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Effect of inherent polyphenolics on the nutritional value of Namibian browse

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ABSTRACT

Total polyphenolics, condensed tannins and protein precipitating capacity were determined on 20 selected browse species collected in the Highland savanna and Forest savanna and Woodland areas of Namibia and correlated with *in vitro* dry matter digestibility and *in situ* nutrient disappearance. The condensed tannin content of the browsed plants that were investigated varied from 0.02% (*Leucosphaera bainesii*) to 50.9% (*Ozoroa paniculosa*). No consistent relationships ($P > 0.05$) was found between the polyphenolic content and digestibility except that the condensed tannin content of browse correlated negatively ($r = -0.73$; $P < 0.01$) with *in vitro* dry matter digestibility. It was concluded that cattle grazing Namibian rangeland did not consume polyphenolics in sufficient amounts to affect *in vitro* dry matter digestibility, or the *in situ* disappearance of nutrients.

INTRODUCTION

Polyphenolics have been reported to adversely affect nutrient digestibility (Barry & Blaney 1987), voluntary intake (Barry & Duncan 1984) and to decrease palatability (Cooper & Owen- Smith 1985). Conversely, tannins may benefit ruminants by protecting protein from bacterial deamination (Driedger & Hatfield 1972) and preventing bloat (Jones & Lyttleton 1970). In a survey by Rhoades and Cates (1976), approximately 17% of the annuals, 14% of herbaceous perennials, 79% of deciduous perennials and 87% of evergreen woody perennials contained tannins. Loutit, Louw & Seely (1987) reported in the only local study available, the total phenolic content of 17 plant species found in Damaraland, Namibia. The soluble tannin content varied from 0.15% (*Cadaba schroeppelii*) to 4.06% (*Welwitschia mirabilis* seeds) on a wet mass basis. Therefore, this study was undertaken to survey the polyphenolic content of selected indigenous plant species and the effect thereof on *in vitro* dry matter digestibility and *in situ* disappearance of nutrients.

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PROCEDURE

The leaves, apices and fine twigs of browse were collected from two vegetation areas of Namibia. The Highland savanna includes the central mountainous areas of Namibia, and is characterized by trees such as *Combretum apiculatum* subspecies *apiculatum, Acacia hereroensis, A. reficiens* and *A. erubescens* among others. The undisturbed grass-cover consists of climax grasses such as *Anthephora pubescens, Brachiaria nigropedata, Digitaria eriantha* and many other good pasture grasses. A large variety of deciduous trees, such as the *Pterocarpus angolensis* are found in the northern and north-eastern areas of the Forest savanna and Woodland vegetation type. The grasses in these regions are usually hard and unpalatable. In the open Forest savanna, however, a good coverage of climax grasses such as *Brachiaria nigropedata*, *Anthephora pubescens* and *Schmidtia pappophoroides* is found (Giess 1971).

The species sampled represent an important part of the diets of wild (Bester 1984) and domestic ruminants (personal communication, M.A.N. Müller, Directorate Forestry, Windhoek). Sampling took place during the end of the warm dry season when browse would most likely be available and utilized by cattle. Samples were selected randomly from several trees and many locations on a tree and combined. A specimen for each collection has been sent to the National Botanical Research Institute of Namibia, Windhoek, for positive identification. The climate in both areas is characterized by distinct wet and dry seasons with the dry season typically extending from May to November, and the wet season from December to April.

After collection, samples were dried in a force-draught oven (24-hour, 55°C), ground in a laboratory mill (1-mm mesh screen) and stored in sealed plastic containers until analyzed. Samples were assayed for dry matter (DM), organic matter (OM) and ether extract (EE) according to the methods of the Association of Official Agricultural Chemists (A.O.A.C. 1984), crude protein (CP) (Anonymous 1983), and neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) by sequential analysis, following (Van Soest & Robertson 1980). Total phenolics (PHEN) (A.O.A.C. 1984), condensed tannins (CT) (Price *et al.* 1978) and protein precipitating capacity (PPC) (Hagerman & Butler 1978) were determined on samples as they most likely appear to identify detrimental polyphenolic fractions.

The two-stage *in vitro* technique (Tilley & Terry 1963) with slight modifications pertaining to the addition of nitrogen as described by Engels and Van der Merwe (1967) was used to estimate the percentage *in vitro* digestibility of dry matter. The *in situ* disappearance of DM, CP, NDF, ADF, ADL were estimated for an incubation period of 48h (Mehrez & Ørskov 1977). The mean flow rate constant (k) from the rumen was estimated from the slope of the regression of the declining chromium concentration in feaces on time (Ørskov & McDonald 1979). Correlations between polyphenolic content and *in vitro* DM digestibility and *in situ* DM, CP, NDF, ADF and ADL disappearance were computed according to the procedures by Snedecor & Cochran (1984).

Table 1: Nutrient content, polyphenolic content and *in vitro* dry matter digestability of ten browse species of the Highland savanna (dry matter basis).

Species	OM* (%)	CP (%)	ADF (%)	NDF (%)	ADL (%)	EE (%)	GE (MJ/kg)	PHEN (%)	CT (%)	PPC (%)	IVDMD (%)
Acacia tortilis	96.85	10.59	46.47	57.10	28.34	1.63	19.29	6.68	4.90	4.93	47.93
Acacia mellifera	96.38	9.03	38.22	55.09	16.25	1.73	19.13	3.48	.42	.60	51.83
Acacia hebeclada	96.16	8.92	46.75	59.08	21.13	1.85	18.83	3.39	2.54	.84	49.27
Tarchonanthus camphoratus	96.23	9.07	43.08	45.31	16.89	5.70	21.06	5.99	.64	2.71	50.27
Rhus marlothii	96.66	9.80	27.61	49.56	13.50	.81	19.17	14.41	18.16	4.21	47.60
Leucosphaera bainesii	96.28	9.56	51.95	51.41	13.96	3.29	19.43	3.64	.02	2.26	49.54
Ziziphus mucronata	95.76	9.33	50.91	49.12	16.06	1.17	18.96	7.21	5.17	6.75	50.55
Grewia flava	95.80	8.39	45.53	54.70	23.32	2.12	18.70	4.95	3.04	3.12	49.38
Catophractes alexandri	95.70	7.07	54.61	53.04	17.50	2.25	18.66	5.47	.04	1.63	53.11
Boscia albitrunca	96.49	10.00	41.89	53.50	19.80	1.83	19.11	2.34	.17	1.97	55.67
Mean	96.23	9.18	44.70	52.79	18.68	2.24	19.23	5.76	3.51	2.90	50.52
Standard deviation	.37	.92	7.36	3.87	4.34	1.31	.65	3.25	5.23	1.82	2.33

*OM = organic matter; CP = crude protein; ADF = acid detergent fibre; NDF = neutral detergent fibre; ADL = acid detergent lignin; EE = ether extract; GE = gross energy (in MJ/kg); PHEN = total phenolics (% tannic acid equivalents); CT = condensed tannins (% catechin equivalents); PPC = protein precipitating capacity (% tannic acid equivalents); IVDMD = *in vitro* dry matter digestibility.

Table 2: Nutrient content, polyphenolic content, *in vitro* dry matter digestibility and *in situ* nutrient disappearance* (48h) of ten browse species of the Forest and Woodland savanna (dry matter basis).

Species	OM** (%)	CP (%)	ADF (%)	NDF (%)	ADL (%)	PHEN (%)	CT (%)	PPC (%)	IVDMD (%)	ISDMD (%)	ISCPD (%)	ISNDFD (%)	ISADFD (%)	ISADLD (%)
Acacia hebeclada	93.84	17.18	51.14	66.52	26.84	1.52	3.15	.42	53.58	56.69	64.58	70.30	59.07	60.00
Acacia mellifera	94.14	13.95	31.00	51.72	12.79	4.34	6.20	.42	63.84	68.31	69.66	75.52	63.76	68.38
Acacia karoo	96.05	9.80	23.77	44.24	5.70	11.29	14.92	9.17	48.41	52.19	39.91	54.69	38.39	51.72
Dichrostachys cinerea	94.94	19.03	58.70	72.85	33.15	2.98	5.48	.43	36.48	28.53	22.08	58.87	72.57	50.71
Albizia anthelmintica	96.09	12.07	50.26	59.30	19.98	2.69	.40	21.40	54.39	45.96	56.47	61.54	60.21	62.82
Lonchocarpus nelsii	94.58	16.19	51.90	74.29	19.55	3.32	2.55	.42	45.60	27.63	24.99	58.35	26.05	53.72
Terminalia sericea	92.40	15.63	57.90	67.75	34.44	7.71	30.00	.64	33.06	42.89	54.24	64.46	83.82	67.08
Combretum apiculatum	96.18	9.56	27.48	28.18	7.60	17.69	.97	18.34	47.99	73.20	72.45	62.25	61.74	74.31
Ozoroa paniculosa	74.69	12.49	40.89	74.22	21.03	7.42	50.97	1.03	34.20	26.50	19.23	59.81	59.24	30.68
Tricholaena monachne	94.25	16.91	53.82	81.25	29.41	2.86	3.38	.42	29.64	27.87	36.97	63.36	59.82	42.08
Mean	92.72	14.28	44.69	62.03	21.05	6.18	11.80	5.27	44.72	44.98	46.06	62.92	58.47	56.15
Standard deviation	6.11	3.06	12.31	15.54	9.58	4.79	15.57	7.77	10.51	16.55	19.06	5.77	15.30	12.49

* Disappearance rate constant = 0.0168/h

**OM = organic matter; CP = crude protein; ADF = acid detergnt fibre; NDF = neutral detergent fibre; ADL = acid detergent lignin; PHEN = total phenolics (% tannic acid equivalents); CT = condensed tannins (% catechin equivalents); PPC = protein precipitating capacity (% tannic acid equivalents); IVMD = *in vitro* dry matter digestibility; IS = *in situ* DM, CP, NDF, ADF, ADL disappearance.

RESULTS AND DISCUSSION

The nutrient and polyphenolic content, *in vitro* dry matter digestibility and *in situ* nutrient disappearance of the various browse species is presented in Table 1 and 2. The condensed tannin content of the browsed plants that were investigated varied from 0.02% (*Leucosphaera bainesii*) to 50.9% (*Ozoroa paniculosa*). Comparable browse species in Transvaal, South Africa, indicate a mean condensed tannin concentration of 4.42% (Van Hoven 1984b). Total phenolic content ranges between 1.52% and 17.69% comparable to 0.15% to 4.06% obtained from species collected in Damaraland, Namibia (Loutit *et al.* 1987).

Correlations between polyphenolic content and *in vitro* dry matter digestibility and *in situ* nutrient disappearance are evaluated in Tables 3 and 4. Correlation coefficients between polyphenolics and dry matter, neutral detergent fibre, acid detergent fibre and lignin disappearance were not significant (Table 4). This is in agreement with studies conducted by Ford (1978), where condensed tannins did not fully explain the correlation coefficients with *in vitro* dry matter digestibility and *in situ* nutrient disappearance.

Table 3: Correlation matrix of polyphenolic content and *in vitro* dry matter digestibility of the Highland savanna browse species.

	PHEN	CT	PPC
PHEN	-		
CT	+0.58*	-	
PPC	+0.84**	+0.21	-
IVDMD	-0.16 -	0.73**	+0.22

PHEN = total phenolics; CT = condensed tannins; PPC = protein precipitating capacity; IVDMD = *in vitro* dry matter digestibility.
*P < 0.05
**P < 0.01

Table 4: Correlation matrix of polyphenolic content and *in vitro* dry matter digestibility and *in situ* nutrient disappearance of the Forest savanna and Woodland browse species.

	PHEN	CT	PPC
PHEN	-		
CT	+0.20	-	
PPC	+0.48	-0.31	-
IVDMD	-0.02	-0.47	+0.35
ISDMD	+0.50	-0.34	+0.45
ISCPD	+0.28	-0.40	+0.42
ISNDFD	-0.27	-0.18	-0.25
ISADFD	-0.01	+0.22	-0.07
ISADLD	+0.30	-0.53	+0.41

PHEN = total phenolics; CT = condensed tannins; PPC = protein precipitating capacity; IVDMD = *in vitro* dry matter digestibility.
*P < 0.05
**P < 0.01

The significant negative effect ($r = -0.73$, $P < 0.01$) of condensed tannins on *in vitro* dry matter digestibility (Table 3) is consistent with results obtained using varieties of single species differing in tannin content, for example crownvetch (*Coronilla varia* L.) (Burns & Cope 1974), *Sericea lespedeza* (Cope & Burns 1971), birdsfoot trefoil (*Lotus corniculatus* L.) (Chiquette *et al.* 1988). Tannins depress *in vitro* dry matter digestibility by forming an insoluble complex with leaf protein, as well as with the enzyme, pepsin. A further possible effect is the inhibition of micro-organisms in the *in vitro* assay by free phenolic compounds, resulting in the reduction of organic matter digestibility.

The protein precipitating capacity is considered to be the measure of biological activity of tannin rich food. In the present study there was no significant correlation, between protein precipitating capacity and dry matter digestibility or nutrient disappearance (Table 4). However, as it was indicated in this study ($r = 0.84$, $P < 0.01$) (Table 3) leaves, although having a mixture of tannins, should have a higher protein precipitating capacity, as they contain the highest content of polyphenolics.

CONCLUSIONS

Care must be exercised when interpreting these results, especially as regards to polyphenolic compounds. Concentrations of tannins vary widely "in time and space both between and within plant species" (Zucker 1983). Drying of the samples at 55°C might underestimate soluble phenolic content in the original sample, since these compounds tend to oxidize and polymerize quite readily (Mould & Robbins 1981). However, research by Robbins *et al.* (1987) indicate that a substantial fraction of these compounds remains soluble after drying.

The wide variation in the data between species, between Table 1 and Table 2 and sometimes also between other nutrient tables could be attributable to differences in soil type, soil moisture content, grazing pressure as well as climate. Species described in Table 1 being sampled on a higher clay content soil (Q19-1a) and in a lower rainfall area, than those described in Table 2, being sampled on a sandy, lower clay, more sour soil (Qc38-1a) (Anonomous 1974). "Maku" lotus contains 8 - 10% condensed tannin (DM basis) when grown in acid (pH = 4.5- 4.8) soils of low fertility compared with 2 - 4% condensed tannin (DM basis) when grown on high fertility lowland soils (Barry & Forss 1983).

Under physiological conditions, dietary tannin is probably not accessible to digestive enzymes. Dietary proteins (Burritt *et al.* 1987) or specialized tannin-binding proteins of the saliva (Mehanso *et al.* 1983) are available to form complexes with dietary tannin before it is exposed to digestive enzymes. Even if digestive enzymes are subject to inhibition by dietary tannins, the effect is likely to be reversed by detergents such as bile acids (Blytt *et al.* 1988).

This study indicated that cattle browsing trees and shrubs on Namibian rangeland, did not consume polyphenolic or tannin compounds in quantities sufficient to mar-

kedly affect nutrient digestibility. Drawing a conclusion on only 20 species, could grossly underestimate the phenolic and/or nutrient content. However, during certain times (late winter) of the year or within game enclosures (Van Hoven 1984a), consumption of a vast amount of plant species with a high phenolic or tannin content, could possible alter fermentation and digestion.

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