Differences in Chemical Composition Among Provenances of Tree Fodder Species in a Subhumid Environment: Relation to use as Supplements

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DIFFERENCES IN CHEMICAL COMPOSITION AMONG PROVENANCES OF TREE FODDER SPECIES IN A SUBHUMID ENVIRONMENT: RELATION TO USE AS SUPPLEMENTS

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ABSTRACT

Studies were initiated in a subhumid Southern African environment to assess the chemical composition and nutritive value of *Acacia angustissima* (Mill.) Kuntze, *Calliandra calothyrsus* Meiss. and *Leucaena* species. The objective was to determine variability in crude protein (CP) concentration, acid detergent fibre (ADF), neutral detergent fibre (NDF), and soluble and insoluble proanthocyanidins from fodder samples of species, subspecies and provenances. A wide range was found in these parameters. The implications of these chemical composition factors, especially proanthocyanidins, on the use of these browse fodders in livestock feeding systems are discussed.

KEYWORDS

Tree fodders, crude protein, fibres, proanthocyanidins, digestibility, supplements, feeding systems.

INTRODUCTION

Leguminous trees produce high quality fodder. However, their major constraint is their chemical composition and anti-nutritional factors, and how these characteristics affect their use in feeding systems. Factors contributing to high quality forage, are high concentrations of N and low concentrations of lignin and polyphenolic secondary plant compounds. Thus, the chemical composition of fodder from tree fodders could have a strong influence on its use (Ndlovu *et al.,* 1997). The present study was undertaken to assess the levels of chemical composition variability in fodder tree species and provenances so as to relate this variability to potential use as feeds.

MATERIALS AND METHODS

Three evaluation studies involving (1) *Leucaena* genus, (2) *Calliandra calothyrsus* Meissen. and (3) *Acacia angustissima* (Mill.) Kuntze. were carried out at Domboshawa Agroforestry Research site in subhumid Zimbabwe. In the first experiment, the different species and provenances were planted out in fodderbanks. Forage (leaf and petioles) were analysed for the concentration of acid detergent fibre content (ADF), neutral detergent fibre (NDF) (Robertson and van Soest, 1981) and crude protein (AOAC, 1990). The content of proanthocyanidins (condensed tannins) was assayed by the butanol-HCl method of Porter *et al.* (1986) while the soluble tannins were determined by the method of Reed *et al* (1985). *In vitro* dry matter digestibility (IVDMD) was determined by the Tilley and Terry method (1963). In the second experiment, dry matter (DM) and nitrogen rumen degradations after 24 and 48 hours of incubation in the rumen, were measured using the nylon bag technique (Orskov *et al.,* 1980). In addition, the water soluble DM and N-fractions of the forages were determined. Nutrient intake, digestion and N-balance were measured in the 3rd experiment using sixteen 28-month old goats (average weight 26 ± 4.2 kg). The digestion trial involving 4 goats per treatment, was conducted over a 21-day period which consisted of 14-day adaptation and 7-day data collection periods. The goats were fed natural grass hay *ad libitum* and all three Leucaena forages were offered at the rate of 120 g/hd/day.

RESULTS

a) ***Leucaena* species and provenances evaluation:** The comparison of nitrogen contents between *L. leucocephala* cv. Cunningham (LL), *L. diversifolia* subspecies *stenocarpa* cv. OFI 53/88 (LD) and *L. pallida* (LP) cv. of CPI 58980 (syn. *L. esculenta* subspecies *paniculata*), showed the contents to be high (Table 1). However, 50% or more of this N was bound to NDF. All three species contained substantial amounts of insoluble proanthocyanidins (PAS) which were much higher than that of veld hay. The chemical composition of other *Leucaena* species showed a great deal of variability in crude protein level (Table 2); range of low values was around 17.0% in *L. diversifolia* subspp. *diversifolia* and *stenocarpa* to the high in *L. leucocephala* (27.6%), *L. salvadorensis* (25.6%) and *L. shannonii* subsp. *magnifica* (24.5%). Among the species with low levels of NDF were *L. leucocephala* hybrids with *L. diversifolia, L. diversifolia* subspp. *stenocarpa* and *diversifolia* with NDF values below 40%. Among the highest were *L. shannonii* subsp. *magnifica*, *L. pallida* and one *L. diversifolia* provenance subsp. *diversifolia* (OFI 45/87). Similarly, a great deal of variability was observed in PAS concentration between species and subspecies and provenances. The highest values were in *L. pallida* and the two *L. diversifolia* subsp. *stenocarpa* provenances (OFI 35/88 and OFI 53/88). When three contrasting *Leucaena* spp. (*L. diversifolia, L. pallida and L. leucocephala)* were fed as supplements to low quality native grass hay, there was an increase in DM intake while intake of digestible DM was only increased by supplementing with *L. pallida* and *L. leucocephala*. However, there were no differences (P>0.05) between treatments in terms of digestible NDF intake. Excretion of N was mainly through faeces (over 90 percent) for all diets. Feeding native grass hay alone or with *L. pallida* or *L. diversifolia* resulted in a negative N-balance. Animals fed *L. diversifolia* had lower (P<0.05) urine N relative to the other animals. This is indicative of the protection from rumen microbes of N by proanthocyanidins in *L. diversifolia*. This result is consistent with rumen degradation results (Table 1).

b.) ***Acacia angustissima* provenances evaluation:** A wide variability was observed in the parameters considered (CP, ADF, NDF, soluble and insoluble PAS and IVDMD). Generally, all provenances had higher CP contents in the leaf than in the stem because the leaf does not contain as much structural material as the stem (data not shown). The range in the leaf IVDMD was from 42% in OFI 65/92 to only 50.9% in OFI 34/88 which was similar to the digestibility coefficients recorded in OFI 66/92 (50.4%) and OFI 68/92 (50.7%). The provenances with high digestibility in *A. angustissima* were superior to *C. calothyrsus* (41% IVDMD) and not very much lower than *L. pallida* (IVDMD of 53.1%).

c) ***Calliandra calothyrsus* provenances evaluation:** A wide variability was found in the parameters measured (ADF, NDF, insoluble and soluble PAS and IVDMD). Some provenances, notably OFI 12/91, OFI 61/92 and to a lesser degree OFI 62/92 appear to have digestibility values that are at least 15% higher than the control provenance, OFI 9/89.

DISCUSSION AND CONCLUSION

From the data on *Leucaena* spp. it is apparent that 3 groups of *Leucaena* are available. The first group is one of low NDF, low to medium PAS and high crude protein concentrations as represented by *L. leucocephala,* its two hybrids with *L. diversifolia*, and *L. shannonii* and *L. salvadorensis*. They represent materials of high nutritive value. Then there is the group which is represented by *L. pallida* and *L. diversifolia* subspecies *stenocarpa* and *diversifolia* to some extent. This group is characterized by high concentrations of PAS with an ABU. value in excess of 45, CP concentration below 20% and NDF values above 35%. These are materials of low nutritive value. The third group is an intermediate group to which the rest of the species, subspecies and provenances belong (including most of the *L. esculenta* species and subspecies). The differences in the world-acclaimed resistance in *L. esculenta* (syn. *L. pallida*) and *L. diversifolia* to the psyllid pest could be related to their condensed tannins content. The efficiency with which these diverse *Leucaena* species and provenances will fit into feeding systems will vary also. Our work has shown lower IVDMD values for *L. diversifolia* and *L. pallida* in addition to higher concentrations of condensed tannin than in *L. leucocephala.* These differences resulted in negative N-balance when the *L. diversifolia* and *L. pallida* were fed as supplements to poor quality native grass hay. These data suggest that consumption of the two *Leucaena* forages (*diversifolia and pallida*) may be limited by the low digestibility/degradability especially for *L. diversifolia.* Thus, while gains may be realized in psyllid resistance of *L. diversifolia* and *L. pallida* relative to *L. leucocephala*, losses in livestock productivity resulting from their use in feeding systems must be anticipated. This is especially important where they are incorporated into concentrate rations as substitutes for expensive commercial protein sources. Other studies have shown that feeding of *A. angustissima* and *C. calothyrsus* as hay has problems of low digestibility and rumen degradability (Ahn *et al.,* 1989; Palmer and Schlick, 1992; Palmer *et al.,* 1994; Dzowela *et al.,* 1995). In the present study the variability found in chemical composition parameters and IVDMD is interesting. Some of the provenances appear to have dry matter digestibility values that are lower than the generally published data of below 40% for the leaf giving options for improvement through selection. In both species, digestibility of the fodder appears to be strongly influenced by the fibre constituents (ADF and NDF) and the concentration of insoluble proanthocyanidins. Regression analyses in our study have established a high negative relationship, in which the IVDMD (%) relationship with chemical composition parameters in both *Acacia* and *Calliandra* provenances are defined by the regression equations:

IVDMD % = -0.340 (DM %) - 0.941 (NDF %)-0.949 (ADF%) + 0.623 (ins. (*Acacia*) PAS) + 0.160 (sol. PAS.)

r^2 = 0.94 ***

and;

IVDMD (%) = -0.141 (DM %) - 0.928 (NDF %) - 0.935 (ADF %) + 0.576 (ins. (*calliandra*) PAS) + 0.739 (sol. PAS).

r^2 = 0.90 ***

The effect of tannins in fodder legumes on intake of cereal crop residues is important for feeding ruminants in the subhumid Southern Africa because these fodder legume trees can be used as protein supplements (Reed *et al.,* 1990). Legume trees with high content of PAS are associated with low intakes of crop residue whereas those that contain low to moderate levels of PAS are associated with high intakes (Woodward and Reed, 1989). Low total intake and low true digestibility of protein in turn, affect rate of gain for growing animals. In our studies the use of *L. esculenta, L. diversifolia* and *L. leucocephala* as supplements has resulted in different utilization efficiencies with *L. diversifolia* producing lower animal performance than the other two species. From this analysis it is evident that the chemical composition of browse species will affect their potential use in feeding systems. Future research emphasis will be directed to fitting the most promising species and provenances into livestock feed delivery in smallholder production systems.

ACKNOWLEDGEMENTS

We thank the Canadian International Development Agency (CIDA) for funding to the SADC-ICRAF Agroforestry Project, Zimbabwe through which this research was done.

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Table 1
Chemical composition of tree fodders from *Leucaena* species compared to native grass hay and IVDMD, DM (%) and N (%) lost after washing and incubating *Leucaena* forage for 24 or 48 hours in the rumen of sheep.

Constituent	Grass Hay	*Leucaena* species LD	LP	LL	SED
Dry matter DM, g/kg	950	942	944	943	-
Organic matter (g/kg DM)	950	930	980	940	_
ADF (g/kg DM)	516	272	325	281	_
NDF (g/kg DM)	772	393	459	371	_
N (g/kg DM)	4.3	26.6	18.2	25.1	_
NDI N (%)	74.4	56.4	54.9	47.8	_
Insoluble PAS (ABU. at $_{550nm}$/g NDF)	1.2	12.8	10.4	8.0	_
IVDMD %	-	48.0	47.8	52.2	-
Washing loss (readily soluble)	DM	19.5	19.9	21.5	1.3
	N	3.7[a]	10.2[b]	8.4[b]	1.4
Rumen degradability	DM	38.1[a]	52.0[c]	41.3[b]	1.5
after 24 hours	N	13.9[a]	48.4[c]	29.0[b]	2.5
Rumen degradability	DM	39.5[a]	56.0[c]	48.1[b]	0.9
after 48 hours	N	19.0[a]	57.3[c]	36.9[b]	1.1

Figures in the row followed by the same letter are not statistically different at P<0.05.
WhereNDI N = Neutral detergent insoluble nitrogen

Table 2
Chemical composition differences of fodders from *Leucaena* species and provenances

Species Provenances	ID Nos	DM (%)	NDF (%)	Insoluble PAS[a]	CP (%)
L. esculenta subsp. *paniculata*	OFI 52/87	89.5	36.5	22.5	22.4
L. esculenta subsp. *esculenta*	OFI 47/87	90.9	40.0	38.2	23.8
L. diversifolia subsp. *diversifolia*	OFI 45/87	91.2	41.9	29.5	17.0
L. diversifolia subsp. *diversifolia*	OFI 46/87	90.2	29.5	26.0	19.4
L. diversifolia subsp. *stenocarpa*	OFI 53/88	92.0	36.3	48.2	17.6
L. diversifolia subsp. *stenocarpa*	OFI 35/88	91.2	38.5	51.6	17.4
L. leucocephala cv. Cunningham	-	91.2	34.6	15.9	27.6
L. pallida	CPI 58980 offspring	90.1	40.6	63.6	19.5
L. leucocephala x *L. diversifolia*	ILCA 15090 (Parent=K743)	90.9	39.3	40.2	22.6
L. leucocephala x *L. diversifolia*	ILCA 15009	90.9	35.1	25.1	19.6
L. shannonnii subsp. *magnifica*	OFI 58/88	92.2	43.6	3.6	24.5
L. shannonii subsp. *magnifica*	OFI 19/84	91.4	49.3	5.6	25.1
L. pulverulenta	OFI 83/87	90.9	38.9	27.9	22.6
L. salvadorensis	OFI 34/87	93.0	40.0	18.4	25.6
Maize stover	R215	91.5	87.9	nil	3.4
Means (*Leucaena*)		91.1	38.9	29.7	21.8
	SD±	±0.89	±4.6	±17.2	±3.4

[a] (ABU at $_{550mn}$/gNDF)