CHEMICAL COMPOSITION AND *IN VITRO* GAS PRODUCTION OF AFRICAN BREAD FRUIT (*TRECULIA AFRICANA*) VAR. DECNE

COMPOSICIÓN QUÍMICA Y PRODUCCIÓN DE GAS *IN VITRO* DEL FRUTO DEL PAN AFRICANO (*TRECULIA AFRICANA*) VAR. DECNE

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ADDITIONAL KEYWORDS

Plant parts.

SUMMARY

Samples of African breadfruit (*Treculia africana*) fruits and foliage were collected across different seasons from different locations within Abeokuta, Ogun State. Nigeria. The fruits were separated into husk, testa and seed and analyzed for proximate and fibre composition. The dry matter (DM) content values which ranged from 88.33-90.80% (p>0.05) were recorded for the husk, testa and seed while a lower range of 34.25-36.03% was recorded for the foliage across the seasons. The crude protein (CP) content followed the same trend as the DM with its values ranging between 16.08 and 18.02% (p>0.05) for the different parts and across the seasons. The ether extract (EE) values were however significantly different (p<0.05) among the different parts while the ash content did not vary significantly between the different parts and across seasons. The seasonal *in vitro* gas production of 56.75ml/200mg DM was recorded for the seed and it was significantly higher (p<0.05) than that of other plant parts. The result of the correlation analysis between extent of gas production and the various chemical constituents of *T. africana* plant parts indicates that there were both positive and negative relationships. Significant correlations were observed between the *in vitro* gas and the ADF, cellulose and hemicellulose contents of testa and leaf. The result showed the presence of highly fermentable substrates in the seeds and leaves of *T. africana*.

PALABRAS CLAVE ADICIONALES

Partes de las plantas.

RESUMEN

Se estudiaron muestras de hojas y frutos del árbol del pan africano (*Treculia africana*) recogidas en diferentes estaciones y lugares de Abeokuta (Estado de Ogun, Nigeria). Los frutos se separaron en cáscaras, testa y semilla y fueron analizados para estimar su composición nutritiva. Los valores de materia seca (DM) para cáscaras, testa y semillas oscilaron entre 88,33 y 90,80% (p>0,05) mientras que para las hojas se registró un rango inferior (34,25-36,03%) en todo el tiempo. La proteína bruta (CP) para las diferentes partes y estaciones, siguió una tendencia similar a la de la DM y sus valores se encontraban entre 16,08 y 18,02 (p>0,05). Los valores del extracto etéreo (EE) fueron, sin embargo, diferentes (p<0,05) para las distintas partes, mientras que las cenizas no variaron entre partes ni estaciones.

La producción estacional de gas *in vitro* fue, para las semillas, de 56,75 ml/200 mg DM y fue significativamente superior (p<0,05) a la de las otras partes analizadas. Hubo correlaciones, tanto positivas como negativas, entre la magnitud de la producción de gas y distintos componentes químicos de las partes de la planta. Se registraron correlaciones significativas entre la producción de gas *in vitro* con las concentraciones de ADF, celulosa y hemicelulosa de la testa y hojas. Los resultados demostraron la presencia de substratos altamente fermentables en las semillas y hojas de *T. africana*.

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INTRODUCTION

Evaluation of indigenous multipurpose tree species (MPTS) is one of the most significant interventions in addressing the seasonal shortages in the quality and quantity of forages from natural pasture. Indigenous MPTS due to their adaptability to the prevailing climatic and soil conditions of tropical countries are preferred to their exotic counterparts and herbaceous pasture species. Such species like *Enterolobium cyclocarpum, Grewia pubescens, Pterocarpus santalinoides* and *Moringa oleifera* have been found to be more persistent during the dry season than the exotic *Leucaena leucocephala* and *Gliricidia sepium* (Shelton *et al.*, 1991; Arigbede, 1998).

African breadfruit (*Treculia africana*) is a deciduous tree species of 24-37 m high with a stem/trunk girth of approximately 3 m at full maturity. It belongs to the family Moracae (Mulberry) and, genus *Treculia* var. Decne. It is native to many parts of West African countries (Lawal, 1997).

According to Okusanya and Lakanmi (1991), two varieties are widely known, the seedless and the seeded; the seeded variety being of two types, one with spiny and the other with smooth outer coating. There are also variations in the seed sizes with some having very small seeds while others have very large seeds. The plant is a common feature of the evergreen and deciduous forests often found along streams. In Nigeria, it is very common in the western and eastern states, especially in Onitsha areas. The plant always maintains green leaves irrespective of the season (Lawal, 1997). The fruits are big and greenish in colour and when ripe, changes to brownish yellow when it eventually drops from the plant. There is evidence that the seeds are being consumed in some parts of Nigeria and the foliage is palatable to ruminant animals (Okusanya and Lakanmi, 1991). There are also claims that the roots, leaves, husk and bark of *T. africana* are utilized in some local communities as ingredients in concoctions for various types of ailments (Lawal, 1997). As part of studies to screen various indigenous tree species, this study was carried out to determine the seasonal chemical composition and nutritive quality of different parts of *Treculia africana* using the *in vitro* gas production method.

MATERIALS AND METHODS

STUDY SITE

The study was carried out in the laboratory of the Department of Pasture and Range Management, College of Animal Science and Livestock Production (COLANIM), University of Agriculture (UNAAB), Abeokuta, Nigeria. The site lies within the derived Savannah zone of Nigeria on latitude 7°N and longitude 3.5°E. The mean annual rainfall is 1037 mm while the annual temperature range is between 22.50-30.72°C. Relative humidity ranges from 63% in January to 96% in August with yearly average of about 82%.

SAMPLE COLLECTION

Samples of the various parts of the plant were collected within Abeokuta over 12 months from the tree stands on the Teaching and Research Farm of the COLANIM, UNAAB and the premises of UNAAB - Leventis Foundation Nigeria Agro- Allied company Ltd. as follows: November 2003 (early dry season), March 2004 (late dry season), May 2004 (early wet season) and October 2004 (late wet season).

Tree stands with fruits at varying stages of maturity were used. Foliage samples used were just the leaves. No stem fraction was included. The fruits used were matured ones that have dropped off from the trees. The fruit type used in this study is the spiny, small seeded type.

Foliage samples were collected, weighed fresh, enveloped and oven – dried at 65°C to constant weight while the fruit samples were harvested and allowed to decompose for 21 days before the seeds were removed and separated into testa and husk. The samples were weighed fresh and transferred into the drying cabinet at 65°C for 72 hours. The dry weights of the samples were recorded. The dry samples were milled in a Hammer mill to pass through 1mm sieve and preserved for both proximate (AOAC, 1995) and fibre (Goering and Van Soest, 1970) analyses.

IN VITRO GAS PRODUCTION

The *in vitro* gas production of the leaves, seed, testa and husk were determined following the procedure of Menke and Steingass (1988). A sensitive scale was used to measure out 200 mg of the milled samples in three replicates and placed into 100 ml graduated glass syringes. Rumen fluid (inoculum) obtained from an abattoir in Abeokuta was mixed with sodium and ammonium bicarbonate buffer (35g $NaHCO_3$ plus 4 g NH_4HCO_3 per litre) at a ratio of 1:2 (v/v) to prevent lowering of the pH of the rumen fluid which could result in decreased microbial activities of the inoculum.

Thirty millilitres of the buffered inoculum was then added to each syringe and the gas released was read off directly on the graduated syringe. The syringes were positioned vertically in a water bath kept at 39°C. A blank syringe containing 30 ml of the buffered inoculum only was also included as control. All the syringes were gently shaken 30 minutes after commencement of incubation and four times daily at regular intervals thereafter. Gas production was recorded at 0, 3, 6, 9, 12, 15, 18, 21, 24, 48, 72 and 96 hours of incubation. The data obtained were fitted to the non-linear equation:

$$V\ (ml/200\ mg\ DM) = b\ (1-e^{-ct})$$

Where:
V= potential gas production at time
t,b= volume of gas that would evolve within time (t), and
c= fractional rate of gas production.

Initial gas production rate (Abs_g) was calculated as the product of b and c (Larbi *et al.,* 1996).

STATISTICAL ANALYSIS

The data collected were subjected to analysis of variance (ANOVA) (SAS, 1997), while significant means were separated with Duncan's multiple range test (Duncan, 1955). The relationships between the various nutrient components were determined using Pearson correlation analysis (SPSS, 1993).

RESULTS AND DISCUSSION

The seasonal chemical composition of the different parts of African breadfruit (*T. africana*) is presented in **table I**. The dry matter (DM) of the plant parts was high but was not significantly different ($p>0.05$) from each other and within season except the foliage, which recorded a lower DM in all the season. The foliage DM content ranged between 34.25% in early dry to 36.03% in late dry seasons. Though, these range of values were significantly lower ($p<0.01$) than for other parts of the plant, it was higher than those reported for other MPTS (Arigbede, 1998; Ly *et al.*, 2001; Makkar and Becker, 1997).

The DM content recorded for the different parts of *T. africana* in this study with the exception of the foliage were high probably because the parts were sun dried and left to ferment for 21 days before the seeds could be removed from the husk. It was quiet difficult to remove the seeds from the fresh fruits. The leaves were however, plucked, weighed fresh and transferred into the oven for DM determination. The DM values recorded for all the plant parts were however comparable with those previously obtained elsewhere for browse plants (Arigbede, 1998; Wong, 1982 and Topps, 1992).

The crude protein (CP) content followed a similar trend with the DM with values in the late dry season ranging between 16.07%

and 18.20% for the husk and foliage, respectively. There were no significant differences (p<0.05) in the CP content of the different *T. africana* parts across the seasons. This confirmed earlier reports that indigenous MPTS are able to retain their nutrients into the dry season than their exotic counterparts as well as grasses (Shelton *et al.,* 1991). The evergreen nature of *T. africana* coupled with its similar CP content throughout the year showed that it is a good protein supplement for resource - poor farmers. The CP content of all the parts of the plant in all the seasons was far above the 6% level recommended as minimum daily requirement of ruminant animals from tropical feeds (NRC, 1984).

The ether extract (EE) values ranged between 5.08 to 17.0%. The EE values which represented the crude fat content was significantly different (p<0.05) among the different parts with the highest value of 17.0% recorded for the seed during the late wet season.

The EE values recorded for the different plant parts however showed that the plant contained adequate crude fat to satisfy the energy requirement of ruminant animals for productive purposes. According to Upadhyaya *et al*. (1974), the EE content of browse plants could be used to rank them as oil containing plant or otherwise. They reported a mean value of 6.54% for *Leucaena leucocephala* and ranked it as oil rich plant. The fact that the values they reported were lower than those recorded in this study means that *T. africana* is clearly an oil rich plant. The mean values were also higher than 3.40% reported for *Grewia tiliaefolia* and 5.90% for *L. leucocephala* by Joshi and Singh (1989).

The ash content of the plant did not vary significantly (p>0.05) between the different parts and across the season. The highest value of 11.67% was recorded for the husk while the leaf, testa and seed recorded 9.87, 7.20 and 2.92%, respectively. The seasonal ash content recorded for *T. africana* in this study showed the presence of a high concentration of inorganic elements in the plant. The result is comparable with values of 10.0, 9.10 and 8.10% reported for

Table I. *Seasonal proximate composition of different parts of* T. africana. (Composición nutritiva estacional de diferentes partes de *T. africana*).

PP	DM				CP			
	ED	LD	EW	LW	ED	LD	EW	LW
Husk	88.33[a]	88.05[a]	89.42[a]	86.42[a]	17.35	16.07	16.25	16.80
Testa	87.77[a]	88.70[a]	90.50[a]	88.00[a]	17.80	17.51	17.40	16.90
Seed	89.67[a]	90.25[a]	90.80[a]	89.25[a]	16.70	17.02	17.17	16.88
Leaf	34.25[b]	36.03[b]	34.50[b]	35.50[b]	17.85	18.20	17.66	17.84
PP	**EE**				**Ash**			
	ED	LD	EW	LW	ED	LD	EW	LW
Husk	11.42[b]	9.33[b]	8.42[b]	9.60[b]	9.25[a]	9.92[a]	11.60[a]	8.83[ab]
Testa	9.00[c]	8.57[c]	7.60[b]	6.08[c]	6.03[b]	8.40[b]	7.83[b]	7.10[b]
Seed	14.00[a]	14.35[a]	15.00[a]	14.95[a]	3.90[c]	3.07[c]	2.95[c]	3.70[c]
Leaf	6.08[d]	6.75[c]	6.42[c]	6.25[c]	8.90[a]	10.15[a]	10.40[a]	10.00[a]

*Means along the same column with different superscripts are significantly different (p<0.05).
*PP= Plant parts. ED= Early dry. LD= Late dry. EW= Early wet. LW= Late wet seasons.

Gliricidia sepium, Erythrina veriegata and *L. leucocephala,* respectively by Rajaguru (1990) and 13.70% for *L. leucocephala* by Joshi and Singh (1989).

Values for the fibre components **(table II)** showed the preponderance of soluble carbohydrates in all the plant parts. The values were significantly different ($p<0.05$) between the plant parts and across the seasons. For instance, the husk recorded the highest NDF and ADF values of 61.37% and 44.29% in late wet season and early dry season, respectively, while the highest lignin content of 21.62% was recorded for the seed during the late wet season.

The NDF, ADF and lignin contents found in various parts of *T. africana* showed high proportion of soluble components which ruminant animals can degrade with the aid of microbes in their rumen. Various fibre components' values have earlier been reported for some MPTS. For instance, Topps (1992) reported 36.10, 29.60 and 14.10% for NDF, ADF and lignin contents, respectively for *E. cyclocarpum* while Bamualin *et al.* (1980) reported 25.0, 19.50 and 8.40% for NDF, ADF and lignin respectively in *Acacia currasarica*. Similarly, Akkasaeng *et al.* (1989) reported 40.30 and 42.10% NDF for dry and wet seasons in *E. cyclocarpum* as well as 47.80 and 51.20% NDF for *L. leucocephala* in dry and wet seasons. All these NDF values were lower than values obtained in this trial, which may suggest *T. africana* as a better source of soluble fibre than other MPTS mentioned.

The seasonal *in vitro* gas production of the different parts of *T. africana* when incubated with rumen buffered fluid is shown in **table III**. The highest volume of 56.75 ml/200 mg DM was recorded for the seed during the early wet season at the end of 96 hrs incubation. This gas production was significantly higher ($p<0.05$) than gas production from other plant parts for all the hours examined. Other plant parts did not produce appreciable volume of gas. According to Blummel and Becker (1997) the *in vitro* gas production technique is a useful tool in determining the nutritional value of forages because the volume of gas produced by forage species reflects the end

Table II. *Seasonal fibre composition of different parts of* T. africana. (Contenido estacional de fibra en diferentes partes de *T. africana*).

PP	NDF				ADF				Lignin			
	ED	LD	EW	LW	ED	LD	EW	LW	ED	LD	EW	LW
Husk	59.34	61.26	59.00	61.30	44.20	41.80	43.42	41.50	20.95	21.47	21.70	20.35
Testa	59.60	60.00	60.77	60.26	42.87	43.66	42.60	42.00	20.60	20.23	21.42	21.90
Seed	60.98	58.74	60.45	59.75	42.65	40.60	42.71	42.98	21.50	20.35	20.30	21.60
Leaf	59.40	58.95	59.60	59.44	41.70	41.90	40.60	42.90	20.60	19.15	20.40	20.90

PP	Hemicellulose				Cellulose			
	ED	LD	EW	LW	ED	LD	EW	LW
Husk	15.05	19.40	15.58	19.80	23.30	20.34	22.25	21.20
Testa	16.72	16.35	18.20	18.30	22.25	23.40	21.20	20.11
Seed	17.35	15.08	17.48	16.75	21.10	23.30	22.35	21.35
Leaf	18.10	18.50	18.02	16.50	21.90	21.10	21.10	20.08

*PP= Plant parts. NDF= Neutral detergent fibre. ADF= Acid detergent fibre. ED= Early dry. LD= Late dry. EW= Early wet. LW= Late wet seasons.

Table III. *Seasonal* in vitro *gas production (ml/200 mg DM) of different parts of* T. africana.
(Producción estacional de gas *in vitro (ml/200 mg DM)* de diferentes partes de *T. africana*).

PP	6 hrs				12 hrs				24 hrs			
	ED	LD	EW	LW	ED	LD	EW	LW	ED	LD	EW	LW
Husk	30.50	30.75	30.75	31.00	30.50[a]	30.75[b]	31.25[b]	31.25[b]	30.75[b]	31.00[b]	31.50[b]	31.45[b]
Testa	30.75	30.75	30.50	31.00	30.75[a]	31.00[b]	30.75[b]	31.75[b]	30.75[b]	31.25[b]	30.75[b]	32.00[b]
Seed	30.50	31.25	31.00	30.75	32.50[a]	39.50[a]	40.25[a]	34.50[a]	33.00[a]	44.00[a]	40.50[a]	35.00[a]
Leaf	30.25	30.00	30.50	30.50	30.75[a]	30.50[b]	30.75[b]	31.50[b]	31.00[b]	30.90[b]	31.00[b]	31.75[b]
SEM	0.23	0.30	0.25	0.16	0.05	0.35	0.45	0.30	0.45	0.28	0.90	0.58

PP	48 hrs				72 hrs				96 hrs			
	ED	LD	EW	LW	ED	LD	EW	LW	ED	LD	EW	LW
Husk	31.00[b]	31.25[b]	31.75[b]	31.50[b]	31.50[b]	32.00[b]	32.00[b]	31.75[b]	31.75[b]	32.25[b]	32.00[b]	31.75[b]
Testa	30.75[b]	31.75[b]	30.90[b]	32.50[b]	30.75[b]	31.75[b]	31.00[b]	32.75[b]	30.75[b]	31.75[b]	32.50[b]	33.25[b]
Seed	39.50[a]	49.75[a]	47.50[a]	36.25[a]	44.50[a]	52.50[a]	51.00[a]	44.50[a]	50.50[a]	53.75[a]	56.75[a]	46.75[a]
Leaf	31.25[b]	31.25[b]	31.25[b]	32.75[b]	31.75[b]	32.00[b]	31.90[b]	33.00[b]	32.75[b]	32.50[b]	32.75[b]	33.00[b]
SEM	0.70	0.99	0.80	0.74	0.95	1.20	1.80	0.95	0.90	1.55	1.80	0.68

*Means along the same column with different superscripts are significantly different ($p<0.05$).
*PP= Plant parts. ED= Early dry. LD= Late dry. EW= Early wet. LW= Late wet seasons.

result of the fermentation of its substrate to volatile fatty acids (VFA), microbial biomass and neutralization of the VFA, thus demonstrating the nutritional value of such forage. Results from this trial is similar to the range of 31.60-52.60 ml/200 mg DM in *Quercus eduardii* and *Opuntia leptocaulis* obtained by Cerillo and Juarez (2004) and value of 49.50 ml/200 mg DM for *M. oleifera* leaves by Makkar and Becker (1997) but was higher than 30.50 ml/200 mg DM reported for *G. sepium* by Brenda *et al.* (1997). The range of values of gas produced by *T. africana* parts in this study showed that its seeds are good source of fermentable substrate capable of contributing to ruminant feed resource. The foliage sample with the highest gas production of 33.0 ml/200 mg DM could also be considered to have potential to contribute to feeding of ruminant animals while the husk and testa could be regarded as roughages with little nutritional value.

Table IV showed the seasonal gas production characteristics of *T. africana* parts. The fractional rate ranged between 0.0006 to 0.0655 ml/hr although there was no significant difference ($p<0.05$) among the plant parts. Getachew *et al*. (2004) earlier reported higher values of 0.056 to 0.169 for fractional rate of gas production in corn grain and Canola meal. This was attributed to higher nutrient concentration in those feedstuffs, which was similar to values obtained for seeds of *T. africana* in this study.

The result of the correlation between extent of gas production at 96 hrs and the chemical constituents of the different parts of *T. africana* indicates that there were both positive and negative relationships between the volume of gas produced from the forages and their chemical constituents **(table V)**. This is consistent with the reports of Nsahlai *et al*. (1994); Getachew *et al*. (2003); Cerrillo and Juarez (2004) and Doane *et al*. (1997). The positive correlation between DM and *in vitro* gas production of all the parts

Table IV. *Seasonal gas production characteristics of different parts of* T. africana. (Características de la producción estacional de gas por diferentes partes de *T. africana*).

Parts	bg (ml/200mg DM)				cg (ml/h)				Absg (ml)			
	ED	LD	EW	LW	ED	LD	EW	LW	ED	LD	EW	LW
Husk	32.89	34.70	31.99	31.76	0.0121	0.0403	0.0513	0.0387	0.40	0.21	1.64	1.23
Testa	48.21	31.81	32.49	33.36	0.0006	0.0443	0.0259	0.0239	0.03	1.41	0.84	0.80
Seed	50.17	53.37	63.18	55.85	0.0655	0.0485	0.0152	0.0108	3.29	2.59	0.96	0.60
Leaf	31.84	32.88	33.05	33.09	0.0156	0.0263	0.0360	0.0439	0.50	0.86	1.19	1.45

b_g= volume of gas produced in time (t); c_g= fractional rate of gas production; Abs_g= absolute initial gas production during first hour; Means in each row with different superscripts are significantly different ($p< 0.05$); ED= Early dry season; LD= Late dry season; EW= Early wet season and LW= Late wet season.

(husk, testa, seed and leaf) is consistent with Apori *et al.* (1998) who reported a positive relationship between gas production and DM content of some MPTS. This could be as a result of the feed constituents, such as NDF and ADF, which contribute more gas if they are degradable. The negative relationships between the *in vitro* gas production and ADF of the testa and leaf were significant. The positive relationships between the *in vitro* gas production and hemicellulose content of the testa and leaf were also significant. The positive correlation between CP and gas production of the leaf of *T. africana* is consistent with the reports of Nherera *et al.* (1999) and Larbi *et al.* (1998). The positive relationship (0.25) between the *in vitro* gas and the CP means that the CP content of the leaf had a contributory effect on the gas and short chain fatty acid (SCFA) production which implies that 6.25% of variation in the gas production can be explained by variation in the CP concentration of the leaf of *T. africana.*

Table V. *Correlation coefficients between* in vitro *gas production and chemical components of* T. africana *parts.* (Coeficientes de correlación entre la producción de gas *in vitro* y los componentes químicos de las partes de *T. africana*).

	Husk	Testa	Seed	Leaf
DM	0.091	0.112	0.111	0.013
CP	-0.208	-0.450	-0.145	0.250
EE	-0.143	-0.101	0.097	-0.022
Ash	0.093	0.148	-0.174	-0.023
NDF	0.060	0.235	-0.009	0.152
ADF	-0.090	-0.303*	0.059	-0.431**
Lignin	-0.135	0.145	0.228	-0.130
Cellulose	0.071	-0.358*	-0.086	-0.252
Hemicellulose	0.023	0.295*	-0.047	0.388**

*Significant at 0.05 level. **Significant at 0.01 level.

This may be due to the higher CP content of *T. africana* leaf than the other plant parts. The EE content of the seed was positively correlated to gas production as a result of its high EE content of 14.58% which was significantly higher than that of the husk (9.69%), testa (7.81%) and leaf (6.38%) which had positive relationships with *in vitro* gas production. Getachew *et al.* (2004) reported that EE contribution to gas production is negligible but the higher and significant value of the seed's EE might have resulted in its contributory effect on gas production in this study. Contrary to earlier reports of Cerillo and Juarez (2004); Getachew *et al.* (2004) and Nsahlai *et al.* (1994), most of *T. africana* parts recorded positive correlation between the NDF and gas production. The negative correlation between the ADF of the leaf and *in vitro* gas is similar to the report of Cerillo and Juarez (2004) which recorded highly significant negative correlation between ADF and *in vitro* gas production.

In conclusion, the study showed the presence of highly fermentable carbohydrate as well as high CP and EE contents in *T. africana.* These results affirm the potential of *T. africana* as a ruminant feed resource. The plant could therefore be multiplied and domesticated for dry season feeding of ruminant animals by resource - poor farmers.

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