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Effects of tanniferous browse plant supplementation on the nutrient digestibility and growth of Djallonké rams

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Two separate experiments were conducted to investigate the effect of tanniferous (CT) browse plant supplementation on the growth, nutrient digestibility and blood biochemical properties of Djallonké sheep. The browse plants were *Albizia lebbeck*, *Gmelina arborea*, *Senna siamea* and *Ceiba pentandra* and were harvested from natural grazing fields within the vicinity of Nyankpala in Ghana. In experiment I, 20 semi-intensively kept Djallonké rams with average initial weight of 12.8±1.7 kg were randomly assigned four browse plants to evaluate their performance in terms of growth and blood biochemical properties. In experiment II, eight intensively managed Djallonké rams with an average initial weight of 13.8±1.56 kg were randomly assigned to a total mixed ration (TMR) made of browse plants, rice straw, minerals and vitamins to determine the nutrient digestibility. In experiment I, whereas lambs supplemented with the highest condensed tannin (CT) browse plant (*C. Pentandra*) had improved (P<0.05) ADWG compared to the control, it did not differ from the ADWG reported in lambs that were supplemented with A. *lebbeck* even though it did not contain measurable levels of CT. The blood metabolites did not differ among treatments. In experiment II, lambs fed with *S. siamea* ration had the lowest DMI with the highest reported in *G. arborea*. Lambs fed with *A. lebbeck* TMR had the highest (P<0.05) CP digestibility and nitrogen balance. The lowest NDF and ADF digestibility were obtained in animals fed the *G. arborea* diet. The tanniferous browse plants used in this experiment were high in nutritive value and resulted in improved live weight of lambs. They could be fed as supplement to lambs grazing natural pasture during periods of feeds scarcity.

Key words: Browse plants, blood metabolite, condensed tannin, Djallonké sheep, digestibility.

INTRODUCTION

The low nitrogen content and high levels of recalcitrant cell wall content of forages and non-leguminous based crop residues like rice straw and maize stover especially in the dry season account for the low intake, digestibility and growth of Djallonké rams in the tropics (Yisehak et al., 2014a). Leaves of trees, serve as important sources of nutrients for ruminants in most tropical countries due to their abundance and accessibility. A number of trees and

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shrubs have been identified as being suitable for feeding livestock (Le Houerou, 1980; Yisehak et al., 2014b). Evaluation of these trees to ascertain their true feeding value has been on-going for some time (Larbi et al., 2008). The leaves of trees (browse) have been shown to contain high amounts of N and low fibre particularly in the dry season when the quality of most forages have dwindled (Seresinhe et al., 2012).

Tropical browse plants have also been found to contain varying levels of condensed tannins (CT) which could have an impact on voluntary feed intake, rumen N and carbohydrate degradation (Getachew et al., 2000; Hariadi and Santoso, 2010). The negative effects of tannins (low feed intake, low digestibility, toxicity) have been reported to occur when ruminants consume forage with CT levels above 50 to 55 g/kg DM (Min et al., 2003). The effect of CT on animal performance is influenced by the source, concentration and molecular weight of CT (Butler and Rogler, 1992; Waghorn, 2008; Nauman et al., 2014).

The use of CT browse plants could play an important role in reducing the amount of ammonia excreted via urine into the environment through the reduction of rumen protein degradation (Hariadi and Santoso, 2010).

This study was undertaken with the aim of evaluating the performance of Djallonké sheep receiving different tanniferous browse plants as supplements on feed intake, weight gain, dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) digestibility and blood metabolites in the Savannah Zone of Ghana.

MATERIALS AND METHODS

Study area for experiment

The study was carried out at the Nyankpala Campus of the University for Development Studies, Tamale, Ghana. Nyankpala is about 18 km west of Tamale in the Tolon District. It is located on latitude 9° 25′ 41″ N and longitude 0° 58′ 42″ W at an altitude of 183 m above sea level. The area is in the Guinea Savannah Zone characterized by a unimodal rainfall pattern. Rains begin in April, rising to a peak in August toSeptember and ending in October or November. Rainfall averages 1060 mm per annum. Temperatures range from as low as 15°C in January when the weather is under the influence of the North Easterly (Harmattan) winds and as high as 42°C around the end of the dry season in March.

Experiment I

A total of 20 one year old male intact Djallonké lambs were purchased from the livestock market at Katingdaa in the Tolon District. The animals were quarantined for 2 weeks. The animals had an initial average weight of 12.8±1.7 kg and were assigned to 4 treatments with 4 replicates each in a completely randomised design. The treatments were shade dried *Albizia lebbeck*, *Gmelina arborea*, *Senna siamea* and *Ceiba pentandra.* In addition, 4 animals were used as controls and so did not receive any browse plant supplement. The animals were housed individually in wooden cages with concrete floors fitted with wooden feed troughs and plastic watering bowls. The animals were fed the supplement *ad libitum* at 07:00 h and were released for grazing on natural pastures at 10:00 h. The animals were led back to the pen at about 17:00 h. Water was served *ad libitum* and was replaced at the same time of feeding. The experiment lasted for 8 weeks with 2 weeks' adaptation period.

Dry matter intake of the supplementary diet (browse plant) was calculated by subtracting the left over feed from the feed offered after correcting for dry matter. The DMI for control animals was not measured because the animals were grazing on natural pasture.

The weekly weight of the animals was taken using a hanging scale (Camry hanging scale, ISO9001:2008, China). From the weekly live weight, the daily live weight gain was calculated by subtracting the initial weight from the final weight for each animal and dividing by the total number of days (56 days).

At the end of the 56 days, blood samples were taken from the jugular vein into clean test tubes. The blood was centrifuged to separate the serum. The serum was then transferred into another set of clean test tube and stored at 4°C until analysis was conducted.

Experiment II

Eight rams of about one year old with an average initial weight of 13.88 ±1.56 kg were randomly assigned to four separate total mixed ration (TMR) prepared from a mixture of browse plants and rice straw. The browse plants used were same as those in experiment 1. The treatment diets comprised of 58% rice straw, 40% browse and 2% minerals and vitamins. The feed was prepared by chopping the rice straw into pieces (Approximately 8 to 10 cm long). The dried leaves of each browse plant was weighed and mixed with the rice straw.

The animals were intensively housed for the entire experiment in metabolism cages made of metal and measuring 91 cm × 40 cm × 76 cm.

The 8 animals were randomly assigned to 4 treatments with two (2) animals per treatment. The cross over design was used in two different periods giving 4 replicates per treatment. The animals were allowed 10 days' adaptation to the feed and 3 days' adaptation to the cage and faecal collection bags. The data collection lasted 5 days in each period.

A sample of the feed was collected each day into plastic bags and stored at 4°C for chemical analysis. Water was served twice daily in a plastic container.

The animals were fitted with faecal collection bags to collect the total faeces voided. The bags were removed at 07:00 daily and the faecal matter weighed. After weighing, 10% subsample of the fresh faecal matter was frozen for chemical analysis.

Total urine was collected daily at 07:00 into plastic containers containing approximately 30 ml of 6 N HCl to prevent ammonia volatization (Dabiri and Thonney 2004). About 10% sub-sample was collected and stored at 4°C for N analysis.

The nutrient digestibility coefficient was calculated by difference between nutrient ingested and nutrient in faeces and was expressed on dry matter basis.

The experiments were conducted following the ethical guidelines of animal research in the University for Development Studies, Ghana.

Chemical analysis

About 50 g of the supplementary feed in Experiment I and TMR in Experiment II was collected into plastic bags and stored at 4°C. The stored feed was each bulked together at the end of the experiment and sub-sample taken for drying in a forced air oven at 105°C for 4 h.

The Nitrogen concentration of the sampled feed was determined according to AOAC (2000) using the Leco (Leco FP-528-UK) after

Table 1. Chemical composition of sole browse plants and total mixed ration (g/kg DM).

Nutrient	*G. arborea*	*C. pentandra*	*S. siamea*	*A. lebbeck*
Chemical composition of sole browse plants (g/kg DM)				
DM	374.25±0.60	365.31±1.29	448.31±0.30	394.63±0.68
CP	151.2±0.5	126.2±2.7	175.8±2.2	229.2±3.6
NDF	248.5±1.0	271.3±1.2	262.7±2.2	296.1±2.2
ADF	163.4±3.9	291.7±0.4	256.9±0.6	193.7±4.5
CT	3.7±0.2	102.8±1.7	1.8±0.2	0.00
Chemical composition of total mixed ration (g/kg DM)				
DM (g/kg)	914.4±31	953.0±0.1	934.2±0.3	914.2±2.4
CP	80.5±0.8	70.3±0.3	90.1±1.2	111.4±1.3
NDF	536.1±5.8	610.3±14.6	538.6±16.9	575.7±1.2
ADF	402.1±2.1	473.2±16.6	370.2±4.8	393.6±2.3

CP, Crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; CT, condensed tannin

which the crude protein was calculated by multiplying the nitrogen content by 6.25. The NDF and ADF were analysed using the Ankom^{200} fiber analyser (Ankom Technology, Macedon, NewYork) following the method of Goering and Van Soest (1970). Condensed tannin (CT) was estimated according to the method of Porter et al. (1986).

Pooled urine and faecal samples from each sheep were analysed for N using the micro Kjeldahl. Nitrogen balance was calculated as the difference between N consumed and the sum of faecal N plus urinary N.

The pooled faecal samples were also analysed for DM, NDF and ADF. The serum was analysed for total protein, albumin, glucose, urea, cholesterol and triglycerides using the Random Access, Fully-Automated, "Walk Away" Clinical Chemistry Analyzer (Flexor XL, Vital Scientific, Netherlands). Globulin was a calculated parameter (total protein-albumin).

Statistical analysis

Data from Experiment I was analysed using one-way analysis of variance from Genstat 12.1 (Payne et al., 2008) with the initial weight as a covariate for the live weight. Data from experiment II was analysed using the analysis of variance with the effect of period used as a block from Genstat 12.1 (Payne et al., 2008). Significant differences of mean were declared at 5%. The means were separated using Fisher's least significant difference test.

RESULTS

The analysed chemical composition of the sole browse plants and the TMR are shown in Table 1. The CP for the sole browse plants ranged from 126.2 to 229.2 g/kg DM for *G. arborea* and *A. lebbeck* respectively whilst that of the TMR ranged from 70.3 to 111.4 g/kg DM for *C. pentandra* diet and *A. lebbeck* diet respectively. The NDF was in the range of 248.5 - 296.1 g/kg DM for the sole *G. arborea* and *A. lebbeck* respectively. The highest ADF and CT were obtained in *C*. *pentandra*. In the TMR, the NDF ranged from 536 to 610 g/kg DM for *G. arborea* and *C. pentandra* respectively. The ADF was however lower (370 g/kg DM) in *S. siamea* and highest (473 g/kg DM) in *C. pentandra*.

The results of the effects of browse plants on the DMI, growth and serum metabolites are shown in Table 2. Relative to the other treatments, feed intake per animal per day was highest (87.70 g/h/day) in animals on the *G. arborea* supplement. Average daily weight gain (ADWG) was lower (P<0.05) in animals that were fed G. *arborea* and *S. siamea* supplement than the *A. lebbeck* which had no CT. However, there was no difference between *C. pentandra* and *A. lebbeck* in relation to ADWG. Animals on supplement, regardless of the CT concentration had higher (P<0.05) daily live weight gain in relation to the control. There was no significant effect of treatment on all the serum parameters.

The results on the effect of TMR in experiment II on intake and nutrient digestibility are shown in Table 3. Dry matter intake (DMI) differed significantly among the experimental diets with the least intake recorded in animals fed with *S. siamea* based diet (255.1 g/h/day).

The DMI in Experiment II, did not differ between the *C. pentandra* TMR and the *A. lebbeck* even though the *C. pentandra* had a numerically higher CT. The trend was similar for crude protein intake (CPI). The DM digestibility coefficient did not differ (P>0.05) between the *A. lebbeck* which had no CT and the other treatments. The intake of CT differed (P<0.01) among the browse plants with the highest (47.04 g/h/day) reported in *C. pentandra.* Relative to the other diets, animals fed with *S*. *siamea* based diet had the least (P<0.05) CP digestibility. The NDF digestibility and ADF digestibility differed (P<0.05) among the treatments with the lowest digestibility reported in *G. arborea*. There was no difference between the *A. lebbeck* and the high CT containing supplement (*C*. *pentandra*) for both NDF and ADF digestibility. The faecal nitrogen (Faecal N g/h/d) differed (P=0.041) among the treatments with the least recorded in *S*. *siamea*. Faecal N was higher in *C. pentandra* and *G*. *arborea* however; the values did not differ statistically from that of *A. lebbeck*. The lambs on *A. lebbeck* were superior (P<0.05) to the other

Table 2. Effects of browse plant on DM intake, growth and serum profile in experiment I.

DM intake and weight	Control	G. *arborea*	C. *pentandra*	S. *siamea*	A. *lebbeck*	SEM	p-Value
DM intake (g/h/d)	-	87.70	35.28	4.15	48.71	-	-
Initial weight (kg)	12.00	12.75	13.63	12.62	13.12	1.35	0.807
Final weight (kg)	14.07^{a}	15.34^{ab}	15.04^{ab}	15.24^{ab}	16.14^{b}	0.568	0.048
ADWG (g)	12.71^{a}	33.11^{b}	41.95^{bc}	34.98^{b}	55.59^{c}	6.47	<.001
Blood metabolites							
Alb (g/l)	20.40	20.13	21.83	22.02	21.39	1.455	0.573
TP (g/l)	63.38	64.39	64.25	65.96	65.98	4.200	0.956
Glb (g/l)	42.98	44.26	42.42	43.94	44.59	4.100	0.976
Glucose (mmol/l)	0.22	0.34	0.37	0.38	0.36	0.124	0.734
BUN (mmol/l)	8.48	8.39	7.13	6.75	7.55	1.466	0.674
Cholesterol (mmol/l)	1.18	1.18	1.08	1.28	1.14	0.145	0.684
Triglycerides (mmol/l)	0.54	0.63	0.49	0.64	0.51	0.243	0.944

Alb, Albumin; TP, total protein; Glb, globulin; BUN, blood urea nitrogen; ADWG, average daily weight gain; SE, standard error of means; same row with different letters point to differences in means at $P<0.005$.

Table 3. Effect of total mixed ration on intake and nutrient digestibility in experiment I.

Parameter	Treatment means					
	A. lebbeck	*C. pentandra*	*G. arborea*	*S. siamea*	SEM	p-Value
DMI (g/h/d)	468.3^{b}	456.1^{b}	509.1^{b}	255.1^{a}	24.91	0.001
CPI (g/h/d)	52.39^{d}	32.17^{b}	40.99^{c}	23.12^{a}	3.35	<0.001
N intake (g/h/d)	8.38^{d}	5.15^{b}	6.56^{c}	3.70^{a}	0.537	<0.001
CT intake (g/h/d)	0.00	47.04^{c}	1.88^{b}	0.46^{a}	0.285	<.001
Faecal N (g/h/d)	0.25^{ab}	0.30^{b}	0.37^{b}	0.17^{a}	0.06	0.041
Urine N (g/h/d)	0.29	0.15	0.22	0.36	0.08	0.099
DM (Coefficient of digestibility)	0.69	0.64	0.59	0.57	0.06	0.141
CP (Coefficient of digestibility)	0.94^{c}	0.91^{b}	0.91^{b}	0.84^{a}	0.01	<0.001
NDF (Coefficient of digestibility)	0.68^{b}	0.65^{ab}	0.55^{a}	0.73^{b}	0.05	0.020
ADF (Coefficient of digestibility)	0.62^{b}	0.56^{ab}	0.46^{a}	0.67^{b}	0.06	0.030
N balance	7.84^{d}	4.69^{b}	5.97^{c}	3.16^{a}	0.53	<0.001

DMI, Dry matter intake; CPI, crude protein intake; N, nitrogen; SE, standard error of means; same row with different letters point to differences in means at $P<0.005$.

treatments in terms of the nitrogen balance (N balance) with the least reported in lambs that fed on *S. siamea*.

DISCUSSION

The four browse plants in Experiment I and total mixed ration in Experiment II had a CP level above the minimum 60 to 80 g/kg DM required to depress appetite, voluntary feed intake and sustain microbial growth (Van Soest, 1982; Belachew et al., 2013). The CP content of the browse plants was in the range of what has been generally reported for browse plants (Ouédraogo-Koné et al., 2008). The high ADF compared to NDF in the sole *C. pentandra* agrees with the findings of Getachew et al. (2000) for some tanniferous plant species and is attributed it to the insoluble complex formed between CT and CP in the NDF solution which became soluble in ADF solution. The relatively lower NDF reported in the sole browse plants compared to the TMR could results in poor animal performance when they are fed as sole diet under intensive system since lower amounts of fermentable carbohydrate will be available. In addition to this, the cumulative effect of the CT could depress feed intake and digestibility.

The lowest feed intake reported in *S. siamea* in both experiments despite the appreciable level of CP (175.87 g/kg) calls for further investigation. The findings in this present study do not agree with earlier reports that attributed the high DM intake in Djallonké sheep to the high CP content of the test diet (Konlan et al., 2012). The condensed tannin (CT) in *S. siamea* was lower than what

was reported in *C. pentandra* but the DM intake did not reflect this. It has been reported elsewhere that high tannin levels have a negative effect on feed intake by causing astringency (Al-Mamary et al., 2001).

In Experiment 1 all the animals gained weight during the period of the study. However, the non-supplemented animals had the lowest ADWG, indicating that browse plants supplementation can enhance the growth of animals grazing natural pasture. The ADWG was not different between C. *pentandra* which had the highest CT and A. *lebbeck* which had no CT. This could be attributed to efficient protein degradation in the rumen of animals that were supplemented with C. *pentandra* (Getachew et al., 2000; Hariadi and Santoso, 2010). It is interesting to note that lambs that fed on *G. arborea* though had the highest DM intake did not correspond to a higher ADWG in experiment I. This might be due to a relatively poor nutrient absorption and utilization in the animals fed the *G. arborea* supplement. The relatively low DMI reported in animals supplemented with S. *siamea* was expected to lead to a lower weight gain similar to the control. That did not happen in this present study suggesting that S. *siamea* may possess certain growth enhancing properties which needs to be investigated.

The total protein (TP), globulin, albumin, blood urea nitrogen and cholesterol compared favourably with the findings of Olafadehan (2011) who fed tannin rich browse plants to West African Dwarf goats. The lack of significant difference in blood metabolites among the lambs that fed the tanniferous browse plants and the *A. lebbeck* suggests that the level of tannin intake did not negatively affect proteolysis in the rumen. This could also mean that tropical animals are able to tolerate high CT diets as is the case in the C. *pentandra*.

The high BUN level reported in the control despite the low weight gain could suggest that there was some level of body protein catabolism in the control group (Leibholz, 1970).

When the browse plants especially *C. pentandra* were fed with rice straw in a TMR to lambs, the DM digestibility did not differ indicating that rumen environment and function were not affected negatively by the presence of CT. This might be due to the inclusion levels, CT concentration and type of browse used. Hervas et al. (2003) did not find significant difference in DM digestibility when CT containing browse plants were fed to ruminants. Even though the CP digestibility of *A. lebbeck* based TMR relative to the other treatment was higher ($P<0.05$), they were all above 80%. This could indicate that the CT did not negatively affect protein degradation in the rumen.

The lack of difference in NDF and ADF digestibility between the *A. lebbeck* based TMR and *C*. *pentandra* suggests that there was no negative effect of the CT on the cellulolytic microbes. It has been suggested that the CT: Protein complex interferes with the ability of cellulolytic bacteria especially *Fibrobacter sucinogenes* to form an attachment with plant cell wall thereby reducing digestion rate since the presence of plant protein in the rumen for microbial breakdown aids in microbial attachment to plant cell wall (Mitsumori and Minato, 1993). The NDF and ADF fractions are part of the structural carbohydrates that supply substrate for cellulolytic microbes to provide acetic and butyric acids for lipogenic nutrient to be made available to the host animal (Smith and Crouse, 1984).

Conclusion

The nutrient composition of the browse plants studied especially CP was within the levels required to enhance feed intake and digestibility. When the browse plants were used in a mixed ration with rice straw, the nutrient composition and digestibility were not negatively affected. Feeding Djallonké sheep that are grazing on native pasture with browse plants as supplement enhanced ADWG with no negative effects on blood metabolites. A further study is recommended to investigate different feed processing methods of S. *siamea* on DMI and growth of Djallonké sheep.

Conflict of interests

The authors have not declared any conflict of interests.

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