International Journal of
Agriculture and Biosciences
www.ijagbio.com P-ISSN: 2305-6622 E-ISSN: 2306-3599 editor@ijagbio.com

RESEARCH ARTICLE

Effect of Supplementation and Voluntary Feed Intake in Red Sokoto Goats offered a Basal Diet of Treated Maize Stover

[a]M Babawuro Yahaya* and [b]A Kibon

[a]Federal College of Education (Technical) Gombe School of Vocational Education PMB 060 Gombe, Gombe State Nigeria; [b]Department of Animal science, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria

ARTICLE INFO

Received: February 03, 2013
Revised: February 20, 2013
Accepted: February 23, 2013

Key words:
Maize bran
Maize Stover
Treatment
Urea

***Corresponding Address:**
M Babawuro Yahaya
sarkinshanu2005@yahoo.com

ABSTRACT

Sixteen young Maradi breed of goats averaging 11 ± 2kg were used at Federal University of Technology Yola, Teaching and Research Farm, Adamawa state, in a 4 by 4 Randomized Complete Block Design for a period of 56 days to study the effects of utilizing maize Stover treated with 4% urea and supplemented with maize bran at 0, 50, 100 and 150g. Results showed that there was significant difference in Average daily feed intake and weight gain among the treatment, in T1 (154.28 and 41.61), T2 (197.42 and 83.83), T3 (246.84 and 102.68), and T4 of 293.35g/day and 120.54g/day, respectively. The feed conversion ratio was higher in T4 (2.56) no significant difference was observed between T4 and T3 (2.50), but significant difference exist between T1 (3.95) and T2 (2.39). The percentage digestibility of the experimental diets was higher in T4 (79.86), and that digestibility differs significantly among the treatments. The Nitrogen (N) balance was significantly higher in T4 and faecal N loss appeared to be highest in the T3 group (1.57g/day) and lowest in T2 (1.43g/d. Faecal collection showed that there was a gradual reduction of faecal output from 64.3, 62.1, 61.4 and 60.4g/day among the treatments, respectively. The chemical composition of the faeces and urine indicated that T1 has the highest composition of all the parameters analyzed. The dry matter, ash, crude protein and crude fiber of the faeces and the urine nitrogen content differ significantly among the treatment. However no significant difference was observed with respect to ether extract. The economy of production reveals that cost of feed was higher in T4 (N675.08) with a cost saving of N46.20 and N100.01 feed cost/kg/Naira gain. It is suggested that feeding 4% UTMS and maize bran inclusion at 150g will provide the farmer adequate and profitable live weight gain required during the dry season feeding programme, hence it should be use in the fattening programme.

Cite This Article as: Yahaya MB and A Kibon, 2013. Effect of Supplementation and Voluntary Feed Intake in Red Sokoto Goats offered a Basal Diet of Treated Maize Stover. Inter J Agri Biosci, 2(1): 30-34. www.ijagbio.com

INTRODUCTION

Goats are multi functional animals and play a significant role in the economy and nutrition of small and marginal farmers in Nigeria. They are essential components of pastoralists' herds, partly due to their ability to withstand drought conditions, preference for browse and crop residues like maize stover during the dry season, which means that they do not compete with cattle for available biomass (FAO, 2005). Maize stover is use to raise goats particularly when they become available after harvest, at the onset of the dry season, during that period animals rely almost totally on natural forages and other crop residues (Makkar and Singh, 1997).

Maize stover is an important feed resource in Nigeria particularly during the dry season, but it is poorly utilized. Recently, because of the realization that land development and expansion of crop farming activities will continue to reduce the available grazing land, efforts are being made to encourage the settlement of pastoralists and to integrate them with the non-pastoralists. The implication of this is that an economic feeding system must be developed, especially for dry season feeding (Fall, 1990). This could eliminate the need for migration in search of pasture and water and limit the cyclical weight loss of livestock. One natural feed resource on which feeding systems can be based during the dry season periods is the maize stover which is in abundance in almost all ecological zones of

Nigeria during the harvest. Makkar and Singh (1997) reported that urea treated maize stover significantly increased the dry matter intake and live weight gain of cattle.

Similarly, Ibrahim *et al.* (2003) reported that sheep given urea treated maize stover alone excreted 42% urine volume, containing significantly more than 70% N, however the Nitrogen retention has been found to increase with inclusion of maize bran in the diet which improved the body weight gain.

Although the problem with maize stover like other tropical grasses is the rapid decline in crude protein and soluble carbohydrate with age, coupled with a progressive increase in crude fibre and lignin, these problems therefore call for extra treatment or supplementation (De Leeuw, 1979; Khan and Davis, 1981; Fall, 1990). The simplest method of processing or treating the stover is by the use of crude process to optimize its utilization by small ruminants to form Urea Treated Maize Stover (UTMS). The process is not hazardous compared with NaOH and NH_3 and it has an added advantage of increasing the nitrogen content of the roughage in form of None Proteineous Nitrogen (NPN), which could be used by the rumen micro flora to synthesize microbial protein; other conditions in the rumen being right.

Improved utilization of low quality tropical hays by treatment with urea, ammonia, sodium and ammonium hydroxide on large ruminants has been reported (Sundstol 1981; Buettner *et al*., 1982; Green halgh, 1984; Munthali *et al*., 1991; Saadullah *et al*., 1991; Smith *et al.,* 2007). In addition to Nguyen (2004) who studies the adoptability of maize stover as feed for growing sheep under smallholder's circumstances, utilization of UTMS with supplements on small ruminants particularly goat is very limited.

Therefore, this experiment was conducted to investigate the effects of supplementing different levels of maize bran on the intake, digestibility, growth rate and economy of production using UTMS with a view to determine its acceptability and utilization for the dry season feeding programme in goat production.

MATERIALS AND METHODS

Location and Climate

The experiment was carried out at the Teaching and Research Farm, Federal University of Technology, Yola, located in Girei Local Government Area of Adamawa state, Nigeria. The area lies between latitude 9^0 and 11^0 north and longitude 11^0 and 14^0 East. It has a tropical climate with district dry and wet seasons. The rainfall begins in April and ends late October, while the dry season commences in November and ends the following April. It has an average minimum temperature of 20.5^0C and maximum temperature of up to 40^0C (Adebayo and Tukur, 1999).

Experimental Animals

Sixteen (16) growing Maradi goats (bucks) aged between 7-9 months and weighing 11 ± 2kg were used for the study. The animals were procured from Girei and Song local market on market days. They were housed, fedad libitum and treated with antibiotics and other dewormers before the commencement of the experiment.

Experimental Design and Treatments

The animals were randomly allocated to four treatments with four (4) animals per treatment in a Randomized Block Design (RBD). The treatments were:

T_1 Offered UTMS adlibitum plus 0.0g of maize bran (control)

T_2 Offered UTMS adlibitum plus 50.0g of maize bran.

T_3 Offered UTMS adlibitum plus 100.0g of maize bran.

T_4 Offered UTMS adlibitum plus 150.0g of maize bran.

Management and Housing

The experiment was conducted under a shade with adequate provision of ventilation. The house was divided into sixteen (16) concrete pens measuring $1.5m^2$ with the height of 1.2m to prevent animals from jumping into another pen. The floor was bedded with wood shavings to absorb moisture from the animals' urine. The shavings were changed on weekly basis. On arrival, the animals were given Ivomectin injection and dewormed using albendazole to treat or protect them against internal parasites. Vitamin B complex was given to improve feed intake and feed conversion efficiency.

Feed preparation

Three batches of maize stover weighing 50kg each were collected and chopped, (at different times) using cutlass into pieces of 3-4 cm, each batch was treated by spraying with 2kg of urea, dissolved in 50 litres of water. Previous work (Munthali *et al.,* 1991) had shown that treatment at the rate of 40 litres resulted in inadequate wetting of the stover, and poor chemical reaction.

The amount of urea used was calculated to give a treatment of 20g urea to 0.5kg maize stover. The stover was covered with an air tied polythene sheet in a pit and left to stand for 21days. The ensiled rectangular pit was 1.5 m in diameter and 2.0 m deep, with a seepage pit at the bottom. The polythene was removed on the twenty second day and stover was allowed to aerate for 1 day to eliminate volatile ammonia and latter bagged and stored.

However 300kg maize bran was purchased at the local market dried and stored to serve as the supplement. Animal feeding commenced with 7-day acclimatization period and latter twice daily morning and evening according to the experimental diets, using plastic feeders and drinkers.

Data Collection

The chemical composition of the experimental diets was analyzed in a laboratory. Daily feed intake and weekly weight gain were recorded, during the last 7 days of the experiment; total faeces and urine samples were collected and measured using a constructed metabolism cage. The samples were stored at 0-5°C for urine, and faeces were sun dried immediately for 48 hours and stored, the daily collections from each treatment were mixed thoroughly weighed, and a 10% sub-sample was taken for chemical analysis. The data generated was used to calculate daily feed intake, daily weight gain, and feed conversion efficiency of the animals, besides digestibility and economy of production.

Chemical Analysis

The Dry Matter Contents of the feed and faecal samples was determined by drying in an oven at 105^o C

for 24 hours, the organic matter was determined by ashing at 550^{o} C. Samples were crushed to obtain the powdered form and analysed according to the standard method of the Association of Official Analytical Chemists (AOAC, 1990), for crude protein (CP), crude fibre (CF), ether extract (EE), total ash, phosphates (P) Calcium (Ca) and nitrogen free extract (NFE). The total Nitrogen from the urine was determined by the use of auto analyser.

Statistical Analysis

The data generated was subjected to Analysis of variance (ANOVA) using Minitab for Widows Computer Statistical Tool. Duncan Multiple Range Test (DMRT) was use to separate the means where significance differences exist as described by Humberg (1977).

RESULTS AND DISCUSSION

Chemical Composition of the Experimental Diet

The chemical composition of the experimental diet from the proximate analysis was shown in Table 1. Dry Matter and Moisture Content of UTMS and Maize bran were 88.30, 11.70 and 92.30, 7.70 % respectively. The CP contents were consistent with values reported by Ibrahim *et al*. (2003). The Urea treatment improved the CP content of the maize stover from 5.1% to 13.59 % a level similar to the one recommended for optimum rumen microbial functioning (Fall, 1990). The high ash content in maize stover 11.35 was similar to that of (Nguyen, 2004), probably an indication of high concentrations of minerals as reported by (Fall, 1990).

Feed Intake

Animals on T1 showed the lowest intake (154.28g/day); however supplementation at 50, 100 and 150g of maize bran improved intake from 197.42, 246.8 and 293.35g/day in T2, T3 and T4, respectively. This however, was enough to support maintenance and slight live weight gains of the animals, showing that maize bran supplementation could have been the limiting factor in T1. This finding agree with the earlier work by Makkar and Singh (1997) and Smith *et al*. (2007) which showed that starch in supplement and Nitrogen in a treated maize stover induced better utilization of non-protein nitrogen than any other carbohydrate source, and the maize bran used in the present study is rich in starch.

Therefore, supplementation is necessary in addition to treatment for meaningful production. The differences in dry matter intake (DMI) among the animals produced some differences in the rate of live weight gain. This explains the differences in absorption, partitioning and efficiency of utilization of the nutrients as pointed out by Mohammed and Owen (2002). Treatments in this experiment resulted in a wide range of growth rates. The much higher intake (309g/day) reported by Nguyen (2004) in evaluation of adoptability of urea treated maize and rice stovers as feed for growing sheep supplemented with maize bran could be as result of better basal diet than the maize stover alone used in the present study. This may be attributed to an increased rate and efficiency of microbial biomass production.

Live Weight Gain

The highest total live weight gain was achieved by animals on T4 (6750.0 g), the treatment with the highest level of maize bran supplementation (Table 2). Animals fed with out supplemented maize bran (T1) gain less weight (3250.0 g).

The improvement in live weight gain by animals on T3 and T4, 5750.0g and 6750.0g respectively could be attributed to the increased intake of energy and an accompanying improvement in the utilization of non-protein nitrogen in the urea-treated maize stover and enhanced by the supplemental diet as indicated by Fall (1990).

Faecal Output, Feed Conversion ratio and digestibility

The faecal output for the last seven days was presented in Table 3, the supplementation with 0, 50, 100 and 150g of maize bran decreased significantly the average total faecal output from 64.3, 62.4, 61.4and 60.1g/day in T1, T2, T3 and T4 respectively. This however, indicated that the stover DM intake and utilization was significantly ($P \leq 0.05$) affected by supplementation, the 150g group had relatively higher intakes (293.35g /day) than the rest of the treatments with lower value of faecal output. This findings tally with that of Smith *et al*. (2007), which suggested that dry matter intake increases with increasing level of supplementation.

Urine Output and Nitrogen Balance

The N balance was shown in Table 3; N intake of the supplemented groups differs but higher than for the non-

Table 1: Percentage Chemical Composition of 4% Urea Treated Maize Stover (UTMS) and Maize Bran (g/100g of dry sample)

FEED	D M	C.P	CF	EE	NFE	Ash	Ca	P
4%UTMS	88.30	13.59	14.00	7.13	58.69	11.35	0.11	0.03
Maize Bran	92.30	13.00	31.21	0.14	44.30	6.60	1.01	0.001
Mean	90.30	13.30	2.60	3.63	51.49	8.98	0.56	0.016

Table 2: Feed Intake, Feed Conversion Ratio and % digestibility of Goats fed 4% UTMS, supplemented with Maize bran

	Supplementation Levels (g)				
	0	50	100	150	
Parameter	T1	T2	T3	T4	SEM
Daily Feed Intake (g/d)	154.28^{d}	197.42^{c}	246.84^{b}	293.35^{a}	0.77
Daily Faecal Output (g/d)	64.3^{a}	62.4^{b}	61.4^{c}	60.1^{d}	1.44
Daily wgt gain (g/day)	41.61^{d}	83.83^{c}	102.68^{b}	120.54^{a}	0.04
Feed Conversion Ratio	3.95^{d}	2.39^{c}	2.50^{a}	2.56^{a}	0.15
% Feed Digestibility	60.87^{d}	74.38^{c}	75.98^{b}	79.86^{a}	1.85

g/d/h = grammes per day per head. SEM=standard error of the mean. Means across a row with different superscripts are significantly different at ($P \leq 0.05$).

Table 3: Performance of Goats fed 4% UTMS, supplemented with Maize bran

Parameter	Supplementation Levels (g)				
	0	50	100	150	
	T1	T2	T3	T4	SEM
Days of trial	56	56	56	56	-
No of Animals	4	4	4	4	-
Initial Live weight (g/h)	12130	11750	11500	11630	0.49
Final Live weight (g/h)	15380^{d}	16450^{c}	17250^{b}	18380^{a}	0.59
Total weight gain (g/h)	3250^{c}	4700^{c}	5750^{b}	6750^{a}	0.39
Daily weight gain (g/d/h)	58.02^{d}	83.93^{c}	102.68^{b}	120.54^{a}	7.04

g/d/h = grammes per day per head. SEM=standard error of the mean. Means across a row with different superscripts are significantly different at (P≤0.05).

Table 4: Nitrogen balance in Goats fed 4% UTMS, supplemented with Maize bran.

Parameter	T1	T2	T3	T4	SEM
Daily F .O (g/d)	64.3^{a}	62.4^{b}	61.4^{c}	60.1^{d}	1.44
Daily U. O (ml/d)	42.9^{b}	46.4^{d}	48.0^{c}	50.0^{a}	0.48
Nitrogen intake (g/d)	14.26^{d}	17.42^{c}	22.19^{b}	26.79^{a}	0.74
Nitrogen Excretion:					
Through faeces (g/d)	1.52	1.43	1.57	1.44	0.033
Through Urine (g/d)	4.26^{d}	4.89^{b}	5.23^{a}	6.69^{c}	0.20
Total Excretion (g/d)	5.78^{d}	6.32^{c}	6.80^{b}	8.13^{a}	0.21
N. balance (g/d)	8.48^{d}	11.10^{c}	15.39^{b}	18.66^{a}	0.66
% N Utilization	59.46^{d}	63.70^{c}	69.36^{a}	69.65^{a}	1.82

SEM=standard error of the mean. g/d=gramme / day, F.I = Feed Intake, F.O = Faecal Output, U.O = Urine Output. Means across a row with different superscripts are significantly different at (P≤0.05).

Table 5: Chemical Composition of Faecal and Urine Nitrogen (N_2) of Goat Fed 4% UTMS, supplemented with Maize Bran

Parameter	T1	T2	T3	T4	SEM
D.M	73.00^{a}	68.20^{b}	65.71^{c}	64.82^{c}	0.89
Ash	3.89^{a}	3.69^{b}	3.51^{b}	3.28^{c}	0.06
C.P	10.89^{a}	9.73^{b}	9.50^{c}	9.23^{d}	0.74
E.E	0.12	0.08	0.07	0.05	0.01
C.F	21.20^{a}	20.61^{b}	18.11^{c}	15.21^{d}	0.61
Urine(% N)	4.49^{a}	3.50^{b}	3.26^{c}	3.11^{c}	0.14

SEM=standard error of the mean. Means across a row with different superscripts are significantly different at (P≤0.05).

Table 6: Economy of Production in Goat fed 4% UTMS, supplemented with Maize bran

Component	T1	T2	T3	T4	SEM	LSD
Days of trial	56	56	56	56	-	-
Feed Intake (kg)	8.64^{d}	11.06^{c}	13.82^{b}	16.43^{a}	0.75	0.34
Feed cost (N/kg)	55.00	43.07	41.71	41.09	-	-
Cost of Feed Intake (N)	475.17^{c}	476.14^{c}	576.54^{b}	675.08^{a}	21.4	4.23
Total Weight Gain (kg)	3.25^{d}	4.70^{c}	5.75^{b}	6.75^{a}	0.39	0.78
Feed Cost/kg/N Gain	146.21^{a}	101.31^{b}	100.27^{c}	100.01^{c}	5.11	1.01
Cost Saving (N)	-	44.90	45.94	46.20	1.85	-

SEM=standard error of the mean. LSD = Least Significant Difference, Means across a row with different superscripts are significantly different at (P≤0.05).

supplemented. Faecal N loss appeared to be highest in the T3 group (1.57g/day) and lowest in T2 (1.43g/d). Urinary loss of nitrogen was also higher in T3 group (5.23g/day). Although rumen ammonia concentration may be an indicator of the degree of feed utilization, it can sometime be unreliable if other factors needed for rumen microbial growth are not supplied in adequate amounts, this result indicated a Nitrogen retention of 8.48, 11.10, 15.39 and 20.66g/day, in T1, T2, T3 and T4 representing 59.46, 63.70, 69.36 and 77.12%, respectively. Ibrahim *et al*., (2003) reported similar findings where sheep given urea treated maize husk alone excreted 42% urine volume, containing significantly more than 70% N. The Nitrogen retention has been found to increase with inclusion of maize bran in the diet.

Though the rumen pH in this experiment was not measured, it was not affected by supplementation as indicated by the faecal chemical analysis. Supplementation with maize bran directly or indirectly by urea as was the case in the current experiment is associated with more ruminating time thus maintaining the rumen pH through salivation. Supplementation generally increased the total DM intake; this may be attributed to ability of the stover and maize bran supplements to provide N and energy for the cellulolytic microbes upon degradation in the rumen, especially for the T4 group.

Economy of Production

The economy of production in UTMS supplemented with various levels of maize bran was presented in Table 6. Feed Intake (kg) among the animals varies from 8.64, 11.06, 13.82 and 16.43kg in T1 to T4, respectively. Cost of Feed Intake was N475.17, N476.14, N576.54 and N675.08. Feed Cost/kg/N Gain among the Treatments was N146.21, N101.31, N100.27 and N100.01, while the Cost Saving was N0.00, N44.90, N45.94 and N46.20 in T1 to T4, respectively.

Summary

Sixteen young Maradi goats averaging 11 ± 2kg, were used in a 4 by 4 Randomised Complete Block Design for a period of 56 days to study the effects of utilising maize stover treated with 4% urea and supplemented with maize bran at 0, 50, 100 and 150g. Results showed that there was significant difference ($P \leq 0.05$) in average daily feed intake and weight gains among the treatments, in T4 of 308.57g/day and 120.54g/day followed by T3 (255.71 and 102.68g/day), T2 (200.71 and 83.83g/day), T1 (164.29 and 41.61g/day, respectively. Faecal collection showed that treatment T1 had 64.3g/day followed by T2 (62.1g/day), T3 (61.4g/day and T_4 (60.4g/day), respectively. Cost benefit analysis indicated that there is a progressive increase of gross margin from T1 to T4. It is suggested that the optimum level of feeding UTMS and maize bran inclusion in the diet should be at 150g, in order to provide both adequate fermentable nitrogen and fibre.

Conclusion

The use of 4% UTMS supplemented with successive increments of maize bran resulted in an enhanced intake of total Dry Matter; this was achieved with the improvement of the digestibility and feed conversion efficiency of the diet, as reflected in the daily weight gain of 41.61, 83.83, 102.68 and 120,54g/day in T1, T2, T3, and T4 respectively. The result indicated that production of goats with UTMS is highly economical and affordable; however, supplementation at higher inclusion levels of maize bran above 150g needs to be investigated.

Recommendation

It is suggested that the strategy for dry season livestock feeding programme and research should be directed towards practical solution of providing simple processing and quality feed e.g. the use of UTMS. Although supplementation at 150g of maize bran produced the best result with respect to weight gain, feed conversion efficiency and percentage digestibility, further studies should be conducted using higher levels of urea treatment and above 150g maize bran supplementation to determine the best economy of producing goats in the area for maximum productivity and profitability for the realization of the Millennium Development Goals and vision 2020. as contain in the transformation agenda of the federal government in the livestock sub sector.

REFERENCES

Adebayo AA and AL Tukur, 1999. Adamawa State in maps Department of Geography, Federal University of Technology Yola, in Cooperation with Paraclete Publishers. Yola, Nigeria. Pp 20-26.

Association of Official Analytical Chemists, 1990. Nutrients determination in Animal Feed: Copper Catalyst Kjeldahl Method, Official Methods of Analysis. 15th Edition.

Buettner MR, Lechtenberg VL, Hendrix KS and JM Hertel, 1982. Composition and digestion of ammoniated tall fescue (Festuca arundinacea Schreb) hay. Journal of Animal Science. 54: 173-178.

De Leeuw PN, 1979. A review of ecology and fodder resources of the sub-humid zone. Paper presented at ILCA/NAPRI Conference, Kaduna.

Fall S, 1990. Improvement of nitrogen level in ruminant's diets based on Cereal straws": The problem of dissemination of research results on utilization of urea and browse plants as nitrogen sources., (Eds.), Addis Ababa, Ethiopia.

Food and Agricultural Organization, 2005. Sheep and Goat Development Project, Kenya: Project findings & Recommendations, (1976) Sheep and goat development project KenyaTerminal Report UNDP/ FAO, Rome.

Greenhalgh JFD, 1984. Upgrading crop and agricultural by-products for animal production. In: (Eds) FMC Gilchrist and R.I. Mackie. Herbivore Nutrition in the sub-tropics and Tropics. Science Press Pretoria, South Africa.

Humburg M, 1977. Statistical Analysis for Decision making 2nd Edition, HarcourtBrace, New York, 1977: 801.

Ibrahim MNM, Fernando DNS and SNFM Fernando, 2003. Evaluation of methods of urea-ammonia treatment application at village level, Australian-Asian Fibrous A Agricultural Residues Research Network, 18.22 April, University of Peradeniya, Sri Lanka (1983).

Khan AKMN and CH Davis, 1981. Effect of treating paddy rice stover with amonia on the performance of local and crossbred lactating cows. Proc. Seminar Maximum Livestock Production from Minimum land 2nd-5th Feb. 1981. Bangladesh Agricultural University, Nymensingh, Bangladesh pp. 168-180.

Makkar A and C Singh, 1997. Urea treatment of stover. In Singh K and Schiere J B (Editors) Handbook for stover feeding systems: principles and application withemphasis on Indian livestock production New Delhi and Department of Animal Production Systems, Agriculture University, AH Wageningen.

Mohammed HH and E Owen, 2002. Comparison of the maintenance requirement of sheep and goats. Animal Production, 30: 479.

Munthali JT, Zimba AWC and LA Kamwanja, 1991. Effects of urea treated maize tover on the performance of lactating crossbred dairy cows. In: Annual TechnicalReport, Dairy/Beef Production Systems (Malawi). University of Malawi and Ministry of Agriculture, Lilongwe, Malawi.

Nguyen T, 2004. An evaluation of adoptability of urea treatment of maize / rice stover as feed for growing sheep under smallholders' circumstances. Livestock Research for Rural Development 16.

Saadullah M, Haque M and F Dolberg, 1991. Practical methods for chemical treatment of rice stover for ruminant feeding in Bangladesh. Proc. Symp. Of Workshop on Utilization of Low Quality Roughages in Africa (January 1981) Tanzania. Bibl. Index ISBN 82-575-9000-2. pp. 151-155.

Sundstol F, 1981. Methods of treatment of low quality roughages. In: (Eds) JLA Kategile, AN Said and F Sundstol. Utilization of low quality roughages in A Africa. Agricultural Development Report, No. 1. Norway.

Smith T, Chakanyuka C, Sibanda S and B Manyuchi, 2007. Maize stover as feed for ruminants. In: Said A N and Dzowela B H (Eds), Overcoming constraints to the efficient utilization of agricultural by-products as animal feed. (African Research Network for Agricultural By-products). ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 218-231.