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Feeding Graded Levels of an Improved Cultivar of Cowpea Haulm as Supplement for Rams Fed Maize Stover Diet

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ABSTRACT

Feed resources commonly utilized by small ruminants in most tropical regions are crop residues. The inherently low concentration of protein limits their intake and hence reduced animal performance. The haulm of cowpea cultivar, IT93K-2045-93 was assessed for its potential as supplement for rams fed a basal diet of maize stover. Four rumen fistulated rams were used in a Latin square design to evaluate the intake degradation and digestibility of Maize Stover (MS) when rams were fed a supplement of cowpea haulm. No significant difference ($p>0.05$) in the intake of MS was observed as the level of supplement increased. Substitution of basal diet by supplement occurred when supplement was fed beyond 14.64 g DM kg^{-1} LW whereas total Dry Matter (DM) intake was similar for the supplemental levels of 7.32 and 21.96 g DM kg^{-1} LW. The DM degradability parameters of maize stover were significantly influenced ($p<0.001$) by the supplement. Where limited quantities of cowpea haulm are available, it is possible to offer small amounts cowpea haulm to improve feed intake when animals are consuming poor quality fodders.

Key words: Cultivar, cowpea haulm, basal diet, supplement, intake, degradation, digestibility

INTRODUCTION

Deficiencies of protein, energy and minerals are the main nutritional factors limiting productivity of sheep in tropical regions (Thomson *et al*., 2000) Moreover, insufficient nitrogen supply for ruminal microbes result in low microbial protein synthesis and intestinal amino acid absorption which can limit forage intake and impair animal performance (i.e. growth, capacity for maintaining live weight and reproduction) (Osuji *et al*., 1995). Owing to inherent nutrient deficiencies, available crop residues, native grasses and cereal crop residues (the main feed resources in Ghana), cannot sustain effective animal production or even maintenance, when fed alone. Therefore provision of appropriate supplementary feedstuffs would be an important step to enhancing the productivity of sheep under smallholder and pastoral production systems in Ghana.

Cowpea is a grain legume utilized as human food and its haulm as livestock feed (Singh and Tarawali, 1997). The haulm of cowpea contain more nitrogen than cereal straws and have been shown to improve intake of low quality forages (Smith *et al*.,1990; Abule *et al*.,1995), average daily gain and carcass dressing percentage of sheep (Koralagama *et al*., 2008), as well as the supply of microbial nitrogen (Osuji and Odenyo, 1997). The cowpea haulm is available after grain harvest and are obtained at little or no cost hence its cost effectiveness as feed supplement. In a study by Antwi *et al*. (2009), an improved dual purpose cowpea cultivar IT93K-2045-93 was reported to have

recorded a high agronomic and nutritive characteristics among the other cultivars assessed namely, SORONKO, IT93K-2309 and IT86D-710. The authors reported that cultivar IT93K-2045-93 had a grain yield of 2.26 t ha^{-1} and a haulm yield of 13.35 t ha^{-1} with 68.6% degradable DM fraction disappearing at a rate of 6.6% h^{-1}. It is important to know how the haulm of this cultivar would influence the intake and degradability of maize stover when used as a supplement. This study therefore aimed at assessing the effects of feeding graded levels of the haulm of cultivar IT93K-2045-93 as a supplement on the intake degradability and digestibility of maize stover offered as basal diet to sheep.

MATERIALS AND METHODS

Location of experiment: The experiment was conducted at the Department of Animal Science (DAS), KNUST, Kumasi, Ghana in the year 2009. The cowpea and the maize were grown on the arable fields of the DAS and harvested during the 11th and 22nd week, respectively. The experiment lasted for 90 days.

Animal diet, treatments and experimental design: Four Djallonké rams with a mean initial weight of 22.28±2.71 kg fitted with rumen cannulae (Nepean Rubber Mouldings Pty Ltd Macan Dicision, Baulkham Hills, Australian) were used. The rams were kept individually in pens with wooden slatted floors with dimensions 1.2 m wide and 2.4 m long. The haulm of the cultivar IT93K-2045-93 and the maize stover were chopped into 4-5 cm length and fed to the rams. A two-week trial prior to the main experiment was carried out where rams were offered maize stover *ad libitum* and 150 g wheat bran daily as supplement. The rams were then adapted to the experimental diets for a further two weeks and randomly assigned to a basal diet of maize stover and three different levels of cowpea haulm (7.32, 14.6 and 21.9 g DM kg^{-1} LW) supplementation over a four period in a (4×4) Latin square design. Each period lasted for 9 days and the animals were rested for a week after each period and allowed to accustom to new treatments in the subsequent period for another week. The supplement was offered at 08:00 h while half of the basal diet was offered at 10:00 h and again at 16:00 h. In instances where the supplement was not completely consumed, it was kept in a separate plastic container to allow animals more time for supplement consumption. However, it is to be noted that, supplements were withdrawn before feeding of maize stover. Water and mineral lick were available *ad libitum*.

Intake, digestion trials and measurements: Rams were accustomed to the digestibility crates for three days prior to intake and digestion trials, during each period following a week adaptation period. The quantities of feed offered and refused were recorded daily; the difference was calculated as feed intake. The total feed offered, refused and feces voided were bulked for each ram for estimation of digestibility.

Degradability studies: Degradation of maize stover in rams offered different levels of cowpea haulm as supplement was assessed during days 1-4 according to the technique described by Orskov *et al.* (1980). Bags were withdrawn from the rumen after they had been incubated for 3, 6, 12, 24, 48, 72 and 96 h. Bags were washed, dried at 55°C for 48 h and weighed.

Chemical analysis: Samples were dried at 55°C for 48 h and finely ground using a laboratory mill (Wiley Mill, UK) to pass through a 1 mm screen. The DM in nylon bag residues was determined by subjecting samples to a temperature of 55°C for 48 h in an oven.

Statistical analysis: Intake and digestibility were analyzed as a replicated 4×4 Latin square using PROC MIXED of SAS (1999) according to the model:

$$Y_{ij(k)} = \mu+P_i+\tau_j+A_{(k)}+\varepsilon_{ij(k)}$$

where, Y_{ijkl} is the measured dependent variable, μ is overall mean, Pi is the fixed effect period i (i = 1, .., 4), $\tau_{(j)}$ is the fixed effect of diet j (j = 1, ., 4), A_k is the random effect of animal and e_{ijkl} being the residual variation. Disapperance of DM from the nylon studies was calculated using the Orskov and McDonald (1979) model:

$$P = a+b\ (1-e^{-ct})$$

where, P is the disappearance of DM at time t, a is the zero time intercept or water-soluble fraction, b is the water-insoluble, but degradable fraction and c is the fraction of insoluble DM that will disappear per hour (t).

The mean separation was done using Waller-Duncan k-ratio t-test at the 0.001 probability level. The effect of the amount of cowpea supplemented was partitioned into orthogonal contrast using SAS (1999).

RESULTS

Chemical composition: The average chemical composition of the maize stover and the cowpea haulm used in this study is presented in Table 1. The dry matter concentration was similar between the two feeds ($p>0.05$), however the organic matter of the supplement was 1.02 times higher than that of the basal diet ($p<0.05$). The N concentration ranged between from 6 g kg^{-1} DM for maize stover to 36.6 6 g kg^{-1} for cowpea haulm. The average fibre concentrations was low ($p<0.01$) for cowpea haulm and high maize stover.

Intake, digestibility and degradability: The intake and digestibility of maize stover (MS) and supplement is shown in Table 2. The results indicated significant differences ($p<0.05$) in the intake of MS as the level of supplement increased. Dry matter intake of the basal diet and the supplement varied from 13.5 to 18.27 and 5.01 to 7.69 g DM kg^{-1} LW, respectively. Supplementation with cowpea haulm resulted in higher ($p<0.05$) intakes of MS, however, the difference between supplement 7.32 g DM kg^{-1} LW and 14.6 g DM kg^{-1} LW only tended to approach significance ($p<0.0860$).

Table 1: Average chemical composition of feed materials

	Content (g kg^{-1} DM)				
Feed	DM	OM	N	NDF	ADF
Maize stover	920	925[b]	6.1[b]	798[a]	585[a]
Cowpea haulm	910	947.5[a]	36.6[a]	466.5[b]	368.6[b]

Within column means with the common letter (a,b,c) are not significantly different ($p>0.05$) comparison of least squares means within PROC MIXED of SAS. DM: Dry matter, OM: Organic matter; N: Nitrogen; NDF: Neutral detergent fibre; ADF: Acid detergent fibre

Table 2: Effect of supplementation level (g DM kg^{-1} LW) on DMI (g DM kg^{-1} LW) and DMD (%) of maize stover

	DMI			
Level	Maize stover	Supplement	Total	DMD
Supplement level				
0	13.5^{b}	0^{c}	13.5^{c}	31.6^{c}
7.3	16.5^{a}	5.0^{b}	21.5^{b}	71.0^{b}
14.6	18.3^{a}	7.0^{ab}	25.3^{a}	74.1^{ab}
21.9				
Significance level				
Treatment	17.0^{a}	7.7^{a}	24.6^{ab}	75.6^{ab}
0 vs 7.32	**	**	**	***
0 vs. 14.6	**	***	***	***
0 vs. 21.9	**	***	***	***
7.3 vs. 14.6	*	*	*	NS
7.3 vs. 21.9	NS	**	*	*
14.6 vs. 21.9	NS	NS	NS	NS

Within column means with the common letter (a,b,c) are not significantly different (P > 0.05;) comparison of least squares means within PROC MIXED of SAS. *p<0.05, **p<0.01, ***p<0.001. DMI: Dry matter intake, DMD: Dry matter digestibility, LW: Live weight, NS: Non significance

Table 3: Rumen DM degradability of maize stover (MS) incubated in nylon bags in rumen of rams fed MS alone or MS supplemented with graded levels of cowpea haulm

		Cowpea haulm supplement (g DM kg^{-1} LW)			
Parameter	MS	7.32	14.64	21.96	P>F
a	6.17^{ab}	8.33^{a}	7.52^{a}	8.47^{a}	0.0414
b	48.00^{c}	50.07^{b}	53.56^{a}	53.40^{a}	0.0003
c (h^{-1})	0.034^{d}	0.0517^{c}	0.0659^{b}	0.073^{a}	0.0001

Within column means with common letter (a, b, c, d) are not significantly different (p>0.05) comparison of least squares means within PROC MIXED of SAS. a: Initially degradable fraction; b: Degradable DM fraction; c: Rate constant for degradation of b

Dry matter intake of supplement varied between 5.0 and 7.7 g DM kg^{-1} LW. Total DM intake was similar (p = 0.0939) among the supplement's level of 7.32 and 21.96 g DM kg^{-1} LW, regardless of the difference in supplement DM intake. This is attributable to decreased intake of MS with increasing levels of cowpea haulm intake, thus the highest level of supplement intake was significantly (p<0.0266) different from the lowest level of intake. This observation implies substitution of the basal diet DM by cowpea haulm DM at the highest level of supplement offered.

Apparent dry matter digestibility significantly (p<0.05) increased with cowpea supplementation at all levels relative to the control group with apparent dry matter digestibility ranging between 31.55 and 75.62%.

The DM degradability parameters for maize stover were significantly influenced (p<0.001) by cowpea haulm supplementation (Table 3). The results showed that cowpea haulm supplemented diets differed significantly (p<0.05) from the control diet in both the readily soluble and potential degradable fractions of the maize stover.

However, no significant difference (p<0.05) was observed between cowpea haulm at the 14.64 and 21.96 g DM kg^{-1} LW levels of supplementation. The rate of disappearance "c" significantly

increased (3.4-7.3%) with increasing level of cowpea haulm supplementation ($p<0.0001$). The amount of DM readily soluble in the rumen represented as "a" ranged from 6.17 to 8.47% while the potentially digestible fraction of the maize stover DM averaged 51.26%.

DISCUSSION

The low intake of MS when fed as a sole diet is a reflection of its lower crude protein and higher fibre contents. The low CP content might have reduced the supply of ammonia-nitrogen and subsequently lowered the fermentation rate, hence the reduced voluntary intake. This is further explained by the low digestibility (31.55%) resulting in a high level of recticulo-rumen fill (Aitchison *et al.*, 1986). Increase in basal diet intake with cowpea supplementation in this study is in consonance with the report by Abule *et al.* (1995) and Smith *et al.* (1990). This observation may be due to increased supply of readily degradable nitrogen, stimulating ruminal fibre degradation and probably enhancing rumen ammonia levels (Silva and Orskov, 1988).

Supplementation with higher levels of cowpea haulm did not significantly ($p>0.05$) affect the intake of the MS. The increased total DM intake therefore was as a result of the higher level of cowpea haulm supplied. This agrees with the study by McMeniman *et al.* (1988) and Manyuchi *et al.* (1997) who observed an increased feed intake when a multipurpose tree was used as a supplement to low nitrogen crop residue. According to Ndlovu and Buchanan-Smith (1985) and McMeniman *et al.* (1988), increased total DM intake is as a result of improved N supply to cellulolytic bacteria, hence an increased rate of degradation of poor quality roughage and a high rate of passage. McMeniman *et al.* (1988) reported that, an ideal supplement should increase or at least maintain intake of the fibrous basal diet. It was observed in this study however that, higher levels of supplementation did not increase the intake of MS but tended to substitute for the basal diet DM intake. This finding contrasts those found in a study by Koralagama *et al.* (2008) who reported that, all levels of cowpea haulm supplementation resulted in a greater intake of a basal diet of maize stover with no apparent effect of substitution when the low (150 g) and high (300 g) inclusion rates of cowpea haulm were compared; but was in agreement with the results of Savadogo *et al.* (2000), who observed that sorghum stover intakes declined linearly ($p<0.01$) with levels (0.424 g g^{-1}) of cowpea supplementation.

The apparent DM digestibility value of 31.55% for the MS control diet in this work was lower than that of 45.2% reported by Koralagama *et al.* (2008). On the contrary, when MS was supplemented with graded levels of cowpea haulm, the results were comparable to those found by the same authors. Siaw *et al.* (1993) and Balogun *et al.* (1998) have reported that drying of forages causes losses in water-soluble carbohydrates due to respiration, Maillard reactions and possibly decomposition. Therefore, the low apparent digestibility of the maize stover could have been influenced by drying of the feed prior to being offered to the rams.

The percentage of readily soluble material for the control diet (6.17) and the mean value of 8.11 obtained for the cowpea supplements (Table 2) compares favourably (7.01 and 8.14, respectively) with the data obtained by Chakeredza *et al.* (2002). Likewise, the digestible fibre disappeared at rates similar to those obtained by them. The relatively higher extent and faster rate of degradation of maize stover in the supplemented diets compared to the control could be due to proliferation of rumen microbes and improved activities of cellulolytic bacteria, owing to the probable higher supply of peptides and amino acids. It is documented in the literature that, the activities of certain cellulolytic bacteria are stimulated by the end-products of proteolytic actions of

ruminal microbes (Ndlovu and Buchanan-Smith, 1985). This might have increased the rate of degradation of the MS, as reported by McMeniman *et al.* (1988). The faster rate of degradation at the higher levels of supplementation may offer some explanation to the substitution effect of the basal diet by the cowpea haulm supplement.

CONCLUSION

Supplementation of cowpea haulm improved intake and digestibility, however substitution effect was observed when cowpea was offered at higher level. It is concluded that, where limited quantities of cowpea haulm is available, it is still possible to offer only small amounts of cowpea haulm (7.32 gDM kg^{-1} LW) to improve intake when animals are consuming poor quality fodders.

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