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In situ degradability of dry matter of browse forages consumed by ruminants in the semi-arid region of northern Nigeria

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Abstract

Three ruminally cannulated bulls were used to determine variations in dry matter (DM) degradability of forage consumed by ruminants in the semi-arid region of north Nigeria. Organic matter and crude protein (CP) contents were higher (P< 0·05) in all the browse forages. Higher numerical values neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin and cellulose were recorded. DM degradability after 24 and 48 h of ruminal incubation were higher (P< 0·05) in all the browses. Higher values (P< 0·05) in DM bag losses at zero time (a fraction) were recorded for the browses. The insoluble but fermentable DM (b fractions) were higher (P< 0·05) in among browse forages. Numerically lower values of DM c fraction were found in browses, whereas DM potential degradability were higher (P< 0·05) in all the experimental leaves. High (P< 0·05) contents of CP in grazed forage, DM degradability after 48 h of ruminal incubation, and b and a+b, were observed in the browse leaves. Thus, these results may be related to both the better feeding value of forage consumed by the animals and better performance of livestock during in this areas. Then, the DM degradability after 48 h, together with the soluble fraction 'a' and insoluble but fermentable fraction 'b' and the c fraction permit the nutritive value of the forage consumed by grazing goats to be accurately described.

1. Introduction

Most laboratory techniques used in food evaluation are still judged according to their ability to predict the nutritive value of foodstuffs. The *in situ* dry matter (DM) degradability of forage consumed by livestock has been used in this way to determine whether degradation characteristics of individual vegetative species could be used to predict its nutritive value (Kibon and Ørskov, 1993). The chemical components of neutral-detergent fibre (NDF) constitute proportionately 0·30 to 0·60 of DM of forages. The NDF degradability, which is usually low, depends on the quantity and distribution of the lignin component. Poorly lignified plant material such as young grass may be highly degradable while the degradation of straw is low due to extensive lignification (Jung, 1989). Nutritive value of forage is closely related to the rate of disappearance of material from the rumen (Ingvartsen, 1994); thus, the degradability of DM and NDF will directly influence the nutritive value of foodstuffs (Van Soest, 1994). The *in situ* technique permits DM and NDF digestion kinetics in the rumen to be estimated and considerable research has been conducted to compare the degradation and fermentation of these factors. Nevertheless, there is little information concerning the DM and NDF degradability of the forage consumed by grazing goats. Consequently, the objective of this study was to determine the DM degradability characteristics of the diet consumed, during dry and wet periods of the year, by ruminant animals in the semi-arid region of Nigeria.

2. MATERIALS AND METHODS

2.1 Description of site and samples

All forages were harvested from Maiduguri (11.05^{0}N; 30.05^{0}E; 364m above sea level) of Borno State, North Eastern part of Nigeria. The species were *Garderna sokotensis, Khaya senegalensis, Kigalia Africana, Leptadenia lancifolia, Maerua angolensis, Olea hochstteteri.* The browse forages were harvested from at least 10 trees per species selected at random in four locations within the study area at the end of rainy season. The samples were sun-dried, milled and sub- sampled for analysis.

2.2 Sample preparation and chemical analysis

About 500g of the harvested and pooled samples from each plant were oven dried at 105^{0}C for 24hours, cooled and weighed. The samples were analyzed in triplicate for 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). Hemi cellulose was estimated as NDF-ADF and cellulose as ADF-lignin.

2.3 In sacco DM degradability study

The rate of nutrient disappearance in the browse species was determined by the use of nylon bag technique. Milled (<1.0mm) samples were oven-dried overnight (24 hrs) at 70°C prior to weighing into the bags measuring 140x20mm when laid flat. A piece of marble was included in each bag containing 5g of feed sample to prevent the bag from floating in the rumen.The weight of each bag and its content was then recorded. Ten bags containing the sample were incubated at the same time in each animal. A bag was removed from each of the three animals at 3, 6, 12, 24, 48, 72 and 96 hours for observation of nutrient disappearance. The bags were tied using a nylon twine and carefully inserted into the rumen. After each incubation period, the bags were carefully removed and rinsed with tap water until the water was clean and clear. The washing procedure took 30 min and then the bags were oven-dried. The bags were allowed to air-calibrate to room temperature for about three hours in a desiccator before weighing to determine bag plus marble plus feed sample residue weight for dry matter determination. The difference between the initial and final weights of each sample was regarded as degraded material and thereafter expressed as a percentage of the initial weight. After incubation, all the bags were withdrawn from the rumen at the same time and immediately placed under running cold tap water until the rinse water became clear. This was done to wash off ingested feed particles adhering to the bags as well as stop further fermentative processes. The bags with the sample residues were then oven dried at 65^0C for 48hours and the weight of the bags plus residues measured and recorded. The zero-hour washing losses that is, losses due to non-incubation, were determined by soaking 5g of each of the samples in triplicates in warm water (37^0C) for 1 hour which was followed by washing and drying of the bags as done with the incubated sample residues. Dry matter losses was computed as the difference between the determined dry matter content of the pre- incubated samples and the determined dry matter content of the incubated residues. The rumen degradation parameter of DM was calculated using the equations of Ørskov and McDonald (1979):

P = a + b (1- e-ct)

Where: P = Potential degradability after time 't'

a = Water Soluble Fraction (zero hour)

b = Insoluble but degradable fraction after time 't'

c = Rate of degradation of slowly degradable fraction b

t = Incubation length i.e. 3, 6, 12, 24, 36, 48, 72, 84 and 96 hours

e = exponential. The effective ruminal degradability of DM (EDDM) was calculated according to Ørskov and McDonald (1979): EDDM = a+b × ($c/(c + k)$) where $k = 0.12h^{-1}$

2.4 Statistical Analysis

Data obtained from the degradation characteristic of the incubated plant species at the different hours were subjected to analysis of variance (Gomez and Gomez, 1984) using the completely randomized design. Treatment means were separated by Duncan's multiple range test.

3. RESULTS AND DISCUSSION

The chemical composition of the browse forage leaves determined in this study is presented in Table 1. Dry matter content ranged from 838.30 g kg^{-1} DM in *Poupartia sirrea* to 983.00 g kg^{-1} in *Garderna sokotensis* on DM basis. Generally, the examined plant leaves had high crude protein content. The values of CP in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen (Njidda, 2011).Values obtained for organic matter content of the browse forages ranged from 742.60% in *Poupartia sirrea* to 868.70 g kg^{-1} DM in *Khaya senegalensis*. NDF, ADF and ADL contents in the browse forages studied were generally higher and similar to the values reported by Njidda (2011, 2012a, b) and this can limit feed intake (Meissner *et al.,*1991). Cellulose levels in the browse forages were within the range of 131.20 g kg^{-1} DM in *Leptadenia lancifolia* to 187.20 g kg^{-1} DM in *Kigalia Africana* while hemicellulose content of the browse leaves ranged from 189.20 g kg^{-1} DM in *Leptadenia lancifolia* to 432.90 g kg^{-1} DM in *Kigalia africana.* There was an increasing disappearance of DM from the incubated leaves over time. This was generally moderately in all plant leaves. At 48 hours of incubation over 40% of the dry matter in most of the leaves had been degraded. Most of the plant leaves were 60% degraded at 96 hours of incubation. The disappearance of dry matter from the browse plant leaves in this study was observed to be moderate and well above 40% of their reported potential degradability values after 48hrs incubation. According to Ehargavi and Ørskov (1987) high degradability values after 48hrs of incubation imply high digestibility since degradability values at this time are regarded as being equivalent to digestibility.

Degradation characteristics for dry matter in the different browse leaves incubated in the rumen of bulls are presented in Table 2. Significant differences (P<0.05) were observed between the leaves in all the degradation characteristics. Soluble dry matter fraction 'a' was observed to be generally low with the least value being in *Maerua* *angolensis* (2.23%). The rapidly degradable fraction 'a' was generally low across the leaves studied. This is possibly an indication of high level lignifications in most of the leaves or may have, according to Adogla-Bessa and Owen (1995), resulted from the accumulation of soluble carbohydrates due to later stages of maturity. The insoluble but degradable DM fraction 'b' was observed to be high in the browse forages. This observation may probably be due to it cell wall content (Wilson, 1994).It was. observed in this study that although relatively close, the potentially degradable DM 'a+b' value was high for all browses. Potentially degradable 'a+b' dry matter in the browse leaves was high, above 60%. However, according to Singh and Makkar (1992) the statistical variations may be associated with their fibrous components such as the structural polysaccharides, which vary in their degradation among forages. The rate of DM degradation 'c' per hour of the potentially degradable portion was slowest in *Ziziphus mauritiana* (0.012/hr) and fastest in *Maerua angolensis* (0.060/hr). The value for the rate of degradation 'c' of the dry matter in the slowly degradable fraction 'b' were generally slower than those reported by Kaitho *et al.* (1997) for some multipurpose tree leaves.Values for effective degradability (ED) of DM at 0.12-outflow rate were found to be highest in *Acacia nilotica* with 29.50 whereas *Prosopis africana* had the least value of 16.30. According to Mupangwa (2003) variations in effective degradability of dry matter in forages closely corresponds with the proportion of potentially degradable dry matter and level of NDF. Llamas-Lamas and Combs (1990) and Njidda *et al.* (2012) have observed forages with low fibre to have high effective dry matter degradability compared to those with high fibre content. This to some extent may explain the low effective degradability reported for the browse forages in this study.

4. CONCLUSION

In conclusion, the leaves of the browse forages showed high potential as a feed supplement to ruminant animal in the semi arid especially in terms of crude protein supply for effective microbial activity in the rumen.

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Table 1. Chemical composition of browse forages of Semi-arid region of Nigeria (g kg^{-1} DM).

Browse Forages	DM	CP	NDF	ADF	ADL	Cell	Hemicel	OM
Garderna sokotensis	983.00^{a}	151.40^{c}	544.20^{d}	219.30^{d}	121.30^{d}	183.20^{b}	324.90^{c}	799.00^{b}
Khaya senegalensis	976.30^{a}	139.60^{d}	486.20^{d}	211.60^{e}	121.00^{d}	182.50^{b}	274.60^{d}	868.70^{a}
Kigalia Africana	946.30^{c}	134.02^{e}	688.10^{a}	255.20^{a}	97.00^{e}	187.20^{a}	432.90^{a}	766.70^{d}
Leptadenia lancifolia	958.30^{b}	163.30^{b}	433.10^{e}	243.90^{b}	152.80^{a}	131.20^{f}	189.20^{f}	782.30^{c}
Maerua angolensis	922.60^{e}	174.30^{a}	586.70^{c}	228.90^{c}	144.70^{b}	164.00^{d}	357.80^{b}	767.60^{d}
Olea hochstteteri	941.30^{d}	138.70^{d}	438.40^{e}	206.80^{f}	96.70^{e}	171.30^{c}	231.60^{e}	801.30^{b}
Poupartia sirrea	838.30^{f}	132.20^{e}	591.20^{b}	230.30^{c}	140.30^{c}	143.00^{e}	360.90^{b}	742.60^{e}
MEANS	**938.01**	**147.64**	**538.27**	**228.00**	**124.82**	**166.06**	**310.27**	**789.74**
SEM	**1.46**	**2.06**	**0.96**	**1.31**	**1.08**	**1.33**	**0.93**	**0.43**

a,b,c,d=mean values along the same column with different superscripts are significantly different P<0.05); DM=Dry matter; CP=Crude protein; NDF=Neutral detergent fibre; ADF=Acid detergent fibre; Acid detergent lignin; Cell.=Cellulose and Hemi cellulose; OM=Organic matter; SEM=Standard error of means.

Table 2. Dry Matter Disappearance of semi-arid browses (% DM)

Browse forages	0	3	6	12	24	48	72	96
Garderna sokotensis	8.76^{a}	9.63^{a}	19.43^{a}	30.39^{c}	40.04^{b}	57.65^{a}	61.08^{b}	71.25^{c}
Khaya senegalensis	8.33^{b}	9.12^{b}	19.34^{a}	29.70^{c}	39.35^{b}	50.99^{b}	61.82^{a}	72.23^{c}
Kigalia Africana	4.91^{d}	5.67^{d}	17.06^{b}	26.90^{d}	38.03^{bc}	48.87^{c}	59.66^{c}	70.14^{c}
Leptadenia lancifolia	6.26^{c}	7.39^{c}	17.76^{b}	36.67^{b}	39.03^{b}	48.57^{c}	60.16^{c}	69.61^{c}
Maerua angolensis	2.23^{a}	3.70^{e}	13.69^{d}	41.64^{a}	46.39^{a}	47.31^{c}	58.58^{d}	70.45^{c}
Olea hochstteteri	4.22^{e}	5.84^{d}	16.24^{c}	27.52^{d}	37.81^{cd}	48.24^{c}	58.96^{d}	69.82^{c}
Poupartia sirrea	3.24^{f}	5.55^{d}	5.47^{e}	24.57^{e}	29.93^{e}	41.27^{d}	54.48^{e}	65.16^{d}
MEANS	**5.42**	**6.70**	**15.57**	**31.06**	**38.65**	**48.98**	**59.24**	**69.80**
SEM	**0.23**	**0.47**	**1.64**	**0.70**	**0.93**	**2.04**	**0.62**	**1.77**

a, b, c, means in the same column with different superscript differ significantly (P<0.05); SEM=Standard error means; NS=Not Significant

Table 3. Degradation characteristics and Effective degradability of DM of semi arid browse forages incubated in the rumen of bulls

Browse Forages	a	b	a+b	c	Lag T	ED
Garderna sokotensis	8.22^{a}	65.86^{c}	74.19^{c}	0.023^{b}	0.50^{b}	19.60^{a}
Khaya senegalensis	8.33^{a}	68.01^{b}	76.34^{b}	0.023^{b}	0.20^{e}	19.80^{a}
Kigalia Africana	4.91^{c}	67.69^{b}	72.60^{d}	0.026^{b}	0.20^{e}	17.10^{b}
Leptadenia lancifolia	6.26^{b}	61.20^{d}	67.46^{e}	0.033^{b}	0.20^{e}	19.90^{a}
Maerua angolensis	2.23^{e}	59.24^{e}	61.47^{f}	0.060^{a}	0.90^{a}	20.00^{a}
Olea hochstteteri	4.22^{c}	67.28^{b}	71.50^{d}	0.026^{b}	0.30^{d}	16.80^{b}
Poupartia sirrea	3.24^{d}	74.86^{a}	78.10^{a}	0.016^{b}	0.40^{c}	12.90^{c}
MEAN	**5.34**	**66.30**	**71.67**	**0.029**	**0.38**	**18.01**
SEM	**0.66**	**0.87**	**0.86**	**0.013**	**0.02**	**1.36**

a, b, c, means in the same column with different superscript differ significantly (P<0.05); SEM=Standard error means; NS=Not Significant