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Nutritive Value and Anthelmintic Properties of Selected Leguminous Shrubs and Trees for Goats

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ABSTRACT

Two related studies were conducted to determine the nutritive value and anthelmintic properties of eight tree legumes used as goat feeds. The degradation characteristics, total extractable phenol (TPEH) and condensed tannin (CT) of Acacia (*Samanea saman*), Desmanthus *(Desmanthus virgatus),* Rensonii (*Desmodium cineria),* Leucaena *(Leucaena leucocephala),* Flemingia *(Flemingia macrophylla),* Gliricidia *(Gliricidia sepium),* Grandiflora *(Sesbania grandiflora),* and Sesban (*Sesbania sesban)* were determined.

Except for *Flemingia*, the different legumes contained highly soluble and degradable components that can provide immediate supply of nitrogen and fermentable matter to meet nutritional needs. *Flemingia* and *Leucaena* had more than 65% extractable tannins and contain high condensed tannin (CT) that could potentially reduce gastro-intestinal parasites in goats. Other species had minimal or no CT content. Feeding the tree-legumes provided cheap source of digestible organic matter, while feeding *Flemingia* and *Leucaena* was expected to reduce internal parasites in goats because they contained anthelmintics.

Key Words: Degradability, leguminous forages, tannin, anthelmintics, goats

INTRODUCTION

Multipurpose trees and bushes such as *Leucaena leucocephala, Gliricidia sepium, Samanea saman, Sesbania grandiflora, Sesbania sesban, Flemingia macrophylla,* and *Desmanthus virgatus* are used as supplementary feeds for goats. These tree legumes improve nutrient intake and growth performance of goats (Orden et al., 2005). Hence, they are potential alternatives to expensive concentrates to improve goat productivity. Most of these multipurpose trees and other legume species are highly abundant in the Philippines. Leaves and pods of tree species are fed to the animals especially during dry season when there are limited fresh forages (Yahaya et al., 2000). The leaves and pods are rich in protein, minerals and vitamins (ILCA, 1988). However, some tree legumes contain secondary compounds which are toxic when fed *ad libitum* (D'Mello, 1992 and Fall-Toure et al., 1998). Acacia contains phenolic compounds that have negative effect on their nutritional value and overall acceptability to livestock (Degen et. al., 1998). Tannin had been identified as the major constraint in the utilization of browse species in feeding livestock (Makkar, 1993). It has negative effect on intake and digestibility of fodder (Kumar and D'Mello, 1995) hence, it limited the intensive use of browse species in livestock feeding.

The presence of high level of condensed tannin in fodder species like *Flemingia macrophylla* limits its usefulness as a sole feed for ruminants as indicated by its low dry matter and crude protein digestibility (Lanting et al., 2003). Condensed tannin provides protection to protein-rich forage materials from further microbial action in the rumen thus, rendering them available at the lower gut as intact protein (Barry and Duncan, 1984). However, the mechanism involved in the utilization of tannin-bound-protein compound has not been fully explained.

Although tannins exert adverse effects on consumption and nutrient degradability, its anthelmintic properties had been reported in some browse species when consumed by ruminants (Butter et al., 2000). The increasing importance of trees legumes requires the thorough assessment of its nutrient contents and anti-nutritional factors to help develop a fodder-based feeding strategies for small ruminants. This study aimed to determine the feeding value and anthelmintic properties of seven leguminous trees and shrubs for goats.

MATERIALS AND METHODS

Source, Collection and Processing of Legume Samples. Representative samples of *Samanea, Desmanthus, Flemingia, Gliricidia, Leucaena, Rensonni, S. grandiflora,* and *S. sesban* were harvested from the Small Ruminant Center, Central Luzon State University, Science City of Muñoz, Nueva Ecija. The area is located at 15043'N, 120^0 54'E with agro climatic condition classified as tropical monsoon type; consisting of two distinct seasons, i.e., dry (December to May) and rainy (June to November). Leaves were about 45-day regrowth when harvested. They were allowed to dry for 24h to approximately 85 percent dry matter (DM) before grinding to pass through a 2 mm mesh screen. The leaf meals were stored properly in plastic bags and shipped to Japan for analysis.

In-situ Degradation. Three upgraded (Merino x Philippine native) male sheep with mean body weight of 30 kg (range of 29 to 31kg) and fitted with permanent cannula were used in the *in-situ* experiment. They were kept individually in the metabolic cage and had free access to fresh drinking water. The animals were fed with 0.725 kg (NRC, 1985) maintenance ration made up of 70% chopped Napier + 20% *Leucaena* or *Gliricidia* + 10% concentrate. Daily ration was offered in two equal proportions, at 09:00h and 17:00h. Nylon bags (internal dimension of 8 x 12cm; pore size of 47μm) containing about 3g leaf meal samples were incubated in duplicate for 0, 4, 8, 16, 24, 36 and 48 hours (Ørskov et al., 1979 and McDonald, 1981). Residual samples were fitted to the NEWAY © F-Curve computer software (X.B. Chen, 1995) to determine DM degradation characteristics based on the model: $p = a + b\ (1 - e^{-ct})$ where p = degradation after t = time (h); a = soluble or highly degradable fraction; b = slowly degradable fraction which disappears at a constant fraction rate (c); c = degradation rate (per h) (Ørskov and Mc Donald, 1979). The slowly degradable fraction (b) was re-estimated as $B = (a + b) - A$, where A = actual soluble fraction (washing loss), (Ørskov and Ryle 1990).

Analytical Method. DM of the different tree legumes and residual matter from the *in-situ* trial were determined after oven drying at 105^{O}C for 24h, organic matter (OM) by ashing at 550^{O}C for 8h, and crude protein (CP) following the AOAC procedure (1984). The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined by the Goering and Van Soest (1970) method.

The extraction of phenolics was done using, solvent of 70% aqueous acetone, i.e. 700 ml acetone + 300 ml distilled water. Total extractable phenols (TEPH) were determined using *Folin Ciocalteu* according to Julkunen-Tito (1985). The concentration of TEPH was calculated using the regression equation of the tannic acid standard. Total extractable tannins (TET) were estimated indirectly after being absorbed to insoluble polyvinylpolyrrolidone (PVP). Concentration of TET was calculated by subtracting the TEPH remaining after PVP treatment from TEPH. The fractionation and total condensed tannins were measured using the method of Porter *et al.,* (1986).

Statistical Analysis. Data collected were subjected to analysis of variance (ANOVA) using General Linear Model of Statistica for Windows™ Released 4.3 (StatSoft, Inc. Tulsa, OK., 1993).

RESULTS AND DISCUSSION

Chemical Composition

All forage species had a crude protein (CP) higher than 20 percent, showing their potential as a leaf protein supplement for goats and sheep (Table 1). Differences in composition among the legumes were largely associated with the level of cell wall constituents (CWC), especially in hemicellulose and lignin (ADL) fractions. NDF representing TWC in Flemigia at 63.13 percent was exceptionally highest than in most of the species with NDF value ranging from 23.51 – 51.15 percent. Moreover, Flemigia had 20.76 percent. ADL that could potentially affect digestibility. Among the tree legumes, *Leucaena, Gliricidia* and *S. sesban* had better nutrient profile with relatively high CP and low CWC. Shahjalal and Topps (2000) examined *Samanea aceleata* and *Samanea rostrata* and also found high CP of 25.4% and 32.7%, respectively. Hence, they can be used intensively to improve voluntary intake and growth performance of stall-fed growing animals. Forage supplements containing higher levels of CP had more profound effects on diet digestibility that could eventually influence DM intake. Orden et al., (2014) pointed out that *Leucaena* and *Gliricidia* are protein-rich forages that can improve the productivity of ruminants consuming low quality roughage. Similar conclusion was derived by Ondiek et al (2000) among dairy goats in Kenya fed with *Leucaena* and *Gliricidia* as supplements to Rhodes Grass.

Table 1. Chemical composition of selected leguminous trees and shrubs grown at the Small Ruminant Center, CLSU, Science City of Muñoz, Nueva Ecija

Forage Species	Nutrient Content (%)				
	DM	CP	NDF	ADF	ADL
Samanea	23.02	21.63	51.16	40.37	18.71
Desmanthus	21.98	24.65	34.82	16.92	8.93
Gliricidia	20.76	26.62	48.64	37.02	9.62
Flemingia	22.83	24.01	63.13	45.17	20.76
Leucaena	27.18	27.22	35.84	18.75	9.16
Rensonii	21.34	22.10	36.17	23.35	7.45
S. grandiflora	21.30	26.77	23.51	15.87	8.79
S. sesban	22.08	24.75	26.85	17.49	4.87

Note: Values on DM basis

In-situ Degradation

Table 2 and Figure 1 present the DM disappearance of the selected tree legumes. *S. grandiflora* had the highest rumen solubility, followed by *S. sesban*. Starting from 16h to 48h, the *S. sesban* and *S. grandiflora* showed consistently higher degradability, although the former had attained more than 80% DM disappearance earlier at 16h. *Desmanthus, Gliricidia* and *Leucaena* required 24h to reach more than

80% DM disappearance. Whereas, *Rensonii* only attained 79.64% DM disappearance at 48h. On the other hand, *Samanea* and *Flemingia* had the lowest range of degradation over the incubation period. Even after 48h, *Flemingia*'s DM disappearance barely reached 42 percent. Only 4.51% and 7.34% increment in degradation occurred when incubation time was extended to 36 and 46h, respectively. Despite the high solubility of *S. sesban* and *S. grandiflora*, a 16h incubation time was not enough to achieve potential degradation contrary to the result of Kibon et al.(1993). The results of this study further indicated that by 24 hours of incubation, four of the eight fodders exceeded the 70 percent degradation. Moreover, result suggests that the 12h incubation period is not enough to predict the digestibility of fodder trees, contrary to earlier report (Merkel *et al.,* 1999). Nonetheless, the ruminal degradation of the tree legume species can be ranked in the following order: *S. grandiflora>S.sesban>Gliricidia>Desmanthus>Leucaena>Arachis>Renzonii>Semanea> Flemingia*

Table 2. *In situ* DM disappearance of selected leguminous trees and shrubs grown at SRC-CLSU

Forage Species	Rank	Incubation Hours					
		4	8	16	24	36	48
Samanea	7th	43.84^{bc}	46.74^{b}	53.75^{b}	57.21^{b}	58.37^{b}	55.17^{b}
Desmanthus	4rd	35.33^{ab}	42.55^{ab}	59.00^{b}	65.16^{bc}	71.83^{bc}	88.16^{de}
Flemingia	8th	29.53^{a}	30.78^{a}	35.32^{a}	35.81^{a}	41.11^{a}	42.07^{a}
Gliricidia	3rd	38.40^{bc}	48.12^{b}	66.78^{bc}	81.37^{def}	86.11^{cd}	88.22^{d}
Leucaena	5th	39.57^{bc}	47.52^{b}	65.88^{bc}	80.86^{def}	85.69^{cd}	86.60^{d}
Rensonii	6th	45.26^{cd}	54.75^{bc}	64.55^{bc}	69.38^{bcd}	71.72^{bc}	79.64^{c}
S. sesban	2nd	56.50^{e}	65.83^{c}	83.83^{d}	88.16^{ef}	93.16^{d}	93.66^{e}
S. grandiflora	1st	53.00^{de}	64.50^{c}	78.66^{cd}	91.50^{f}	94.00^{d}	95.16^{e}
SEM		8.37	10.77	14.01	17.27	17.23	18.14
Level of Significance		**	**	**	**	**	**

Note: Ranking has been done on the basis of 36h and 48h degradability
Means with the letter superscripts within column are not significantly different (p<0.01)

The *in situ* DM degradation characteristics of the different tree legumes was estimated by fitting the residual DM into the equation P = a + b (1 – e^{ct}) as shown in Table 3. The effective degradability at 0.02 outflow rate was highest for *S. grandiflora* at 85.53 percent while *S. seban* had the next highest value at 85.23 percent. Their high effective degradability showed faster ruminal turn over as indicated by their highly soluble fraction (A). This result supports the findings of Osuji and Odenyo (1997) that the leaves of *S. sesban* and *S. gandiflora* are superior than other tree fodders such as *Acacia albida* and *Acacia sieberiana* in terms of the rate of degradation (0.133/h) and potential degradability (891 g/kg DM). *Flemingia* had the lowest effective degradability at 39.80 percent indicating the low degradability of its A + B fractions in the rumen. This could be attributed mainly to its high ADL content (Table 1).

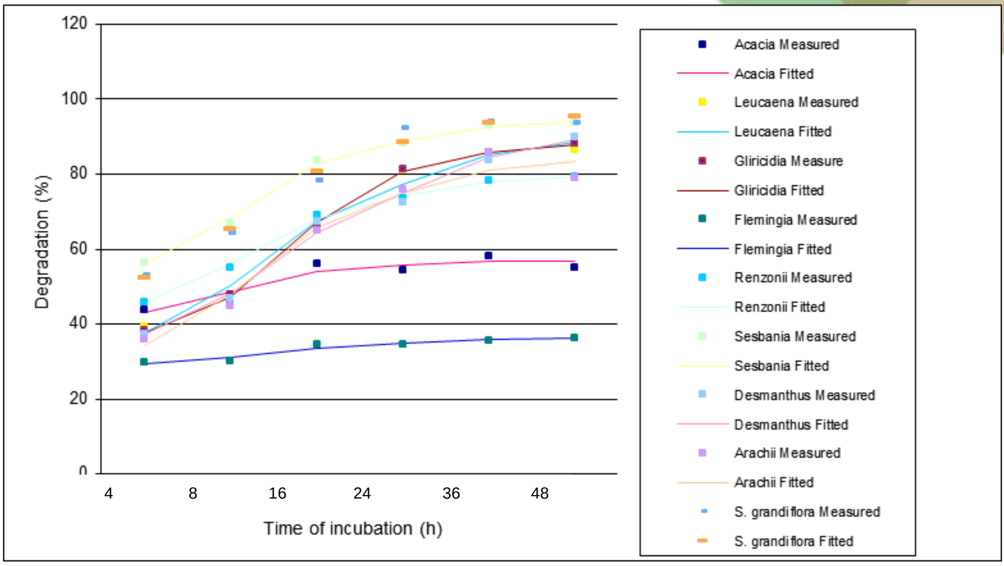

Figure I. *In-situ DM disappearance of selected leguminous trees and shrubs at different incubation time*

Table 3. *In situ* DM degradation characteristics of selected leguminous trees and shrubs as defined by the equation P = a + b (1 – e ^{ct})

Legume Species	Degradability %				Effective Deg.
	A	B	A + B	C	at 0.02
Samanea	36.16^{ab}	21.86^{a}	58.13^{a}	0.033	54.46^{b}
Desmanthus	43.73^{bc}	50.16^{bc}	94.00^{bc}	0.009	80.63^{de}
Gliricidia	34.90^{ab}	55.70^{c}	90.60^{bc}	0.066	74.63^{cd}
Flemingia	28.43^{a}	25.23a	53.63^{a}	0.003	39.80^{a}
Leucaena	39.13^{b}	52.16^{bc}	91.30^{bc}	0.006	75.93^{cd}
Rensonii	42.90^{bc}	39.20^{b}	82.40^{b}	0.005	69.80^{c}
S. seban	39.33^{b}	55.33^{c}	94.70^{bc}	0.0035	85.23^{e}
S. grandiflora	49.33^{c}	49.00^{bc}	98.33^{c}	0.078	85.53^{e}
SEM	5.922	12.544	16.205	0.027	14.96
Level of Significance	*	*	**		**

Means with common letter superscripts within column are not significantly different ($p<0.05$*; **$p<0.01$*)*

SEM – Standard Error of the Mean

Except for *Flemingia* and *Samanea* leaves, tree legumes had high degradability due to their high A and B values. Almost 50 percent of the DM content of *S. grandiflora* and 42 percent of *Rensonii* and *Desmanthus* were readily soluble. On the contrary, *Leucaena, Gliricidia and S. sesban* leaveswere not as soluble as *S. grandiflora, Rensonni* and *Desmanthus*, but more than 50 percent of their DM fractions were degradable as incubation time progressed. Results suggest that majority of the tree legume species could provide highly fermentable substrate in the rumen when used as supplemental feeds for stall-fed goats. Moreover, they maintain a steady supply of degradable substrate and elevate NH_3-N and volatile fatty production in the rumen that could increase efficiency of microbial N supply (Merkel et al., 1999).

Phenolic Concentration of Selected Legume Species

Phenolic concentrations expressed as total extractable phenolics (TEPH) or the tannic acid equivalent (TAE) and total extractable tannin (TET) on a DM basis of the selected legume species fed are presented in Figure 2. The TEPH ranged from 1.71% to 12.28% DM while TET ranged from 0.16% to 8.27% DM. *Flemingia* had the highest TEPH value of 12.28 percent followed by *Leucaena* (11.86%) and *Desmanthus* (8.9%). The rest of the species had TEPH content below 8 percent. Interestingly, more than 65 percent of the extractable phenolic compounds in *Flemingia* and *Leucaena* were accounted as total extractable tannins. This could be a potential factor to affect nitrogen degradation in the rumen and protein availability in the lower gut. Lanting et al., (2003) also pointed out the high tannin content of *Flemingia* (8.66% TAE) than other legume species commonly used as forage supplements. Our studies corroborated with the earlier findings of Ilao *et al.* (1997) as cited by Sevilla et al. (2003) that the TAE value of *Flemingia* is higher than the average 5.57% TAE of 15 species of fodder trees and shrubs commonly used as feeds for ruminants in the province of Batangas, Philippines.

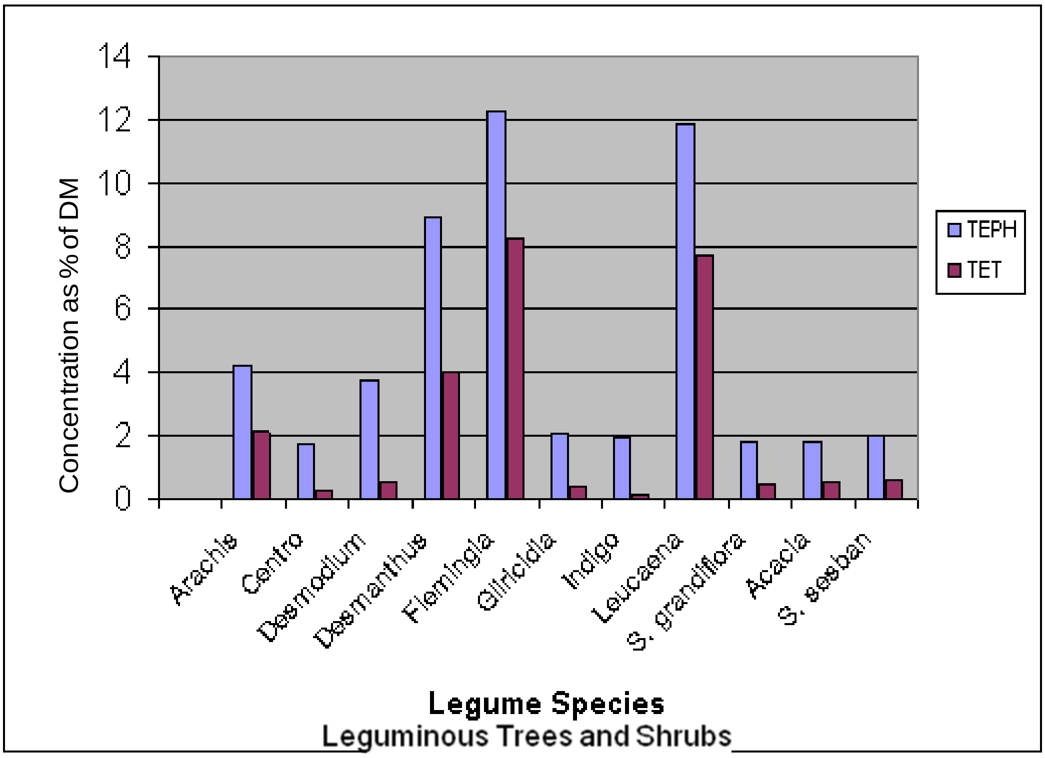

Figure II. *Phenolic concentration of selected leguminous trees and shrubs at SRC-CLSU*

Condensed Tannin Concentration of Selected Legume Species

Among the eight species of forage legumes that were analyzed, *Flemingia* and *Leucaena* had complete condensed tannin fractions both during dry and rainy seasons (Table 4). *Desmanthus* was detected to contain delphinidin and cyanidin, while Acacia was found to contain cyanidin only. No CT fractions were detected from the rest of the legume species that were subjected to tannin assay. Compared with the TEPH and TET concentrations, the same trend was observed with CT fractions and TCT concentrations in all the legume species. TCT contents of *Flemingia* (4,698.94 μg/g DM during rainy season and 5,667.24μg/g DM dry season) and *Leucaena* (2,826.45 μg/g DM during rainy season and 3,797.93 μg/g DM dry season) were the two highest values. Whereas, *Desmanthus* had 1,176.40μg/g DM while *Gliricidia* had 476.81μg/g DM. *Flemingia* was also found to have the highest level of CT of >6% in Sevilla (2002) and Lanting *et al.* (2003). On the other hand, Acacia had the lowest TCT concentration of 45.33μg/g DM. Higher levels of tannin in forage legumes can significantly reduce consumption and DM degradability (Merkel *et al.,* 1999; Perez-Maldonado and Norton, 1996). Low voluntary intake among goats fed with *Samanea* pods was also reported by Barcelo and Barcelo (2012) which they associated to the presence of anti-nutritional factors like tannins and albuminoids.

Table 4. Condensed tannin contents of selected leguminous trees and shrubs grown at SRC-CLSU

Legume species	Condensed Tannin Fractions (µg/g DM)			Total CT	Level of Sig
	Delphinidin	*Cyanidin*	*Pelargonidin*		
Samanea					
Dry season	--	45.33	--	45.33	
Wet season	--	--	--	--	
Desmanthus					
Dry season	1132.21	103.54	--	1,235.75	ns
Wet season	1,077.82	98.58	--	1,176.40	
Gliricidia					
Dry season	98.72	378.09	--	476.81	
Wet season	--	--	--	--	
Flemingia					
Dry season	4,003.08	1,561.37	102.79	5,667.24	ns
Wet season	3,578.08	1,028.37	92.49	4,698.94	
Leucaena					
Dry season	1,987.23	1,522.13	288.57	3,797.93	ns
Wet season	1,140.53	1,431.43	254.49	2,826.45	
Rensonii					
Dry season	--	--	--	--	
Wet season					
S. grandiflora					
Dry season	--	--	--	--	
Wet season	--	--	--	--	
S. sesban					
Dry season	--	--	--		
Wet season	--	--	--	--	

-- not detected

The condensed tannin present in *Flemingia, Leucaena* and *Desmanthus* did not show significant correlation with DM degradability (Table 5). Likewise, condensed tannin was not associated with CWC, expressed as NDF, ADF and ADL.

Table 5. Correlation coefficient (r) of condensed tannin concentration and CP, NDF, ADF and DM degradability of *Leucaena, Flemingia* and *Desmanthus*

Variable	Correlation coefficient with			
	CP	NDF	ADF	Degradability
Condensed Tannin	-0.223	0.285	0.013	0.003

Results suggest that only *Leucaena* and *Flemingia* could be potential sources of anthelmintics when consumed by goats as shown by the presence of condensed tannin. Khan and Hernandez (1999) reported that leguminous crops which are rich in condensed tannins exert vermifuge effects and tend to reduce gastrointestinal nematodes in grazing animals. Therefore, the relatively high TCT present in *Flemingia* makes the fodder a cheap source of control against nematodes in goats. Condensed tannins from forages can enhance tannin-nematode interactions that effectively reduce the larvae survival of several nematodes (Drew, 2000) or react directly by interfering with the parasite egg hatching and development to infective larvae stage in goats (Butter et al. 2000). Although *Flemingia* had a very low rumen degradability (Table 3), it can be an effective feed for a sustainable parasite control among goat raised under complete confinement.

CONCLUSION AND RECOMMENDATION

Except for *Flemingia* and *Samanea*, leguminous fodders contain high CP, rumen-soluble and degradable organic matter, which when fed to goats can provide N and fermentable carbohydrates. Moreover, *Flemingia* and *Leucaena* were found with antinutrients in the form of TEPH, total extractable tannin (TET) and total condensed tannin (TCT). They can be potential sources of anthelmintics against internal parasites when fed to goats.

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