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Original Article

Intake, digestibility and nitrogen retention in goats fed ensiled maize stover and supplemented with snake bean (*Bobgunnia madagascariensis*) pod meal

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ABSTRACT

Objective: The aim of this study was to assess nutrient intake, digestibility and nitrogen (N) retention in goats fed ensiled maize stover (EMS) when supplemented with snake bean (*Bobgunnia madascariensis*) pod meal (BMM).
Materials and methods: Eight local goats (21±2 Kg) in individual metabolic cages were divided into two groups. One group received a 100 gm BMM daily supplement to basal diet (EMS+50 gm maize bran), while the other group did not receive any supplement. The experimental design was a 2x2 switchback with 7 days of adaptation and 5 days of sampling of orts, feces and urine. Feed intake was recorded and total fecal collection was done to analyze digestibility of dry matter (DM), crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), as well as N balance.
Results: Goats receiving BMM supplement had higher ($P<0.05$) intake and digestibility of the analyzed nutrients than the group without supplementation. BMM supplementation also significantly increased N intake and fecal N output, compared to those without supplementation. BMM-supplemented goats had significantly better N retention than those without supplementation.
Conclusion: Thus, supplementing BMM to goats fed EMS induced a higher ($P<0.05$) intake and digestibility of nutrients as well as better N retention.

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KEYWORDS

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INTRODUCTION

The major constraint to ruminant production in Zambia is poor nutrition, particularly in the dry season when feed supply is inadequate and of poor quality. This usually results in poor animal performance as characterized by frequent abortions, high mortality rates, slow growth rates and delays in attaining breeding age or slaughter weights. To improve performance, providing supplemental nitrogenous compounds, such soybean cake or urea, has been recommended (Sampaio et al., 2010; Souza et al., 2010; Detmann et al., 2014). However, most smallholder farmers in Zambia cannot afford these products because they are either too expensive or not readily available especially in the rural areas. Thus, there is need to find cheaper and locally available protein supplements. One feed resources with such attributes is Snake bean (*Bobgunnia madagascariensis*) pods.

B. madagascariensis is a leguminous tree that grows in much of the Miombo woodlands (Hostettmann et al., 2000; Schaller et al., 2001; Smith and Allen, 2004). In Zambia, Ncube et al (2012) estimated that approximately 14.5 million $m^3$of merchantable volume of *B. madagascariensis* is available. This suggests that this tree species is quite abundant in the country, and may contribute substantially to dry season feeding of ruminants. Its pods are rich in nitrogen (Mojeremane, 2012), and are ripe during the dry season when most forages are at their lowest level of quantity and nutritional quality. Thus, *B. madagascariensis* pods could serve as protein supplement for ruminants during this time of the year. In fact, cattle have been seen butting the trunks of *B. madagascariensis* trees to shake down the pods. However, Stevenson et al. (2010) reported the occurrence of high quantities of flavonoid, pentaglycosides in *B. madagascariensis* pods (as much as 20% of dry pod weight). Ordinarily, these compounds (quercetin and kaempferol glycosides) that are ubiquitous in this plant may not be harmful, but their occurrence at such high levels is likely to have a detrimental effect on the animals. It is well known that high levels of potential anti-nutritional compounds in tree legumes are usually associated with low dry matter intakes, low animal production, weight loss and poisoning (Murdiati et al., 1990; Garg et al., 1992). However, literature indicating detrimental effects of feeding *B. madagascariensis* pods to ruminants as a protein supplement is not readily available. Thus, the objective of this study was to determine the effects of supplementing *B. madagascariensis* pod meal to goats fed ensiled maize stover on nutrient intake, total tract digestibility and nitrogen retention.

MATERIALS AND METHODS

Ripe *B. madagascariensis* pods were obtained from Lundazi district in the Eastern province of Zambia (12°30′S, 32°45′E), where they were harvested by hand and sun-dried before grinding them into a pod meal (BMM), bagging and storing in a cool dry place till the commencement of the feeding trial. Prior to the feeding trial, separate samples of BMM and ensiled maize stover (EMS) were collected for proximate composition analysis.

Animal studies: All animals used in this study were managed according to the guidelines outlined by the University of Zambia Animal Ethics Committee. Eight local goats weighing 21±2 Kg on average were housed individually in metabolic cages and divided into two groups. All goats in both groups were fed a basal diet of EMS+50 gm of maize bran only during the first 7 days. Thereafter one group was supplemented with 100 gm of BMM every morning, while the other group did not receive any supplementation. To ensure complete consumption of the supplement, the 100 gm BMM supplement was first mixed with the 50 gm maize bran and fed to the animals. EMS was later offered to the animals twice every day at 08:00 and 16:00 h. All goats had free access to the basal diet and clean drinking water. The experimental period consisted of 7 days of adaptation to dietary treatments and 5 days of measuring and sampling of feed residues, feces and urine.

Sampling and laboratory analysis: During the sampling period, total fecal output and feed residues for each goat was measured daily, and a 10% representative sample of feces and feed residues were taken and dried in a forced-air oven at 55°C for 24 h before analyzing their proximate composition. Daily urine output from each animal was also collected in buckets containing 10% concentrated sulfuric acid. The acid was added to prevent loss of N through volatilization to ammonia. The total urine output was measured daily and a 50 mL sample was collected for freezing and N analysis later.

Dried samples of feed residues and feces were ground through a 1 mm mesh sieve. They were later pooled per goat on a 5 day basis and analyzed for dry matter (DM) [55°C for 24 h], nitrogen (N) by Kjeldahl method (AOAC, 1990, ID No 945.01), neutral detergent fiber (NDF) and acid detergent fiber (ADF) by procedure of Van Soest et al. (1991) without amylase, sodium sulfite, or correction for residual ash. Similarly, frozen urine samples were thawed, pooled per goat on 5 day basis, and analyzed for N by a Kjeldahl method (AOAC, 1990, I.D. No 954.01).

Data analysis: Data collected was statistically analyzed by the general linear model (GLM) Procedure of SAS (2002), with treatment and goat as factors, based on the mathematical model;

$Y_{ijkl} = \mu + T_j + P_j + A_k + e_{ijkl}$

Where: Y_{ijkl} is the observation; μ *is* the overall population mean; T_i is the effect of treatment, P_j is the effect of sampling period, A_k is the effect of animal, and e_{ijkl} is random error.

Means were compared using student t-test (SAS, 2002), and statistically significant differences were accepted at $P<0.05$.

RESULTS

The proximate compositions of EMS and BMM are shown in **Table 1**. The EMS contained 4.4% CP, 26.1% ADF, and 42.7% NDF, while BMM had 16.9% CP, 29.3% ADF and 48.2% NDF. There was a wider variation in the DM content between EMS and BMM (35.4% *vs* 91.8%, respectively). The low CP content in the EMS indeed warranted supplementation with a feedstuff that is high in CP, such as BMM.

Table 2 shows the nutrient intake by both groups of goats. Supplementing goats with BMM increased the intake of total DM, CP, ADF and NDF at 528.2, 52.1, 222.3 and 252.4 gm/day, respectively, which was significantly higher than 436.3, 45.7, 158.7 and 186.4 gm/day, respectively, recorded for the group that did not receive any supplementation. It was interesting to observe that total DM, CP, ADF and NDF intake by goats that received BMM supplement increased by 21, 14, 40 and 35% when compared to those without supplementation.

Results on digestibility of these nutrients areshown in **Table 3**. Just as observed in intakes, digestibility of DM, CP. ADF and NDF for goats that were supplemented with BMM was higher ($P<0.05$) at 43.7, 47.4, 64.8 and 47.4%, respectively, than that of those that were not supplemented at 34.3, 31.3, 48.3 and 31.3%, respectively. It is also worth noting that digestibility of these nutrients was higher ($P<0.05$) in the supplemented goats by 9.4, 16.1, 16.5 and 16.1% points when compared to the group without supplementation.

Monitoring the N balance is a useful and accurate method of assessing the value of protein to ruminants and therefore it is used widely for this purpose. Data pertaining to N intake, excretion in feces, urine and balance are presented in **Table 4**. N intake was higher ($P<0.05$) in goats supplemented with BMM (22 *vs* 11.4 gm per day) than in those fed basal diet only. It was higher by 10.6 gm per day. Similarly, the fecal output of N followed the intake pattern where it was higher ($P<0.05$) in goats that received supplementation when compared to those fed EMS only (10.3 *vs* 1.8 gm per day). It was higher in supplemented animals by 8.5 gm per day. However, it was surprising to note that N output through urine was similar between the groups (3 *vs* 3.6 gm per day).

Table 1: Proximate composition (%) of ensiled maize stover (EMS) and *Bobgunnia madagascariensis* pod meal (BMM)

Parameter	EMS	BMM
DM	35.4	94.3
CP	4.4	16.9
ADF	26.1	29.3
NDF	42.7	48.2

Table 2: Total nutrient intake (gm/day) by goats fed ensiled maize stover (EMS) as a basal diet and supplemented with *Bobgunnia madagascariensis* pod meal (BMM) as a protein source.

Parameter	EMS	BMM
DM	436.3±23^{a}	528.2±17^{b}
CP	45.7±2.4^{a}	52.1±1.8^{b}
ADF	158.4±8.5^{a}	222.3±6.2^{b}
NDF	186.4±10.4^{a}	252.4±7.3^{b}

Values are presented as means±SD (n=8). Means within the same row with different letter superscript (a–b) are different ($P<0.05$).

Table 3: Total tract nutrient digestibility (%) in goats fed ensiled maize stover (EMS) supplemented with *Bobgunnia madagascariensis* pod meal (BMM) as a protein source.

Parameter	EMS	BMM
DM	34.3±9.1^{a}	52.7±3.5^{b}
CP	31.3±2.4^{a}	47.4±1.8^{b}
ADF	48.3±6.4^{a}	64.8±5.8^{b}
NDF	31.3±7.2^{a}	47.4±4.4^{b}

Values are presented as means±SD (n=8). Means within the same row with different letter superscript (a–b) are different ($P<0.05$).

Table 4: Nitrogen intake, excretion (gm/day), and retention (%) by goats fed ensiled maize stover (EMS) and supplemented with *Bobgunnia madagascariensis* pod meal (BMM).

Parameter	EMS	BMM
N intake	11.4±0.9^{a}	22.0±0.5^{b}
Fecal N	1.8±0.2^{a}	10.3±0.3^{b}
Urinary N	3.6±0.6	3.0±0.5
N Retained	6.0±0.8^{a}	8.7±0.6^{b}
N Retained as % N digested	62.5±3.3^{a}	74.4±6.0^{b}

Values are presented as means±SD (n=8). Means within the same row with different letter superscript (a–b) are different ($P<0.05$).

This resulted in higher ($P<0.05$) retention of N in goats on BMM supplementation when compared to the group without supplementation (8.7 *vs* 6 gm per day). Similarly, the proportion of N retained when calculated as a proportion of the N digested was higher ($P<0.05$) in goats that received BMM than in those that were fed the basal diet only. BMM supplementation induced an 11.9% N retention compared to the group that did not receive any supplement.

DISCUSSION

Goats in both groups remained healthy throughout the experiment, implying that daily intake of 100 gm BMM had no deleterious effect on their health. The EMS used in this study was similar in DM, CP, ADF and NDF contents to that which Chea et al. (2015) and Sekhonyana and Fulpagare (2015) determined. However, the CP content of EMS was lower than the 7% minimum deemed critical for microbial growth and roughage intake by ruminants (Abdulrazak et al., 2005; Wambui et al., 2006). This agreed with the long-held view of many authors (Leng, 1990; Ndlovu, 1992; Yirga et al., 2011; Abdul et al., 2012) that crop residues alone cannot meet the critical level for microbial growth if fed as a sole diet. This warranted EMS to be supplemented with a high protein feedstuff. On the other hand, BMM had CP content that was higher than the EMS. The high CP content was as reported by Mojeremane (2012), and at 16.9%, it was higher than the 14% requirement for growing small ruminants (Waldroup and Smith, 2008; Kikelomo, 2014). This was the motivation in this study to use it as protein supplement to EMS fed to the goats.

Nutrient intake is influenced by the digestibility of the feed ingested, and as digestibility increases so does its intake (Detmann et al., 2014). In this study, digestibility of total DM, CP, ADF and NDF (**Table 3**) increased when goats were supplemented with BMM. This was also reported by others (Mupangwa et al., 2000, Köster et al., 2002; Foster el al., 2009; Kikelomo, 2014), who observed that the supplementation of roughage-based diets with proteinous feed stuff increases the rate and extent of degradation of the basal diet. Increased of DM, CP, ADF and NDF had a positive feedback on intake of the same nutrients (**Table 2**). The positive effect of supplemental BMM on intake and digestibility was attributed to high supply of N (**Table 4**) to rumen microorganisms, which increased their growth rate and led to higher degradation rate and extent of EMS by cellulolytic bacteria, as well as the passage rate of the digesta in the gastro-intestinal tract (GIT). This observation reinforces the notion that increases in dietary CP content positively affects the nutrient intake when the basal diet is deficient in N. Meanwhile, nutrient intake in the goats not supplemented was likely constrained by low digestibility of the same nutrient due to low N content in EMS.

The interpretation that goats supplemented with BMM had higher rate of rumen microbial growth and activity may seem to be in conflict with observations by Jones et al. (1994), Nsahlai et al. (1995) and Makkar (2003), who observed that supplementation of roughage based diets with feedstuffs high in tannins depresses microbial activity in the rumen. BMM is reported to have high levels of tannins (Stevenson et al., 2010), and these compounds have the ability to form reversible complexes with dietary proteins, minerals and structural carbohydrate polymers found in plant cell walls (Min et al., 2003; Smith et al., 2005; Ahnert et al., 2015). The overall effect of this, is the lowering of bioavailability of these nutrients at specific sites in the GIT (Ngwa et al., 2002), thereby constraining their degradation and absorption. However, in this study, this phenomenon seems to have benefited the goats supplemented with BMM by increasing the quantity of protein reaching the lower GIT as hypothesized by Wang et al. (1996), Ngwa et al. (2002), Min et al. (2003) and Ahnert et al. (2015). These authors explained that, at low concentrations, condensed tannins bind with plant protein at near neutral pH in the mouth and rumen to form tannin-protein complexes which are stable and insoluble at pH 3.5-7.0. However, these complexes dissociate and release protein at pH<3.5 in the abomasum.

In this study, the increased protein supplied to the lower GIT was evidenced by the high fecal N output in goats supplemented with BMM, which was most likely, part of the N in the tannin-protein complexes escaping rumen degradation. This assumption can also be explained by lack of significant difference in urinary N output between the two treatments. According to Khattab et al. (2013), the amount of N excreted in urine is influenced mainly by the plasma urea N emanating from the rumen. Only excessive ruminal ammonia N and its consequent absorption increases urinary excretion of N (Russell et al., 1992). On this understanding, urinary N in the BMM-supplemented goats would have been higher than in the EMS only-fed group if all the BMM proteins was hydrolyzed in the rumen and absorbed in the blood stream. However, this was not so because condensed tannins have been shown to reduce not only rumen ammonia N, but also urinary N excretion (Merkel et al., 1999; Mui et al., 2002). This could be the reason for urinary N in the supplemented goats not significantly differing from that in the goats not supplemented with BMM. It also suggests efficient use of the CP hydrolyzed in the rumen by BMM-supplemented goats to support microbial protein synthesis, resulting in significantly increased average daily N retention when compared to EMS only-fed goats.

CONCLUSION

Supplementation of goats fed low quality roughage diets such as EMS with BMM positively affects the intake and digestibility of total DM, CP, ADF and NDF. It also improves the efficiency with which dietary CP is utilized by goats, resulting in better N retention.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

AUTHORS' CONTRIBUTION

FK conceived the idea of the study, and MN collected the study materials and processed them in readiness for the feeding trial. MN and AM carried out the field and laboratory works. The first author analysed the data and drafted the manuscript, but all authors read through the manuscript and approved finally.

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