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The Feeding Value of Four Cowpea Hay Cultivars and Effect of their Supplementation on Intake and Digestibility of Buffalo Grass Hay Fed to Pedi Goats

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ABSTRACT

The study was carried out to determine the effect of cowpea cultivar supplementation on intake, digestibility and live weight changes of Pedi goats fed *ad libitum* buffalo grass hay. This involved five experiments. Experiments 1.1 to 1.4 involved Pan 311, Red caloona, Black eye and Agripeas cowpea cultivars, respectively, while Experiment 1.5 compared the levels of supplementation for optimum intake from each of the first four experiments. Twelve growing male indigenous Pedi goats were used in each experiment. Each cowpea hay cultivar was given as a supplement at four levels (50, 100, 150 and 200 g day^{-1}) to a diet of buffalo grass fed *ad libitum* to indigenous Pedi goats. A completely randomized design was used for all experiments. The experiments were run for 25 days of preliminary period plus 5 days of collection period. Feed intake, digestibility, live weight changes and nitrogen intake were measured. All the cowpea cultivars contained more than 15% crude protein. Pan 311 had higher ($p<0.05$) feeding values than the other cultivars. However, Pan 311 contained the highest amounts of condensed tannins. These high amounts of condensed tannins in Pan 311 did not exert negative effects on its intake and digestibility. Chemical composition values of the cowpea cultivars found in the present study are quite high and hence the legumes should be able to supply enough nutrients, particularly proteins, to ruminant animals when given as supplements.

Key words: Cowpea cultivar, tannins, protein, weight gain, *in vivo* digestibility

INTRODUCTION

Ruminants in rural areas of Africa subsist under poor nutritional conditions, utilizing feedstuff from poor natural pastures and crop residues (Motubatse *et al*., 2008; Lanyasunya *et al*., 2006). During the dry season live weight losses do occur because the forages are generally deficient in nutrients such as protein, sulphur, minerals and vitamins (Kawas *et al*., 2010). The feeding value of these feedstuffs needs to be improved to achieve high productive performance of the animals. Hence, supplementation with on-farm produced forage legumes or with locally available ones is being examined in relation to the ability to overcome nutritional deficiencies in the rumen and on their possible contribution of undegradable but otherwise digestible nutrients, particularly protein.

Legumes have become popular among farmers, not only for use in reinforcement of veld and planted grass pastures but also as protein banks to supplement other poor-quality roughages like maize stover and grass (Sumberg, 2004; Aganga *et al*., 2005). Legumes are known to have high protein contents (Ranjbar, 2007; Ajayi *et al.*, 2009), usually in the range of 120 to 230 g kg^{-1} DM. There is increasing interest in making use of legumes as sources of protein-rich supplements to improve the productivity of ruminants given low quality feeds (Moalafi *et al.*, 2010).

Cowpea is an important fodder legume crop grown in many parts of the world (Sebetha *et al.*, 2010). Among the cowpea cultivars grown by farmers in Limpopo province of South Africa include Pan 311, Red caloona, Agripeas (Agrinawa) and Black eye. These cowpeas are under the family name *Vigna unguiculata* (L.), (Takim and Uddin, 2010; Sebetha *et al.*, 2010). 2005/2006 fodder production of Pan311 and Red caloona was estimated at 132.5 to 1373.2 kg ha^{-1} (Sebetha *et al.*, 2010). The protein percentage for both Pan311 and Red caloona leaves was ranging from 25.98 to 30.68 for Pan 311 and 24.14 to 28.08, respectively (Sebetha *et al.*, 2010). Odhiambo (2004) found that the biomass production for Agripeas (Agrinawa) cultivar is estimated at 2.0 ton ha^{-1}. Its biomass nitrogen concentration was 78 kg ha^{-1}. Blackeye cultivar is also called southern pea and regarded as summer annual legume. Typical biomass production is 1361 to 1814 kg ha^{-1} per annum. The biomass yield for the Blackeye cultivar can reach 6 ton ha^{-1} (Clark, 2007). It has high nutritive value. Crude protein in green foliage is ranging from 14 to 21% (Fatokun *et al.*, 2002). However, little is known about the feeding values of cowpea cultivars grown in Limpopo Province when given to goats as supplements. Evaluation of these legumes is, therefore, important in order to design feeding strategies for ruminant animals on low quality roughages (Ajayi *et al.*, 2010; Kiraz, 2011). The objective of this study was to determine the feeding value of cowpea cultivars and the effect of their supplementation on diet intake, digestibility and live weight change of Pedi goats fed buffalo grass hay.

MATERIALS AND METHODS

Study site: The study was conducted at the University of Limpopo Experimental Farm situated 10 km west of the Turfloop campus. Temperatures in winter (May to July) range between 5 and 28°C and in summer (November to January) they range between 10 and 36°C. Mean annual rainfalls range between 447 and 468 mm. The dry season is between April and October and the rainy season is between November and March.

Animals, experimental design and diets: Four cowpea cultivars, Pan 311, Red caloona, Agripeas and Black eye, were used in this study. They were harvested at vegetative stage and dried. The cowpeas were planted in September 2007 and harvested in November, 2007. The cowpea hays were chopped into small pieces of 20 to 30 mm lengths. Buffalo grass hay was harvested in June, 2007, dried, baled and used as low quality roughage. The buffalo grass was also chopped into pieces of 20 to 30 mm lengths.

Twelve growing male Pedi goats, weighing 16±3 kg (average) live weight, were used in each experiment. The goats were housed in individual metabolic cages. All animals were dosed (Anthelmintic, Ivomec) against worms before the start of the experiment. The experiments were run for 25 days of adaptation period plus 5 days of collection period. The animals were allocated to one of four dietary treatments indicated below on the layout of experiments. Water was offered *ad libitum* and each animal had access to a mineral mixture.

Experiment 1:

$\mathbf{Pan_{50}}$: *ad libitum* buffalo hay plus 50 g Pan 311/goat/day
$\mathbf{Pan_{100}}$: *ad libitum* buffalo hay plus 100 g Pan 311/goat/day
$\mathbf{Pan_{150}}$: *ad libitum* buffalo hay plus 150 g Pan 311/goat/day
$\mathbf{Pan_{200}}$: *ad libitum* buffalo hay plus 200 g Pan 311/goat/day

Experiments 2 to 4 had similar rations but with Red caloona, Agripeas and Black eye, respectively. Experiment 5 compared the estimated levels of supplementation for optimum intake from each of the first four experiments. The treatments for Experiment 5 were as follows:

Pan 311: *ad libitum* buffalo hay plus estimated level of supplementation for optimum intake (161 g/goat/day) of Pan 311

Red caloona: *ad libitum* buffalo hay plus estimated level of supplementation for optimum intake (159 g/goat/day) of Red caloona

Agripeas: *ad libitum* buffalo hay plus estimated level of supplementation for optimum intake (148 g/goat/day) of Agripeas

Black eye: *ad libitum* buffalo hay plus estimated level of supplementation for optimum intake (119 g/goat/day) of Black eye

A completely randomized design was used in each experiment and each treatment within the experiment had three replications.

Faecal collection: During five days of the collection period, faeces were collected in the mornings before feeding and watering. Each experimental animal, housed in a digestibility crate designed for easy collection of urine, was harnessed with a faecal-collection bag four days before the commencement of actual faecal collection. The faecal samples for each experimental animal were thoroughly mixed and put in sealed polythene bags. Faeces collected during the collection period were bulked, weighed, sampled and dried in an oven at 105°C for 48 h to determine dry matter content. The samples were then stored at room temperature until required for nutrient analysis.

Feed intake and live weight changes: The daily feed intake was determined during the collection period by the difference in weight of feed offered and the feed refusals or leftovers. Sub-samples of the feed offered and refusals were dried at 65°C to constant weight for dry matter determination. The goats were weighed in the beginning and the end of each experiment to reduce stress during the collection period. The weighing of the goats was carried out before morning feeding to avoid feed effect (Yong and Paengkoum, 2009). SAS (2008) was used to analysis growth rate of goats. Means were separated using the Duncan multiple range test.

Chemical analysis: Dry Matter (DM) and ash of feeds, feed refusals and faeces were determined according to AOAC (2000), Acid and Neutral Detergent Fibres (ADF and NDF) by the method of Van Soest *et al.* (1991) and nitrogen content by the Kjedahl method (AOAC, 2000). Extraction of polyphenolics from plant material was done using the method used by Hagerman and Butler (1989), Makkar *et al.* (1995), Reed (1995) and Waterman and Mole (1994) (University of Limpopo laboratory, Polokwane). Extracted condensed tannins were done using the method described by Porter *et al.* (1986).

Statistical analysis: General Linear Model (GLM) procedures of SAS (2008) were used to test the effect of cowpea hay cultivar supplementation on intake, digestibility and live weight change of Pedi goats fed with buffalo grass hay. Means were separated using the Duncan multiple range test. The model used was:

$$Y_{ij} = \mu+P_i+e_{ij}$$

where, Y_{ij} is the observation on voluntary intake, in vivo digestibility, growth rate and due supplementation level of cowpea cultivar and their interaction; μ is overall mean; P_i is the ith effect of level of cowpea cultivar and e_{ij} is the residual effect. The responses in optimum intake, digestibility and live weight changes to level of supplementation were modeled using the following quadratic equation:

$$Y= a+b_1\times+b_2x^2$$

where, Y is optimum intake, digestibility or growth rate; a is intercept; b is coefficients of the quadratic equation; x is dietary level and-b_1/2b2 = x value for optimum response. The quadratic model was fitted to the experimental data by means of the NLIN procedure of SAS (SAS, 2008). The quadratic model was used because it gave the best fit. Only figures on live gain are given because of page restrictions.

RESULTS

Nutrient composition: Nutritional composition of mineral block offered to experimental animals is shown in Table 1. The results of the nutrient composition of cowpea cultivars and buffalo grass hay are presented in Table 2. Cowpea cultivars had higher ($p<0.05$) Crude Protein (CP) contents

Table 1: Nutritional composition of the mineral block offered to the experimental animals

Nutrient	Quantity
Calcium	48.0 g kg^{-1} max
Phosphorus	10.0 g kg^{-1} max
Sulphur	6.0 g kg^{-1}
Magnesium	10 mg kg^{-1}
Manganese	100 mg kg^{-1}
Copper	25 mg kg^{-1}
Cobalt	0.30 mg kg^{-1}
Iron	208 mg kg^{-1}
Sodium	2.5 mg kg^{-1}
Zink	100 mg kg^{-1}
Selenium	0.5 mg kg^{-1}
Vitamin A	12750 I.E kg^{-1}

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Table 2: The nutrient composition of cowpea hay cultivars and buffalo grass hay

	Treatment					
Nutrient	Pan 311	Red caloona	Agripeas	Black eye	Buffalo grass	SE
Dry matter (g kg^{-1})	933^a	867^b	880^b	895^b	943^a	0.964
Crude protein (g kg^{-1} DM)	229^c	195^d	245^b	260^a	33^e	0.139
Organic matter (g kg^{-1} DM)	867^b	880^{ab}	873^{ab}	813^c	907^a	0.964
Neutral detergent fibre (g kg^{-1} DM)	453^b	449^b	472^b	426^b	596^a	1.687
Acid detergent fibre (g kg^{-1} DM)	303^{ab}	289^{ab}	333^a	236^b	357^a	2.087
Polyphenols (mg 0.5 mL^{-1})	0.075^a	0.077^a	0.071^a	0.081^a	0.000^b	0.0067
Condensed tannins (% DM)*	0.113^a	0.074^c	0.085^b	0.085^b	0.000^d	0.0006

[a, b, c] means in the same row not sharing a common superscript are significantly different ($p<0.05$), SE: Standard error, * Percentage DM leucocyanidin equivalent

Table 3: Dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Pan 311

	Treatments				
Variable	50 g	100 g	150 g	200 g	SE
Intake (g/goat/day)					
DM	339^{d}	441^{c}	541^{a}	496^{b}	6.40
OM	305^{d}	396^{c}	485^{a}	441^{b}	5.80
CP	20^{d}	33^{c}	45^{b}	53^{a}	0.21
NDF	195^{c}	249^{b}	302^{a}	269^{b}	3.82
ADF	118^{c}	152^{b}	186^{a}	167^{b}	2.29
Intake (g $kg^{-1}W^{-0.75}$)					
DM	40.55^{b}	47.47^{ab}	53.37^{a}	52.43^{a}	1.870
OM	36.48^{b}	42.63^{ab}	49.64^{a}	46.62^{ab}	1.680
CP	2.39^{c}	3.55^{b}	4.61^{a}	5.60^{a}	0.160
NDF	23.33^{b}	26.80^{ab}	30.91^{a}	28.44^{ab}	1.050
ADF	14.11^{b}	16.36^{ab}	19.04^{a}	17.65^{ab}	0.640
Digestibility (decimal)					
DM	0.64	0.65	0.67	0.65	0.007
OM	0.67^{c}	0.75^{b}	0.79^{a}	0.77^{ab}	0.005
CP	0.70^{c}	0.71^{bc}	0.73^{b}	0.76^{a}	0.003
NDF	0.49^{c}	0.53^{b}	0.55^{a}	0.56^{a}	0.003
ADF	0.36^{c}	0.37^{bc}	0.38^{ab}	0.39^{a}	0.003
Live weight changes					
Initial (kg)	16.46	18.80	19.93	19.00	0.806
Final (kg)	16.96	19.53	20.90	20.00	0.778
Weight gain (g/goat/day)	100^{b}	146^{ab}	194^{a}	200^{a}	0.943

DM: Dry matter; OM: Organic matter; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; CP: Crude protein. $^{a, b, c, d}$ Means with different superscripts within a row are significantly different at 5% level ($p<0.05$). SE: Standard error

than buffalo grass hay. Among the cowpea cultivars, Black eye had higher ($p<0.05$) protein content than Pan 311, Red caloona and Agripeas. Buffalo grass hay had higher ($p<0.05$) NDF values than cowpea cultivars which had similar ($p>0.05$) NDF contents. Pan 311, Red caloona, Agripeas and buffalo grass had similar ($p>0.05$) ADF contents. However, Black eye had lower ($p<0.05$) ADF contents than those of Agripeas and buffalo grass. All the cowpea cultivars contained similar ($p>0.05$) amounts of total polyphenols. Pan 311 had the highest ($p<0.05$) condensed tannin contents followed by Agripeas and Black eye and then Red caloona. However, there were no traces of polyphenols and condensed tannins in buffalo grass.

Experiment 1: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Pan 311.

The results for dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Pan 311 are presented in Table 3. Daily DM intakes were different ($p<0.05$) across dietary treatments, ranging from 339 to 541 g DM per goat per day. Goats on 150 g level of supplementation had the highest ($p<0.05$) DM intakes compared to those on other levels of supplementation. However, goats on 200 g dietary treatment level had the highest ($p<0.05$) CP intakes compared to those on other treatments.

All dietary treatments with Pan 311 had similar ($p>0.05$) DM digestibility values. The lowest values ($p<0.05$) of Organic Matter (OM), CP on the 50 g dietary treatment. The highest values

Table 4: Levels of supplementation of Pan 311 for optimum dietary DM intake (g/goat/day), DM digestibility (decimal) and live weight change (g/goat/day) in Pedi goats on a basal diet of buffalo grass

Factor	Formula	Optimal level (g/goat/day)	r^2	P
Intake	$Y = 127.75+4.817x +-0.015x^2$	161	0.955	0.212
Digestibility	$Y = 0.594+0.001x +-0.0000034x^2$	147	0.712	0.536
Live weight change	$Y = 23.00+1.696x +-0.004x^2$	212	0.985	0.122

P: Probability, r^2: Regression co-efficient

Table 5: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Red caloona

	Treatments				
Variable	50 g	100 g	150 g	200 g	SE
Intake (g/goat/day)					
DM	294^{b}	360^{ab}	415^{a}	379^{ab}	13.0
OM	265^{b}	324^{ab}	372^{a}	339^{ab}	11.8
CP	17^{d}	26^{c}	34^{b}	38^{a}	0.5
NDF	169^{b}	202^{ab}	228^{a}	200^{ab}	7.8
ADF	102^{b}	123^{ab}	139^{a}	124^{ab}	4.7
Intake (g kg^{-1} W$^{-0.75}$)					
DM	35.34^{b}	39.30^{ab}	43.73^{a}	40.32^{ab}	0.880
OM	31.85	35.37	39.19	36.06	0.080
CP	2.04^{d}	2.84^{c}	3.58^{b}	4.05^{a}	0.070
NDF	20.31	22.05	24.03	21.28	0.530
ADF	12.26	13.43	14.65	13.19	0.320
Digestibility (decimal)					
DM	0.65	0.67	0.68	0.67	0.012
OM	0.62^{b}	0.69^{ab}	0.73^{a}	0.70^{a}	0.011
CP	0.68^{c}	0.73^{b}	0.73^{b}	0.75^{a}	0.002
NDF	0.44^{b}	0.45^{b}	0.53^{a}	0.55^{a}	0.005
ADF	0.33^{c}	0.35^{b}	0.37^{ab}	0.38^{a}	0.004
Live weight changes					
Initial (kg)	16.56	18.63	19.33	19.03	0.721
Final (kg)	16.87^{b}	19.17^{ab}	20.10^{a}	19.83^{a}	0.710
Weight gain (g/goat/day)	62^{b}	108^{ab}	154^{a}	160^{a}	0.850

DM: Dry matter; OM: Organic matter; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; CP: Crude protein. [a, b, c d] Means with different superscripts within a row are significantly different at 5 % level ($p<0.05$). SE: Standard error

for the same parameters were observed with 150 and 200 g dietary treatments (Table 3). Goats on 100, 150 and 200 g of supplementation attained similar ($p>0.05$) and higher live weight gains (146, 194, 200 g day^{-1}) than those on 50 g (100 g day^{-1}).

The results of series of regression equations that predict the level of supplementation of Pan 311 for optimum dietary DM intake, DM digestibility and live weight changes in Pedi goats on a basal diet of buffalo grass are presented in Table 4. Dietary intake, digestibihty and hive weight gain were optimized at supplementation levels of 161, 147 and 212 g/goat/day, respectively.

Experiment 2: Dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Red caloona.

The results for dietary intake, digestibihty and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Red caloona are presented in Table 5.

Table 6: Levels of supplementation of Red caloona for optimum dietary DM intake (g/goat/day), DM digestibility (decimal) and live weight change (g/goat/day) in Pedi goats on a basal diet of buffalo grass

Factor	Formula	Optimal level (g/goat/day)	r^2	P
Intake	$Y = 157.00+3.170x +-0.010x^2$	159	0.959	0.204
Digestibility	$Y = 0.593+0.001x +-0.000003x^2$	167	0.989	0.103
Live weight change	$Y =-14.00+1.680x +-0.004x^2$	210	0.987	0.113

P: Probability, r^2: Regression co-efficient

Goats on diets supplemented with 100, 150 and 200 g dietary treatments had similar ($p>0.05$) DM, OM, NDF and ADF intakes. There were differences ($p<0.05$) in CP intakes among dietary treatments. Goats on 200 g dietary treatment had the highest ($p<0.05$) crude protein intake value. DM digestibility was similar ($p>0.05$) across dietary treatments. Goats on 100, 150 and 200 g dietary treatments had similar ($p>0.5$) OM digestibility. The highest ($P<0.05$) CP digestibility was observed on the 200 g dietary treatment. Goats on 50 g supplementation attained lower ($p<0.05$) live weight change than those on 150 and 200 g.

Daily dietary intake, digestibility and live weight gain in Pedi goats were optimized at supplementation levels of 159, 167 and 210 g/goat/day, respectively (Table 6).

Experiment 3: Dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Agripeas.

The results for dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Agripeas are presented in Table 7. Daily DM, OM, NDF and ADF intakes were similar ($p>0.05$) across dietary treatments. CP intake ranged between 17 and 48 g/goat/day, with 200 g dietary treatment having the highest value.

Diet DM and OM digestibility values were similar ($p>0.05$) across the treatments. Goats on diets supplemented with 150 and 200 g had higher ($p<0.05$) CP, ADF and NDF digestibility values than those on diets supplemented with 50 and 100 g. Similar ($p>0.05$) live weight changes were observed on 100, 150 and 200 g supplementation levels with a higher ($p<0.05$) value observed on the 150 g dietary treatment. Daily dietary intake, digestibility and live weight gain were optimized at supplementation levels of 148, 154 and 161 g/goat/day, respectively (Table 8).

Experiment 4: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Black eye.

The results for dietary intake, digestibility and live weight changes of Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Black eye are presented in Table 9. Goats on 100, 150 and 200 g supplementation levels had higher ($p<0.05$) DM and OM intakes than those on 50 g. Goats had different ($p<0.05$) CP intakes across the dietary treatments. Goats on the 200 g dietary treatment had the highest ($p<0.05$) CP intake with the least CP intake value observed on the 50 g dietary treatment.

Diet DM, CP and NDF digestibility values were similar ($p>0.05$) across dietary treatments. Diet OM digestibility was higher ($p<0.05$) on diets supplemented with 100, 150 and 200 g than the 50 g supplementation level. Diets of 150 and 200 g supplementation levels had similar ($p>0.05$) ADF digestibility which were higher ($p<0.05$) than those of 50 and 100 g. The highest ($p<0.05$) live weight gain (60 g/goat/day) was observed on the 200 g supplementation treatment.

Daily dietary intake, digestibility and live weight gain were optimized at supplementation levels of 119, 167 and 191 g/goat/day, respectively (Table 10).

Table 7: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Agripeas

	Treatment				
Variable	50 g	100 g	150 g	200 g	SE
Intake (g/goat/day)					
DM	241	333	351	336	25.63
OM	217	299	314	299	23.24
CP	17^{d}	30^{c}	40^{b}	48^{a}	0.84
NDF	138	187	193	179	9.15
ADF	85	117	122	116	15.27
Intake (g $kg^{-1}W^{-0.75}$)					
DM	28.83	36.47	36.60	35.22	2.110
OM	25.96	32.75	32.74	31.34	1.920
CP	2.03^{d}	3.29^{c}	4.17^{b}	5.03^{a}	0.080
NDF	16.51	20.48	20.13	18.76	1.280
ADF	10.17	12.81	12.72	12.16	0.760
Digestibility (decimal)					
DM	0.57	0.65	0.68	0.64	0.020
OM	0.52	0.66	0.71	0.61	0.030
CP	0.63^{b}	0.65^{b}	0.68^{a}	0.71^{a}	0.004
NDF	0.41^{b}	0.43^{b}	0.47^{a}	0.48^{a}	0.003
ADF	0.29^{b}	0.31^{b}	0.34^{a}	0.36^{a}	0.003
Live weight changes					
Initial (kg)	16.93	18.63	19.83	19.67	0.724
Final (kg)	16.97	19.07	20.37	20.23	0.743
Weight gain (g/goat/day)	8^{b}	88^{a}	108^{a}	112^{a}	7.817

DM: Dry matter; OM: Organic matter; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; CP: Crude protein. $^{a, b, c, d}$ Means with different superscripts within a row are significantly different at 5 % level ($p<0.05$). SE: Standard error

Table 8: Levels of supplementation of Agripeas for optimum dietary DM intake (g/goat/day), DM digestibility (decimal) and live weight change (g/goat/day) in Pedi goats on a basal diet of buffalo grass

Factor	Formula	Optimal level (g/goat/day)	r^2	P
Intake	$Y = 108.00+3.250x +-0.011x^2$	148	0.989	0.104
Digestibility	$Y = 0.368+0 .004x +-0.000013x^2$	154	0.990	0.099
Live weight change	$Y =-99.00+2.564x +-0.008x^2$	161	0.986	0.117

P: Probability, r^2: Regression co-efficient

Experiment 5: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of cowpea cultivars.

The results of the dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts (levels for optimum intake) of cowpea cultivars are presented in Table 11. Goats on diets supplemented with Pan 311 and Red caloona had higher ($p<0.05$) dietary DM, OM, NDF and ADF intakes than those on diets supplemented with Agripeas or Black eye. Goats on Agripeas and Black eye supplemented diets had similar ($p>0.05$) dietary DM, OM, NDF and ADF intakes. Similarly, goats on Pan 311 and Red caloona supplemented diets had similar ($p>0.05$) dietary DM, OM, NDF and ADF intakes.

Table 9: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts of Black eye

	Treatments				
Variable	50 g	100 g	150 g	200 g	SE
Intake (g/goat/day)					
DM	189^{b}	219^{a}	207^{ab}	201^{ab}	2.99
OM	174^{b}	205^{a}	196^{a}	192^{a}	2.72
CP	16^{d}	28^{c}	37^{b}	46^{a}	0.22
NDF	105^{ab}	115^{a}	101^{bc}	90^{c}	1.77
ADF	62^{ab}	67^{a}	58^{b}	51^{c}	1.06
Intake (g kg^{-1} W$^{-0.75}$)					
DM	22.60^{ab}	23.75^{a}	22.90^{ab}	21.00^{b}	0.400
OM	20.81	22.23	20.74	20.06	0.370
CP	1.91^{d}	3.04^{c}	3.91^{b}	4.80^{a}	0.090
NDF	12.56^{a}	12.47^{a}	10.69^{b}	9.40^{c}	0.200
ADF	7.42^{a}	7.27^{a}	6.14^{b}	5.33^{b}	0.120
Digestibility (decimal)					
DM	0.56	0.58	0.59	0.58	0.010
OM	0.43^{b}	0.51^{a}	0.49^{a}	0.48^{a}	0.008
CP	0.63	0.64	0.66	0.67	0.004
NDF	0.38	0.42	0.44	0.46	0.002
ADF	0.25^{c}	0.28^{b}	0.30^{a}	0.32^{a}	0.004
Live weight changes					
Initial (kg)	17.13	19.20	19.77	20.03	0.636
Final (kg)	16.97	19.33	19.97	20.33	0.646
Weight gain (g/goat/day)	-32^{d}	26^{c}	40^{b}	60^{a}	6.922

DM: Dry matter; OM: Organic matter; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; CP: Crude protein. a, b, c d Means with different superscripts within a row are significantly different at 5 % level ($p<0.05$). SE: Standard error

Table 10: Levels of supplementation of Black eye for optimum dietary DM intake (g/goat/day), DM digestibility (decimal) and live weight change (g/goat/day) in Pedi goats on a basal diet of buffalo grass

Factor	Formula	Optimal level (g/goat/day)	r^2	P
Intake	$Y = 159.00+0.948x+-0.004x^2$	119	0.754	0.496
Digestibility	$Y = 0.522+0.001x+-0.000003x^2$	167	0.989	0.103
Live weight change	$Y = -96.500+1.530x+-0.004x^2$	191	0.973	0.163

P: Probability, r^2: Regression co-efficient

Diet DM digestibility values were similar ($p>0.05$) across the dietary treatments. Diets supplemented with Pan 311 or Red caloona had higher ($p<0.05$) OM digestibility values than those supplemented with Agripeas or Black eye. There were no differences ($p>0.05$) in OM digestibility values for diets supplemented with Agripeas or Black eye. Diets supplemented with Pan 311 or Red caloona had similar ($p>0.05$) CP digestibility values. However, diets supplemented with Red caloona or Agripeas had higher ($p<0.05$) CP digestibility values than those supplemented with Black eye. Pan 311 had higher ($p<0.05$) NDF and ADF digestibility values than the other cultivars. However, Agripeas and Black eye had similar ($p>0.05$) NDF and ADF digestibility values. Goats on Red caloona, Agripeas and Black eye had similar ($p>0.05$) live weight changes. However, goats on Pan 311 had higher ($p<0.05$) live gains than those on Black eye.

Table 11: Dietary intake, digestibility and live weight changes in Pedi goats on *ad libitum* buffalo grass hay supplemented with different amounts (levels for optimum intake) of cowpea cultivars

	Treatments				
Variable	Pan 311 (161 g/goat/day)	Red caloona (159 g/goat/day)	Agripeas (148 g/goat/day)	Black eye (119 g/goat/day)	SE
Intake (g/goat/day)					
DM	501^a	510^a	323^b	321^b	12.59
OM	448^a	459^a	288^b	280^b	11.42
CP	48^a	42^b	43^b	38^c	0.77
NDF	271^a	284^a	180^b	186^b	7.51
ADF	171^a	173^a	113^b	102^b	4.50
Intake (g kg^{-1} W$^{-0.75}$)					
DM	53.9^a	55.4^a	35.2^b	37.3^b	2.85
OM	48.2^a	51.9_a	31.4^b	32.6^b	2.57
CP	5.17^a	4.57^a	4.69^{ab}	4.42^b	0.27
NDF	29.2^a	30.9^a	19.6^b	21.6^b	1.59
ADF	18.4^a	18.8^a	12.3^b	11.9^b	0.98
Digestibility (decimal)					
DM	0.67	0.70	0.66	0.65	0.017
OM	0.78^a	0.78^a	0.65^b	0.64^b	0.014
CP	0.74^a	0.71^{ab}	0.70^b	0.66^c	0.008
NDF	0.51^a	0.45^b	0.42^c	0.40^c	0.008
ADF	0.36^a	0.34^b	0.32^{bc}	0.30^c	0.006
Live weight changes					
Initial (kg)	18.50	18.37	18.50	17.07	1.407
Final (kg)	19.53	19.27	19.20	17.63	1.465
Weight gain (g/goat/day)	206^a	180^{ab}	140^{ab}	112^b	22.85

DM: Dry matter; OM: Organic matter; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; CP: Crude protein. $^{a, b, c, d}$Means with different superscripts within a row are significantly different at 5 % level ($p<0.05$). SE: Standard error

DISCUSSION

Buffalo grass contained low crude protein content of 3.3 g kg^{-1} DM. This value is similar to that reported by Giacomini *et al.* (2006) and Motubatse *et al.* (2008). All cowpea cultivars had over 15% CP content. However, Black eye hay had higher protein content than the other cowpea cultivars. These values are similar to the ones reported by Savadogo *et al.* (2000), Baloyi *et al.* (2001), Chakeredza *et al.* (2002) and Rivas-Vega *et al.* (2006). All the cowpea cultivars contained traces of condensed tannins but the total amounts varied between the cultivars. Pan 311 contained the highest amounts of condensed tannins while Red caloona contained the lowest amounts of condensed tannins (Table 2). Baloyi *et al.* (2001) also indicated that some cowpea cultivars contained high proportions of protein-binding tannins. It can be concluded that cowpea cultivars used in the present experiment had high CP contents and, thus, offered great potential as protein supplements for goats and sheep fed low quality roughages.

Goats responded positively to different levels of supplementation with all the cowpea cultivars. This is in support to the findings of Baloyi *et al.* (2007) who found that animals supplemented with legumes have higher intake and responded better than those offered hay alone. However, intake, digestibility and live weight gains of goats were optimized at different cowpea supplementation levels. Generally, live weight changes were optimized at higher supplementation

Table 12: Cowpea supplementation levels for optimal responses (intake, digestibility and live weight gain) in goats fed *ad libitum* buffalo grass

Variable	Pan 311	Red caloona	Agripeas	Black eye
Intake				
Optimum intake (g/goat/day)	515	408	348	215
Supplementation level (g/goat/day)	161	159	148	119
Digestibility				
Optimum digestibility (decimal)	0.676	0.676	0.675	0.605
Supplementation level (g/goat/day)	147	167	154	167
Live weight				
Optimum live weight gain (g/goat/day)	202	162	106	50
Supplementation level (g/goat/day)	212	210	161	191

levels than intake and digestibility when compared within the same cultivar. Thus, it would be advisable to use supplementation levels for optimal live weight gains when doing dose-response type of trials because changes in live weight are better indications of the feeding values of forages (McDonald *et al.*, 2002). Estimated optimal live weight gain of goats on Pan 311 was the highest followed by Red caloona, Agripeas and Black eye (Table 12). No such analysis of cowpeas for goats was found in the study.

When supplementation levels for optimal intakes of each cowpea cultivar were used in Experiment 5, goats responded positively to all the treatments. Diet DM intakes ranged between 35.2 g kg^{-1} $W^{-0.75}$ for Agripeas and 55.4 g kg^{-1} $W^{-0.75}$ for Red caloona. Diet OM digestibility ranged from 0.64 for Black eye to 0.78 for Red caloona and Pan 311. Daily live weight changes ranged from 112 g/goat/day for Black eye to 206 g/goat/day for Pan 311. The highest live weight gain was obtained from goats on Pan 311 cultivar. These intake, digestibility and live weight gain values in goats are within the ranges reported elsewhere in the literature (Mandal *et al.*, 2005; Mupangwa *et al.*, 2000; NRC, 1981) on goat and sheep.

Pan 311 had lower protein content compared to Agripeas and Black eye and yet animals on Pan 311 exhibited better intake, digestibility and live weight gain responses. This is contrary to the findings by Islam *et al.* (2010), Scollan *et al.* (2001), Iyeghe-Erakpotobor (2007) and their view findings and context view indicated that animals on supplements with higher protein contents exhibit better intake, digestibility and live weight gain responses. Pan 311 had the highest amount of condensed tannins. Feeds high in condensed tannins tend to have low digestibility and intake values (Goromela *et al.*, 1997; Makkar, 2003). This is because condensed tannins tend to bind with proteins and other nutrients, thus rendering them indigestible (Cooper and Owen-Smith, 1985; Frutos *et al.*, 2002; Makkar, 2003). Aganga *et al.* (2006) also stressed that it is possible that both small ruminants can adapt to diet high in tannins. However, dietary concentrations of CT, ranging from 2 to 4.5%, improved efficiency of N use and increased the daily weight gain in lambs on temperate fresh forages like *Lotus corniculatus* (Min *et al.*, 2003). Other authors have also indicated that condensed tannins used in little amounts can have a positive effect on diet digestibility and animal productivity (Terril *et al.*, 1992; Reed, 1995). This may, therefore, explain the better intake, digestibility and live weight gain responses observed with Pan 311 supplementation.

CONCLUSION

All the cowpea cultivars contained more than 15% crude protein. Therefore, they can be used as protein supplements for goats on low quality roughages. Pan 311 had higher feeding values than the other cultivars. All cultivars contained small amounts of tannins which did not adversely affect their intake and digestibility. The amount of tannins in the cultivars may have actually played a positive role in protein protection against ruminal degradation.

Intake, digestibility and live weight gains were optimized at different cowpea supplementation levels. Generally, live weight gains were optimized at higher supplementation levels than intake and digestibility across the cultivars. Thus, it is recommended that supplementation levels for optimal live weight gains be used when doing dose-response type of trials.

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