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Nutritional Evaluation of Selected Browse Plants Consumed by Small Ruminants in Northern Sudan Savannah of Nigeria

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Browse plants species have high potentials as important feed resources for ruminants during the dry season, are quite palatable and less susceptible to a climate fluctuation. A study was therefore conducted to determine the nutritional evaluation of selected browse plants consumed by small ruminants on free range in Northern Sudan Savannah region of Nigeria using *in vitro* gas production, proximate composition, fiber components, methane gas production and dry matter degradation as response tools. The leaves samples of the selected browse plants were collected, processed and incubated using *in vitro* gas dry matter degradation techniques. The results revealed variation in the rate of degradation. The chemical analysis showed that the crude protein (CP) content of *A. occidentale* (26.49%) was higher than *F. thonningi* (23.58%), *M. indica* (20.58%) and *T. catappa* (18.61%). Both ADF and NDF of *A. occidentale* (40.00 and 50.00) were as well higher than *F. thonningi* (20.00 and 40.00), *M. indica* (20.00 and 40.00) and *T. catappa* (20.00 and 42.00). Results from *in vitro* gas production, however, showed that *T. catappa* (23.67 mL/DM) has a significantly higher ($p<0.05$) value than *F. thonningi* (20.67 mL/DM), *A. occidentale* (16.67 mL/DM), and *M. indica* (14.00 mL/DM) at 72 hours of incubation. It is therefore evident from this study that methane gas production and *in vitro* gas production can be used to predict dry matter

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degradation and nutritive value of feedstuff for small ruminants. *A. occidentale* with the least methane gas production and highest crude protein (CP) content might have the most nutritive value among the browse plants investigated.

Keywords: In vitro; degradation; browse; methane; small ruminants.

1. INTRODUCTION

The prohibitive cost of concentrate diets for animals in the tropics during the dry season necessitates the pressure on the utilization of non-conventional feed resources and continuous search for less expensive and high nutritive feedstuff [1]. Multipurpose trees and shrubs commonly called browses are important components of agroforestry systems in West-Africa. Browse plants species have high potentials as important feed resources for ruminants during the dry season and are quite palatable. They are less susceptible to climate fluctuation [2]. Since they are trees or perennial shrubs, they remain green all year round, thus constituting a ready source of feed during off-season feeding [3]. The study by [4] confirmed that higher percentage of the tropical browse and legumes are seed and fruit-bearing which had been reported to be high in crude protein and other nutrients. Browse plants provide vitamins and frequently mineral elements, which are most lacking in grassland pasture. Their year-round evergreen presentation and nutritional abundance provide for year-round provision of fodder [5,6]. It also enables standing feed reserve to be built so that herd can survive critical periods of shortfall or even prolonged periods of drought, without remarkable losses [7]. The great potential of browse plants feeding to animals is better noticed during the dry season, a critical period when the availability of pastures and grassland forages is low. These browse plants remain green throughout the dry season when most grasses and legumes have withered away and they form the bulk of ruminant feed in addition to forbs (weeds and flowers) during this period.

Information on the preference and intake of *F. thonningii, A. occidentalis, M. indica* and *T. catappa* by goats is limited and such information is important since the value of any forage feed is determined by its acceptability, digestibility and eventual utilization by animals. Past studies on these plants have concentrated on their agronomic characteristics with their potential as alternative feed sources for ruminants yet to be fully exploited.

It is therefore imperative to know the nutritional composition of these browse plants; *Ficus thonningii, Anarcadium occidentalis, Mangifera indica* and *Terminalia catappa* and their varying levels of acceptability, degradability or nutrient release, so as to ascertain whether it can be fed to or grazed/browse by animals or whether it can be used in compounding rations. This will help to prevent deficiency of essential nutrients and any form of toxicity.

2. MATERIALS AND METHODS

2.1 Study Location

The study was carried out at the *in vitro* and Rumen Kinetics laboratory of Animal Science Department, University of Ibadan, Oyo State, Nigeria.

2.2 Source and Preparation of Feed

The leaves of selected browse plants and shrub legumes were collected and oven-dried at 60^0C for 3 days to determine the dry matter. The dried samples were milled and analyzed for proximate compositions: Crude protein, crude fiber, ether extract and ash content of the browse plants was determined according to the official methods of analysis [8]. The fiber fractions such as neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to [9].

2.3 Animal Management

For *in vitro* digestibility study, rumen fluid was obtained from four (4) WAD goats through the suction tube before morning feed. The goats were previously fed with 40% concentrate feed (40% corn, 10% wheat offal, 10% palm-kernel cake, 20% groundnut cake, 5% soybean meal, 10% dried brewers grain, 1% common salt, 3.75% oyster shell and 0.25% fishmeal) and 60% *Pennisetum purpureum.*

2.4 Incubation and Methane Gas Production Procedures

The rumen liquor was collected into the thermo flask that had been pre-warmed and Incubation procedure according to [10] using 120 mL calibrated transparent syringes with fitted silicon tube was used. The samples weighing 200 mg was carefully dropped into the syringes and thereafter 30 ml inoculum containing cheese cloth stained-rumen liquor and buffer 1 g/L under continuous flushing with CO_2 was dispensed using another 50 mL plastic calibrated syringe. The syringe is tapped and pushed upward by the piston in order to completely eliminate air in the inoculum. The silicon tube in the syringe was tightened by a metal clip so as to prevent escape of gas. Incubation was carried out at 39 ± 1℃ and the volume of gas production was measured at 3, 6, 9, 12, 18, 24, 36, 48, 60, 72 hours. The method described by [11] was used after 72 hours of incubation, where 4 mL of NaOH was introduced to estimate the amount of methane produced. The average volume of gas produced from the blanks was deducted from the volume of gas produced per sample. Constituent of McDougall's buffer solution for the *in vitro* gas production includes the following: Sodium bicarbonate ($NaHCO_2$), 9.80 g/L; Sodium phosphate dibasic (Na_2HPO_4), 2.77 g/L; Potassium chloride (KCl), 0.57 g/L; Sodium chloride (NaCl), 0.47 g/L; Magnesium sulphate ($MgSO_4.7H_2O$), 0.12 g/L; Calcium chloride ($CaCl_2.2H_2O$) , 0.16 g/L; Urea (NH_3O), 1.0 g/L.

2.5 Data Analysis

Data obtained were subjected to analysis of variance (ANOVA) and significant differences between means were compared using Duncan multiple range test using Statistical Analysis System package [12].

3. RESULTS AND DISCUSSION

The proximate composition of *F. thonningii, A. occidentale, M. indica* and *T. catappa* are shown in Table 1. The dry matter content recorded was 27.55% for *F. thonningii*, 35.11% for *A. occidentale*, 41.98% for *M. indica* and 27.08% for *T. catappa*. The highest dry matter content of *M. indica* observed in the current study contradicts [13] who reported that the broader the leaf, the higher the dry matter of the leaf. In this study, *T. catappa*, however, has the least DM content (27.08%) despite the broad leaf, which was a little higher than that reported by other studies [14]. The dry matter content (DM) recorded for the browse plants in this study were in agreement with [15] except for *T. catappa* which was slightly higher than the values reported for some other multipurpose trees by [16]. The high DM observed could be attributed to the well-matured leaves which have lost some moisture during the dry season. The crude protein (CP) content of the selected browse plants ranged from 18.61 – 26.49%. The CP content was highest for *A. occidentale* (26.49%) and *T. catappa* the least (18.61%), while *F. thonningii*, *M. indica* had 23.86% and 20.58% respectively. The slight variation observed in CP contents of the browse plant is however similar to those reported for other browse plants such as *Ficus* species: 20.5%, *F. thonningii by* [17], 24.88% *F. thonningii* [18] and 16.63% *F. exasperated* by [3]. These were much higher than values reported for *Ficus sycomorus,* 9.50% [19]. However, in comparison with crude protein (CP) of other recognized browse plants, the crude protein (CP) value of *F. thonningii* in this study is higher than the values reported for *Leucaena leucocephala* [20], *Spondia Mombin* [21] and *F. thonningii* [17]. The crude protein (CP) content of browse plants in this study corroborates [16]. The crude protein (CP) levels are adequate for maintenance and growth of small ruminants [22]. However, the ether extract (EE) content of *M. indica* in this study fell below that reported by [23].

Table 2 shows the result of the fiber contents of the selected browse plants. The leaves of *A. occidentale* (50%) have the highest NDF value while the least but the similar value was recorded for *F. thonningii* and *M. indica* (40%) respectively and *T. catappa* has intermediate value (42%). The NDF values recorded for browse plants in this study fell below that reported for some multipurpose trees [15,18]. Although, the NDF value of browse plants recorded in this study was slightly higher than that reported by [24]. The values however corroborate with that reported for browse plants by [23]. These NDF values are also higher than that reported for most *Ficus* species [25]. The differences recorded insoluble fractions could be attributed to the content of readily fermentable carbohydrates. The build-up of digestible starch in some plants with increasing maturity may also account for these differences [26]. The ADF and ADL content varied between 20 and 12.62% and 40 and 30.26% respectively, with *A. occidentale* having the highest ADF value (40%) and *F. thionnigii*, *M. indica* and *T. catappa* having similar but (20%)

least value. These ADF values in agreement with that reported by [27] for some browse plants. The slight differences observed could be due to the season of collection or harvest. The ADF values recorded in this study are in agreement with other findings [25] and also fell within the range of the values reported by [23]. These ranges of values are in agreement with [15]. The ADL value of *F. thonningii* recorded in this study (18.68%) fell slightly below that reported by [25] for *Ficus* species. *A. occidentale* recorded the highest ADL value (30.26%) while *T. catappa* (12.62%) *F. thonningii* (18.68%), and *M. indica* (17.52%) which is higher than the value (9.95%) reported by [23] for *M. indica*. The ADL value reported by [23] is low compared to that recorded in this study. The variations of fiber fractions observed in this study and those reported in literature might be due to the time of harvest and analytical procedures.

Results of the *in vitro* gas production study (Table 3) showed an increase in cumulative gas production as the incubation time increased from 3 to 72 hours for all the browse plants. The highest *in vitro* gas production (P<0.05) at 3 hours of incubation was obtained from *T. catappa* (3.67 mL/DM), while those obtained from *F. thonningii and A. occidentale* were the lowest (P<0.05) (2.00 mL/DM). Intermediate value (P<0.05) was obtained from *M. indica* (2.67 mL/DM). The similar gas production (P<0.05) recorded for *F. thonningii*, *A .occidentale* and *M. indica* may probably be due to the comparable crude protein (CP) and fiber fractions. This corroborates what [28] reported that there are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fiber, the presence of secondary metabolites and potency of the rumen liquor for incubation. This observation was not noticed for *M. indica* and *T.catappa*. However, at 6 hours of incubation, similar (P<0.05) but higher (P<0.05) gas production was further observed for *T. catappa* and *M. indica* (4.67 mL/DM) than *F. thonningii* and *A. occidentale* (2.67 mL/DM) each. The *in vitro* gas produced by *T. catappa* (5.67 mL/DM), *M. indica* (5.67 mL/DM) and *A. occidentale* (4.00 mL/DM) was significantly higher (P<0.05) than that produced by *F. thonningii* (3.67 mL/DM) at 9 hours of incubation. However, a different trend was observed for the browse plants at 12 hours of incubation. The *in vitro* gas produced by *T. catappa* (5.67mL/DM), *M. indica* (7.00 mL/DM) and *F. thonningii* (4.67 mL/DM) respectively were significantly higher (P<0.05) than that produced by *A. occidentale* (4.00 mL/DM). The mean values of *in vitro* gas produced from the browse

Table 1. Proximate composition of selected browse plants

Composition	*F. thonningii*	*A. occidentale*	*M. indica*	*T. catappa*
% Dry matter (DM) (Fresh Samples)	27.55	35.11	41.98	27.08
% Crude protein (CP) (Dried Samples)	23.86	26.49	20.58	18.61
Ether Extract (EE) (Dried Samples)	9.52	5.56	4.17	4.54
Ash (Dried Samples)	14.40	3.75	6.11	10.77

Table 2. Fibre composition of selected browse plants

Composition	*F. thonningii*	*A. occidentale*	*M. indica*	*T. catappa*
% NDF	40.00	50.00	40.00	42.00
% ADF	20.00	40.00	20.00	20.00
% ADL	18.68	30.26	17.52	12.62
% Hemicellulose	20.00	10.00	20.00	22.00
% Cellulose	1.32	9.74	2.48	7.38

plant at 12 hours were lower than values reported by [29]. The variations could be due to the nature of the forage. The values of *in vitro* gas produced from the browse plants were not significant (P>0.05) *M. indica* (10.00 mL/DM), *A. occidentale* (5.33 mL/DM), *F. thonningii* (6.33 mL/DM) and *T. catappa* (6.00 mL/DM) at 18 hours. This same trend continued at 24 hours for the various treatments *M. indica* (11.33 mL/DM), *A. occidentale* (7.33 mL/DM), *F. thonningii* (9.33 mL/DM) and *T. catappa.* (8.00 mL/DM). However, a different trend was observed from gas production pattern of the browse plants at 36 hours. *F. thonningii* (19.00 mL/DM) is significantly higher (p<0.05) than *M. indica* (11.33 mL/DM), *A. occidentale* (14.00 mL/DM) and *T. catappa* (13.00 mL/DM). This sudden change in *in vitro* gas production observed from the browse plant at 36 hours could be as a result of the sudden breakdown of incubator during incubation which might affect the activities of the microbes degrading the plants. This experience attests to what [30] also reported, that factors such as methodology used, type of animals and number of measurements and hence precision of degradation curve could affect result obtained.

Considerable variations were observed from the *in vitro* gas production of the browse plants at 48 hours of incubation. *F. thonningii* (20.00 mL/DM) recorded the highest value (P<0.05). *A. occidentale* (16.00 mL/DM) and *T. catappa* (17.00 mL/DM) were not significantly different (P>0.05), while *M. indica* had the least value (12.33 mL/DM), despite the slightly increasing gas trend. This corroborates what [14] reported, that the *in vitro* gas production pattern of the forages have indicated that more degradation of dry matter was still possible beyond 30 hours. This situation depicts that of the typical dry season in Nigeria when most of the forages are fibrous and therefore take a longer time to degrade in the rumen. *In vitro* gas production of the browse, plants maintain constant values from 60 hours of incubation through to 72 hours. However, *T. catappa* (23.67 mL/DM) had the highest value but not significantly different (P>0.05) from *F .thonningii* (20.67 mL/DM) and *A. occidentale* (16.67 mL/DM) while *M. indica* (14.00 mL/DM) had the least value. Though *M. indica* has high (P<0.05) gas production from 3 hours, it, however, produced the least gas at 72 hours of incubation. The significant differences (p<0.05) in gas production of these browse plants at some hours may be due to the presence of secondary metabolites [10]. It is possible to attain potential gas production of feedstuff if the donor animal from which rumen liquor for incubation was collected had its nutrient requirement met. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrate [31].

Fig. 1 present methane gas production of browse plants. The methane production range from (5-10 mL/200 mg DM) in the browse plants at 24 hours of incubation. And methane production of the browse plants ranges from (4-7 mL/200 mg DM) at 48 hours of incubation. At 24 hours *M. indica* has the highest methane gas production of (10 mL/200 mg DM) and *F. thonningii* (7 mL/200 mg DM) produced intermediate value while *A. occidentale, T. catappa* had similar values. Consequently, there was a decrease in methane production with an increase in the incubation period for *F. thonningii, A. occidentale*, *M. indica. T. catappa* produced the higher methane gas at 48 hours than 24 hours. *M. indica* and *F. thonningii* produced (5 mL/200 g DM) methane at 48 hours while *A. occidentale* (4 mL/200 mg DM).

Table 3. *In-vitro* gas production of selected browse plants (mL/DM)

Hours of incubation	*F. thonningii*	*A. occidentale*	*M. indica*	*T. catappa*	SEM
3	2.00^{b}	2.00^{b}	2.67^{b}	3.67^{a}	0.13
6	2.67^{b}	2.67^{b}	4.67^{a}	4.67^{a}	0.20
9	3.67^{b}	4.00^{ab}	5.67^{a}	5.67^{a}	0.37
12	4.67^{ab}	4.00^{b}	7.00^{a}	5.67^{ab}	0.52
18	6.33	5.33	10.00	6.00	0.66
24	9.33	7.33	11.33	8.00	0.92
36	19.00^{a}	14.00^{b}	11.33^{b}	13.00^{b}	0.88
48	20.00^{a}	16.00^{ab}	12.33^{b}	17.00^{ab}	0.93
60	20.67^{ab}	16.67^{ab}	14.00^{b}	23.33^{a}	0.91
72	20.67^{ab}	16.67^{ab}	14.00^{b}	23.67^{a}	0.89

a, b means within the row with the different superscript are significantly different (p<0.05)

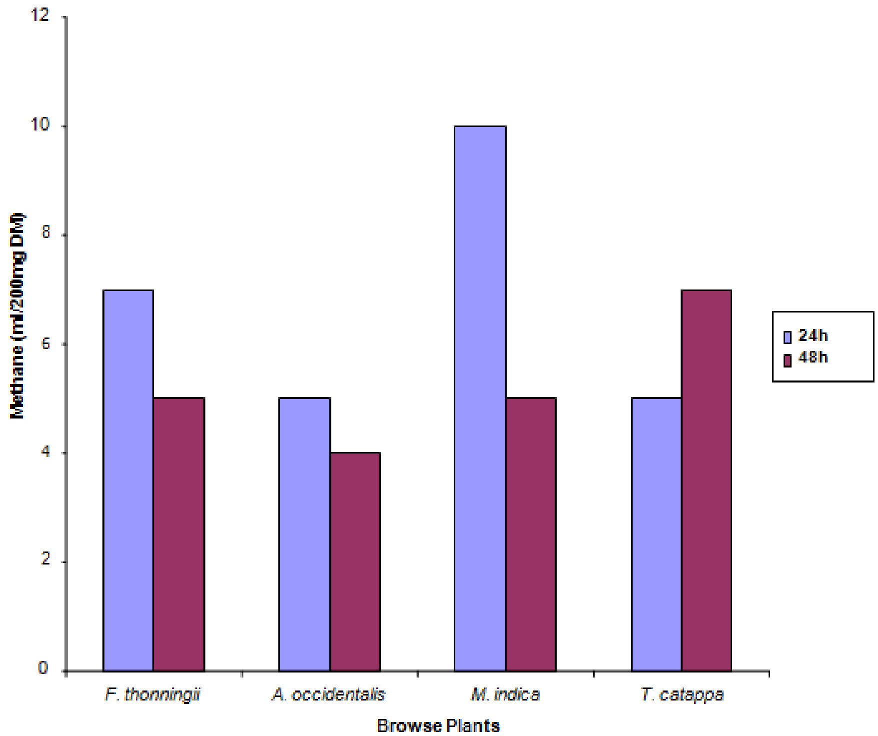

Fig. 1. Methane gas production of browse plants

4. CONCLUSION AND RECOMMENDATIONS

The study showed that the selected browse plants has the potential of high degradability by the rumen microbes and are readily available for absorption by the small ruminant as feed for maintenance and production. This will further alleviate the problem of available feed with high nutritive value during the critical period of the dry season in the Northern Sudan Savannah region of Nigeria.

DISCLAIMER

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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