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Performance, Digestibility and Nitrogen Balance of West African Dwarf Goats Fed *Azadirachta indica, Newbouldia laevis* and *Spondias mombin* Leaves

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Target audience: Small-holder farmers and Ruminant nutritionists.

Abstract

The effect of dietary inclusions of ground tree leaves (Azadirachta indica, Newbouldia laevis and Spondias mombin) on performance, digestibility and nitrogen balance of West African dwarf goats was studied for a ten week period. Twenty four (24) bucks were (10.8±0.6 kg) distributed into four treatments (tree leaves and a control (no leaf)) in a completely randomised design. The leaves were included at 40g/day into the concentrate feed at 2% of body weight on dry matter basis while Panicum maximum was provided as basal diet ad libitum intake. Data obtained on chemical composition, performance, nutrient digestibility and nitrogen balance were analysed using one way analysis of variance. The crude protein (g/kg) content of P. maximum was significantly (P < 0.05) lowest (78.00) while the highest was in N. laevis (177.00). Saponin (g/kg) contents of the leaves ranged from 10.56 in N. laevis to 80.14 in S. mombin. Daily intake (616.82 g/day) and weight gain (22.00 g/day) of goats increased (P < 0.05) with inclusion of S. mombin but the inclusion of A. indica resulted in loss of weight (12.43 g/day). Digestibility of dry matter, organic matter and fibre fractions were not affected (P > 0.05) by inclusion of ground leaves. However, crude protein and ash digestibility of the animals fed ground leaves decreased significantly (P < 0.05) compared with the animals in the control. Inclusion of A. indica and S. mombin into the diets of the animals reduced the nitrogen balance of goats. It can be concluded that feeding goats with ground leaves of S. mombin significantly increased weight gain while inclusion of N. laevis in the diets of goats resulted in better crude protein digestibility, nitrogen balance and retention.

Keywords: saponin, tannin, intake, weight gain, rumen

Description of problem

Indigenous animals in developing countries when browsing to overcome the challenge of low quality forages especially during dry season, often consume plants that have not been evaluated for animal feeding. (1) determined the chemical composition, proanthocyanidin contents and, amino and fatty acid profiles of some Nigerian plant species that are better known for their ornamental or medicinal uses, but are readily consumed by indigenous ruminants. Such information is important for exploiting the natural resources in developing countries and enhancing the global competitiveness of their animal products.

An enormous variety of secondary compounds are produced by plants to provide protection against microbial and insect attack (2, 3). Some are toxic to animals, but others may not be, and indeed many have been used to manipulate gut function in both ruminant and non-ruminant animals (4). Consumption of feeds containing saponins and tannins might lead to higher absorption of both condensed and hydrolysable tannins, and possibly of nutrients such as glucose and amino acids (5). The decrease in the rate of ruminal degradation of feeds by tannins could help in synchronizing the release of various nutrients, which in turn might be responsible for increased efficiency of microbial synthesis. On the other hand, saponin-containing plants and their extracts appear to be useful in suppressing the bacteriolytic activity of rumen ciliate protozoa and thereby enhancing total microbial protein flow from the rumen. Saponins also have selective antibacterial effects which may prove useful in, for example, controlling starch digestion (6).

Inclusion of the foliage of plants containing these phytochemicals in moderate measures such as being a dietary additive in quantities lower than the allowable threshold could help achieve certain levels of metabolic adjustment that can be beneficial to the animal.

For instance, *Azadirachta indica* (Neem) contains Azadirachtin which is one of the most potent growth regulators that repel or reduce the feeding of many species of pest insects as well as some nematodes (7). (8) reported the antimicrobial activity of root bark methanolic extract of *N. laevis* on some bacterial isolates, while the leaves extract have also been said to exhibit antimicrobial activity (9). *S. mombin* Linn, a fructiferous tree that belongs to the family Anacardiacae is readily common in Nigeria and several other tropical forests of the world with high genetic variability among populations (10). The aim of this study was to evaluate the impact of the leaves of these tree species on the performance, digestibility and nitrogen balance of WAD goats.

Materials and Methods

This study was conducted at the Small Ruminant Unit of the College of Animal Science and Livestock Production Farm, Federal University of Agriculture, Abeokuta located in the derived savannah zone of the South-Western part Nigeria on latitude 7° 13' 49.46″ N and longitude 3°25' 11.98″ E (11). At the time of the experiment, the climate was humid with a mean annual rainfall of

1,037mm and mean temperature and humidity of 31.7^{0}C and 83% respectively.

Twenty-four West African dwarf bucks weighing 10.8 ± 0.6 kg were distributed into four (4) groups and housed in individual pens with asbestos roofing material and slatted planks as raised floor. The animals were randomly allocated to four treatment groups of ground tree leaves inclusion in a completely randomized design (*A. indica, N. laevis* and *S. mombin*; and a control i.e. no leaves inclusion (*Panicum maximum*). Collection of leaves took place within the University campus environment through random and manual harvest from different parts of the tree branching to obtain both young and mature leaves from each tree species. The leaves were sun-dried for 72 hours, ground in a mill to pass through a 1mm sieve and then stored in plastic bags. The experimental pens were properly cleaned and disinfected; the animals were kept intensively and maintained for an initial adaptation period of 14 days before application of treatments.

Panicum maximum grass was harvested at 6 weeks of age from 15cm above ground level at vegetative stage and was made available *ad libitum* to the animals, while the concentrate was served at 2% body weight on dry matter basis. Dietary treatments were prepared by adding 40grams of each ground leaf to the concentrate feed served to the animals. The concentrate feed composed of maize (13%), wheat offal (54%), palm kernel cake (20%), groundnut cake (7%), oyster shell (4%) and common salt (2%). Diets were fed once daily at 0700, with concentrate served first and chopped forage after one (1) hour in separate feeding troughs. Daily adjustments were made for about 10% of the feed leftovers. The feeding trial lasted for 70 days and water was available free choice to bucks during the entire experiment. Forage and concentrate samples were collected once per week, and respective samples were pooled after drying for chemical analysis.

Data collection

Feed intake and weight gain

Daily records of concentrate and forage intake were maintained throughout the experimental period. Bucks were weighed prior to their allocation to treatments and body weight were kept on a bi-weekly basis using spring balance. The difference between the initial and final live-weight was used to compute live-weight change (gain/loss) for bucks in each dietary treatment.

Metabolism study

A metabolism study with a 3-day sample collection period was conducted on 3 representative bucks per treatment at the end of the study after a 4-day adaptation period to the metabolic cages. The cages had provision for individual feeding of concentrate and forage, water, and collection of faeces and urine separately. Daily feed offered, residue left, faeces voided and urine excreted was recorded on a 24 h basis. Samples of concentrate, forage, and faeces were dried in a forced air oven at 70°C to constant weight for DM determination. Samples were ground to pass a 1mm screen and preserved for chemical analysis. Similarly, urine was collected in plastic bottles containing a solution of 10 % H_2SO_4 to prevent ammonia-N loss and maintain pH below 3.0 (12). Total volume of urine voided was measured and 10 % aliquot was retained daily, bulked for each goat within the collection period and stored in the refrigerator for onward analysis.

Determination of chemical composition

Saponin content of leaves was determined according to the method described by (13) while total tannin was quantified according to the methods described by (14). Proximate composition (dry matter /(DM), crude protein (CP), ether extract (EE) and ash) of feed and faecal samples was carried out using the methods of (15), while neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by using the method of (16).

Statistical analysis

Data collected on intake, digestibility and nitrogen balance of West African dwarf goats were analysed as a completely randomized experiment using (17).

Results and Discussion

Table 1 showed the chemical composition of *Panicum maximum*, *A. indica*, *N. laevis* and *S. mombin*. Among the tree leaves, the highest ($P < 0.05$) CP was obtained for *N. laevis* (177.00 g/kg) while the lowest was recorded with *A. indica* (128.00 g/kg). *Panicum maximum* had higher ($P < 0.05$) levels of NDF (612 g/kg) when compared with the ground leaves. The leaves of ***S.*** *mombin* and *A. indica* had saponin levels that were above the value reported for *Yucca schidigera* (4.4%) which was favourably recommended for rumen manipulation in methane mitigation strategy (18). This implies that they can both serve as saponin source in ruminant diet, and could conveniently be used as rumen fermentation manipulator. The CP contents of the browse leaves used in this study were above the basic minimum required for optimal microbial activities that helped in increasing the productivity of ruminants (19).

Table 1: Chemical composition of *Panicum maximum, A. indica, N. laevis* and *S. mombin*

Nutrient (g/kg)	*Panicum maximum*	*A. indica*	*N laevis*	*S. mombin*	SEM
Dry matter	511.33^{c}	693.34^{b}	716.20^{b}	884.17^{a}	40.034
Organic matter	868.00^{b}	840.00^{c}	880.00^{b}	920.00^{a}	9.160
Crude protein	78.00^{d}	128.00^{c}	177.00^{a}	149.00^{b}	11.091
Ether extract	50.00^{c}	70.00^{b}	30.00^{d}	90.00^{a}	7.097
Ash	132.00^{b}	160.00^{a}	120.00^{b}	80.00^{c}	9.160
NDF	612.00^{a}	320.00^{c}	520.00^{b}	300.00^{c}	40.096
ADF	325.00^{b}	300.00^{c}	360.00^{a}	280.00^{d}	9.126
Saponin	ND	50.78^{b}	10.56^{c}	80.14^{a}	10.173
Tannin	ND	30.12^{b}	120.09^{a}	30.17^{b}	15.246

[abc] Means on the same row having different superscripts are significantly different ($P < 0.05$), SEM, standard error of the mean; NDF: Neutral Detergent Fibre, ADF: Acid Detergent Fibre

Effects of inclusion of tree leaves on performance of West African dwarf goats were presented in Table 2. Dry matter intake of grass by goats was significantly influenced with higher (P < 0.05) intakes recorded for goats on ground tree leaves inclusion 345.20 g/day in *N. laevis* to 421.91 g/day in *S. mombin* while animals on control had the least 332.41 g/day. Goats fed *N. laevis*, *S. mombin* inclusion and control had similar concentrate intake while those on *A. indica* inclusion had significantly (P < 0.05) lower intake of concentrate (125.48g/day). The total feed intake was highest (P < 0.05) for goats on *S. mombin* (616.82g/day) while the least intake was obtained from the group fed *A. indica* (493.69g/day). The DM metabolic intake of the goats was similarly influenced by the addition of ground tree leaves. However, intake as a percentage of body weight was highest (P < 0.05) in the control (6.01%) while the lowest intake per body weight was observed with goats served *A. indica* at 4.31%. Goats with inclusion of *S. mombin* leaves recorded the highest (P < 0.05) live-weight change with 22 g/day weight increase, however, a weight loss was observed with goats fed inclusion of *A. indica* recoding an average loss of 12.03 g/day over the course of the experimental period. There was increased feed intake by goats that received *S. mombin* inclusion and this could be attributed to the high levels of total digestible carbohydrate as reported by (20). This increased intake could also be attributed to ability of the leaves additive to make available nitrogen and energy for the expected increased population of cellulolytic microbes for productive degradation in the rumen. This was notable especially for the *S. mombin* group, which had the highest intake of nutrients. These results are in agreement with (21) who proposed that a good supplement is one that either maintains the intake of the basal diet or enhances it. Reduced concentrate intake by goats served *A. indica* can be attributed to the bitter taste of the leaves, an indication of the presence of triterpenoids which could have hindered acceptability (20). Reductions were recorded in the feed intake of rabbits fed raw neem seeds due to this inherent bitter component (20). Although the goats consumed enough grass to make up for near optimum DM intake that is higher than the recommended 3% of body weight, the goats were observed as having lost weight over the course of the study of the experiment. Similar report in weight reduction was recorded in rats fed neem flower alcoholic extract which had a significant 6.46% loss in weight at the end of the study (21). The DM intake as percentage of body weight of goats obtained in this study from the treatment subjects were though lower than that of the control but higher than recommendation of (22) for tropical environments (1.8 to 3% body weight). The values were however similar to that recommended by (23) for animals with similar weights in temperate environments (5–6% body weight).

Table 2: Performance of West African Dwarf goats fed diet containing ground leaves of *A. indica*, *N. laevis* and *S. mombin*

Parameters (g/d)	Control	Diet + *A.*	Diet + *N. laevis*	Diet + *S. mombin*	SEM
DMI *Panicum maximum*	332.41^c	368.21^b	345.20^{bc}	421.91^a	11.090
Concentrate intake	194.91^a	125.48^b	185.24^a	194.91^a	9.013
Total feed intake	527.31^b	493.69^b	530.44^b	616.82^a	14.777
CP intake	56.53^b	48.42^c	56.01^b	63.51^a	1.710
Metabolic intake (g/d/kgw$^{0.75}$)	84.44^b	83.33^b	83.88^b	97.47^a	1.831
Intake/body weight (%)	6.01^a	4.31^d	4.98^b	5.66^a	0.281
Initial live-weight (kg)	10.95	11.15	11.08	10.94	0.064
Final live-weight (kg)	12.05^b	10.28^c	12.31^{ab}	12.48^a	0.334
Live-weight change (kg)	1.05^b	- 0.87^c	1.23^{ab}	1.54^a	0.359
Live-weight change (g/d)	15.00^b	-12.43^c	17.57^b	22.00^a	4.163

^{abc} Means on the same row having different superscripts are significantly different ($P < 0.05$); SEM, standard error of the mean;

Table 3 shows the effects of inclusion of tree leaves on apparent digestibility of WAD goats. The percentage apparent digestibility of DM, OM, NDF and ADF were not significantly affected by the inclusion of tree leaves with similar values obtained for all the goats fed various inclusions. Crude protein digestibility was highest ($P < 0.05$) for goats in the control and *N. laevis* groups recording 83.12% and 81.32 % respectively, lower in *A. indica* group with 76.15% and lowest *S. mombin* (71.70%). Ether extract digestibility was significantly highest ($P < 0.05$) in goats fed *N. laevis* inclusion (78.93%) while the lowest digestibility (65.30% and 66.30%) was in animals fed *A. indica* and control diets respectively.

The effects of tree leaves inclusion on nitrogen balance and digestibility are presented in

Slightly less nutrient digestibility was found when ground *A. indica* was added to the diets of goats. This result showed that inclusion of ground *N. laevis* and *S. mombin* leaves possesses the most potential for nutrient digestibility. Crude protein digestibility was significantly higher in the control group that were not served tree leaves. Plant phytochemicals have been reported to decrease apparent digestibility at levels higher than 5% for tannins (24), and there are also findings that high levels of dietary saponins and/or tannins decreased apparent digestibility, especially of nitrogen (25, 26). However, in this study, the inclusion of ground *N. laevis* in the diet of goats had CP digestibility similar to the control group. This result may be due to concentration of tannins that has been known to promote post-ruminal digestion and absorption of protein. This result showed that inclusion of ground *N. laevis* leaves possesses the most potential for nutrient digestibility. Inclusion of these tree leaves did not affect the NDF and ADF digestibility of the animals. This result implies that there was no selective suppression of cellulolytic bacteria by saponins and tannins as suggested by the reports of (27). This was also reported by (5) which fed soapberry mangosteen pellets with saponin and tannin contents of 15.7% and 12.1% to heifers.

Table 3: Apparent total tract digestibility of nutrients in West African dwarf goats fed diet containing ground leaves of *A. indica*, *N. laevis* and *S. mombin*

Nutrients (%)	Control	Diet + *A. indica*	Diet + *N. laevis*	Diet + *S. mombin*	SEM
Dry matter	74.12	69.60	71.83	71.30	0.772
Organic matter	74.32	71.00	71.99	72.06	0.685
Crude protein	83.12^{a}	76.15^{b}	81.32^{a}	71.70^{c}	1.412
Ether extract	66.30^{c}	65.30^{c}	78.93^{a}	73.01^{b}	1.761
Ash	72.74^{a}	59.30^{c}	70.58^{ab}	65.51^{b}	1.734
NDF	75.01	70.80	72.81	72.34	0.734
ADF	52.50	44.67	51.91	49.31	1.414

^{abc}Means on the same row having different superscripts are significantly different (P < 0.05), SEM, standard error of the mean; NDF: Neutral Detergent Fibre, ADF: Acid Detergent Fibre

Table 4 show the effects of tree leaves on nitrogen utilization of West African dwarf goats. There was significant difference (P < 0.05) in nitrogen intake, faecal nitrogen output, urinary nitrogen, nitrogen absorption, nitrogen balance and nitrogen retention of the animals that were fed different ground leaves. Intake and faecal nitrogen output were significantly (P < 0.05) highest for goats fed *S. mombin* inclusion with values of 10.16g/day and 2.87g/day respectively. Urinary nitrogen output was highest for goats on *A. indica* inclusion with 2.10 g/day, lowest in *N. laevis* goats and significantly similar for control and *S. mombin*. Nitrogen absorption and nitrogen balance recorded higher (P > 0.05) values for control (7.52g/day, 6.21g/day), *N. laevis* (7.29 g/day, 6.50 g/day) and *S. mombin* (7.29 g/day, 5.89 g/day) goats compared to *A. indica* (5.89 g/day, 3.79 g/day) fed respectively. Nitrogen retention varied among the goats of the four groups with significant differences. The highest (P < 0.05) was obtained in goats fed *N. laevis* (72.50%), followed by the control (68.69), *S. mombin* (57.07), while *A. indica* (48.94) was the lowest.

The higher nitrogen intake observed with goats that were served *S. mombin* can be attributed to higher levels of intake recorded from bucks in this group. In an earlier report, (28) stated that when feed is high in soluble plant protein, nitrogen metabolism occurs mainly in the rumen. This result is also in agreement with the reports of (29) which observed high nitrogen intake by sheep fed browse species. Goats served *N. laevis* recorded the highest nitrogen retention and this can be due to higher tannin content of the leaves. Nitrogen retention has been found to increase with inclusion of tannins in the animal diets because protein-tannin complexes are protected from rumen degradation but are released further down the digestive tract and are thus digested (30). On the other hand, the low tannin levels of *A. indica* and *S. mombin* leaves can be implicated in the low nitrogen retention of goats in both groups. With as high as 70% organic matter digestibility of the diets, this could have led to extensive degradation in the rumen, thus producing ammonia that was converted to urea in the liver for excretion out of the body. (31) stated that nitrogen excretion and nitrogen retention should reflect differences in nitrogen metabolism, because nitrogen retention represents the most important index of the protein nutrition status of ruminants. High rumen degradation of dietary protein could also be responsible for the high faecal nitrogen in goats served *S. mombin* while high urinary nitrogen was observed in goats served *A. indica*.

Table 4: Nitrogen utilization of West African dwarf goats fed diet containing ground leaves of *A. indica*, *N. laevis* and *S. mombin*

Parameters (g/day)	Control	Diet + *A. indica*	Diet + *N. laevis*	Diet + *S. mombin*	SEM
N Intake	9.04[b]	7.75[c]	8.96[b]	10.16[a]	0.274
Feacal N	1.53[c]	1.86[b]	1.67[bc]	2.87[a]	0.165
Urinary N	1.31[b]	2.10[a]	0.79[c]	1.40[b]	0.123
N absorption	7.52[a]	5.89[b]	7.29[a]	7.29[a]	0.211
N balance	6.21[a]	3.79[b]	6.50[a]	5.89[a]	0.330
N retention (%)	68.69[b]	48.94[d]	72.50[a]	57.97[c]	2.832

[abc] Means on the same row having different superscripts are significantly different ($P < 0.05$)
SEM: Standard Error of Mean; N: Nitrogen

Conclusion and applications

1. Addition of ground leaves of *Spondias mombin* to the diet of goat brought about increased intake and weight gain.
2. Serving goats with diet of *Newbouldia laevis* resulted in better crude protein digestibility, nitrogen balance and retention and is recommended as additive for ruminant feeding.
3. Inclusion of *A. indica* in the diet of goats reduced the intake, weight and nitrogen balance and should not be used as a feed component for animals.

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