

The effect of three tropical shrub legumes on intake rate and acceptability by small ruminants

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Introduction

A number of leguminous shrubs and trees have been identified as a source of forage for ruminant animals in tropical areas (Blair, 1990). However, many of the shrub legumes widely used or with potential for supplementing livestock are not well adapted to acid soil with high levels of exchangeable aluminum (Perdomo, 1991; Shelton et al., 1991). Thus the Tropical Forage Program of CIAT undertook the task of selecting shrub legumes for acid infertile soil and some promising species has identified. However, their nutritional value for ruminants could be limited due to high levels of condensed tannins (CT) which are polyphenols that form complexes with proteins, carbohydrate and metals. Therefore, it could depress intake, protein and fibre digestion (Lascano and Carulla, 1992). To better define strategies for utilization of these legumes in feeding systems, further determine the value of these species on diet selection is necessary.

Thus an early evaluation with animals is essential. Intake as a critical element for forage quality evaluation is now generally recognized (George Jr. et al., 1994) and relative palatability should be included in early evaluation, particularly when evaluating tropical legumes (Joblin, 1962). This paper reports the results of a feeding trial designed to assess the effect of shrub legume leaves on intake rate and acceptability of *C. argentea*, *D. velutinum*, and *F. macrophylla* by sheep and goats.

Materials and methods

The feed trial was undertaken at Quilichao experimental station of CIAT, Cauca, Colombia, using two groups of three African hair sheep (18-25 kg LW) and native goats (10-20 kg LW). Animals were randomly assigned to one of the following treatments: (1) *C. argentea* (free of tannins); (2) *D. velutinum* (free of tannins); and (3) *F. macrophylla* (high level of tannins). Treatments were arranged in a 3 x 3 Latin square reversible design. The entire trial was put into three periods. Each last 14 days, of 10 days for animal to adjust to the cages and the following 4 days for measurement. Between adjacent two periods animal had 3 days for rest to keep body health and minimize the selective effect from the previous period. The legumes tested were fresh leaves of 6-8 month regrowth separated and chopped from thick stems.

Animals housed in metabolism crates were offered tested legumes 15 g DM/LW^{0.75} per day, twice daily: in the morning (9:00-9:30 h) and in the afternoon (14:00-14:30 h). Before and after feeding test legumes, the animals were offered 80 g DM/LW^{0.75} per day *Brachiaria dictyoneura* hay as basal diet and 25 g DM/LW^{0.75} concentrate. During the whole trial animals were free access to a mineral salt mixture and were offered water individually two times daily.

Measurements

After a 10-day adjustment period, the amount of forage consumed and refused and the intake time were measured twice daily during 4 consecutive days. Meantime the samples of offered forages also were collected. Forage samples were analyzed for total Kjeldahl nitrogen (N) (AOAC, 1980), neutral detergent fibre (NDF), acid detergent fibre (ADF) (Van Soest, 1963), nitrogen in acid detergent fibre (N-ADF) (Goering

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et al., 1972), in vitro dry matter digestibility (IVDMD) (Tilley and Terry, 1968, modified by Moore, 1970). Extractable condensed tannins (ECT) and bound tannins (BT) were analyzed in freeze-dried samples of *F. macrophylla* using Butanol-HCl (Porter et al., 1986) and purified tannins of *F. macrophylla* as the standard.

Statistics treatment

The amount of forage consumed was expressed as dry matter intake per live weight ($LW^{0.75}$) kilogram per day. The results were subject to analysis of variance with treatment, group and animal with group, time on offer, period with group, day within period, group x treatment, group x day, group x time, group x day x time, animal individual x day, animal individual x time, animal individual x day x time as sources of variation. Correlation between some animal response variables and forage quality attributes were also analyzed using SAS procedure package.

Results

Chemical analysis of forage offered

The chemical composition and in vitro dry matter digestibility (IVDMD) of forage offered to animals is shown in Table 1. The N content and IVDMD of *F. macrophylla* were significantly lower than the other two legumes. As expected, condensed tannins level in *F. macrophylla* was considerably high. However, BCT value was higher than ECT. This was different from the result that Jackson (1996) found 60% extractable and

40% bound. *Cratylia argentea* and *D. velutinum* were free of tannins and high N content, but high levels of ADF and N-ADF. The nitrogen fraction bound to ADF were 39% and 44% of total N in *C. argentea* and *F. macrophylla*, respectively, which was similar to the results of Fassler (1995).

Among the three tested legumes, *D. velutinum* was free of tannins and lower values of NDF, ADF, N-ADF, and highest IVDMD.

Dry matter intake

Dry matter intake rate of tested legumes by animals is presented in Table 2 and Figure 1. It varied with forage and animal species. According to the mean intake rate, the small ruminants significantly consumed more *C. argentea* and *D. velutinum* than *F. macrophylla*. And DM intake by sheep is also different between *C. argentea* and *D. velutinum*, but no difference by goats was shown.

However, from results on DM intake by animal species, intake rate of goats (380.5 g DM/LW^{0.75} per day) was higher ($P < 0.05$) than that of sheep (296.5 g DM/LW^{0.75} per day).

Table 3 showed that there were no differences in the chemical composition of shrub legumes fed in the morning and in the afternoon. The animal intake rates were different with the time of a day. Intake in the morning was significantly lower than in the afternoon.

Table 1. Chemical composition (%) and in vitro dry matter digestibility (%) of forage fed to animals housed in metabolism crates.

Forage	DM ^a	N	NDF	NDF(S)	ADF	N-ADF	Total CT	ECT	BT	IVDMD
<i>C. argentea</i>	95.88	3.37 a*	58.87 a	36.73 a	1.32 a	0 b	0 b	48.42 b		48.42 b
<i>D. velutinum</i>	95.99	3.33 a	44.41 b	29.44 b	0.53 b	0 b	0 b	0 b	53.43 a	53.43 a
<i>F. macrophylla</i>	96.08	2.86 b	48.56 b	36.80 a	1.26 a	12.44 a	5.13 a	7.31 a	22.87 c	22.87 c

a. DM = dry matter; N = nitrogen content; NDF = neutral detergent fibre; NDF(S) = neutral detergent fibre in sulphite acid; ADF = acid detergent fibre; N-ADF = nitrogen content in the acid detergent fibre; IVDMD = in vitro dry matter digestibility; CT = condensed tannin; ECT = extractable condensed tannin concentration (Butanol-HCl); BT = bound tannin concentration.

* Means in the same row followed by different letters are significantly different ($P < 0.05$).

Table 2. Dry matter intake by sheep and goats fed the three tested shrub legumes.

Animals	<i>C. argentea</i>	<i>D. velutinum</i>	<i>F. macrophylla</i>	S.E.
Goats (g DM/LW ^{0.75} per day)	412.308 a*	421.320 a	308.028 b	19.620
Sheep (g DM/LW ^{0.75} per day)	381.984 a	298.740 b	208.932 c	22.944
Mean (g DM/LW ^{0.75} per day)	397.140 a	360.024 a	306.480 b	16.320

* Means in the same row followed by different letters are significantly different ($P < 0.05$).

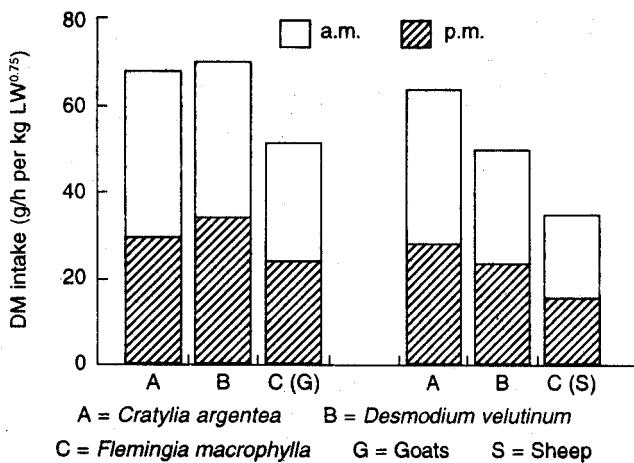


Figure 1. Average DM intake by animals.

Correlation analysis

In this study, the results indicated that DM intake rate was positively correlated with IVDMD and N

($r = 0.38244$, $P < 0.0001$; $r = 0.39693$, $P < 0.0001$, respectively), negatively correlated with ADF and CT ($r = -0.21399$, $P < 0.0001$; $r = -0.40006$, $P < 0.0001$, respectively) (Table 4). IVDMD was positively correlated with N ($r = 0.74254$, $P < 0.0001$) and negatively with ADF, N-ADF and CT ($r = -0.59666$, $P < 0.0001$; $r = -0.54420$, $P < 0.0001$; $r = -0.96450$, $P < 0.0001$) (Table 5).

Further analysis of correlation coefficient within *F. macrophylla* showed that ECT was negatively correlated with DM intake ($r = -0.63710$, $P < 0.001$), it is seemed that ECT could depress IVDMD. However, this effect was not significant. BCT was not significantly correlated with DM intake rate and IVDMD. It was not clear if BCT would influence DM intake and IVDMD from this study.

Discussion

The results from this study indicated that DM intake varied with plant qualities and animal species and fed time. Generally sheep was more sensitive to tropical shrub

Table 3. Chemical composition and dry matter intake rate of shrub legumes fed in the morning and in the afternoon.

Time	N	NDA	NDF(S)	ADF	N-ADF	CT	IVDMD	Mean DM intake (g DM/LW ^{0.75} per day)
a.m.	3.17	41.68	53.62	34.33	1.04	12.18	41.85	312.588b*
p.m.	3.14	41.14	53.82	34.30	1.03	12.69	41.97	364.512a
S.E.								13.320

* Means in the same row followed by different letters are significantly different ($P < 0.05$).

Table 4. Correlation coefficients between DM intake rate and some chemical composition contents of legumes offered.

	IVDMD	N	NDF	ADF	N-ADF	Total CT	ECT	BT
r ^a	0.3969	0.38244	-0.11096 ^c	-0.21399	-0.06972	-0.40006 ^d	-0.63711 ^d	0.40120
P ^b	0.0001	0.0001	0.4528	0.0100	0.5606	0.0001	0.0010	0.0528

IVDMD = in vitro dry matter digestibility; N = nitrogen content; NDF = neutral detergent fibre; ADF = acid detergent fibre; N-ADF = nitrogen content in the acid detergent fibre; ECT = extractable condensed tannin, BT = bound tannin.

- a. r = correlation coefficient.
- b. P = level of significance.
- c. Correlation coefficient only in *D. velutinum*.
- d. Correlation coefficient only in *F. macrophylla*.

Table 5. Correlation coefficient between IVDMD and some chemical composition contents of legumes offered.

	N	NDF	ADF	N-ADF	Total CT	ECT	BT
r ^a	0.74254	-0.35596 ^c	-0.59666	-0.54420	-0.9645 ^d	-0.16406 ^d	0.29412
P ^b	0.0001	0.0878	0.0001	0.0001	0.0001	0.4337	0.1630

IVDMD = in vitro dry matter digestibility; N = nitrogen content; NDF = neutral detergent fibre; ADF = acid detergent fibre; N-ADF = nitrogen content in the acid detergent fibre; ECT = extractable condensed tannin, BT = bound tannin.

- a. r = correlation coefficient.
- b. P = level of significance.
- c. Correlation coefficient only in *D. velutinum*.
- d. Correlation coefficient only in *F. macrophylla*.

legumes than goats which preferred more shrub legumes. *Cratylia argentea* and *D. velutinum* was of higher acceptability by sheep and goats than *F. macrophylla* which was high level of tannins, thus it could be suggested that the shrub legumes should be fed flexibly depending on animal species in production. It was possible to provide more shrub legumes in the diet for goats than for sheep. And *C. argentea* and *D. velutinum* could be used as significant proportions of the diet fed small ruminants. In contrast, *F. macrophylla* only be used as supplements to crude grass basal.

Among the tested shrub legumes, *F. macrophylla* was the lowest in acceptability, DM intake and IVDMD. This could be related to its low N content, high N-ADF and condensed tannins. *Cratylia argentea* had high N content and DM intake, but it also had high ADF and N-ADF, which could be responsible for its lower IVDMD than *D. velutinum*. Goering et al. (1972) observed high level of faecal N-ADF (55% of total faecal N) with supplementation of *C. argentea* and suggested that this case could not be attributed to tannin-protein complexes, but rather to other phenolic-protein linkages. Both *C. argentea* and *D. velutinum* had similar high levels of N, DM intake, and free of tannins. But IVDMD of *C. argentea* was lower than that of *D. velutinum*, which was possibly associated with high ADF and N-ADF values of *C. argentea*.

The results also showed that animals consumed more shrub legumes in the afternoon than in the morning. It was unknown what responsible for it because of no other data available. It could be possibly related to animal intake habit and some hormone and digestive juice.

Conclusion

It was generally concluded from this study that dry matter intake and acceptability were significantly affected by feeding time, legume and animal species and shrub forage qualities such as IVDMD, N and condensed tannins (CT). Both sheep and goats consumed more *C. argentea* and *D. velutinum* than *F. macrophylla* which is of high level of tannins, low nitrogen, and IVDMD. However, sheep had a more sensitive acceptability and lower intake rate on shrub legumes than goats. It was also suggested that of the species evaluated, *C. argentea* and *D. velutinum* had a higher DM intake and acceptability than *F. macrophylla*. Both with high N and IVDMD and free of tannins could be used as significant proportions of the diet fed small ruminants. While *F. macrophylla* with high level of tannin and low DM intake rate and IVDMD should only be used as supplements to crude grass diet in animal production. Future studies on *F. macrophylla* selection

and breeding should focus on high protein, low fibre and condensed tannins.

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Resumen

En el Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, se realizó un experimento con el fin de evaluar la aceptabilidad y el consumo de forraje fresco de leguminosas arbustivas por pequeños rumiantes (ovejas y cabras). Las leguminosas utilizadas fueron *Cratylia argentea*, *Desmodium velutinum* y *Flemingia macrophylla*, que se cosecharon entre 6 y 8 meses de edad y se suministraron como forraje (hojas) fresco a los animales durante 30 min en horas de la mañana y de la tarde. Los resultados indicaron que el consumo de MS fue afectado significativamente por las especies vegetal y animal, la hora de alimentación y la calidad del forraje (DIVMS, contenido de N, FAD y contenido de taninos condensados). Tanto las ovejas como las cabras consumieron más *C. argentea* y *D. velutinum* que *F. macrophylla* que tiene alto contenido de taninos, y baja DIVMS y contenido de N. No obstante, las ovejas tienen más restricciones para aceptar el forraje y consumen menos las leguminosas arbustivas evaluadas que las cabras. Se concluye que *C. argentea* y *D. velutinum* presentan mayores tasas de consumo y aceptabilidad por pequeños rumiantes que *F. macrophylla*.

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