Chemical composition, *in vitro* digestibility and gas production characteristics of six ficus species based diets with *Panicum maximum* in the dry season

* T.O. Abegunde¹, O.J. Babayemi² and A.O. Akinsoyinu²

¹Department of Animal Science and Production, Joseph Ayo Babalola University, Ikeji-Arakeji, P.M.B 5006 Ilesà, Osun State, Nigeria.

²Department of Animal Science, University of Ibadan, Ibadan, Oyo state, Nigeria

*Corresponding Author

Abstract

The nutritive value of *Ficus exasperata*, *F. polita*, *F. vogelli*, *F. abutilifolia*, *F. thonningii*, and *F. mucoso* in mixtures with 30% *Panicum maximum* were investigated in terms of their chemical composition, saponins, phenols, *in vitro* gas production (IVGP), metabolizable energy (ME), organic matter digestibility (OMD%) and short chain fatty acids (SCFA). Neutral detergent fibre (NDF) was significantly ($P < 0.05$) lowest in *F. thonningii*. Saponin was detected in *F. polita*, while Phenol was detected in all *Ficus* species except *F. polita* and *F. thonningii*. IVGP, ME, OMD and SCFA obtained for all *Ficus* species were significantly ($P < 0.05$) higher than values obtained for *F. mucoso*. Least value for soluble 'a' fraction of the samples was recorded for *F. mucoso* (5.76), similar to values obtained for *F. thonningii* (7.17), *F. abutilifolia* (7.92) and *F. exasperata* (7.92). Potential gas production 'b' values differed significantly ($P < 0.05$) among *F. exasperata* (50.50), *F. vogelli* (43.92) and *F. mucoso* (37.25), but was similar among *F. polita* (46.17), *F. thonningii* (44.83) and *F. abutilifolia* (44.50). Potentially degradable 'a+b' fractions for all *Ficus* species except *F. mucoso* were similar and significantly ($P < 0.05$) higher than *F. mucoso*. Rate of fermentation 'c' differed significantly ($P < 0.05$) between *F. exasperata* (0.06) and *F. mucoso* (0.04). Data from this study showed that all *Ficus* species except *Ficus mucoso* had potential to be used as forage supplements in the dry season.

Key words: Dry season, ficus species, gas characteristics, *in vitro* gas production.

Introduction

Browse species play a major role as feed for ruminants in arid and semi arid regions, particularly during the dry season when poor quality forage and crop residues are common (Kibon and Ørskov, 1993). The inclusion of

multipurpose tree legumes like *Gliricidia sepium*, *Ficus* species, *Leucaena leucocephala* among others is one of the ways of improving the utilization of low quality roughages. *Gliricidia sepium* and *Leucaena leucocephala* are age-long browse plants but their extensive use is hampered

by coumarin in the former and mimosin in the latter (Babayemi *et al.*, 2006) Ficus species belong to the family Moraceae and are common homestead plants in Nigeria where they are established mostly for provision of shade and beautification of surroundings (Bamikole *et al.*, 2004). Literature information about nutritive value of ficus plants is scanty. Quick, cheap and accurate methods of accessing nutritive values of forages have been developed (Menke *et al.*, 1979). *In vitro* gas production is a technique that involves volumetric measurement of gas production in phosphate and bicarbonate buffered *in vitro* incubations in syringes. Although gases produced during rumen fermentation are waste products and of no nutritive value to the ruminants, gas production tests are used routinely in feed research as gas volumes are related to both the extent and rate of substrate degradation (Blummel *et al.*, 1997). This study was undertaken to provide information on the nutritive value of six *ficus* species through the analysis of their chemical composition, antinutritional components, *in vitro* digestibility and gas production potential.

Materials and Methods

Sample collection and preparation.

Approximately 5kg of leaf samples from six species of ficus (*Ficus polita*, *Ficus mucoso*, *Ficus abutilifolia*, *Ficus exasperata*, *Ficus vogelli* and *Ficus thonningii*) were collected in the dry season (December 2005 - January 2006) within and outside the premises of University of Ibadan, Ibadan, Nigeria. Samples from each *ficus*

species were collected from at least four individual trees and from different parts of the trees and pooled for further analysis. *Panicum maximum* was obtained from the pasture of the Teaching and Research farm at the same time that the ficus samples were collected. Cassava peel was obtained from freshly peeled tubers, to prevent fermentation, from a gari processing industry in Ibadan.

Dried ficus leaves, *Panicum maximum* and cassava peels were ground in a hammer mill to pass through a 1mm sieve. 200mg of samples were prepared, comprising of 3 different ingredients; 60% ficus species leaves, 30% *Panicum maximum* and 10% cassava peels.

Chemical analysis

Ficus species leaves, *Panicum maximum* and cassava peels were oven dried at 65°C until a constant weight was obtained for dry matter determination. For each sample, crude protein, crude fibre, ether extract and ash were determined according to AOAC (1995). Neutral detergent fibre, acid detergent fibre, and acid detergent lignin were determined as described by VanSoest *et al.* (1991). Saponin and tannins were determined as reported by Babayemi *et al.* (2004a).

In vitro gas production

The *in vitro* gas production was determined according to Menke and Steingass (1988). Rumen liquor was obtained from three female West African dwarf goats in the morning before the goats were fed their daily ration of 40%

concentrate (30% maize, 30% wheat offal, 20% PKC, 10% BDG, 5% soyabean cake, 1% salt, 3.75% oyster shell and 0.25% fish meal) and 60% *Panicum maximum*. 200 mg of each species of ficus and the other ingredients in the given proportions were placed in 120 ml calibrated syringes in triplicates. To the 200 mg sample in the syringe was added 30 ml inoculum containing cheese-cloth strained rumen liquor and buffer (1:4, V/V) under constant flushing with CO₂ (Babayemi *et al.*, 2006). The gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24h. After 24 hr of incubation, the amount of methane produced were estimated (Babayemi *et al.*, 2006). Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD, %) were estimated as established (Menke and Steingass, 1988) and short chain fatty acids (SCFA) were calculated as described by Getachew *et al.* (1999). The volume of the gas produced was plotted against the incubation time, and the gas production characteristics were estimated using the equation: $Y = a + b(1 - e^{-ct})$ described by Ørskov and Macdonald (1979), where Y= volume of gas produced at time 't', a= intercept (gas produced from the soluble fraction), b= gas production from the insoluble fraction, c = gas production rate constant for the insoluble fraction (b), t = incubation time. Metabolizable energy (ME, MJ/ Kg DM) and organic matter digestibility (OMD, %) were estimated as established (Menke and Steingass, 1988) and short chain fatty acids (SCFA) was calculated as reported (Getachew *et al.*, 1999).

$$ME = 2.20 + 0.136GV + 0.057CP + 0.0029CF$$

$$OMD = 14.88 + 0.889GV + 0.45CP + 0.651XA$$

$$SCFA = 0.0239GV - 0.0601$$

Where GV, CP, CF and XA are gas production (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) procedure of SAS (1999) in a completely randomized design. Significant means were separated using the Duncan multiple range test of the same package.

Results

Chemical composition and fibre analysis of six species of ficus, *Panicum maximum* and cassava peels in the dry season are shown in Table 1. Significant ($P < 0.05$) differences were observed in the crude protein values for all the ficus species with highest value observed in *F. vogelli* (16.66g/ 100 g DM) and significantly ($P < 0.05$) least value observed in *F. exasperata* (7.55 g/100 g DM). Fibre and ash contents were observed to be significantly ($P < 0.05$) highest 32.05 g/100 g DM and 20.50 g/100 g DM respectively in *F. thonningii*.

The ash contents of *F. abutilifolia* (13.50 g/100 g DM) and *F. mucoso* (14.00 g /100 g DM) did not differ significantly. The least ash content was obtained in *F. polita*. The NDF value recorded for *Panicum maximum* (79.50 g/100 g DM) was significantly ($P < 0.05$) higher than values recorded for all ficus species in the dry season. *F. thonningii* had significantly ($P < 0.05$) lowest

Table 1: Chemical compositions (g/100 g DM) of six *ficus species* in the dry season

	CP	CF	EE	ASH	NDF	ADF	ADL	DM
<i>F. polita</i>	15.71 ^b	22.00 ^f	20.50 ^b	7.75 ^f	67.00 ^d	82.50 ^a	22.00 ^c	30.44 ^e
<i>F. vogelli</i>	16.66 ^a	30.25 ^c	18.90 ^c	11.00 ^d	74.50 ^d	40.50 ^c	33.25 ^b	34.40 ^e
<i>F. abutilifolia</i>	12.43 ^c	26.00 ^e	20.05 ^b	13.50 ^c	70.75 ^c	45.75 ^b	35.40 ^a	23.51 ^g
<i>F. mucoso</i>	11.38 ^d	21.10 ^g	16.75 ^f	14.00 ^c	67.20 ^d	29.00 ^c	21.25 ^f	37.00 ^b
<i>F. exasperata</i>	7.55 ^f	27.00 ^d	18.05 ^{de}	15.05 ^b	74.53 ^b	19.50 ^g	10.52 ^h	25.70 ^f
<i>F. thonningii</i>	9.63 ^e	32.05 ^a	22.05 ^a	20.50 ^a	52.50 ^c	33.00 ^d	26.00 ^d	20.46 ^h
<i>P. maximum</i>	6.33 ^g	31.25 ^b	18.50 ^{cd}	9.00 ^e	79.50 ^a	33.50 ^d	27.50 ^c	31.00 ^d
Cassava peels	6.11 ^h	14.05 ^h	17.50 ^e	7.05 ^f	70.00 ^c	23.00 ^f	16.95 ^g	66.76 ^a
SEM	0.00	0.02	0.05	0.08	0.22	0.17	0.04	0.02

a, c, d, e, f, g, means on the same column with different superscripts are significantly different ($P < 0.05$). CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, DM = Dry matter, SEM = Standard error of mean; F = Ficus, P = Panicum.

value of NDF, ADF value was significantly ($P < 0.05$) highest in *F. polita* (82.50 g/100 g DM) and lowest ($P < 0.05$) in *F. mucoso* (29.00g/100 g DM). The values of ADF for *F. thonningii* and *P. maximum* were similar. ADL was highest ($P < 0.05$) in *F. abutilifolia* (35.40 g/100 g DM) and significantly ($P < 0.05$) lowest in *F. exasperata* (10.52g/100 g DM). DM values in all the ficus species were significantly ($P < 0.05$) different from one another with *Ficus mucoso* having

significantly ($P < 0.05$) highest value among the *Ficus species*.

Qualitative contents of saponin and phenol of the ficus species (Table 2) revealed that in the dry season, the content of saponin is low in *F. polita* but absent in other ficus species investigated. Tannin was not found in *F. polita* and *F. thonningii* but was present in *F. vogelli*, *F. abutilifolia*, *F. mucoso*, and *F. exasperata* in the form of condensed tannin.

Table 2: Qualitative contents of saponin and phenols in six ficus species in the dry season

Sample	Saponins		Phenols	
	Foam (mm)	Comment	Colour change	Comment
<i>F. polita</i>	6	Low	-	Negative
<i>F. vogelli</i>	2	Negative	Dark green	CT
<i>F. abutilifolia</i>	2	Negative	Dark green	CT
<i>F. mucoso</i>	-	Negative	Dark green	CT
<i>F. exasperata</i>	-	Negative	Dark green	CT
<i>F. thonningii</i>	2	Negative	-	Negative

F = Ficus, CT = Condensed tannins.

The effect of *in vitro* fermentation on IVGP, ME, OMD and SCFA for the six ficus species containing diets incubated for 24 hrs in the dry season are presented in Table 3. IVGP, ME, OMD and SCFA obtained for *F. abutilifolia*, *F. exasperata*, *F. polita*, *F. thonningii* and *F. vogelli* were not significantly ($P>0.05$) different from one another, but were significantly ($P<0.05$) higher than values obtained for *Ficus mucoso*.

The *in vitro* gas production characteristics of ficus species incubated with *Panicum maximum* for 24 hr in the dry season is as shown in Table 4. Potential gas production 'b' (ml/200 mg DM) recorded for *F. polita*, *F. thonningii*, *F. abutilifolia* and *F. exasperata* were significantly ($P<0.05$) higher than that of *F. vogelli* and *F. mucoso*. The soluble 'a' fraction of the samples was lowest and significant ($P<0.05$) in *F. mucoso* (5.76), and highest in *F. polita* (9.08).

There were no significant differences in the 'a+b' values (potentially degradable fractions) of *F. polita*, *F. thonningii*, *F. vogelli*, *F.*

abutilifolia and *F. exasperata*. These values were however, significantly ($P<0.05$) higher than 'a+b' value obtained for *Ficus mucoso* (43.00%). The degradation constant 'c' of the insoluble but fermentable fraction of *Ficus exasperata* (0.06) was significantly ($P<0.05$) higher than that of *Ficus abutilifolia* (0.04) and *F. mucoso* (0.04).

Discussion

The variations observed in chemical composition of the ficus species in the dry season were similar to those previously reported in other West African browse trees (Rittner and Reed, 1992) and also consistent with the pattern observed in some multipurpose trees in Nigeria (Arigbede *et al.*, 2003). Differences in cell wall lignification could be responsible for the variations observed in the chemical compositions of the ficus species. The range of crude protein for the ficus species as indicated by the proximate composition confirmed the high protein content. The high level of crude protein contents in the ficus species

Table 3: Effect of *In vitro* fermentation on IVGP, ME, OMD and SCFA for six ficus species containing diets in the dry season

Ficus species	IVGP	ME	OMD	SCFA
<i>F. abutilifolia</i>	36.42 ^a	7.75 ^a	58.24 ^a	0.81 ^a
<i>F. exasperata</i>	42.42 ^a	8.44 ^a	63.16 ^a	0.95 ^a
<i>F. mucoso</i>	27.00 ^b	6.44 ^b	49.94 ^b	0.59 ^b
<i>F. polita</i>	39.25 ^a	8.21 ^a	59.95 ^a	0.88 ^a
<i>F. thonningii</i>	35.75 ^a	7.59 ^a	59.12 ^a	0.79 ^a
<i>F. vogelli</i>	36.25 ^a	7.71 ^a	57.35 ^a	0.81 ^a
SEM	2.34	0.31	2.05	0.06

a, c, d, e, f, g; means on the same column with different superscripts are significantly different ($P<0.05$).

F = Ficus; IVGP = In vitro gas production; ME = Metabolisable energy; OMD = Organic matter digestibility; SCFA = Short chain fatty acids. SEM = Standard error of means

compared favourably with earlier reports (Rittner and Reed, 1992; Larbi *et al.*, 1998; Arigbede *et al.*, 2002; Aye, 2002; Bamikole *et al.*, 2003; Bamikole *et al.*, 2004). The high levels of crude protein in the *Ficus* species, particularly *Ficus polita* could make these tree foliages good dry season supplement of *P. maximum* which had CP of 6.33g/100 g DM. The CP values in *F. polita* and *F. vogelli* were higher than that reported for *Lablab purpureus* (Babayemi *et al.*, 2006). Except in *F. polita*, the ash contents of all the ficus species investigated were higher than values of ash reported for *Leucaena leucocephala*, *Lablab purpureus* and *Gliricidia sepium* (Ajayi *et al.*, 2005).

However, the ash content of ficus species were consistent with the value of 17.31% reported for *Ficus thonningii* (Ajayi *et al.*, 2005), but higher than the 3.33g/100 g DM reported by Bamikole *et al.* (2004) for *F. thonningii*. There seems to be an inconsistent variation in the crude fibre, NDF and ADF contents of the ficus species. The moderate level of NDF in *Ficus polita*

(67.00g/100 g DM) and its relatively higher CP (15.71g/100 g DM) presents it as forage of choice in the dry season amongst others when they are all available. The levels of NDF in the *Ficus* species investigated in this study were comparable to those reported elsewhere for some valuable multipurpose trees in Nigeria (Bayer, 1990, Larbi *et al.*, 1993).

The presence of saponin in low quantity in *Ficus polita* makes it a quality feed for ruminant livestock production, particularly in the dry season. Feedstuffs containing saponin had been shown to be defaunating agents (Teferedegne, 2000), and capable of reducing methane production (Babayemi *et al.*, 2004b).

F. abutilifolia, *F. exasperata*, *F. polita*, *F. thonningii* and *F. vogelli* were all similar in their values of IVGP, ME, OMD and SCFA but significantly higher than *F. mucoso*. So the forages are suitable in supplementing forages fed to ruminant animals particularly in the dry season when grasses are scarce. *F. mucoso* seems not to be adequate as a supplement in

Table 4: Gas production characteristics of six ficus species based diets incubated for 24 hr in dry season

Ficus species	a	b	a+b	c
<i>F. polita</i>	9.08 ^a	46.17 ^{ab}	55.25 ^a	0.05 ^{ab}
<i>F. thonningii</i>	7.17 ^{ab}	44.83 ^{ab}	51.75 ^a	0.05 ^{ab}
<i>F. vogelli</i>	8.33 ^a	43.92 ^b	52.25 ^a	0.05 ^{ab}
<i>F. abutilifolia</i>	7.92 ^{ab}	44.50 ^{ab}	52.42 ^a	0.04 ^b
<i>F. exasperata</i>	7.92 ^{ab}	50.50 ^a	58.42 ^a	0.06 ^a
<i>F. mucoso</i>	5.76 ^b	37.25 ^c	43.00 ^b	0.04 ^b
SEM	0.01	4.07	4.34	1.49

a, c, d, e, f, g; means on the same column with different superscripts are significantly different (P<0.05).

F = Ficus; a = Soluble fraction; b = Potential gas production; a+b = Potentially degradable fraction; c = rate of fermentation (constant). SEM = standard error of means.

ruminant feeding compared to other ficus species investigated in terms of the parameters examined. The values of ME, OMD and SCFA for *F. mucoso* were however higher than the values reported for both tea leaf and spent tea leaf (Babayemi *et al.*, 2006) and also higher than some Agro-industrial wastes e.g Dried brewers' grains, cocoa waste meal; and rice bran (Aregheore and Abdulrazak, 2005). *In vitro* gas production, which is an indicator of the degradability of a forage sample was also significantly low in *F. mucoso*.

The potential gas production in this study were similar to 49.5ml/200mg DM reported by Makkar and Becker (1996) for *Moringa oleifera* leaves, Cerillo and Juarez (2004), (45.0-52.6 ml/200 mg DM), for tree species in the semi arid region of North Mexico and Arigbede *et al.* (2006) (12.5-44.9 ml/200 mg DM) for multipurpose trees in Abeokuta, Nigeria. The high protein content of *F. exasperata* could have imparted positive influence on the microorganisms, since gas production is positively related to microbial protein synthesis. The same poor result in *F. mucoso* was evident in the potentially degradable fraction 'a+b' value, the fermentable fraction 'b' and the rate constant for fermentation 'c'. The values of 0.04-0.06 obtained for the fractional rate of gas production of the Ficus species investigated in this study revealed high digestibility as the rate at which a feed or its chemical constituents are broken down in the rumen is as important as the extent of digestion (Arigbede *et al.*, 2006). These values were also similar to 0.026-0.059 reported for multipurpose

trees (Makkar and Becker, 1996), 0.048-0.055 reported for *Leucaena leucocephala* and *Gliricidia sepium* respectively (Brenda *et al.*, 1997). Higher values of 0.056-0.17 were reported for corn grain and canola meal by Getachew *et al.* (2004) probably due to higher nutrient concentration in those feeds than forage samples used in this study. The poor performance of *Ficus mucoso* in all these parameters may be a result of its low ether extract, crude fibre, acid detergent fibre, acid detergent lignin and high dry matter amongst the ficus species.

Conclusion

In terms of their *in vitro* gas production parameters, contents of saponin and phenols, and gas characteristics, except *F. mucoso*, the ficus species investigated showed potentials as supplements for dry season feeding of ruminants. These ficus species can be fed to ruminants either as supplements or as whole diets without detrimental effects.

References

- AOAC (1995). Official Methods of Analysis, 16th ed. (Association of Official Analytical Chemists, Arlington, VA).
- Ajayi D.A., Adeneye J.A. and Ajayi F.T. (2005). Intake and Nutrient utilization of West African Dwarf Goats Fed Mango (*Mangifera indica*), Ficus (*Ficus thonningii*), Gliricidia (*Gliricidia sepium*) Foliages and Guinea Grass (*Panicum*

maximum). *World Journal of Agricultural Science* 1 (2): 184 – 189.

Argheore E.M. and Abdulrazak S.A. (2005).

Estimation of organic matter digestibility and metabolizable energy content of agro industrial wastes using in vitro gas production. *Nig. J. Anim. Prod.* 32 (1): 79-87.

Arigbede O.M, Anele U.Y., Olanite J.A., Adekunle I.O., Jolaoso O.A and Onifade O.S. (2006). Seasonal in vitro gas production parameters of three multipurpose tree species in Abeokuta, Nigeria. *Livestock Research for rural Development* 18 (10). <http://www.cipav.org.co/lrrd/lrrd18/10/arigbed.htm>

Arigbede O.M., Bamikole M.A., Olanite J.A., Jolaoso A.O. and Onifade O.S. (2002). Seasonal degradability of Dry matter, Organic matter and Crude protein in some multi- purpose tree species by West African Dwarf goats. *Proc 27th Ann. Conf. Nig. Soc. For Anim. Prod. Fed. Univ.Tech. Akure*, Pp 191- 194.

Arigbede O.M., Bamikole M.A. and Babayemi O.J. (2003). Evaluation of three forms of two indigenous multipurpose tree species fed to West African dwarf goats. *ASSET series, A*. 3:33-41.

Aye P.A. (2002). Effect of *Gliricidia sepium* leaves on intake and digestibility of West

African Dwarf goats fed dried elephant grass. *Proced. 27th Ann. Conf. Nig. Soc. For Anim. Prod.* Pp. 195-197.

Babayemi O.J., Demeyer D. and Fievez V. (2004a). Nutritive value and qualitative assessment of secondary compounds in seeds of eight tropical browse, shrub and pulse legumes. *Comm. Agric. Appl. Biol. Sci.* Ghent University, 69(1): 103 –110

Babayemi O.J., Demeyer D. and Fievez V. (2004b). *In vitro* fermentation of tropical browse seeds in relation to their content of secondary metabolites. *J. Anim Feed. Sci.*, 13 suppl. 1:31-34.

Babayemi O.J., Hamzat R.A., Bamikole M.A., Anurudu N.F. and Olomola O.O. (2006). Preliminary studies on spent Tea leaf: *In vitro* gas production as affected by chemical composition and secondary metabolites. *Pakistan Journal of Nutrition* 5 (5): Pp 497 – 500.

Bamikole M.A, Babayemi O.J., Arigbede O.M. and Ikhatua U.J. (2003). Nutritive value of *Ficus religiosa* in West African Dwarf goats. *J. Anim. Feed Sci Tech.* 105:71-79.

Bamikole M.A., Ikhatua U.J., Ajulo M.T. and Oseji A.C. (2004): Feed utilization potential

- of West African Dwarf Goats Fed different proportions of *Ficus thonningii* and *Panicum maximum*. *Proceedings, 29th Ann. Conf. NSAP*. Vol. 29. Pp 336 – 340.
- Bayer W. (1990). Use of native browse by Fulani cattle in central Nigeria. *Agroforestry systems* 12: 217-228.
- Blummel M., Makker H.P.S., Becker K. (1997). *In vitro* gas production: a technique revisited. *J. Anim. Physiol. Anim. Nutr.* 77: 24-34.
- Brenda K, Nguyen V.L., Preston T.R. and Orskov E.R. (1997) Nutritive value of leaves from tropical trees and shrubs: 1. *In vitro* gas production and in sacco rumen degradability. *Livestock research for rural development*. (9) 4: <http://www.cipav.org.co/lrrd/lrrd9/4/bren941.htm>.
- Cerillo M.A and Juarez R.A.S. (2004). *In vitro* gas production parameters in cacti and tree species commonly consumed by grazing goats in a semi arid region of North Mexico. *Livestock Research for Rural dev.* Vol. 16, Art. #4 Retrieved March 19, 2004, <http://www.cipav.org.co/lrrd/lrrd16/4/cerr16021.htm>.
- Getachew G., De Peters E.J. and Robinson P.H. (2004). *In vitro* gas production provides effective methods for assessing ruminant feeds. *California Agriculture* 58, 1-12.
- Getachew G., Makkar H.S.P. and Becker K. (1999). Stoichiometric relationship between short fatty acid and in vitro gas production in presence and absence of polyethylene glycol for tannin containing browses, EAAP Satellite symposium, Gas production: Fermentation kinetics for feed evaluation and to assess microbial activity. 18 – 19 August. Wageningen. Netherlands.
- Kibon A. and Ørskov E.R. (1993): The use of degradation characteristics of browse plants to predict intake and digestibility by goats. *Anim. Prod.* 57, 247 – 251.
- Larbi A., Jabbar M.A., Orok N.N., Idiong B. and Cobbina J. (1993). *Alchornea cordifolia*, a promising indigenous browse species adapted to acid soils in Southeastern Nigeria for integrated crop-livestock-agroforestry production system. *Agrofor. Syst.* 22, 33-41.
- 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. *Anim. Feed Sci. Technol.* 72:81-96.
- Makkar H.P.S and Becker K. (1996). A bioassay for polyphenols (tanins). In: Vrcauteren J, Cheze C, DDumon M.C. and Weber J.F (Eds) *Proceedings of the 18th International Conference on Polyphenols*,

- 15-18 July 1996, Bordeaux, France. Polyphenols Communications 96 (1): 197-198.
- Menke K.H., Raab L., Salewski A., Steingass H., Fritz D. and Schneider W. (1979).** The estimation of the digestibility and metabolizable energy content of ruminant feeds stuffs from gas production when they are incubated with rumen liquor *in vitro*. *J. Agric. Sci. (Camb)*. 93:217-222.
- Menke K.H. and Steingass H. (1988).** Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Anal. Res. Develop*, Separate Print 28, 7-55.
- Ørskov E.R. and McDonald I. (1979).** The estimation of protein degradability in rumen from incubation measurements according to rate of passage. *J. Agric. Sci. (Camb.)* 92: 449-503.
- Rittner U. and Reed J.O. (1992).** Phenolics and *in vitro* degradability of protein and fibre in West African browses. *J. Sci. food Agric.* 58, 21-28. Van Soest, P.J., Robertson, J.B and Lewis, B.A., 1991. Method for dietary fiber, neural detergent fiber and nonstarch Polysaccharides in relation to animal nutrition. *J. Dairy Sci.* 74, 3583-3597.
- SAS (1999).** SAS /STAT User's Guide version 8 for windows. SAS Institute Inc., SAS Campus Drive, Cary, North Carolina, U.S.A.
- Teferedegne B., (2000).** New perspectives on the use of tropical plants to improve ruminant nutrition. *Proc. Nutr. Soc.*, 59: 209-214.
- Van Soest P.J., Robertson J.B. and Lewis B.A. (1991).** Method for dietary fiber, neural detergent fiber and nonstarch Polysaccharides in relation to animal nutrition: *J. Dairy Sci.* 74, 3583-3597.

(Received 25th August, 2008; Accepted 2nd Feb. 2009).