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Chemical Composition, Fibre Fraction and Anti-Nutritional Substances of Semi-arid Browse Forages of North-Eastern Nigeria

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ABSTRACT: The nutritive value of leaves from eight different browse trees and shrubs were analyzed. They include *Ficus polita, Ficus thonningii, Batryospermum paradoxum, Kigalia africana, Celtis integuifolis, Khaya senegalensis, Leptadenia lancifolia,* and *Ziziphus abyssinica.* were collected from Gwoza, in Borno, State, Nigeria. The browse samples were analyzed for chemical composition, fibre fractions and anti-nutritive components of their leaves. Results showed no significant differences (P>0.05) in the DM content, which ranged from 95.2 to 97.0%. *Leptadenia lancifolia, Ficus thonningi* and *Ficus polita* recorded higher CP content which was significantly higher (P<0.05) than the CP content of the other browse plants analyzed. A range of 2.00 to 5.00% and 8.00 to 18.00% were recorded for EE and Ash values for the eight browse plants. The values reported for minerals showed that *Ficus thonningii* had the lowest value of Ca (0.75%) while *Kigalia africana* was low in P and Mg (10.00 and 0.15%). Their fibre contents showed a range of 37.3 to 51.2, 16.2 to 41.2, 4.9 to 12.7, 45.84 to 50.92, 12.4 to 26.90g/100g for NDF, ADF, ADL, ADIash and Cellulose respectively. The values reported for anti nutritive factors range from 0.08 to 0.39 for TCT, 0.24 to 0.65 for phenolics, 2.02 to 2.55 for Saponin, 4.58 to 8.15 for Oxalate, 2.85 to 5.81 for phytate, 0.04 to 0.08 for HCN and 0.0005 to 0.002mg/g. The results showed that the browse species studied have good nutrients contents, low and safe levels of anti-nutritional factors, and may therefore form good feed resources for modern intensive ruminant animal production.

Key words: Browse forage species, anti-nutritive factors, tannins

INTRODUCTION

During the dry season, ruminant diets are limited by shortages in amount and quality of available forage (Shelton, 2004), crop residues or by products (Babayemi *et al.,* 2004a) which result in reduced livestock productivity in the tropical countries (Odenyo *et al.,* 1997). Tree fodders are important in providing nutrient to grazing ruminants in arid and semi-arid environments, where inadequate feeds are a major constraint to livestock production (Aganga and Tshwenyane, 2003). Tree fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity (Shelton, 2004). Tree fodders are important source of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feeds. Tree fodders form part of the complex interactions between plants, animals and crops (Aganga and Tshwenyane, 2003). They help to balance a plant-animal-soil ecosystem and from which there is a sustainable source of feeds (Devendra, 1994). The availability of a variety of these feeds and the selection process enable the herbivores, especially the goats to extend as well as meet their feed preferences. Traditional farmers in the semi-arid region of Nigeria allow their goats, sheep and cattle to browse on tree forages, in the range lands and they also cut and feed these tree foliages as supplements based on experience and convenience. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation. Many plants also produce chemicals which are not directly involved in the process of plant growth (secondary compound) but act as deterrents to insects and fungal attack. These compounds also affect animals and the nutritive value of the forages. Mycotoxins (fungal metabolites) produced by saprophytic and endophytic fungi are also a potential source of toxins in forages (Norton, 1994).

The utilisation of browse is limited by the high lignin content and the presence of anti-nutritional factors, which may be toxic to ruminants. Many browse species have chemicals that appear to be produced for the purpose of deterring invasion or consumption of their leaves by microbes, insects and herbivorous animals. However, the toxic compounds seem to become of significance nutritionally only when the plant constitutes a high proportion of the diet. Hence, the effects of high protein forage could override the effect of the toxic compounds when used as supplement in the diets. The present study therefore examines the nutrient composition and anti-nutritional constituents of some browse species in the semi-arid region of Nigeria.

MATERIALS AND METHODS

Forage samples collection and experimental site: The leaves of eight indigenous browse species commonly consumed by ruminant animals were used in this study. The species were: *Ficus polita, Ficus thonningii,* ***Batryospermum*** *paradoxum, Kigalia africana, Celtis integuifolis, Khaya senegalensis, Leptadenia lancifolia* and *Ziziphus abyssinica.* All the plants were harvested from Gwoza Local Government Area (LGA) of Borno State Nigeria. The area is located at 11.05^0 North and 30.05^0 East and on an elevation of about 364 above sea level in the North Eastern part of Nigeria (Ijere and Daura, 2000). The ambient temperature ranges between 30^0C and 42^0C being the hottest period (March to June) while its cold between November to February with temperatures ranging between 19 - 25^0C (Ijere and Daura, 2000). The browse forages were harvested from at least 10 trees per each specie selected at random in four locations within the study area at the end of the rainy season. The harvested sample were then pooled for each individual tree species and then oven dried at 105^0C for 24h to constant weight and ground to pass through a 1.0mm, sieve. The samples were then sub-sampled to obtain three samples for each tree species and used for the laboratory analysis.

Chemical Analysis: Samples browse species were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crue fibre (CF) Oxalate, Fluoroacetate and ash according to AOAC (2002). The mineral composition (calcium and magnesium) of the forages were analyzed using atomic absorption spectrophotometry (Zohary, 1973). Phosphorus was determined according to the Vanadomolybdophosphoric Acid Method (Shiou, 1996) using a spectrophotometry (Jenway 6100, UK). The leaf samples were analyzed for neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and cellulose according to Van Soest *et al.* (1991). Percentage hemi-cellulose content was obtained by finding the difference between NDF and ADF values (Church, 1975) Anti nutritional constituents: Phytate in the plants was estimated as phytic acid using the method of Maga (1982),while hydrogencyanide (HCN) was determined by the Knowels and Watkins distillation method as described by Pearson (1976), Saponins and total condensed tannin was determined as reported by (Babayemi *et al*., 2004a) and (Polshettiwar *et al*., 2007), phenolics was determine using Folin Ciocalteu as describe by Makkar (2000).

Statistical analysis: The means and standard error of means were calculated for the proximate and anti-nutritional factor values. Means were separated using the least significant difference (LSD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The Crude protein (CP) content of *Ficus polita*, *Ficus thonningii* and *Leptadenia lancifolia* were higher than the other species. The CP of the browse species ranged from 13.85 to 16.65%, which is above the 7% CP requirement for ruminants which will provide ammonia required by rumen microorganism to support optimum microbial activity. Norton (2003), justifies the use of browse forages in small quantities in order to supplement poor quality pastures and crop residues. The high CP content of browse species is well documented and is one of the main distinctive characteristic of browse compared to most grasses. Norton (1998) reported a range of CP contents from 12 to 30% for tropical tree legumes, and Le Houerou (1980) found a mean of 12.5% in West African browse species with about 17% for the leguminous species. Generally, the CP content in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen (Norton, 1998). The species in the Leguminosae family have a higher protein content compared to other species, although species in the Capparidaceae family have on average 25% more protein than legumes (Le Houerou, 1980). Le Houerou (1980) also noted that all browse species are able at all their phenological stages to meet the energy requirements of livestock at maintenance level and often well above, and thus West African browse are considered to be excellent fodder, with very few exceptions. The difference in CP content between species can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil and/or to fix atmospheric nitrogen, which is the case for legumes plants. The other factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem, pod), age of leaf and season. With regard to the location, some authors have reported that browse plants in the Sahelian zone are higher in N compared to plants in the humid zone (Rittner and Reed, 1992). Younger leaves are richer in N than mature leaves, which however contain more N than the litter. The fruits are shown to have a N content in between young and old leaves, and vary little with stage of maturity (Breman and Kessler, 1995).

Table 1: Proximate composition (% DM) of some semi arid browses

Browse species Forages	DM	CP	EE	Ash	OM	Ca	P	Mg
Ficus polita	95.20	16.21[a]	3.00[c]	10.00[d]	85.20[b]	1.75[b]	50.00[a]	1.09[a]
Ficus thonningii	95.20	16.47[a]	2.00[d]	18.00[a]	77.20[d]	0.75[f]	41.25[b]	0.36[d]
Batryospermum paradoxum	95.80	14.63[b]	5.00[a]	8.00[e]	87.80[a]	1.20[c]	11.25[f]	0.30[d]
Kigalia africana	96.40	13.85[c]	3.00[c]	18.00[a]	78.40[d]	0.90[e]	10.00[f]	0.15[e]
Celtis integuifolis	96.20	15.89[a]	3.00[c]	16.00[b]	80.20[d]	1.95[a]	11.25[f]	1.03[b]
Khaya senegalensis	97.00	14.11[b]	3.00[c]	10.00[d]	87.00[a]	0.95[e]	26.25[d]	0.25[e]
Leptadenia lancifolia	95.80	16.65[a]	4.00[b]	18.00[a]	77.80[d]	1.05[d]	31.25[c]	0.40[c]
Ziziphus abyssinica	97.00	14.37[b]	2.00[d]	14.00[c]	83.00[c]	1.10[d]	20.00[e]	0.46[c]
Means	**96.07**	**15.27**	**3.13**	**14.00**	**82.08**	**1.21**	**25.16**	**0.51**
SEM	**0.14NS**	**0.18**	**0.12**	**0.69**	**0.63**	**0.08**	**3.56**	**0.08**

a, b, c, means in the same column with different superscript differ significantly ($P<0.05$). DM = Dry matter; CP = Crude Protein; EE = Ether Extract; OM = Organic matter; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; Ca = Calcium; P = Phosphorus; Mg = Magnesium

Table 2: Mean Fibre (g/100g DM) content of some browse species

Browse species Forages	NDF	ADF	ADL	ADIash	Cell.	Hemi Cell.
Ficus polita	37.30[fg]	27.20[d]	4.90[d]	45.84	22.20[b]	10.10[cd]
Ficus thonningii	51.20[a]	41.20[a]	10.00[c]	50.92	26.90[a]	10.00[cd]
Batryospermum paradoxum	47.60[b]	32.10[b]	11.60[b]	50.89	18.70[c]	15.50[b]
Kigalia Africana	38.40[f]	29.60[c]	12.10[a]	50.15	17.20[d]	8.80[e]
Celtis integuifolis	42.30[d]	31.20[b]	12.50[a]	50.13	16.50[e]	11.10[c]
Khaya senegalensis	44.60[c]	32.10[b]	11.30[b]	41.23	18.30[c]	12.50[c]
Leptadenia lancifolia	41.20[d]	31.70[b]	12.70[a]	49.89	12.40[f]	9.50[e]
Ziziphus abyssinica	39.60[e]	16.20[e]	5.90[d]	50.22	16.70[e]	23.40[a]
Means	**42.77**	**30.41**	**10.13**	**48.66**	**18.61**	**12.62**
SEM	**0.88**	**0.82**	**0.74**	**0.96**	**0.68**	**0.65**

NDF=Neutral detergent fibre; ADF=Acid detergent fibre; Acid detergent lignin; ADIash=Acid detergent Insoluble ash;Cell.=Cellulose and Hemi cellulose

With regard to the fibre content, Rittner and Reed (1992) reported similar mean for NDF and lignin contents across different ecological zones as follows 40.1% and 11.7% in the

Sahelian zone, 45.7% and 10.5% in the sub-humid zone and 43.6% and 9.3% in the humid zone respectively. Fall (1993) found a range of 31 to 57% for NDF and 19 to 43% for ADF. The values of the present study fall within the range reported by Njidda *et al.* (2010a) and Njidda *et al.* (2010b). NDF and ADF contents in *Ficus polita* and *Ziziphus abyssinica* were lower than the values reported by Bibi-Farouk *et al.* (2006) and Sena *et al.* (1998). This species also had a high lignin content. Lignin is a component of the cell wall, and deposited as part of the cell wall-thickening process (Boudet, 1998). Lignin is in general higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. Positive correlations were reported between contents of lignin and soluble or insoluble proanthocyanidins (Rittner and Reed, 1992). Reed (1986) also found a negative correlation between the content of NDF and soluble phenolics, while the correlation with insoluble proanthocyanidins was positive. The browse forages had low to moderate content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi and Wadhwa 2004).

Table 3: Anti nutritive constituent (mg/g DM) of some semi arid browses

Browse species Forages	TCT	PHE	SAP	OXA	PHY	HCN	FLU
Ficus polita	0.20^{b}	0.24^{d}	2.31	5.92^{d}	4.29^{b}	0.05^{d}	0.0012
Ficus thonningii	0.24^{b}	0.65^{a}	2.55	8.15^{a}	4.02^{b}	0.05^{d}	0.0020
Batryospermum paradoxum	0.19^{c}	0.42^{b}	2.36	8.00^{a}	3.40^{c}	0.08^{a}	0.0011
Kigalia Africana	0.08^{d}	0.37^{c}	2.02	5.02^{d}	2.22^{d}	0.08^{a}	0.0014
Celtis integuifolis	0.39^{a}	0.39^{b}	2.40	4.58^{e}	2.85^{d}	0.06^{c}	0.0005
Khaya senegalensis	0.21^{b}	0.48^{b}	2.02	7.20^{b}	5.81^{a}	0.04^{e}	0.0010
Leptadenia lancifolia	0.15^{c}	0.45^{b}	2.16	6.22^{c}	4.51^{b}	0.06^{c}	0.0010
Ziziphus abyssinica	0.38^{a}	0.34^{c}	2.23	5.04^{d}	4.08^{b}	0.07^{b}	0.0010
Means	**0.23**	**0.41**	**2.26**	**6.23**	**3.82**	**0.61**	**0.001**
SEM	**0.01**	**0.02**	**0.02**	**0.17**	**0.14**	**0.002**	**0.0005**

TCT=Total condenced tannin; PHE=Phenolics; SAP=Saponin; OXA=Oxalate; PHY=Phytate: HCN=Hydrogen cyanide; FLU; Fluoroacetate

The total condensed tannins (TCT) ranged from 0.15mg/g to 0.39mg/g DM. The level is lower than the range of 60 to100g Kg DM that is considered to depress feed intake and growth (Barry and Duncan, 1984). However, in ruminants, dietary condensed tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987). The phenolic content of the browse ranged from 0.24 to 0.65mg/g DM. The values are lower compared to that reported by Osuga *et al.* (2006). Phenolic compounds are the largest single group of SPCs, and total phenolics in plants can reach up to 40% of the dry matter (Reed 1986; Tanner *et al*., 1990). In grasses, the major phenolic is lignin that is bound to all plant cell walls, and is a significant limiting factor in their digestion in the rumen (Minson, 1990). Lignin is also a limiting factor in the digestion of legumes, but is bound largely to the vascular tissue (Wilson 1993), with often high concentrations of other free and bound phenolic compounds (phenolic acids, coumarins and flavonoids) in floral, leaf and seed tissues (McLeod, 1974).

Oxalate content in this present study was low. It has been reported that 20g/kg oxalate can be lethal to chicken (Acamovic *et al*., 2004). Oxalate has been shown to deplete the calcium reserve, but these browse species were found to contain repsonable amount of ccalcium, magnesium and phosphorus (Le Houerou, 1980; Akinsoyinu and Onwuka, 1988). Ca and carbon are also released from the hydrolysis of Ca Oxalate some of which will be either absorbed or excreted by the ruminant animals. With Ca absorption rate of ruminants put at 31% (Randy *et al*., 1984; Haenlein 1987) and P at 4% absorption (Adeloye and Akinsoyinu, 1985) reasonable amount of the Ca and P intakes will be lost via faeces and urine to the soil. Such voided minerals/nutrients are thereby recycled for further use to support plants which are ploughed back into the soil, when so much N is returned to the soil. This reduces the use of inorganic N fertilizer and lends weight to the use of organic manure in farming. However, given the time to adapt, the microorganisms in the rumen can metabolise moderate amounts of oxalate.

The mean saponin value was 2.26% with a range of 2.02mg/g to 2.55 mg/g DM. Feedstuffs containing saponin had been shown to be defaunating agents (Teferedegne, 2000) and capable of reducing methane production (Babayemi *et al.* 2004b). Cheeke (1971) reported that saponin have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant) inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absortion. Saponins have been reported to alter cell wall permeability and therefore to produce some toxic effect when ingested (Belmar *et al.*,1999). The anti-nutritional effects of saponins have been mainly studied using alfalfa saponins. Sharma and Chandra (1969) observed that 4-7 weeks of *ad libitum* feeding of *albizia* gave rise to toxic manifestation in sheep. Symptoms include listlessness, anorexia, weight loss and gastro-enteritis. The toxicity of saponins can be reduced by repeatedly soaking the feed in water, though the level recorded in this present study may not pose any problem to the animals.

The phytin levels reported in this study ranged from 2.22 to 5.81mg/g DM, which is lower than 13.80 to 25.20mg/g DM reported by Okoli *et al.* (2003) for the southeastern browses in Nigeria. These levels are unlikely to have any adverse effects on ruminants.

The HCN contents of the browse species examined were equally low. The HCN ranged from 0.05 mg/g to 0.08mg/g DM. The lethal dose of HCN for cattle and sheep is 2.0 to 4.0mg per kg body weight. The lethal dose for cyanogens would be 10 to 20 times greater because the HCN comprised 5 to 10% of their molecular weight (Conn, 1979). However, the quantity of HCN produced by most of these species is too low to pose major animal health problems (Kumar and D'Mello, 1998). Animals suffering from cyanide toxicity must be immediately treated by injecting a suitable dose of sodium nitrate and sodium thiosulphate (Kumar, 2003). Generally, only plants that produce more than 20mg HCN/100g fresh weigth are considered deleterious (Everist, 1981). The value for fluoroacetate ranged from 0.0010 to 0.0014mg/g DM. The value was negligible to pose any problem to animals although if the compound is in large amounts it is known to inhibit the Krebs cycle by formation of fluoroacetate (Everist, 1974) and is used as a poison for rats and rabbits (Norton, 1994a).

Conclusion: The browse species evaluated in the current study had high CP content which would make them good protein supplements to poor quality roughages, especially during the dry season in the semi arid region of Nigeria

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