FEED POTENTIAL OF *ACACIA* SPECIES TO RUMINANTS IN BOTSWANA

POTENCIAL ALIMENTICIO PARA LOS RUMIANTES DE LAS ESPECIES DE *ACACIA* DE BOTSWANA

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ADDITIONAL KEYWORDS

Browse. Nutritive value. Processing. Tannin. Goats.

PALABRAS CLAVE ADICIONALES

Pastos leñosos. Valor nutritivo. Procesado. Tanino. Cabras.

SUMMARY

Four separate studies were conducted to evaluate the feed value of indigenous browses of Botswana. In the first study, browse seeds from nine *Acacia* species were analysed for proximate composition and *in vitro* dry matter digestibility. Nutrient composition of the seeds varied, crude protein content of *Acacia robusta* was 12.52 p.100 while *Acacia erubescens* was 21.82 p.100. The second study was to evaluate the influence of processing on fibre content and *in vitro* digestibility of seeds from five browse species using three physical forms of the seeds namely whole seeds, coarsely ground and finely ground. Physical forms of the seeds affected the neutral detergent fibre, acid detergent fibre and dry matter digestibility of all seeds evaluated. The third study was to evaluate the tannin content and crude protein degradation of leaves and twigs from indigenous *Acacia* species in Botswana rangelands. Correlation between crude protein was found to be negative (-0.582). The fourth study was a feeding trial lasting 98 days using 12 yearling Tswana male-goats fed buffalo grass hay as basal diet and *Acacia fleckii* or *Acacia tortilis* as supplements and lucerne to the control group to evaluate animal performance on these browses. Average daily dry matter intake of goats on *Acacia fleckii* as supplement was 768.40 g and 790.79 g for those on *Acacia tortilis* as supplements. The average daily body weight gain was higher for goats on lucerne 81 g compared to 72 g and 76 g for those on *Acacia fleckii* and *Acacia tortilis* as supplements respectively. Goats fed on the *Acacia* species consumed the leaves, twigs and even the thorns leaving only the stalks.

RESUMEN

Se han realizado cuatro estudios diferentes para evaluar el valor alimenticio de forrajes leñosos indígenas de Botswana. En el primero, se ha analizado la composición nutritiva y digestibilidad *in vitro* de la materia seca de semillas de nueve especies de *Acacia.* La composición nutritiva de las semillas varió; así, el contenido de proteína bruta de *Acacia robusta* fue 12,52 p.100 mientras que el de *Acacia erubescens* fue 21,82 p.100. El segundo estudio fue para evaluar la influencia del procesado sobre el nivel de fibra y

la digestibilidad *in vitro* de semillas de cinco especies, presentadas como semillas enteras, molidas groseramente y finamente molidas. La forma física afectó a la fibra neutro detergente, fibra ácido detergente y digestibilidad de todas las semillas. En el tercer estudio se evaluó el contenido de taninos y la degradación de la proteína de hojas y brotes de especies indígenas de *Acacia* en Botswana. El cuarto estudio fue un ensayo de alimentación durante 98 días usando 12 machos de la raza caprina Tswana alimentados con heno de buffalo grass como dieta basal y *Acacia fleckii* o *Acacia tortilis* como suplementos y alfalfa en el grupo control para evaluar la eficacia de los animales con los mencionados forrajes. La ingestión media diaria de materia seca de las cabras cuando eran suplementadas con *Acacia fleckii* fue de 768,4 g y de 790,79 g para *Acacia tortilis.* La ganancia diaria de peso vivo fue superior, 81 g, con suplemento de alfalfa que la conseguida con *Acacia fleckii* o *Acacia tortilis,* 72 y 76 g respectivamente. Las cabras alimentadas con *Acacia* consumieron las hojas, brotes e incluso las espinas dejando sólo los tallos.

INTRODUCTION

There are about two million, ninety-two thousands and four hundred goats in Botswana (MOA 1990) with over 97 p.100 on communal lands under extensive management. Goats thrive well in the semi-arid regions of Botswana due to their ability to feed on different types of plant species, mainly browses and grasses. The mobile upper lip of the goat enables it to browse a variety of plants to obtain nutrients for its maintenance and production under harsh conditions.

Acacia is the most important single genus in Botswana (Timberlake, 1980). The leaves of most Acacias are distinctively feathery and consist of many leaflets. The number, shape and size of leaves pinnae and leaflets is often distinctive for certain species. Acacias belong to the family Leguminosae, many species of which are quite rich in proteins and minerals. Acacias' leaves, twigs and pods contain fairly high concentrations of protein. The seeds in particular have high protein content, but normally, pass through the herbivore's system without being digested due to the hard covering. During the prolonged dry season of about 8 months in a year especially drought years, *Acacia* species serve as source of much needed nutrients to the domestic herbivores and wildlife since 97 p.100 of the domestic ruminants are kept extensively on the ranges. It is important to evaluate the feed potential of the numerous *Acacia* species in Botswana for nutrient composition in leaves, twigs and seeds. Also, it is vital to examine methods of improving the utilization of the Acacia seeds since a high amount of protein is concentrated there. *Acacia* species contain some anti-nutritional factors like tannins; consequently it is useful to determine the tannin levels in these common *Acacia* species in Botswana. Lastly, the performance of the animals on these *Acacia* species as supplementary feeds will show the feed value of the *Acacia* browses to the ruminant.

Acacia fleckii and *Acacia tortilis* are the most widespread and common throughout much of Botswana and goats browse heavily on these *Acacia* species. It will be beneficial to evaluate these Acacias as feed supplements to goats. On the ranges, a large proportion of the seeds of these browses normally

pass undigested through the animal's crushing or changing the physical state of the seeds may help in the utilisation of the proteins and other nutrients that are contained in the seeds. Tannins are complex polyphenolic compounds with great structural diversity which can be present in browse plants and influence digestibility of the protein in the browse. It is therefore important that the tannin level of the browse plants should be analysed to obtain an estimate of the inhibitory effect on crude protein disappearance in the rumen that would result after consumption of such feed. This study therefore is to evaluate feed potential of Botswana Acacias' for nutrient and tannin composition and utilisation as supplementary feed.

MATERIALS AND METHODS

Four trials were conducted to evaluate feed value of browse. In Trial 1, the nutrient composition (proximate, macro and micro minerals) were evaluated while Trial 2 involved fibre analyses and evaluation of browse seeds' processing using three physical forms. Tannin contents of some browse leaves and twigs were evaluated in Trial 3 while Trial 4 was conducted to study performance of Tswana goats on some browse species as supplements.

Trial 1

Seeds (mature, dry) from nine locally available *Acacia* species belonging to Mimosodeae subfamily namely *Acacia karoo, A. rehmannaiana, A. nigrescens, A. arenaria, A. robusta, A. erubescens A. erioloba, A. nilotica* and *A. tortilis* collected from the savanna and woodlands of Botswana were analysed for chemical composition and dry matter digestibility.

Trial 2

Seeds from five indigenous *Acacia* species namely *A. hebeclada, A. leuderitzii, A. erioloba, A. tortilis* and

Table I. *Dry matter (dm) content (g/kg) and chemical composition (g/kg) of feeds fed to experimental goats**. (Nivel de materia seca (g/kg) y composición química (g/kg) de los alimentos suministrados a las cabras de la experiencia)*.

	Buffalo grass	Lucerne	*A. fleckii*	*A. tortilis*
Dry matter	933.3	950.1	489.9	495.6
Crude protein	69.7	142.6	139.8	126.1
Crude fibre	279.7	296.3	280.4	269.3
Crude fat	19.6	28.5	49.6	35.6
Ash	11.8	68.7	72.5	69.9

*Goats on all diets were allowed free access to mineral block containing (in addition to NaCl): Calcium 120.0, Phosphorus 60.0, Sulphur 25.0, Fluorine 0.4 (in g/kg) and Iron 750.0, Manganese 600.0, Zinc 600.0, Copper 150.0, Iodine 7.5, Cobalt 1.5 and Selenium 1.5 (in mg/kg).

Table II. In vitro *dry matter digestibility (DMD) and nutrient composition of the seeds of some indigenous* Acacias *in Botswana.* (Digestibilidad *in vitro* de la materia seca (DMD) y composición nutritiva de las semillas de algunas *Acacias* índigenas de Bostwana).

	(in g/100g DM)				
	DM	DMD	Ash	CP	Extr. fat
A. tortilis	90.90	56.17	4.50	20.16	2.86
A. robusta	90.70	48.49	4.20	12.52	2.29
A. nilotica	91.95	50.20	4.15	17.64	4.04
A. arenaria	92.55	53.13	4.05	19.93	5.00
A. erioloba	91.10	51.81	3.20	18.88	3.67
A. nigrescens	91.90	58.42	3.40	17.14	4.16
A. karoo	91.75	55.99	4.20	13.67	5.42
A. rehmanniana	92.00	46.00	4.75	12.74	4.19
A. erubescens	91.55	62.04	4.10	21.80	4.84

A. robusta obtained from Botswana range lands were evaluated. The seeds were randomly assigned into three physical forms namely: (a) whole seeds (b) coarse texture was obtained by grinding the seeds to pass through 1-5 mm sieve size and (c) fine texture was ground to pass through 0.1-0.2 mm sieve size.

ANALYTICAL METHODS

Analyses for proximate composition of the seeds in trial 1 were done using the procedures of A.O.A.C. (1990). The mineral composition was determined on ash using atomic absorption spectrophotometer (Varian A A10) after hydrochloric acid digestion and flame photometer was used for potassium and sodium. Crude protein was determined by the Kjeldahl method using semi-automatic equipment (Bach 323 distillation unit). *In vitro* dry matter digestibility was done for trials 1 and 2 using the method of Tilley and Terry (1963) modified by Van Soest (1967). In trial 2, the seeds were analysed for neutral detergent fibre (NDF) using the procedures of Van Soest and Robertson (1980).

Table II (continuation). *Mineral composition of the seeds of some indigenous Acacias in Botswana.* (Composición mineral de las semillas de algunas Acacias indígenas de Bostwana).

	(Macrominerals in g/100g DM)					(Microminerals in mg/kg DM)			
	Ca	P	K	Na	Mg	Cu	Fe	Mn	Zn
A. tortilis	0.60	0.25	1.32	0.05	0.22	53	70	13	45
A. robusta	0.80	0.18	0.94	0.06	0.24	37	90	26	33
A. nilotica	0.57	0.41	1.60	0.04	0.27	27	92	27	87
A. arenaria	0.37	0.48	1.39	0.05	0.20	21	77	9	54
A. erioloba	0.27	0.35	1.76	0.06	0.24	20	27	1	39
A. nigrescens	0.52	0.29	0.99	0.04	0.40	21	40	20	37
A. karoo	0.66	0.33	1.32	0.08	0.30	24	50	21	20
A. rehmanniana	0.88	0.32	1.10	0.02	0.29	28	57	13	24
A. erubescens	0.91	0.37	0.94	0.07	0.37	42	50	20	21

Table III. *Influence of physical forms on* in vitro *dry matter digestibility, neutral detergent fibre and acid detergent fibre (in g/100 g DM) of five* Acacia *species seeds in Botswana.* (Influencia de la forma física sobre la digestibilidad *in vitro* de la materia seca, fibra neutro detergente y fibra ácido detergente (en g p.100 g de materia seca) de semillas de cinco especies de *Acacia* en Bostwana).

	Physical seed forms			
	Whole	Coarse	Fine	SEM
A. erioloba				
DMD	11.8[a]	46.6[b]	51.8[b]	3.5
NDF	18.4[a]	47.1[c]	31.7[b]	2.8
ADF	11.3[a]	25.1[b]	22.6[b]	1.7
A. hebeclada				
DMD	19.8[a]	57.4[b]	55.0[b]	2.7
NDF	9.4[a]	59.4[c]	33.3[b]	1.2
ADF	7.7[a]	31.5[c]	21.8[b]	1.6
A. leuderitzii				
DMD	18.9[a]	54.9[b]	52.7[b]	5.4
NDF	11.1[a]	40.3[b]	38.6[b]	2.5
ADF	12.3[a]	25.7[c]	18.2[b]	1.5
A. robusta				
DMD	8.4[a]	44.6[b]	47.5[b]	3.7
NDF	11.4[a]	47.8[c]	38.3[b]	2.4
ADF	9.7[a]	36.9[c]	17.2[b]	3.2
A. tortilis				
DMD	12.0[a]	47.8[b]	53.7[b]	2.3
NDF	16.1[a]	43.3[c]	31.7[b]	3.1
ADF	11.7[a]	25.3[b]	26.5[b]	2.1

SEM standard error of the mean (8 observations per mean).
[abc]values on the same line with different superscripts are different, p<0.05.

Trial 3

Leaves and twigs of eleven different *Acacia* species were collected from the rangelands in Kgatleng, Kweneng and Central districts of Botswana. The leaves and twigs were dried, ground and sifted through 2 mm sieve. The samples were used for forage quality evaluation using the nylon bag method by Orskov *et al.* (1980) using two fistulated Simmental steers. The steers were fed on 1: 1 ratio of *Cenchrus ciliaris* chopped hay and lucerne hay during the degradability period. Samples were degraded in triplicate after 72h incubation. Tannin determination was done using the procedures of Burns and Cope (1974).

Trial 4

The experiment was conducted at Botswana College of Agriculture Content farm, Gaborone from late November 1995 to early March 1996 for a period of 14 weeks (98 days). Twelve Tswana yearling male goats were divided into three groups of four animals in a completely randomised design. Buffalo grass hay (*Buchloe dactyloides*) constituted 60 p.100 of the ration as basal diet to all goats while the control group received lucerne hay (*Medicago sativa)* as supplement. The other two groups were supplemented with *Acacia fleckii* and *Acacia tortilis*. The legumes formed 40 p.100 of the ration offered to the goats daily on dry matter basis. Water was provided daily and the goats were individually penned under a common roof. Cleaning of the pens and removal of left-overs of the previous day was done daily before placement of the days' ration. Water and feed left were measured daily while the goats were weighed every two weeks, before the morning feeding. The three treatment groups were:

Control: Buffalo grass plus lucerne.

Treatment 1: Buffalo grass plus *Acacia fleckii*.

Treatment 2: Buffalo grass plus *Acacia tortilis.*

All goats were provided with a commercial mineral block *ad libitum.*

A measuring cylinder was used to measure the volume of water given and left-overs while a platform electronic scale was used to measure the feed given and left-overs. An avery walk-in scale was used to measure the weight of each goat every two weeks. Proximate analysis of feeds fed were done using the procedures of A.O.A.C. (1990). Data collected were subjected to analysis of variance following the procedures of Steel and Torrie (1980).

RESULTS

The results are given in **tables II, III, IV** and **V**. Chemical composition and *in vitro* dry matter digestibility (DMD) are shown in **table II** while **table III** shows effect of processing on the five *Acacia* species seeds on NDF, ADF and DMD. The DMD of the seeds increased significantly ($p<0.05$) with processing. **Table IV** shows the tannin content and crude protein (CP) disappearance in the rumen of some indigenous Botswana Acacia leaves and twigs. Tswana goats' performance on *Acacia fleckii* and *Acacia tortilis* as supplements are shown in **table V** and shows no difference ($p>0.5$) on weight gains compared to lucerne hay as supplements.

DISCUSSION

Botswana livestock production is

Table IV. *Percent crude protein (CP) and tannin contents, dry matter digestibility (DMD) and CP disappearance of browse after 72 h incubation in rumen.* (Porcentaje de proteína bruta, contenido de taninos totales, digestibilidad de la materia seca (DMD) y desaparición de proteína bruta del forraje leñoso después de 72 horas de incubación en el rumen).

Browse Species	Crude protein p.100 Leaves and twigs	Residues	Disappearance	p.100 DMD	T. Tannin p.100 Vanillin - HCL
Acacia burkei	15.78	11.61	26.43	37.00	0.8
Acacia erubescens	14.81	9.55	35.52	44.38	1.9
Acacia fleckii	12.56	8.47	32.54	48.54	1.3
Acacia galpanii	15.62	11.65	25.42	37.19	11.2
Acacia girraffae	15.65	9.44	39.68	40.32	0.5
Acacia kirkii	16.38	11.87	27.50	33.13	6.5
Acacia mellifera	11.63	5.82	49.96	58.61	0.9
Acacia robusta	10.20	6.21	39.07	49.29	8.0
Acacia karoo	12.57	8.65	31.18	42.63	2.28
Acacia tortilis	12.86	9.18	25.84	41.85	1.77
Acacia nilotica	12.06	9.95	17.49	38.78	2.12

heavily dependent on the range. The country has a well defined short rainy season and a prolonged dry season which lasts for about eight months of the year. It is during the dry season and drought period that browses such as *Acacia* species are very important to livestock nutrition. The Ca content for all the evaluated seeds are lower than those reported by Terry *et al.* (1992) while the Mg contents fall below adequate levels reported by McDowell (1985) for normal growth of beef cattle. Acacia seeds contained low levels of Na.

Acacia tortilis is the most abundant browse in Botswana rangelands thus readily available and accessible to grazing ruminants. When the seeds are crushed, the digestibility improved from 12.0 p.100 for whole seeds to 53.7 p.100 for finely ground seeds. Neutral detergent fibre was highest for coarsely ground *A. tortilis* seeds with 47.8 p.100 digestibility. The grazing animals on the range swallow these seeds whole a lot of times which means that the seeds pass through the gut poorly digested and the animal derive minimal benefit from the seeds. This can be attributed to the fact that the whole seeds have hard outer covering hence microbial activities in the rumen could not fully utilize the inner seed contents like in crushed seeds. The results of this study are in line with the finding of Teixeira *et al.* (1993) which showed that reduction in particle size increased dry matter digestibility in cotton seeds.

Table V. *Intake and response of Tswana goats during the experimental period.* (Ingestión y respuesta de las cabras Tswana durante el periodo experimental).

Feed types	Control Buffalo grass + Lucerne hay	Treatment 1 Buffalo grass + *Acacia fleckii*	Treatment 2 Buffalo grass + *Acacia tortilis*	
Initial liveweight (kg)	20.25 ± 5.33	20.31 ± 5.07	20.00 ± 3.30	NS
Final liveweight (kg)	28.21 ± 4.55	27.18 ± 4.02	27.67 ± 3.78	NS
Metabolic mass (kg $W^{0.75}$)	10.92 ± 0.89	10.73 ± 0.95	10.83 ± 0.82	NS
Body weight gained (kg)	7.97 ± 0.84	7.06 ± 1.10	7.43 ± 0.64	NS
Average daily body weight gained (kg)	0.081 ± 0.0085	0.072 ± 0.0109	0.076 ± 0.0065	NS
Average daily dry matter intake (g)	717.62 ± 14.44^{a}	768.78 ± 26.04^{b}	790.79 ± 28.62^{b}	*
Average daily DM buffalo grass hay intake (g)	302.25 ± 18.72^{a}	466.03 ± 22.20^{b}	481.40 ± 21.37^{b}	*
Average daily DM legume intake (g)	449.73 ± 7.22^{a}	336.56 ± 13.97^{b}	344.55 ± 15.85^{b}	*
DM intake p. 100 body weight	2.96 ± 0.03	3.25 ± 0.05	3.30 ± 0.04	NS
DM/gain (g/g) (feed conversion)	8.86 ± 0.05^{a}	11.85 ± 0.07^{b}	11.56 ± 0.04^{b}	*
DM Legume intake p. 100 body weight	1.86 ± 0.02^{a}	1.42 ± 0.04^{b}	1.44 ± 0.03^{b}	*
DM intake g/kg $W^{0.75}$	65.72 ± 1.38^{a}	71.61 ± 1.02^{b}	73.02 ± 1.56^{b}	*
Average daily water intake (ml)	1977.96 ± 63.14^{a}	1549.67 ± 72.30^{b}	1537.09 ± 82.14^{b}	*
Average daily water intake ml/kg $W^{0.75}$	181.13 ± 5.31^{a}	144.42 ± 6.12^{b}	141.93 ± 7.32^{b}	*

± SD = Standard deviation. ^{abc}values on the same row with different superscripts are different, $p<0.05$. NS = $p> 0.05$.

Correlation between crude protein disappearance and tannin content **(table IV)** was negative (-0.582) and this is significant ($p<0.05$) while the correlation between percent DMD and tannin content was also negative (-0.29) but not significant ($p>0.05$). *Acacia fleckii* had an average DMD (48.54 p.100) with a low tannin content of (1.3 p.100) which suggested that *Acacia fleckii* could be a useful forage for ruminant livestock especially during the long dry season in Botswana. *Acacia galpanii* had a low DMD and a very high tannin content with low crude protein disappearance in the rumen. This suggests that *A. galpanii* is of poor nutritional value to ruminant livestock. The concept that protein-tannin interactions are both protein-dependent and tannin-dependent was demonstrated by Asquith and Butler (1986). Verzele *et al.* (1986) stated that tannins present in browse leaves may be of different molecular weights. Their tendency to interact with proteins differed, such that those with higher molecular weight have more interactions with proteins making them less available. Robbins *et al*. (1991) observed that tannins formation of indigestible complexes with protein varies with animal species.

The chemical composition of the *Acacia* species **(table I)** indicates that *Acacia tortilis* and *A. fleckii* are good sources of protein. In addition, they are rich sources of crude fat and total minerals which is relatively higher than those present in lucerne. **Table V** shows that the goats on the *Acacia species* consumed more feed than those on lucerne. The goats fed on *Acacia tortilis* supplement consumed more Buffalo grass hay than the other two groups. The daily DM intake was higher for goats fed on *Acacia tortilis* as supplement (790.79 g) compared to 717.62 g DM intake for goats fed on lucerne as supplement. The DM intake was also higher in the *A. tortilis* supplemented diet when expressed either as a percentage of body weight or on the basis of metabolic body weight ($W^{0.75}$). **Table V** shows that the legume DM intake as p.100 of body weight is 1.42 for *Acacia fleckii* and 1.44 for *Acacia tortilis* which falls within the range of optimum dietary levels (ODL) of 0.9-1.5 p.100 as percentage of live weight suggested by Devendra (1988).

Feed conversion and average daily gain were best for goats fed on Lucerne as supplement. However, the difference in average daily gain was not statistically significant ($p>0.05$). Overall, feed conversion and growth rates were good for the three diets.

Acacia fleckii and *Acacia tortilis* belong to the subfamily Mimosaceae which is the most important source of browse in many African countries (Agishi, 1984) both in number and by density therefore they are readily available and accessible especially in Botswana. These *Acacia* species can serve as supplementary feeds to grazing small ruminants especially goats thus reducing the cost of feeding.

Results of trial 4 show a significant difference in water intake ($p<0.05$) between the three groups of goats. In the study, water intake varied with types of feed, indicating that water in feed influenced the amount of drinking water required by goats. Goats in the control group on lucerne hay as

supplementary feed drank a significantly ($p<0.05$) higher quantity of water (1977.96ml) compared to goats on the *Acacia species* which contained more water **(table I)**. Average daily water intake ml/kg$^{0.75}$ was significantly ($p<0.05$) higher for goats fed lucerne hay as supplement 181.13 compared to 144.42 and 141.93 for goats supplemented with *A. fleckii* and *A. tortilis* respectively. Results of this study are in line with the findings of Aganga (1992) that water intake of Nigerian goats were influenced by diet types, combinations and processing methods. *Acacia fleckii* and *Acacia tortilis* used in this study were obtained from the rangelands surrounding the goat units without cost, i.e. cost of production of Tswana goats could be reduced by using these *Acacia* species as supplementary feeds.

CONCLUSIONS

This study showed that *Acacia* seeds and leaves could provide part of the solution to shortage of energy and protein feedstuffs during the dry season to supplement low quality forage grazed by ruminant livestock. Also the study showed that Botswana indigenous *Acacia* plants contain varying amounts of tannins which may influence protein availability in some of the browse leaves and twigs to ruminants. The digestibility of the seeds could be improved by coarsely crushing them if used as supplementary feeds.

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Recibido: 27-10-97. Aceptado: 31-3-98.