SIGNIFICANCE OF BROWSES IN THE NUTRITION OF TSWANA GOATS

LOS FORRAJES LEÑOSOS EN LA NUTRICIÓN DE LAS CABRAS TSWANA

Aganga, A.A., T. Adogla-Bessa, U.J.Omphile and K. Tshireletso

Department of Animal Science and Production. Botswana College of Agriculture. Private Bag 0027. Gaborone. Botswana.

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Nutrient composition. Intake.

PALABRAS CLAVE ADICIONALES

Composición nutritiva. Ingestión.

SUMMARY

The nutritional value of shrubs and tree fodders browsed by Tswana goats in Botswana were evaluated. In the first study, seeds from twenty browse species were analysed. Nutrient composition of the seeds varied widely. Crude protein content of *Bauhania petersiana* was 6.42 g/100g while *Sterculia africana* was 35.59 g/100g.

The second study showed that twigs from five browses varied in tannin and nutrient composition. *Acacia tortilis* and *Grewia flava* leaves and twigs had similar crude protein content but their tannin contents differ significantly ($p<0.05$). The third study was to evaluate available browse resources for Tswana goats reared extensively in South East Botswana. The most commonly occuring species were *Acacia erioloba, A. tortilis*, *Dichrostachys cinerea*, *G. flava* and *Terminalia seracea*. Browses varied in their seasonal availability but *A. tortilis*, *G. flava* and *T. seracea* were present on the ranges all year round. The fourth study was a feeding trial using yearling males fed buffalo grass hay (*Buchloe dactyloides*) as basal diet and *Acacia nilotica* or *D. cinerea* as supplements to evaluate animal performance on these browses. The fifth study demostrated that *A. erubescens* and buffalo grass hay fed as supplement to grazing Tswana goats improved their weight gains.

RESUMEN

Se evaluó el valor nutritivo de arbustos y árboles ramoneados por cabras Tswana en Botswana. Primero se analizaron las semillas de veinte especies leñosas. La composición nutritiva de las semillas varió ampliamente: el porcentaje de proteína bruta osciló entre 6,42 de *Bauhania petersiana* y 35,59 de *Sterculia africana*.

El segundo estudio mostró que las hojas y brotes de cinco especies leñosas variaron en el nivel de taninos y composición nutritiva. Las hojas y brotes de *Acacia tortilis* y *Grewia flava* tienen niveles similares de proteína bruta, pero diferentes ($p<0,05$) de taninos. El tercer estudio se llevó a cabo para evaluar los recursos leñosos disponibles para las cabras Tswana explotadas en régimen extensivo en el Sudeste de Botswana. Las especies más frecuentes fueron *Acacia erioloba, A. tortilis*, *Dichrostachys cinerea*, *G. flava* y *Terminalia seracea.* La disponibilidad de los recursos varió estacionalmente

pero *A. tortilis*, *G. flava* y *T. seracea,* se encontraron disponibles todo el año. El cuarto estudio fue una experiencia de alimentación usando chivos, que fueron alimentados con heno de *Buchloe dactyloides* como dieta basal y *Acacia nilotica* o *D. cinerea* como suplementos y heno de alfalfa para el grupo control para evaluar la eficacia de dichos recursos leñosos en la alimentación. El quinto estudio evaluó durante 98 días la utilidad de *Acacia erubescens* y suplemento de heno de *B. dactyloides,* para pastoreo de las cabras Tswana. Dieciseis chivos Tswana castrados fueron pesados y aleatoriamente distribuidos en cuatro grupos de cuatro repeticiones en un diseño completamente al azar. El estudio demostró que la suplementación con *A. erubescens* y el heno de *B. dactyloides,* mejoró la ganancia de peso de las cabras Tswana en pastoreo.

INTRODUCTION

The quantity and quality of water are limiting factors in crop and forage production in Botswana. Therefore, ruminant livestock depends predominantly on natural pastures and range, with the addition of some imported raw feed ingredients mainly from South Africa and Zimbabwe that are processed locally into concentrates. Feed shortage is the major constraint affecting the development of the country's animal industry (Aganga and Moganetsi, 1998). Browse leaves and pods form a natural part of the diet of goats which meets over 60 per cent of the forage requirement and have been used by traditional farmers as sources of forage in Botswana. There are several types of leguminous and non-leguminous trees used as forage by goats but the predominant genus in Botswana is *Acacias*. Feed potential of browse in the diet of herbivores in Botswana is reflected in reports by Aganga *et al*. 1998 and Aganga, 1999. The nutritional importance of browse is especially significant for free ranging goats in extensive communal system of production. Goats have a great tendency to change their diet according to seasonal feed availability and growth rate of plants. Some parts of browse species can be found during the dry season (winter) and these include pods, fruits and leaves of evergreens. Most trees/shrubs produce their leaves during wet season (summer), thus browse is more available during the spring (August to May) (Palgrave, 1983). This study therefore is to evaluate feed potential of browses for nutrient and tannin composition, availability on the range and utilisation as supplementary feed for Tswana goats.

MATERIALS AND METHODS

Five trials were conducted to evaluate feed value of browse in Tswana goats feeding and nutrition. In trials 1 and 2, the nutrient composition (proximate, macro and micro minerals) and tannins were determined. In trial 3, available browse plants under extensive range condition were evaluated, while trials 4 and 5 were conducted to study performance of Tswana goats on some browse species as supplements.

TRIAL 1

Seeds (mature, dry) from twenty locally available browse species, nine belonging to Mimosodeae, four to Caesalpinioideae and one each to Bombacaceae, Euphorbiaceae, Com-

bretaceae, Papilionoideae, Ochnaceae, Rubiaceae and Sterculiaceae subfamilies collected from the savanna and woodlands of Botswana were analysed for chemical composition and *in vitro* dry matter digestibility.

TRIAL 2

Twigs and leaves from five indigenous browse species namely *Kirkia accuminata* Oliver, *Acacia karoo* Hayne, *Acacia tortilis* (Forsk.) Hayne, *Acacia nilotica* (L.) Willd ex Delile and *Grewia flava* DC obtained from Botswana rangelands were evaluated.

TRIAL 3

The study was carried out at two sites at Kopong and Mosinki lands in Kweneng district of South East Botswana. In each study area, three sampling locations were evaluated each being 7 km from the other. Within each sampling location, three replications of 20 m by 20 m were marked. Replicates were 100 m apart. Sampling was done on marked plants, every two months for a period of twelve months, thus ending up with six batches of samples. Sampling was done by cutting the leaves and twigs of the browse plants. Shrub density was determined for each sampling site (i.e. the number of shrubs in a 20 m by 20 m area) and this converted to shrubs per hectare of land. Shrubs and tree fodders were sampled to determine the yield of the area during different periods of the year. Patterns of utilisation of different parts of browseable tree species were determined from visual observations by the researchers with the assistance of agricultural extension workers and goat farmers. Pods, leaves and fruits were dried in a laboratory oven at 50 °C for 72 hours then ground to pass through a 1 mm sieve. The vegetation of the study area is a thorn-bush savanna with a sparse cover of annual grasses, herbs and shrubs. Annual rainfall here ranges from 280 to 500 mm, and average temperatures are 28-39°C in summer and 15-26°C in winter.

TRIAL 4

The experiment was conducted at Botswana College of Agriculture Content farm, Gaborone for a period of 120 days. Twenty four Tswana yearling male goats (average initial body weight 12.8 kg) were divided into three groups of eight animals in a completely randomised design. Buffalo grass hay (*Buchloe dactyloides*) constituted 60 per cent of the ration on dry matter basis as basal diet to all goats. The control group received lucerne hay (*Medicago sativa*) as supplement. The other two groups were supplemented with *Dichrostachys cinerea* (L.) Wight & Arn (Treatment 1) and *A. nilotica* (Treatment 2). 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 day's ration. Water and feed left were measured daily while the goats were weighed every two weeks, before the morning feeding.

TRIAL 5

The experiment was conducted at Botswana College of Agriculture, goats unit, for a period of 98 days. Castrated Tswana goats, between the age of 10-12 months were chosen from the

College's herd and allocated to four groups (control, treatments 1, 2 and 3) of four replicates each with an average initial body weight of 12.7 kg.

The goats were randomly allocated in a completely randomized design to the treatment groups. The control goats depended 100 per cent on free grazing which lasted 7 hours (from 8.00 h to 15.00h) daily and water was provided *ad. lib.* Treatment 1 goats grazed 7 hours daily and were given mineral block *ad. lib.* and water. Treatment 2 goats were provided buffalo grass hay equivalent to 2 per cent of their body weight on dry matter basis along with mineral block and water *ad. lib.* after their 7 hour a day free grazing. Treatment 3 goats had 7 hours free grazing plus water and mineral block *ad. lib*, along with 60 per cent buffalo grass hay (CP 8.82 per cent DM) and 40 per cent *Acacia erubescens* Welw. ex Oliver (CP 12.5 per cent DM) both equivalent to 2 per cent of their body weight on dry matter basis as supplementary feeds. Water was given when the goats returned from grazing. Each goat was housed individually in a 1.5 m by 1.0 m pen under a common roof, overnight throughout the trial period. Parameters monitored were daily water intake, buffalo grass hay intake and *A. erubescens* intake. All experimental goats in trials 4 and 5 were weighed every two weeks in the morning before they were taken out for grazing. An Avery walk-in scale was used to measure the weights of the goats, while Adams electronic platform scale was used to weigh the feed given and left-overs. A measuring cylinder was used to measure the volume of water given and left-over. Data collected were subjected to the analysis of variance (Steel and Torrie, 1980).

Analytical methods

Analyses for proximate composition were done using the procedures of A.O.A.C. (1995). The mineral composition was determined using atomic absorption spectrophotometer (GBC 908 AA, Victoria, Australia) after sulphuric acid digestion and flame photometer was used for potassium and sodium. Crude protein (CP) was determined by Kjeldahl method (Vapodest Gerhardt, Germany). Fibre analysis: neutral detergent fibre (NDF) and acid detergent fibre (ADF) and *in vitro* true dry matter digestibility (IVTDMD) were determined using the procedures of Ankom 200/220 Fiber Analyzer and Daisyll (1997). For quantification of tannins proanthocyanidins were oxidatively depolymerised in a butanol-HCl mixture into anthocyanidins. Extraction of tannins was done in 70 per cent aqueous acetone, ie. 700 ml acetone + 300 ml distilled water. For each sample four replicates were analysed and the absorbance of the tannin extracts were measured at 550 nm (Makkar, 1995).

RESULTS

The nutritional composition of the twenty evaluated browse seeds are given in **table I** while **table II** shows the tannin and chemical constituents of five indigenous browse leaves and twigs. Many of the tree species were common to both sites for Trial 3 but Kopong sites had higher overall shrub

Table I. *The chemical composition of the ground seeds of 20 indigenous browse species (on dry matter basis).* (Composición química de semillas molidas de veinte especies de plantas leñosas indígenas; sobre materia seca).

Browse Species	Sub-family	DM*air-dry basis	Ash	Crude protein	Crude fat	Tannins	NDF*	ADF*	IVTD*	Ca*	Mg*	P*	Cu ppm	Zn ppm	Mn ppm	Fe ppm
Acacia albida Delile	Mimosoideae	94.7	1.5	29.3	8.2	4.13	12.2	19.4	92.7	0.41	0.16	0.26	12	0.29	45	89
Acacia galpinii Burtt Davy	Mimosoideae	97.3	1.4	31.2	9.3	3.62	22.6	19.9	93.7	0.63	0.24	0.14	9	0.30	31	94
Acacia gerrardii Benth	Mimosoideae	98.3	1.4	35.5	3.1	1.60	20.8	27.4	77.4	0.13	0.25	0.61	12	0.30	55	71
Acacia haematoxylon Willd	Mimosoideae	98.5	1.1	20.6	8.1	3.57	13.7	14.3	80.7	0.39	0.24	0.25	14	0.34	29	73
Acacia sieberana DC	Mimosoideae	97.5	2.0	25.9	3.5	6.82	24.0	60.6	82.0	0.18	0.19	0.41	9	0.18	14	53
Acacia burkei Benth	Mimosoideae	93.0	4.0	29.2	4.8	2.86	17.0	22.6	77.6	0.56	0.38	1.01	17	0.52	47	90
Adansonia digitata L.	Bombacaceae	94.8	2.7	18.2	12.7	1.65	37.0	26.5	74.7	0.49	0.43	0.44	13	1.12	33	98
Albizia amara (Roxb.) Boiv.	Mimosoideae	98.4	1.2	9.3	8.7	0.08	10.5	17.3	92.1	0.33	0.10	0.35	13	0.23	48	75
Albizia harveyi Fourn	Mimosoideae	96.6	5.8	32.6	4.1	0.32	21.1	16.9	84.8	0.12	0.24	0.27	7	0.36	25	64
Bauhania petersiana Bolle.	Caesalpinioideae	98.4	3.8	6.4	19.1	1.27	20.4	66.2	47.6	0.11	0.15	0.53	9	0.22	64	64
Bridelia mollis Hutch.	Euphorbiaceae	97.0	2.4	21.7	2.6	5.97	55.1	10.5	95.1	0.31	0.10	0.37	9	0.17	41	81
Burkea africana Hook.	Caesalpinioideae	96.3	1.6	21.0	2.1	8.21	20.6	18.1	82.9	0.07	0.15	0.38	9	0.21	39	144
Bolusanthus speciosus (Bolus) Harms	Papilionoideae	98.3	2.1	13.6	10.2	1.43	6.7	19.3	97.0	0.10	0.09	0.25	13	0.34	27	29
Cassia abbreviata Oliver	Caesalpinioideae	95.2	3.5	28.8	4.9	1.07	10.4	45.2	67.1	0.28	0.20	0.16	8	0.28	34	88
Combretum collinum Fresen.	Combretaceae	96.5	4.4	17.2	6.8	1.14	51.4	23.7	92.0	0.30	0.15	0.50	18	0.30	122	104
Colophospermum mopane (Kirk ex Benth.)	Caesalpinioideae	92.2	7.6	24.0	10.8	6.61	26.0	38.3	97.0	0.48	0.06	0.37	12	0.25	30	70
Ochna pulchra Hook.	Ochnaceae	94.8	2.8	23.7	26.1	6.27	45.0	31.4	51.3	0.10	0.11	0.18	7	0.24	48	134
Sterculia africana (Lour.) Fiori	Sterculiaceae	94.2	1.5	35.6	22.8	3.53	15.4	6.5	96.3	0.13	0.25	0.26	6	0.30	42	99
Vangueria infausta Burch.	Rubiaceae	97.1	2.6	21.3	7.0	0.89	12.4	19.0	87.2	0.38	0.06	0.39	10	0.16	40	162

NDF: neutral detergent fibre; ADF: acid detergent fibre; IVTD: *in vitro* true dry matter digestibility
*(p.100)

Table II. *Tannins and chemical constituents(on dry matter basis) of five indigenous browse leaves and twigs in Gaborone rangelands.* (Taninos y componentes químicos, sobre materia seca, de hojas y brotes de cinco especies leñosas en los pastos de Gaborone).

Browse	*K. accuminata*	*A. karoo*	*A. tortilis*	*A. nilotica*	*G. flava*
Tannin (percent)	1.28^{d}±0.001	2.22^{b}±0.008	1.77^{c}±0.10	0.12^{b}±0.05	3.63^{a}±0.05
CP (percent)	9.5^{c}±0.12	12.6^{b}±0.01	14.2^{b}±0.11	18.1^{b}±1.12	16.4^{a}±0.72
P (percent)	0.12^{c}±0.001	0.13^{c}±0.01	0.18^{b}±0.01	0.14^{c}±0.001	0.21^{a}±0.002
K (percent)	1.20^{b}±0.001	0.97^{c}±0.001	1.05^{c}±0.03	1.37^{a}±0.12	1.23^{b}±0.03
Na (percent)	0.01±0.00	0.01±0.0	0.01±0.00	0.01±0.001	0.01±0.001
Ca (percent)	1.00^{b}±0.01	1.73^{a}±0.02	1.47^{a}±0.02	0.93^{b}±0.26	1.69^{a}±0.02
Mg (percent)	0.27^{b}±0.008	0.32^{a}±0.001	0.22^{c}±0.009	0.23^{c}±0.02	0.27^{b}±0.001
Fe (ppm)	153.5^{b}±24.5	175^{b}±18.00	279^{a}±31.00	173.5^{b}±18.5	171.5^{b}±23.5
Zn (ppm)	72^{a}±4.00	66^{ab}±2.00	60^{b}±4.00	68^{a}±5.20	75^{a}±1.20
Mn (ppm)	27.5^{a}±9.50	13^{b}±3.00	24^{a}±4.00	15.5^{b}±7.50	24.5^{a}±4.50
IV DMD (percent)	32.9^{c}±5.63	40.9^{b}±7.88	39.6^{d}±8.25	38.6^{b}±4.05	51.7^{a}±6.75

Mean ± standard error; Means in the same row having different superscript are different ($p<0.05$).

density than Mosinki sites. The mean shrub density (plants/m^2) at Kopong was 0.23 while that at Mosinki was 0.19. At both sites, leaves and twigs were the tree parts most utilised by Tswana goats. The chemical analyses of the leaves eaten by the goats showed relatively high protein content ranging from 8.03 per cent for *Torconapthus camphoratus* L. to 29.9 per cent for *Acacia flecki* Schinz **(table III)**. The protein content was at its peak in January/February, and dropped to its minimum in July/August. Phosphorus level is generally low, ranging from 0.05 per cent in August to 0.16 per cent in December/January. The calcium content ranges from 0.5 per cent in December for *G. flava* to 3.6 per cent in September/October for *Ziziphus mucronata* Willd.

Table IV indicates the chemical composition of feeds fed to Tswana goats in trial 4. Tswana goats performance on *D. cinerea* and *A. nilotica* as supplements are shown in **table V**. No significant difference ($p>0.05$) on weight gains compared to lucerne hay as supplements were found. In this trial, the goats supplemented on *Dichrostachys* consumed more feed (727 g) than those on *A. nilotica* (661 g) or lucerne (618 g). The goats fed on the two browse consumed more Buffalo grass hay than the control group ($p<0.05$). Feed conversion and average daily gain were best for goats fed lucerne as supplement. Goats in the control group on lucerne hay as supplementary feed drank a significantly ($p<0.05$) higher quantity of water compared to goats on the browse species which contained more water **(table VI)**. *D. cinerea* and *A. nilotica* leaves and twigs used in this study were obtained from the rangelands

Table III. *Crude protein ,Ca and P (g/100g on dry matter basis) content of browse plants (leaves and twigs) available in Kopong and Mosinki lands in Kweneng districts of Botswana throughout the year.* (Evolución del contenido de proteína bruta, Ca y P, en porcentaje de materia seca, de hojas y brotes de las plantas leñosas existentes en territorios Kopong y Mosinki en el distrito Kweneng de Botswana).

	Crude protein					Ca					P				
Species	Mar/ April	July/ Aug	Sep/ Oct	Nov/ Dec	Jan/ Feb	Mar/ April	July/ Aug	Sep/ Oct	Nov/ Dec	Jan/ Feb	Mar/ April	July/ Aug	Sep/ Oct	Nov/ Dec	Jan/ Feb
Acacia erioloba E.Meyer	8.6	9.9	13.1	14.3	13.5	1.68	1.86	0.58	0.54	0.80	0.06	0.05	0.17	0.13	0.10
Acacia fleckii Schinz	15.4	12.8	16.8	22.4	29.9	1.02	1.27	2.17	0.46	0.87	0.07	0.04	0.07	0.27	0.16
Acacia tortilis (Forsk.) Hayne	12.3	11.3	13.4	15.7	18.0	1.49	2.00	2.54	0.77	0.88	0.07	0.05	0.07	0.17	0.13
Acacia hebeclada DC.	12.8	11.8	13.0	16.7	16.1	1.61	0.88	0.51	0.74	0.51	0.07	-	0.27	0.11	0.10
Combretum hereroense Schinz	8.7	8.7	13.2	18.5	12.3	1.16	1.80	1.50	0.26	0.86	0.06	0.06	0.04	0.12	0.11
Dichrostachys cinerea (L.) Wight & Arn	10.3	-	-	19.1	18.4	1.11	-	-	0.12	0.38	0.06	-	-	0.12	0.11
Diospyros lycioides Desf.	6.2	-	-	9.4	11.6	1.30	-	-	1.62	0.45	0.06	-	-	0.14	0.11
Dombeya rutindifolia (Hochst). Planchon	13.7	10.4	14.6	14.6	15.3	1.07	1.14	1.57	0.77	0.84	0.10	0.07	0.07	0.13	0.13
Grewia flava DC	12.6	9.5	14.3	15.8	20.0	1.54	2.21	1.21	0.50	0.89	0.07	0.04	0.16	0.14	0.14
Grewia flavescens Juss.	13.6	-	-	13.1	18.1	1.53	-	-	1.24	0.43	0.08	-	-	0.10	0.15
Grewia bicolor Juss.	11.9	8.4	8.21	11.8	19.6	0.93	1.62	1.81	1.40	0.93	0.02	0.02	0.06	0.15	0.13
Lippia scaberrima	10.7	-	-	-	20.8	1.02	-	-	-	0.64	0.10	-	-	-	0.16
Torconanthus camphoratus L.	10.4	8.0	-	-	15.8	0.68	0.73	-	-	0.61	0.06	0.02	-	-	0.06
Terminalia sericea Burch.ex DC.	10.4	15.6	-	10.3	13.4	0.71	1.06	-	0.31	1.11	0.06	0.03	-	0.13	0.09
Ziziphus mucronata Willd.	13.4	-	10.5	17.7	18.9	1.90	-	3.55	0.69	0.59	0.07	-	0.05	0.13	0.10

Table IV. *Dry matter content (g/100g) and chemical composition (g/100g on dry matter basis) of feeds used in trial 4.* (Contenido de materia seca y composición química de los alimentos utilizados en el ensayo 4).

	Buffalo grass hay	Lucerne hay	*D. cinerea*	*A. nilotica*
Dry matter	94.6	95.1	57.0	50.8
Crude protein	6.9	14.0	12.9	16.5
Crude fibre	28.1	29.9	20. 9	21.3
Ash	1.2	6.9	6.2	5.5

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

surrounding the goat units without cost, i.e. cost of production of Tswana goats could be reduced by using these browse species as supplementary feeds.

The nutrient composition of *A. erubescens* fed to Tswana goats as supplements in Trial 5 in (g/100g dry matter basis) were CP 12.5; crude fat 1.34; P 0.07; Ca 2.75; Mg 0.33; Na 0.07; K 0.67. The composition of buffalo grass hay is shown in **table IV**. **Table VI** shows that utilization of *A. erubescens* as supplement for grazing Tswana goats was beneficial as it resulted in better growth rate of the goats. The average daily weight gain (ADG) of the Tswana goats on treatment 3 (57.5 g) was slightly higher than those on treatment 2 (52.5 g), treatment 1 (45 g) and 35 g for control group.

DISCUSSION

Compared with tropical, mature grasses, browse appears to be richer in protein and minerals (Le Houerou, 1980). Devendra (1993) reviewed the significance of shrub and tree fodders as sustainable feed resources. The importance of browse for the survival of goats is reflected in the data of Sarson and Salmon (1978). They stated that maintenance and production requirements of goats may be provided on a pure browse diet (4.72 MJ ME/kg DM). The chemical composition of some browse seeds, leaves and twigs reported in this study varied considerably due to the variation in plant species. These shows the enormous nutritional potentials of these browses to the free-ranging herbivores. The extent of this contribution to meeting dietary needs is dependent on the type and quantity of browse available, preference of animals, accessibility, palatability and presence of toxic principles (Devendra, 1995). Browse is seldom utilized exclusively. In most situations, its practical use is as a supplement to enhance the intake and utilization of other fibrous crop residues like cereal straws and hays, and thus meet the maintenance and variable levels of production requirements.

Crude protein content in browse species seeds varied from 6.42 per cent for *Bauhania petersiana* Bolle to 35.6 per cent for *Sterculia africana* (Lour.) Fiori. The protein levels reported here for these browse seeds compare favourably with values for grain legumes reported by Valentine and Bartsch (1987), Schlink and Burt (1993). Solvent- extractable fat levels

Table V. *Intake and performance of Tswana goats fed buffalo grass hay supplemented with browse plants or lucerne hay (trial 4).* (Ingestión y rendimiento de las cabras Tswana alimentadas con heno de *Buchloe dactyloides* suplementado con plantas leñosas o heno de alfalfa en el ensayo 4).

Feeds	Control	Trt 1	Trt 2
Initial liveweight (kg)	16.0±1.13	15.6±0.69	15.6±0.53
Final liveweight (kg)	24.5±0.91	23.9±0.58	23.1±0.56
Metabolic mass ($kg^{0.75}$)	9.54±0.59	9.37±0.39	9.24±0.67
Body weight gained (kg)	8.50±0.46	7.88±0.54	7.50±0.27
ADG (kg)	0.071±0.004	0.066±0.004	0.063±0.002
Average daily DMI (g)	618.3±26.9[b]	727.1±13.5[a]	661.2±12.5[b]
Daily DM buffalo grass hay intake (g)	268.0±25.2[b]	448.2±12.1[a]	413.0±11.2[a]
Daily DM legume or browse intake(g)	351.1±3.71[a]	282.0±2.83[b]	248.2±2.60[c]
DM intake/p.100 bodyweight	3.05±0.38[b]	3.68±0.55[a]	3.41±0.91[a]
DM/gain (g/g)	8.70±0.08[b]	11.01±0.06[a]	10.49±0.05[a]
DM legume or browse p.100 body weight	1.73±0.78[a]	1.42±0.12[b]	1.28±0.49[b]
DM intake g/kg $W^{0.75}$	64.8±1.23[b]	77.6±1.65[a]	71.6±1.77[a]
Average daily water intake (ml)	1485.4±30.6[a]	1275.0±32.9[b]	1275.2±36.3[b]
Average daily water intake ml/$kg^{0.75}$	155.7±16.6[a]	136.1±12.7[b]	138.0±14.7[b]

Control= Buffalo grass+Lucerne; Trt 1= Buffalo grass + D. cinerea; Trt 2= Buffalo grass + A. nilotica. Mean ± standard error. Means in the same row not having common letters differ significantly ($p<0.05$)

range from 2.13 per cent for *Burkea africana* Hook to 26.1 per cent for *Ochna pulchra* Hook seeds which is higher than the fat level reported for soya bean (17.5 per cent) but lower than sunflower (32.5 per cent) and rapeseed (45.1 per cent) (Hansen and Czochanska, 1974). The crude fat of all browse seeds evaluated are higher than the levels found in pasture grass (0.6-1.3 per cent), maize (4.4 per cent) stated by Schlink and Burt (1993). The *in vitro* true digestibility of dry matter (IVTD) percentages were relatively high for all the browse species seeds, with 47.6 per cent for *B. petersiana* Bolle and 97.0 per cent for *Bolusanthus speciosus* (Bolus) Harms. These high values may be due to the fine particle size of the seeds since they were ground to pass through a 1 mm sieve size. These values show that the seeds are highly digestible when ground and the ruminant animals could benefit from the nutrients when fed ground browse seeds as supplement to complement forages and grazing. The Ca, Mg and P contents were low in various seeds evaluated, which suggest that browsing ruminant animals may require mineral supplementation for optimal productivity depending on the quantities of the browse species seeds consumed. The requirements of goats indicate that 0.21-0.52 per cent Ca and 0.16-0.37 per cent P are adequate (NRC, 1980). McDowell (1985) stated that adequate Ca and P nutrition depends not only on

Table VI. *Utilization of Acacia erubescens by grazing Tswana goats (trial 5).* (Utilización de *Acacia erubescens* por las cabras Tswana en pastoreo en el ensayo 5).

Feeds	Control	Trt 1	Trt 2	Trt 3	Significance
Initial body weight (kg)	12.25±2.06	12.75±3.59	13.00±2.94	12.75±2.99	NS
Final body weight (kg)	15.75±1.26	17.00±3.14	18.13±2.32	18.50±2.38	NS
Weight gain (kg)	3.50±1.26	4.25±1.55	5.13±1.65	5.75±2.50	NS
Average daily weight Gain (kg)	0.035±0.01[a]	0.04±0.02[b]	0.052±0.02[c]	0.0575±0.03[d]	*
Average daily buffalo grass hay supplement intake	-	-	178.13±27.11	95.29±23.74	*
Average daily legume supplement intake (g)	-	-	-	68.47±1.62	
Average daily water Intake (ml)	867.93±73.73	883.82±46.19	816.71±39.80	840.45±13.67	NS

Control= Grazing only;TRT1= Grazing+mineral block;TRT2= Grazing+mineral block+buffalo grass hay;TRT3= Grazing + mineral block+buffalo grass hay +*Acacia erubescens*
Mean ± standard error. Means in the same row not having common letters differ significantly (p<0.05)

sufficient total dietary supplies, but also on the chemical forms in which they occur in the diet and on the vitamin D status of the diet fed to the animal.

Most of the browse seeds evaluated contain appreciable quantities of condensed tannins ranging from 0.08 per cent (0.8 g/kg) in *Albizia amara* (Roxb.) Boiv to 8.21 per cent (82.1 g/kg) in *B. africana*. Most goats in Botswana (98 per cent) are kept by traditional farmers and these animals depend on the rangelands for their feeds. Goats browse extensively and a lot of the browse plants contain secondary plant metabolites such as tannins. Topps (1992) stated that the phenolics appear to be the major constraint on the use of legume shrubs and trees for animal fodders because of their effect on intake, digestibility and the animal's metabolism. Hill and Tamminga (1998) stated that there are two major nutritional advantages of the consumption of feeds high in tannins for ruminants. The first relates to the prevention of bloat when animals eat pastures that are rich in soluble proteins (Griffiths, 1991). The second advantage is the ability of tannins to form complexes with free protein in the rumen and thus protect the protein from degradation in the rumen. Therefore, bloat is not a problem for grazing ruminants in the tropics (Cheeke and Shull, 1985). Overall, it appears that the presence of tannins in legume seeds are probably an advantage in ruminant feeding. This needs to be evaluated by means of digestibility and feeding trials.

All the five browse leaves and twigs vary in tannin and nutrient composition **(table II)**. The *in vitro* dry matter

digestibilities were low for all the five browses. *A. tortilis* contains low tannin content which may benefit the ruminants by protecting protein from bacterial degradation in the rumen, whenever an adequate supply of available N or microbial growth is provided, and also prevent bloat. *A. tortilis* and the others are abundant in Botswana rangelands and the browses could be used as supplements to low quality roughages for feeding ruminant livestock (Aganga *et al.*, 1998).

In trial 3 shrub density (plants/m^2) was relatively high at Kopong when compared with Mosinki and this could be attributed to the soil differences as Mosinki soils are mostly sandy soils as compared to loamy soils in Kopong. Shrub density is reported to be important as it indicates the amount of biomass available for livestock (Sibanda and Ndlovu, 1992).

In trial 5, the daily feed choice and intake of the experimental goats during the 7 hours of grazing were not controlled but the grazing area was mainly an *Acacia* bush veld. Tswana goats in trial 4 had higher body weight gains than those in trial 5 because the trial 4 goats were in confinement and did not expend energy for grazing. *A. erubescens* is rich in protein just like most browse species available in the rangelands of Botswana. It could be used as a supplementary feed by goats.

CONCLUSIONS

This study showed that browse seeds and leaves could provide part of the solution to shortage of protein and other nutrients during the dry season to supplement low quality forage grazed by goats. Some browse species are available on the range throughout the year producing leaves, twigs and at times pods. Crude protein and calcium levels in the browse species were relatively high both in the dry and wet seasons but phosphorus levels were low indicating that the goats need to be supplemented with phosphorus. The study also showed that Botswana indigenous browses contain varying amounts of tannins. Browse trees are important in the nutrition of range goats in Botswana. Research on the management and use of tree foliage should be encouraged in order to reach a balance between feeding of tree forages and the environment. This is vital as the nutrient potential of the indigenous tree forages is increasingly being recognised.

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