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Evaluation of fodder potential of some tropical browse plants using fistulated N'dama cattle

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The fodder potential of edible foliage samples of six browse plants; *Ficus exasperata, Dactyledania barteri, Manniophyton fulvum, Palisota hirsuta, Newbouldia laevis* and *Microdesmis puberula* were determined by evaluating the rumen degradation characteristics [soluble fraction, potential degradation (PD), effective degradation (ED), degradable fraction, rate of degradation] at rumen outflow rates of 3, 4 and 5% h^1 using fistulated N'dama cattle. Voluntary dry matter intake (VDMI), digestible dry matter intake (DDMI) and growth rate (GR) were predicted from the degradation characteristics. Dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), tannins and ash contents were also determined. Results showed significant ($p < 0.05$) differences in the degradation characteristics of the browse plants. *F. exasperata* significantly ($p < 0.05$) had more feed value than the other browse plants, chemical composition of the browses and their rumen degradation characteristics proved that the evaluated browse plants are excellent feed sources that could be utilized by ruminants for both maintenance and production.

Key words: Browse plants, N'dama cattle, effective degradation, potential degradation.

INTRODUCTION

Browse plants, beside grasses, constitute one of the cheapest sources of feed for ruminants (Ahamefule et al., 2006). Their year round evergreen presentation and nutritional abundance provides for year round provision of fodder (Ibeawuchi et al., 2002). The importance of browse plants is increasingly acknowledged throughout the world today; they provide protection, vitamins and frequently mineral elements which are lacking in grassland pastures (Keay, 1989). Browse plants play important roles within the farming systems of humid tropical Africa, contributing significantly to soil maintenance and fertility.

Ruminants are important components in the crop-based farming systems of the humid, tropical lowlands of West Africa. The major constraint to livestock productivity in this region is inadequate nutrition because the primary feed resources (natural pastures and crop residues) are bulky, high in fibre, low in nitrogen and of poor quality. The identification therefore, of browse plants with the po-

tential for providing high quality fodder for livestock and maintaining soil fertility is a major focus of agro-forestry research in these regions (Kang et al., 1990; Larbi et al., 1997, 1998 and 2000).

So far, several indigenous browse plants have been evaluated for the development of integrated crop-livestock agro-forestry technology such as alley farming in the humid tropical lowlands of West Africa (Duguma et al., 1994). A considerable number of these species have potential as forage (Onwuka, 1992).

Since ruminant animals are an integral part of the farming system in the humid lowlands of West Africa, the present study was conducted to evaluate the fodder potential of some tropical plants using fistulated N'dama cattle.

MATERIALS AND METHODS

Sample collection and preparation

Six tropical browse plants, *Ficus exasperata, Dactyledania barteri, Manniophyton. fulvum, Newbouldia laevis, Palisota hirsuta* and *M. puberula* were used for the study.

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Table 1. Rumen degradation characteristics of some tropical browse plants at different outflow rates of digesta.

Browse plants	Soluble fraction a (g100g^{-1} DM)	Degradable fraction b (g100g^{-1} DM)	Rate of degradation c (%h^{-1})	Potential degradation PD (g100g^{-1}DM)	Effective degradation		
					ED$_1$	ED$_2$	ED$_3$
					3%	4%	5%
Dactyledania barteri	7.09^b	38.93^d	3.61^c	46.02^e	27.26^c	24.52^c	22.44^c
Ficus exasperata	1.11^c	73.53^a	4.27^b	74.64^a	44.09^a	38.87^a	34.78^a
Newbouldia laevis	6.76^b	44.20^c	3.37^d	50.96^d	29.29^c	26.23^c	23.92^c
Microdesmis puberula	5.87^b	61.56^b	3.67^c	67.43^b	39.72^b	35.31^b	31.91^b
Manniophyton fulvum	18.97^a	41.96^c	3.47^d	60.93^c	41.10^b	38.16^a	35.92^a
Palisota hirsuta	6.69^b	20.57^e	8.14^a	27.26^f	21.56^d	20.32^d	19.26^d
Mean	7.74	49.79	4.42	54.53	33.83	30.56	28.03
* LSD (df = 12)	3.74	7.01	0.03	20.80	2.21	2.25	2.28

[a, b, c, d, e, f]Means in the same column with different superscripts differ significantly (p < 0.05)
* LSD: Least significant difference at 5% level of probability.
ED = a + b *c / (c + k) according to the equation of Orskov et al. (1988). a = soluble water fraction, b = insoluble fraction, c = rate of degradation and k = rumen outflow rate at 3% h^{-1}, 4%h^{-1} and 5%h^{-1}. PD = a + b in time t.

Table 2. Predicted voluntary dry matter intake (VDMI), digestible dry matter intake (DDMI) and growth rate (GR) in N'dama cattle using rumen degradation characteristics of some tropical browse plants.

Browse plants	VDMI (kgd^{-1})	DDMI (kgd^{-1})	GR (gd^{-1})
Dactyledania barteri	4.1^c	1.7^d	0.206^d
Ficus exasperata	6.5^a	3.7^a	0.752^a
Newbouldia laevis	4.4^c	1.9^d	0.266^d
Microdesmis puberula	5.7^b	3.0^b	0.575^b
Manniophyton fulvum	5.1^b	2.6^c	0.445^b
Palisota hirsuta	4.5^c	2.3^c	0.319^c
Mean	5.05	2.53	0.427
* LSD (df = 12)	0.63	0.61	0.143

[a,b,c,d]Means in the same column with different superscripts differ significantly (p < 0.05)
* LSD: Least significant difference at 5% level of probability.
VDMI (kg d^{-1}) = - 0.822 + 0.0748 (a + b) + 40.7c
DDMI (kg d^{-1}) = - 2.595 + 0.06244 (a+b) + 39.Oc
GR (kg d^{-1}) = - 0.922 + 0.017 (a + b) + 9.55c, according to the equation of Orskov et al. (1988).

The leaves were collected from mature plant tops, which were separated from the stalk. The samples were oven-dried at 60°C for 48 h. The samples were thereafter milled to pass through a 2.5 mm sieve using a Christy Hunt Laboratory mill. This sample was used to determine *in situ* dry matter (DM) degradation, using fistulated N'dama cattle (Table 1) and to predict voluntary dry matter intake (VDMI), digestible dry matter intake (DDMI) and growth rate (GR) (Table 2).

Fresh leaf samples of the six browse plants were harvested from various farm locations. The samples were duplicated and about 300 g of each of the samples were put in a clean tray and dried in an oven at 100°C until a constant weight was obtained and DM determined. Dried samples were ground with a hammer mill to pass through a 1 mm screen. The dried and ground samples were stored in sealed polythene bags and kept away from direct sunlight. The chemical compositions (Table 3) of the six browse plants were determined with these samples. Nitrogen (N) was determined using the Kjeldahl process (AOAC, 1990) and crude protein (CP) calculated as N x 6.25. Crude fibre and ash contents were analyzed according to AOAC (1990) methods. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) analysis were carried out according to the

procedure of Goering and Van Soest (1970). Concentrations of tannin were determined using the method described by Deshpande et al. (1986).

Management of animals

Three rumen fistulated N'dama cattle with an average weight of 267 kg were used for the DM degradation study. The animals were placed in individual pens and fed maize stover *ad libitum* as basal diet. The basal diet was supplemented with 1.5 kg of wheat bran per animal per day. The animals were given free access to mineral licks and clean drinking water for the duration of the experiment.

***In situ* dry matter degradation**

5 g each of the oven dried and milled leaf samples were weighed and placed in labeled nylon bags measuring 90 mm x 120 mm with a pore size of 40 μm. The bags were incubated in duplicates for 6, 12, 24, 36, 48, 72 and 96 h in the rumen of three fistulated N'dama

Table 3. Chemical composition of some tropical browse plants.

Parameters (g kg⁻¹ DM)	Dactyledania barteri	Ficus exasperata	Newbouldia laevis	Microdesmis puberula	Manniophyton fulvum	Palisota hirsuta	Mean	± SD
Dry matter	233[b]	264[b]	410[a]	300[b]	350[ab]	385[a]	323.7	69.64
Crude protein	96.2[c]	166.2[a]	161.8[ab]	179.4[a]	144.4[b]	135.6[b]	147.3	29.51
*NDF	400[b]	490[ab]	460[b]	600[a]	310[bc]	270[c]	421.7	121.56
**ADF	260[b]	220[bc]	260[b]	330[a]	200[c]	180[c]	241.7	53.82
Ash	40[b]	70[a]	40[b]	60[a]	40[b]	40[c]	48.33	13.30
Tannin	42.6[a]	12[bc]	12[bc]	7.2[c]	23.4[b]	8.4[c]	17.2	13.52

a, b, c Means in the same row with different superscripts differ significantly (p < 0.05).
*NDF: Neutral detergent fibre
**ADF: Acid detergent fibre
DM: Dry matter
SD: Standard deviation
Nitrogen, crude fibre and ash determined by AOAC (1990) methods.
CP = N x 6.25, NDF and ADF by the procedure of Goering and Van Soest (1970), Tannin by the method of Deshpande et al. (1986).

cattle. At the end of each incubation period, the bags were withdrawn from the rumen, soaked in a bucket of water at about 30°C and later rinsed thoroughly under clean running tap water for about 25 min. The residues were then air-dried in a Gallenkamp oven for 48 h at 60°C for computing DM disappearance (DMD) for each incubation period.

The degradation constants were estimated by fitting data to the exponential model of Orskov et al. (1988):

$$y = a + b(1 - c^{-ct})$$

Where: y = dry matter disappearance at time t
a = zero time intercept or the soluble water fraction
b = insoluble fraction that will degrade in time t
c = rate of degradation (% h⁻¹) of the b fraction

The constants were used in computing the potential degradation (PD) and effective degradation (ED), as

PD = potential degradability or extent of degradation (a + b) in time t
ED was estimated from the equation:

$ED = a + b*c/(c + k)$, where k is the rumen outflow rate of digesta at 3, 4 and 5% h⁻¹ for estimated ED_1, ED_2 and ED_3 respectively.

The mean values of the constants a, b and c of the browse plants was used in predicting VDMI, DDMI and GR in cattle as:

VDMI (kg d⁻¹) = -0.822 + 0.0748 (a + b) + 40.7c
DDMI (kg d⁻¹) = - 2.595 + 0.06244 (a + b) + 39.0c and
GR (kg d⁻¹) = - 0.922 + 0.017 (a + b) + 9.55c

Statistical analysis

Data were subjected to analysis of variance, procedures of the statistical analysis systems (SAS) (1989). Data were analyzed as a completely randomized design (CRD) with three replications. Differing treatment means were separated using the least significant difference (LSD) test option at the 5% level of probability. Mean values for the chemical compositions of the browses were statistically compared using standard deviations.

RESULTS

The results of the soluble fraction, degradable fraction, rate of degradation, PD and ED of the six tropical browse plants are presented in Table 1.

Soluble fraction

Significant (p < 0.05) differences were observed in the soluble fractions of the browse plants. *M. fulvum* had the highest value (18.97/100 g DM) and *F. exasperata* the least (1.11/100 g DM).

Degradable fraction

There is significant (p<0.05) differences in the degradable fractions of the browse plants. *F. exasperata* had significantly (p<0.05) higher degradable fractions (73.53/100g DM) than the other plants. *N. laevis* and *M. fulvum* had similar (p > 0.05) values, (44.20/100g DM) and (41.96/100g DM) respectively.

Rate of degradation

The rate of degradation was highest (p<0.05) in *P. hirsuta* (8.14% h⁻¹) and least in *N. laevis* (3.37% h⁻¹), with *F. exasperata, M. puberula, D. barteri* and *M. fulvum* having values of 4.27, 3.67, 3.61 and 3.47% h⁻¹ respectively.

Potential degradation

There was a marked increase from 27.26/100g DM in *P. hirsuta* to 74.64/100g DM in *F. exasperata,* which significantly ($p < 0.05$) had the highest PD value.

Effective degradation

Effective degradation showed a marked decrease as the rumen out flow rate increased. ED was significantly ($p < 0.05$) highest in *F. exaperata* (44.09% h^{-1}) and lowest in *P. hirsuta* (21.56% h^{-1}) at the 3% out flow rate with *M. fulvum* and *M. puberula* having similar ($p > 0.05$) values of (41.10% h^{-1}) and (39.72% h^{-1}) respectively. No significant ($p > 0.05$) difference was observed between *F. exasperata* and *M. fulvum* in ED values at both the 4 and 5% out flow rates. There were however, significant ($p<0.05$) differences in ED at the 4 and 5% rumen outflow rates for the other browse plants.

VDMI, DDMI and GR

VDMI varied from 4.1 kgd^{-1} in *D. barteri* to 6.5 kgd^{-1} in *F. exasperata* (Table 2). Significant differences ($p < 0.05$) were observed in VDMI with *F. exasperata* being superior to other plants. Similarly, the DDMI ranged from 1.7 kgd^{-1} in *D. barteri* to 3.7 kgd^{-1} in *F. exasperata,* which was significantly ($p < 0.05$) more digestible. Growth rate in cattle ranged from 0.206 gd^{-1} in *D. barteri* to 0.752 gd^{-1} in *F. exasperata* with *F. exasperata* being statistically ($p<0.05$) superior to other plants in promoting daily gains in cattle.

DISCUSSION

In situ dry matter degradation

The significant ($p < 0.05$) differences observed in soluble fractions in Table 1, could be due to variations in the chemical compositions in the contents of the readily fermentable carbohydrates (Table 3). Soluble fraction was highest ($p<0.05$) in *M. fulvum* (18.97g/100g DM) and least in *F. exasperata*. (1.11 ng/100g DM). The increase in soluble fractions may have resulted from the accumulation of more soluble carbohydrates in the leaf components. Adogla-Bessa and Owen (1995) reported the build-up of highly digestible starch in winter crops as being responsible for increased soluble fractions with increasing maturity. According to Dzowela et al. (1995), high soluble fractions in browse plants were associated with low CP and high ADF and vice versa. Although CP content was poorer in *D. barteri*, soluble fractions for *N. laevis M. puberula, P. hirsuta* and *D. barteri* did not differ ($p > 0.05$) significantly. Higher level of soluble fraction is known to result in a more efficient fermentation in the rumen (Beever et al., 1978). The differences in soluble fraction could be attributed to the proportion of soluble carbohydrates to structural carbohydrates. According to Van Soest (1982),

the soluble carbohydrates ferment faster than structural carbohydrates, which are determined by differences in the stage of maturity.

Degradable fraction in the browse plants was highest in *F. exasperata* (73.53/ 100g), while this same plant had the least soluble fraction (1.11/100g DM) because of its high CP and NDF. The decreased soluble fraction recorded in *F. exasperata* and *M. puberula* may be attributed to an increased concentration of NDF and ADF with maturity (Balde et al., 1993; Adogla-Bessa and Owen, 1995; Antoniewiez et al., 1995; Khazaal et al., 1995). *P. hirsuta* was least in the insoluble but degradable fraction, perhaps due to its fairly high CP content and low NDF and ADF.

The rate of degradation was significantly ($p < 0.05$) higher in *P. hirsuta* and lower in *N. laevis* (Table 1). High NDF and ADF (Table 3), suggest a high lignin content of the cell wall which may have resulted in the low rate of degradation of *N. laevis.* Conversely, *P. hirsuta* recorded the highest rate of degradation and the least NDF and ADF. This trend was however, not consistent with *M. puberula*, which had the highest NDF and ADF values but placed third in the rate of degradation. The limiting factor in the rate of degradation may have been due to the proportion of lignin in the cell wall, since cell wall lignin increases with plant maturity (Cherney et al., 1986). This may have been the case with *N. laevis* where the leaves may have attained considerable lignification at the time of leaf collection. *P. hirsuta,* on the other hand, was maybe not fully mature at the time samples were collected.

F. exasperata had consistent PD and ED values (Table 1). *P. hirsuta* which was significantly higher than the other plants in the rate of degradation, had a PD that was significantly ($p < 0.05$) lower. *F. exasperata* with a significantly ($p < 0.05$) higher PD value had a relatively low rate of degradation. *M. fulvum* and *N. laevis*, both with low rates of degradation, had relatively high PD. The time required for a fraction to degrade in the rumen during an infinite period depends on the proportion of cell wall and the rate of degradation (Carro et al., 1991). This trend suggests that PD depends on rate of degradation of the cell wall (Mertens, 1977). Differing PD of the samples may have been as a result of their variable chemical compositions, especially the proportion of cell wall and its composition (Carro et al., 1991).

The results of ED at rumen outflow rates of 3, 4 and 5% h^{-1} followed a characteristic pattern. There was a marked decrease in ED as the rumen outflow rate increased. This might be due to the reduced time spent in the rumen as the outflow rate increased. This trend suggests that the higher rate of degradation in *P. hirsuta* may also be responsible for the lower ED in this plant. Fractional rate of flow through the rumen (Uden et al., 1980) has a major effect on rumen degradability. Increased fractional rate of passage (Mir et al., 1991) decreases fractional rate of rumen protein degradability. This may have been responsible for the decreased ED when rumen outflow

rate increased.

The significantly (p<0.05) high ED of *F. exasperata* (Table 1), suggests that it contains a higher proportion of nutrients that can be degraded in the rumen than can flow out. The presence of secondary plant compounds like tannins, which may affect nutritive qualities of plants through their binding effects on nutrients (Dzowela et al., 1995), may be implicated in the low ED of *D. barteri*, as it has higher tannin concentration (42.6 g/kg DM) than is seen in the other plants (Table 3). Tannin contents of over 40 g/kg DM in ruminant rations (Barry et al., 1986) have been found to have negative effects on digestibility in sheep. The higher the CP content of forage, the higher is the effective protein degradability (Von Keyserlingk et al., 1996). *F. exasperata*, with a CP of 166.2 g/kg DM exhibited this trend, which may be responsible for its high ED. This trend was also observed in *D. barteri*, where the low ED was as a result of low CP content of 96.2 g/kg DM.

Predicted intake and growth rate

The predicted VDMI, DDMI and GR in this study indicate that the values were highest in *F. exasperata* and least in *D. barteri* (p<0.05), when all plants were compared (Table 2).

The browses varied in DM degradation characteristics and these differences were reflected in DM intake and GR. The DDMI of the plants may be related to the varying nutrient composition among browse plants (Skarpe and Bergston, 1986). The low DDMI of *D. barteri* (4.1 kgd⁻¹) may be attributed to the relatively high tannin content (42.6g kg/DM) of this plant. Several researchers (Nastis and Malechek, 1981; Storrs, 1982; Mehansho et al., 1987; Kibon and Orskov, 1993) have identified the inhibitory effect of tannin on feed intake and protein availability. The negative effects of tannin on digestibility (and reduction in weight gain) have been identified at tannin level of over 4% in sheep rations (Barry et al., 1986). This may have been the case with *D. barteri*.

The VDMI, DDMI and GR values of *F. exasperata* in this study, may be attributed to its low tannin (high palatability) and high CP content and hence its availability for tissue metabolism and growth.

However, leaf age and degree of maturity (Smith et al., 1995), season and individual differences (Baldwin et al., 1987) are factors that may influence tannin content which may have contributed to the variations in DDMI and GR of the plants evaluated.

Conclusion

Results obtained in this study showed that there were significant (p<0.05) differences in the degradation characteristics of the individual browse plants. *F. exasperata* significantly (p<0.05) had more feed value than the other browse plants. The chemical composition of the browses

and their rumen degradation characteristics indicate that browse plants are excellent feed sources that could be utilized by ruminants for both maintenance and production. Furthermore, DM intake and GR of cattle given browse could be safely predicated from their degradation characteristics.

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