Asian Journal of Advances in Agricultural Research

3(2): 1-8, 2017; Article no.AJAAR.37054
ISSN: 2456-8864

Intake and Digestibility of Goats Fed Browse Mixtures as Supplement to Sorghum Stover

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Authors' contributions

This work was carried out in collaboration between all authors. Authors JBA and FIA designed the study. Authors AJH and AM performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors FIA and AJH managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2017/37054
Editor(s):
(1) Wuyi Liu, Department of Science & Technology Research, Fuyang Normal College (West), Anhui Province, China.
Reviewers:
(1) Khalifa Muhammad Aljameel, Usmanu Danfodiyo University, Nigeria.
(2) Arbab Sikandar, University of Veterinary and Animal Sciences, Pakistan.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/21629

Original Research Article

Received 28th September 2017
Accepted 24th October 2017
Published 30th October 2017

ABSTRACT

The study was conducted to evaluate the feed intake, weight gain and apparent nutrient digestibility of goats fed browse mixtures (*Balanites aegyptiaca* and *Ziziphus mauritiana*) as supplement to urea treated maize stover. Four nondescript goats weighing 19.33 to 20.23 Kg were used for the experiment in a 4x4 Latin square design (LSD), with four periods, for a duration of eight weeks. The treatments were; A (control): the basal diet (sorghum stover) plus 100g cotton seed cake, B: control + 150g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:1), C: control + 150g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:2) and D: control + 150g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:3). All animals were allowed *ad-libitum* access to water and

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mineral lick. Results showed variation (P<0.05) in the basal diet and total dry matter intake between the treatments. When compared to the control, the supplemented groups had better daily weight gain and feed conversion ratio. Apparent dry matter and nutrient digestibility increased (p<0.05) with supplementation. Generally, Treatment C had better performance and apparent nutrient digestibility. In conclusion, browse mixtures can be used to upgrade the feeding value of cereal crop residues and improve the performance of goats.

Keywords: Goats; performance; Sorghum stover; Balanites aegyptiaca; Ziziphus mauritiana.

1. INTRODUCTION

Animal protein is one of the most important components of human diet and its consumption varies from country to country [1]. Over the years, there has been a great increase in the production of goats in Nigeria which has resulted in poverty alleviation and the supply of high quality animal protein in order to meet the demand of the teeming population [2]. Productivity of these livestock will depend to a large extend on their ability to utilize feeds that have no value in human feeding [3].

In Nigeria, 96% of traditionally managed goats are under the free roaming and tethering system and chronic feed deficit represent major constraints to animal production in many developing countries of the world [2]. One of the major constraints to livestock production in the country is lack of feeds, especially during the dry season. Sources of cheaper alternative forages of high quality for ruminant livestock production have been a subject of research in recent years [4], especially for small scale livestock producers in tropical areas during the dry season. Small ruminants are usually reared with the aims of getting products such as meat, milk, wool and skin. The four products assume varying degrees of importance in different countries, depending on the existing agro-ecological conditions, production system and choice or interest of the producers [5].

Crop residues which are post-harvest materials or roughages left after the removal of the primary feed (grain) from crop plants constitute important feed for ruminants during the long dry season. In northern Nigeria, crop residues such as cowpea and groundnut haulms, sorghum, maize and rice straws are the most important (quantitatively) and regularly used ruminant feeds [6]. However, their value is low with limited intakes due to their composition and structure [7]. The consequences for ruminant animals are low feed intake (about 1.2kg DM/100kg live weight) and low performance [8]. Therefore, there is the need to improve the low nutrient status of the available crop residues in order to enhance their proper utilization and curtail the problem of non-availability of year round feed resources for ruminant production. This can be achieved through chemical treatment, biological treatment and supplementation of the crop residues.

Tree fodders (browse plants) are important in providing nutrients to grazing ruminants in arid and semi-arid environments, where feed supply is a major constraint to livestock production [9]. Traditional farmers in the semi-arid region of Nigeria allow their goats, sheep and cattle to browse on tree forages in the range lands and they also cut and feed these tree foliages as supplements based on experience and convenience. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation [10]. They are less susceptible to climatic fluctuation since they are trees or perennial shrubs and they remain green all year round [11]. Browse plants maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity [12].

This study was designed to determine the dry matter intake, weight gain and apparent nutrient digestibility coefficients of goats fed mixed leaves of *Balanites aegyptiaca* and *Ziziphus maritiana* as supplement to sorghum stover.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the University of Maiduguri Livestock Teaching and Research Farm, Maiduguri, Borno State. Maiduguri is located between latitude 11.15 and 11.45^{o}N, longitude 30.05 and 30.35^{o}E and on altitude of 364m above sea level in the North East of Nigeria. The dry season lasts for about nine months with the hottest period occurring between the months of March and June where the normal

ambient temperature reaches 40°c or more. The mean relative humidity ranges from 30 - 50% with maximum of about 90% in August. The annual rainfall ranges from 500 – 600 mm [13]. The area is characterised by sparse vegetation consisting mostly of browse plants such as *Balanites aegyptiaca, Faidherhia albida* and *Ziziphus mauritiana*.

2.2 Source and Preparation of Feed

The leaves of *Balanites aegyptiaca* and *Ziziphus mauritiana* were collected within the University. Leaves from the browse plants were collected by lopping the branches. The lopped branches were sun-dried for two days, which were then shaken to remove the leaves. The leaves were shade-dried for eight days and then stored in bags. Sorghum stover was obtained from farms within the University. The sorghum stover was chopped using cutlass to a size of 2-4cm in length and then stored in bags. Cotton seed cake was purchased from the Maiduguri livestock market and was ground using mortar and pestle and there after stored in bags.

2.3 Experimental Animals, Their Management and Feeding

Four nondescript goats weighing between 19.33 to 20.23 Kg were used for the experiment. The animals were selected from the flock of goats kept at the University of Maiduguri Teaching and Research Farm. Prior to the commencement of the experiment, the animals were given prophylactic treatment against internal and external parasites. The animals were kept in individual metabolism cages which facilitate separation of faeces and urine. The metabolism cages were housed in a common pen made of cement blocks with concrete floors, which have wide windows for adequate ventilation. The metabolism cages and the pen were kept clean throughout the experimental period. Experimental feeds were offered in the morning. The supplements were offered before the basal diet was offered. Sorghum stover, water and mineral lick were offered *ad-libitum*. Feed refusals were collected and weighed in the morning before fresh feeds were offered.

2.4 Experimental Design and Treatments

The animals were weighed and randomly assigned to four treatments in a 4x4 Latin square design (LSD), with four periods. Each period lasted for 14 days (seven days adaptation period and seven days collection period). The experiment lasted for eight weeks.

The experimental treatments were:

A - Chopped sorghum stover + 100 g cotton seed cake (control)

B - Control + 150 g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:1)

C - Control + 150 g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:2)

D - Control + 150 g of *Balanites aegyptiaca* and *Ziziphus mauritiana* (1:3)

2.5 Data Collection

2.5.1 Feed intake

Feed intake was determined by collecting and weighing the amount of leftover every morning before feeding, and subtracting the leftover from the total amount of feed offered.

2.5.2 Weight gain

The animals were weighed at the beginning and end of each collection period. Weight gain of each animal was determined by subtracting the initial weight from the final weight of the animal. Daily weight gain was obtained by dividing total weight gain by the number of days of the collection period. Feed conversion ratio was obtained by dividing daily dry matter intake by daily weight gain.

2.5.3 Dry matter and nutrient digestibility

The dry matter digestibility (DMD) was determined by the formula:

$$\frac{\text{DM intake} - \text{DM faecal output}}{\text{DM intake}} \times 100\%$$

The digestibility of CP, CF, EE, ash and NFE were determined by the formula:

$$\frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrint intake}} \times 100\%$$

2.6 Chemical Analysis

The feeds and faecal samples collected were analysed for dry matter, crude protein, crude fibre, ether extract and ash, using the A.O.A.C methods [14].

2.7 Statistical Analysis

Data generated were subjected to one way analysis of variance (ANOVA) using SPSS version 9 [15]. Means were separated using Least Significant Difference (LSD) SAS [16].

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Experimental Feeds

The proximate composition of the experimental feeds is shown in Table 1. The dry matter content obtained for sorghum stover (94.8%) is higher than 88.20% [17] but similar to 94.6% [6]. The crude protein content of the stover (4.6%) is higher than 3.9% [18] but lower than 5.2% [6]. The value falls within the range of 4.5 - 9.8% for dry season crop residues in Adamawa state [6]. Hamed and Elimam [19] reported a crude fibre of 42.98±0.01%, which is higher than 35.0% obtained. Bello and Tsado [20] reported a relatively similar sorghum stover crude fibre (31.20%). The stover ash content obtained is similar to 7.0% [17] but higher than 3.90% [20]. The stover ether extract obtained is the same with 1.43±0.02% [19] and also falls within the range of 1.30 - 2.10% for dry season crop residues in Adamawa state [6]. Mohammed and Idris [17] reported 52.10% as nitrogen free extract for sorghum stover, which is similar to 51.8% obtained. Bello and Tsado [20] reported a higher sorghum stover nitrogen free extract (54.39%) but Hamed and Elimam [19] reported a much lower value (40.96±1.24%).

For *Balanites aegyptiaca*, the dry matter content obtained (94.8%) is higher than 92.5% [21] but lower than 955.00 g/KgDM (95.5%) [22]. It had a crude protein content of 14.9%, which is similar to 15.0% [23] but higher than 11.9% [21]. The crude fibre obtained (19.0%) is higher than 17.33% [24] but relatively similar to 20.0% [21]. The ash content obtained (11.0%) is lower than 15.0% [24] but higher than 65.00 g/KgDM (6.5%) [22]. Kamal and Nour [24] reported a higher ether extract of 6.15% and Njidda and Ikhimioya [22] reported a lower ether extract of 23.30 g/KgDM (2.33%). Hyelda et al. [21] reported a nitrogen free extract of 46.9%, which is lower than the value obtained.

Ziziphus mauritiana had a dry matter content of 95.7%, which is higher than the maximum value (93.3%) compiled by Heuzé et al. [25], similar to 95.6% [26] and lower than 973.00 g/KgDM (97.3%) [27]. Njidda and Ikhimioya [22] reported a higher crude protein of 182.40 g/KgDM (18.24%) and Ibrahim et al. [26] reported a lower crude protein of 15.35% when compared to 16.8% obtained. Generally, the crude protein content in browses has been shown to be above the minimum level (7%) required for microbial activities in the rumen [28]. The crude fibre obtained (17.0%) is similar to 176.70 g/KgDM (17.67%) [22] but lower than 26.0% [26]. The ash content obtained (13.1%) falls in the range of 7.74 - 13.25% for some browse plants in Adamawa state [6]. Njidda and Olatunji [27] reported an ash content of 139.40 g/KgDM (13.94%) which is similar to 13.1% obtained. The ether extract value obtained falls in the range of 1.4 - 6.8% compiled by Heuzé et al. [25]. The nitrogen free extract obtained is similar to the mean of 48.10% for some browse plants in Adamawa state [6].

For cotton seed cake, the dry matter content (92.7%) is similar to 92.9 [29]. The crude protein content obtained (23.6%) is similar to 230.01 g/KgDM (23.0%) [30] but lower than 386 g/KgDM (36.8%) [31]. Jokthan et al. [30] reported a crude fibre content of 172.80 g/KgDM (17.28%) which is similar to 17.5% obtained. Ndemanisho et al. [31] reported an ash content of 61 g/KgDM (6.1%) which is higher than 4.3% obtained and Jokthan et al. [30] reported a similar ash value of 46.60 g/KgDM (4.66%).The ether extract and nitrogen free extract obtained agrees with that of Jokthan et al. [30].

The proximate composition of the browse mixtures which is shown in Table 2 falls within the range of values for sole *Balanites aegyptiaca* and *Ziziphus mauritiana* obtained in this study.

Table 1. Chemical composition of experiment feeds (%DM)

Samples	SS	BA	ZM	CSC
Dry matter	94.8	94.8	95.7	92.7
Crude protein	4.6	14.9	16.8	23.6
Crude fibre	35.0	19.0	17.0	17.5
Ash	7.2	11.0	13.1	4.3
Ether extract	1.4	3.9	4.2	20.4
Nitrogen free extract	51.8	51.2	48.9	34.2

SS = sorghum stover, BA = Balanites aegyptiaca, ZM = Ziziphus mauritiana, CSC = cotton seed cake

3.2 Feed Intake and Growth Performance

Table 3 shows the feed intake and growth performance of the goats fed the different

experimental feeds. Treatment A recorded the highest stover intake (379.41 g/day). Treatments B, C and D recorded a stover intake of 350.38, 366.74 and 358.35 g/day respectively. There were significantly differences (P<0.05) between the treatments. Hirut et al. [32] stated that the lower basal diet dry matter intake in high level of supplementation could be attributed to the high intake of the supplement dry matter as a proportion of total dry matter intake, thus preventing maximum intake of the basal feed. Among the supplemented treatment groups, Treatment C (1:2) recorded the highest stover intake. Supplementation with the browse mixtures increased (P<0.05) the total feed intake. Treatment A that was not offered the mixed browse supplement recorded the lowest total feed intake (472.11 g/day). Treatment C (1:2) recorded the highest total feed intake (599.24 g/day). The higher feed intake recorded by the animals supplemented with the browse mixtures is in agreement with the findings of Hyelda et al. [21] and Ondiek et al. [33] who observed significant increase in feed intake in their trial with goats fed cereal crop residues supplemented with browse leaves.

Supplementing the basal diet with the browse mixtures positively influenced the growth performance of the goats. The average daily weight gain for treatments A, B, C and D were 16.43, 31.07, 46.79 and 38.57g respectively. There were significant differences (P<0.05) between treatments. The control group (treatment A) was the least in feed conversion ratio when compared to other treatments because it was not supplemented with the browse mixtures. Treatment C (1:2) recorded the best growth performance and feed conversion ratio. In their research, Abdu et al. [34] reported a similar average daily weight gain of 43.33 g/day in Yankasa lambs fed maize stover basal diet and a concentrate diet containing 20% *Ziziphus mauritiana*. The feed conversion ratio obtained in this study also agrees with the findings of Abdu et al. [34].

Table 2. Chemical composition of browse mixtures (%DM)

Samples	1:1 BA:ZM	1:2 BA:ZM	1:3 BA:ZM
Dry matter	95.0	95.1	95.4
Crude protein	15.4	15.9	16.3
Crude fibre	18.6	17.8	17.2
Ash	11.0	11.5	12.1
Ether extract	4.0	4.0	4.2
Nitrogen free extract	51.0	50.8	50.2

BA = Balanites aegyptiaca, ZM = Ziziphus mauritiana

3.3 Apparent Nutrient Digestibility

Result of the apparent nutrient digestibility is presented in Table 4. Supplementing sorghum stover with the browse mixtures had significant effect (P<0.05) on apparent digestibility of all parameters considered. Dry matter, crude protein, ash and nitrogen free extract digestibility were significantly higher (P<0.05) in goats fed 1:2 (treatment C) of the browse mixtures. Treatment D (control) recorded the highest crude fibre and ether extract digestibility. Generally, least digestibility was observed in treatment A

Table 3. Performance characteristics of goats fed sorghum stover and browse mixtures

Parameters	Treatments				
	A	B 1:1 BA:ZM	C 1:2 BA:ZM	D 1:3 BA:ZM	SEM
Dry matter (DM) intake (g/day)					
Sorghum stover	379.41^{a}	350.38^{d}	366.74^{b}	358.35^{c}	4.26*
Browse mixtures	-	139.65^{a}	139.80^{a}	140.24^{a}	0.15*
Cotton seed cake	92.70	92.70	92.70	92.70	
Total DM intake (g/day)	472.11^{b}	582.73^{ab}	599.24^{a}	591.29^{a}	36.70*
Growth performance					
Initial live weight (Kg)	19.33	20.23	19.44	20.20	0.32
Final live weight (Kg)	19.79	21.10	20.75	21.28	0.35
Total weight gain (Kg)	0.46^{c}	0.87^{b}	1.31^{a}	1.08^{b}	0.16*
Daily weight gain (g)	16.43^{c}	31.07^{bc}	46.79^{a}	38.57^{b}	7.58*
Feed conversion ratio	28.73^{d}	18.83^{c}	12.81^{a}	15.33^{b}	3.96*

Means with different superscript in the same row differ significantly (p<0.05)

*BA = Balanites aegyptiaca, ZM = Ziziphus mauritiana, SEM = Standard error of mean, * = Significant at (p<0.05)*

Table 4. Apparent nutrient digestibility of goats fed sorghum stover and browse mixtures

Digestibility (%)	Treatments				
	A	B 1:1 BA:ZM	C 1:1 BA:ZM	D 1:1 BA:ZM	SEM
Dry matter	52.63^{d}	58.91^{c}	64.41^{a}	61.03^{b}	0.23*
Crude protein	56.14^{d}	71.25^{c}	75.62^{a}	73.70^{b}	0.12*
Crude fibre	73.95^{a}	72.39^{b}	72.65^{b}	74.24^{a}	0.13*
Ash	48.92^{c}	51.85^{bc}	55.87^{a}	53.06^{b}	0.18*
Ether extract	69.13^{b}	69.52^{b}	72.19^{a}	72.46^{a}	0.21*
Nitrogen free extract	58.01^{c}	63.75^{b}	67.71^{a}	66.91^{a}	0.36*

Means with different superscript in the same row differ significantly (p<0.05)

*BA = Balanites aegyptiaca, ZM = Ziziphus mauritiana, SEM = Standard error of mean, * = Significant at (p<0.05)*

obviously because it was not offered the browse mixtures. When compared to the control (treatment A), the increase in apparent nutrient digestibility of the supplemented treatments agrees with the findings of Hyelda et al. [21] and Ondiek et al. [33] who observed significant increase in apparent nutrient digestibility for the supplemented treatment groups in relation to the control treatment group when goats were fed cereal crop residues supplemented with browse leaves.

4. CONCLUSION

The use of browse mixtures as supplement to sorghum stover improved the total feed intake, weight gain and apparent nutrient digestibility of the goats when compared to the control (Treatment A). Thus, mixtures of *Balanites aegyptiaca* and *Ziziphus mauritiana* can be utilized when feeding goats with low quality basal feeds such as cereal crop residues.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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