml); b = is the gas production from the insoluble but degradable fraction (ml) a + b = is the potential gas production (ml); c = is the rate constant of gas production (fraction/h).

Chemical analysis

The samples were analyzed in triplicate for dry matter (DM) and crude protein (CP), according to AOAC (2002) procedures. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined as described in Van Soest *et al.* (1991). Total condensed tannin were determined as reported by (Polshettiwar *et al.*, 2007). Finally, phenolics were determined using Folin Ciocalteu method as described by Makkar (2000).

Statistical analysis

Data obtained were subjected to analyzed as a randomized complete block design using GLM procedure of SAS (Statistical Analysis System Institute Inc., 2003). Standard errors of means were calculated from the residual mean square in the analysis of variance. A simple regression analysis was used to establish the relationship among chemical composition *in vitro* gas production and fermentation characteristics.

RESULTS AND DISCUSSION

Chemical composition

The result of the chemical composition is presented in Table 1. The CP of the browse leaves in this study were within the range of 56-213 g kg^{-1} DM, 96.30 – 166.60 g kg^{-1} DM and 139.60 – 214.20 g kg^{-1} DM reported by Abegunde *et al.* (2009). The CP contents of all the browse forage species is high enough and can be used to supplement poor quality roughages/pastures during the dry season to increase productivity in ruminant livestock in tropical regions. The NDF, ADF and ADL contents of the browse forage leaves obtained in the present study is in the range of 535.60 – 568.10 g kg^{-1} DM, 215.00 – 246.50 g kg^{-1} DM and 81.0 – 134.10 g kg^{-1} DM, respectively, are within the range reported by Abegunde *et al.* (2009) and, Njidda and Ikhimioya (2010) for tropical browse species. The moderate to higher NDF, ADF and ADL in the present study is a positive attribute of the browse species since the voluntary DM intake and digestibility are dependent on the cell wall constituent (fibre), especially the NDF and lignin (Bakshi and Wadhwa, 2004).

***In vitro* gas production of five *Ficus* species leaves**

Kinetics of gas production obtained from the exponential model is presented in Table 2. Both rate constants *(b)* and *(c)* showed significant differences among browse forages. Similarly, the extent $(a + b)$ of gas volumes was higher for *F. damarensis* than the other *Ficus* species. Khazaal *et al.* (1995) indicated that intake of a feed is mostly explained by the rate of gas production (*c*) which affects the rate of passage of the feed through the rumen, whereas the potential gas production $(a + b)$, is associated with the degradability of the feed. Thus, the higher values obtained for the (*c*) and (a + b) parameters in the browse forages may indicate a better nutrient availability for rumen micro organisms in animals grazing such vegetative species in semi-arid areas. The 'a' and 'b' fractions compare favourably with the findings of Abegunde *et al.* (2009) while the 'a+b' in the present study were lower (17.00 to 29.33%) compare to the values (43.00 to 58.2%) reported by Abegunde *et al.* (2009). For some *Ficus* species in the tropics. The potential gas production (a+b), is associated with the degradability of the feed. Thus, the higher values obtained for the *c* and *a+b* parameters in the *Ficus* species leaves may indicate a better nutrient availability for rumen microorganisms in animals fed with these *Ficus* species (Getachew *et al.*, 2004). The results of the gas production and fermentation characteristics of the browse forages are presented in Table 3. The values are within the range reported earlier for browse forages from Nigeria (Njidda and Ikhimioya, 2010). Chemical composition and *in vitro* fermentation and digestibility are largely affected by plant species, plant morphological fraction, environmental factors, and stage of maturity (Mbugua *et al.*, 2008). These factors influence the amount of substrate OM that is fermented and the short chain fatty acids (SCFAs) produced upon fermentation. Njidda (2011) reported a decrease in rate and extent of gas production of some shrubs due to their high contents of lignin and tannins through increasing the adverse environmental conditions as incubation time progressed. Also, the relatively high level of ADL in browse species as shown in Table 1 explained in part the limited *in vitro* degradation and therefore the lower amount of gas produced.

Correlation coefficient (*r*) of the relationship between the chemical composition and *in vitro* gas production or estimated parameters from different browse leaves

A summary of correlations obtained between chemical constituents and *in vitro* gas production is presented in Table 4. The results of the correlation shows that there were both positive and negative relationships between the volume of gas produced and their chemical constituents. This is consistent with the reports of Cerillo and Juarez (2004). The correlation between CP and gas production and estimated parameters were positive except for 96 h and lag 't' which tends to be negative. The positive relationship implies that the CP content of the *Ficus* leaves had a contributory effect on the gas production and short chain fatty acid (SCFA) production and this means that variation in the gas production can be explained by variation in the concentration of the *Ficus* species, this may be due to the significantly higher CP content of *Ficus* species leaves. Also, there was significant positive and high correlation between chemical composition and ADL, PHE while relationship between NDF and *in vitro* gas production and estimated parameters were mostly negative and non significant. Nsahlai *et al.* (1994) worked on 23 browse species of the genus *Sesbania*, Larbi *et al.* (1998) worked on 18 MPT and shrubs species and Njidda (2011) worked on 37 semi arid browse species of Northern Nigeria noted that gas production was negatively correlated with the NDF and proanthocyanidins, but positively correlated with the CP content. The extent of the negative effect of the NDF on gas production was higher at 96 h than any other incubation period and high at Y (potential gas production). The negative correlation between ADF and chemical constituents was on the high side and is similar to the report of Cerillo and Juarez (2004) which recorded highly significant correlation between ADF and *in vitro* gas production, though a high and positive correlation was observed between ADF and *in vitro* gas production at 96 h.

CONCLUSION

Semi-arid browses are forages with high protein concentration, as such, they have potential as a forage for farmers during the long period of dry season when feed is scarce. Chemical composition and *in vitro* digestibility can be considered useful indicators for the preliminary evaluation of the likely nutritive value of previously uninvestigated shrubs.

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Table 1. Chemical composition of the ficus leaves (g kg^{-1} DM).

Browse Forages	DM	CP	NDF	ADF	ADL	TCT	PHE
Ficus damarensis	927.30^{c}	148.80^{c}	545.50^{b}	236.40^{b}	134.10^{a}	0.23^{a}	0.62^{b}
Ficus platyphylla	942.30^{d}	130.70^{c}	535.60^{c}	246.50^{a}	81.40^{e}	0.18^{c}	0.48^{c}
Ficus polita	952.00^{a}	165.30^{a}	536.20^{c}	237.20^{b}	92.30^{d}	0.20^{b}	0.24^{d}
Ficus sycomorus	965.60^{a}	144.60^{d}	536.00^{c}	246.40^{a}	112.40^{c}	0.17^{c}	0.81^{a}
Ficus thonningii	955.00^{a}	162.80^{b}	568.10^{a}	215.00^{c}	121.10^{b}	0.24^{a}	0.65^{b}
SEM	1.43	1.25	1.27	1.35	0.21	0.02	0.02

a, b, c, means in the same column with different superscript differ significantly, DM=Dry matter; CP=Crude Protein; NDF=Neutral detergent fibre; ADF=Acid detergent fibre; Acid detergent lignin ($P<0.05$);TCT=Total condensed tannin; PHE=Phenolics; SEM=Standard error of means.

Table 2. *In vitro* fermentation characteristics of the *Ficus* species

Browse Forages	a	b	a+b	c	T	Y
Ficus damarensis	4.67^{a}	24.67^{a}	29.33^{a}	0.027^{b}	13.00^{c}	11.33^{b}
Ficus platyphylla	2.00^{b}	15.00^{b}	17.00^{d}	0.028^{b}	12.00^{c}	7.33^{c}
Ficus polita	5.33^{a}	17.00^{b}	22.33^{c}	0.047^{a}	15.00^{b}	14.33^{a}
Ficus sycomorus	2.00^{b}	25.00^{a}	27.00^{a}	0.023^{b}	20.00^{a}	11.33^{b}
Ficus thonningii	2.00^{b}	23.00^{a}	25.00^{ab}	0.024^{b}	12.00^{c}	7.33^{c}
SEM	1.21	2.67	2.12	0.019	1.37	1.21

a,b,c,d=mean values along the same column with different superscripts are significantly different ($P<0.05$); SEM=Standard error of means

Table 3. *In vitro* gas production of selected *Ficus* species (ml/ 200 mg DM)

Browse forages	3	6	12	24	48	72	96
Ficus damarensis	4.66^{b}	5.66^{b}	9.66^{b}	19.66^{a}	25.22^{a}	29.33^{a}	30.33^{a}
Ficus platyphylla	2.00^{c}	3.00^{d}	6.00^{c}	7.66^{d}	14.66^{d}	17.00^{d}	18.00^{d}
Ficus polita	5.33^{a}	7.66^{a}	11.66^{a}	14.66^{b}	17.66^{c}	22.33^{c}	23.33^{c}
Ficus sycomorus	2.00^{c}	2.66^{d}	5.66^{c}	13.33^{b}	21.33^{b}	27.00^{b}	28.00^{b}
Ficus thonningii	2.00^{c}	4.00^{c}	5.66^{c}	12.00^{bc}	19.66^{c}	25.00^{b}	26.00^{b}
SEM	0.46	0.92	1.77	1.52	2.24	2.49	2.33

a,b,c,d=mean values along the same column with different superscripts are significantly different (P<0.05); SEM=Standard error means

Table 4: *In vitro* correlation coefficients (*r*) of the relationship between the chemical composition and gas production or estimated parameters from different browse leaves

In vitro	CP	NDF	ADF	ADL	TCT	PHE
3	0.676*	-0.067	-0.190	0.032	0.388	-0.748***
6	0.454	-0.301	0.065	-0.006	0.388	-0.748***
12	0.426	0.059	-0.124	0.747**	0.466	0.077***
24	0.224	0.238	-0.174	0.936***	0.447	0.529*
48	0.370	0.301	-0.260	0.931***	0.427	0.555*
72	0.370	0.301	-0.260	0.931***	0.427	0.555*
96	-0.535*	-0.798**	0.822***	-0.673**	-0.996***	0.005
A	0.480	-0.255	0.038	0.112	0.277	-0.638*
B	0.208	0.401	-2.80	0.917***	0.340	0.799**
pd	0.370	0.301	-0.260	0.931***	0.427	0.555*
c	0.474	-0.380	0.102	-0.477	-0.063	-0.921***
T	-0.019	-0.476	0.484	0.038	-0.629**	0.382
Y	0.437	-0.507*	0.305	0.032	-0.164	-0.390

CP=Crude protein; NDF=Neutral detergent fibre; ADF=Acid detergent fibre; Acid detergent lignin (P<0.05);TCT=Total condenced tannin; PHE=Phenolics; ***P<0.001; **P<0.01; *P<0.05