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Effect of urea treated maize stover with different levels of concentrate supplementation on growth, digestibility and nitrogen utilization in cattle

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Target Audience: *Commercial cattle farmers, extension workers, students, researchers.*

Abstract

The study was conducted to evaluate the effect of urea treated maize stover with different levels of concentrate supplementation on growth, nutrient digestibility and nitrogen utilization in cattle fed urea treated maize stover. Sixteen heifers aged 8-10 months, weighing 90-120kg were divided into four equal groups and randomly allotted to four dietary treatments for the growth trial. In the control ration, chopped, untreated maize stover fed ad libitum was supplemented with concentrate mixture at 2.0% of body weight (T1). For the test diets, urea treated maize stover was supplemented with concentrate mixture at 2.0, 1.5 and 1.0% body weight in groups T2, T3 and T4 respectively. Sixteen bulls aged 8-12 months with an average weight of 146kg were used for the metabolism trial. Urea treatment increased crude protein content from 4.5% in untreated stover to 9.4% in urea treated maize stover. Daily weight gain was not significantly different (P>0.05) among the treatment groups. T2, T3 and T4 treatment groups had better feed conversion ratio than T1 group. Dry matter digestibility was similar between bulls fed T3 and T4 rations. Bulls fed T2, T3 and T4 rations had higher crude protein digestibility (P>0.05) than T1. Neutral Detergent Fibre digestibility values were lower in T1 and T2 compared to T3 and T4. Total nitrogen output values were higher in T1 (P<0.05) compared to T2, T3 and T4 treatments. Therefore, feeding urea treated maize stover with concentrate supplementation enhanced feed intake, growth, nutrient digestibility and nitrogen utilization in cattle.

Keywords: *urea treatment, concentrate supplementation, growth, nitrogen retention, nutrient digestibility*

Description of Problem

Livestock production is an important component of the farming systems in Nigeria and plays a vital role in the livelihood of Nigerians (1). The livestock sector is however constrained by limited availability of feed with high nutrient value to meet the nutrient requirements of ruminants. The livestock feed supply in Nigeria is based on natural pasture, hay and crop residues.

Maize stover is abundantly available crop residues in most tropical and subtropical countries and commonly used as a diet for ruminants. Maize stover is an important cereal crop residue in Nigeria, particularly, during the dry season and large quantities of stover are produced after grain harvest. In this country however, maize stover is usually burnt or incorporated into the soil after harvesting of the maize cob in preparation of the land for the next cropping season (2). Maize stover are also left in the field to be grazed by pastoral herds without regard to processing and supplementation. Feeding only maize stover does not provide enough nutrients to the ruminants to maintain high production levels due to the low nutritive value of this highly lignified material. Cereal crop residues are low in easily degraded carbohydrates, minerals and other nutrients require balancing the products of digestion to requirements, leading to limited intake, poor rumen function and low animal productivity (3; 4). Various chemical methods (NaOH, CaOH, KOH) have been used to improve utilization of cereal crop residues like maize stover and other low quality forages (5). Among the methods, urea treatments are preferred, due to its ease of handling (6). Urea has been used to improve the nutritive value of poor quality crop residues (7; 5).

Better utilisation of stover treated with both urea and molasses, when supplemented with concentrate feed have been reported earlier (5). Supplementation to provide essential nutrients is therefore an important means of improving stover utilization. Therefore, supplementing low quality forage-based diets with concentrates are expected to correct any imbalance in the nutrients presented for metabolism (8). This study was conducted to determine the feed intake, nutrient digestibility and nitrogen balance in crossbred cattle fed urea treated maize stover supplemented with different levels of concentrate.

Materials and Methods

Experimental Site

The experiment was carried out at the Dairy Research Programme farm of the National Animal Production Research Institute (NAPRI), Shika-Zaria. Shika is located in the Northern Guinea Savannah Zone of Nigeria on latitude 11o12'N and longitude 7o33`E at an altitude of 610m above sea level. Annual rainfall is 1100-1200mm, while mean temperatures is about 24.40C (14.5-39.30C), with the lowest temperature occurring during the early dry season (November-January), while, the highest temperatures are experienced during late dry season between February-April (9).

Feed Collection and Processing

Maize stover was collected after grain harvest, from farms within NAPRI, Shika-Zaria. The stover was chopped to 1-2cm long, using a forage chopper. The chopped maize stover was treated with urea (3.5% w/w) at 40 percent moisture. In a batch, 14kg urea was dissolved in 200 litres of water and sprinkled on 386kg maize stover (10). The stover was mixed thoroughly on a concrete floor and covered with polythene sheet for 14-days fermentation. The treated maize stover was opened and aerated 24 hours before feeding to the animals.

Experimental animals and management

Sixteen crossbred (Friesian x Bunaji) heifers aged between 8-10 months and weighing between 90-120kg were used for the growth trial. The animals were obtained from the Dairy Research Programme farm, NAPRI, Shika-Zaria. Prior to the commencement of the trial, the animals were dewormed with Albendazole® 2,500mg bol at the rate of 5mg/kg body weight. They were treated against ectoparasites by weekly dipping with Acaricide®. The experimental animals were housed individually in well ventilated pens with concrete floor.

Experimental treatments, design and feeding of animals

The experimental animals were randomly allotted to four dietary treatments with four animals per treatment, in a completely randomized design. The treatments were; untreated maize stover with concentrate mixture offered at 2.0 percent of body weight (T1), urea treated maize stover with concentrate mixture offered at 2.0 percent of body weight (T2), urea treated maize stover with concentrate mixture offered at 1.5 percent of body weight (T3), urea treated maize stover with concentrate mixture offered at 1.0 percent of body weight (T4). T1 served as the control. The concentrate mixture, consisting of crushed maize grain, cottonseed cake, wheat bran, rice bran, bone meal, common salt and vitamin premix (Nagge mix® dairy cattle), was formulated to contain approximately 14% crude protein as shown in Table 1. Untreated and urea treated maize stover was fed ad libitum. The daily allowance of the concentrate mixture was offered in the morning and consumed before the basal maize stover was offered. The animals had free access to fresh water. The animals were weighed fortnightly and the feeding allowances were adjusted accordingly. Daily record of feed offered and orts was maintained. The growth trial lasted for 90 days.

Table 1: Ingredient composition of concentrate mixture

Ingredients	Inclusion (%)
Wheat bran	28.00
Rice bran	15.70
Bone meal	2.00
Common salt	1.00
Vitamin premix	0.30
Total	**100**
Calculated analysis	
Crude protein	14
ME:Kcal/kg	2,245

Metabolism Trial

After the growth trial, sixteen crossbred (Friesian x Bunaji) bull calves aged between 8-12 months and with an average weight of 146kg were used for metabolism trial. Four bulls were randomly allocated to each treatment and housed in metabolic crates for easy total faecal and urine collection. The animals were fed the treatment diets for a 14 days adaptation period, followed by a 7 days collection period. Water was provided ad libitum.

During the collection period, feed offered, refusals and feaces were collected, weighed and recorded at 08.00 a.m. daily. Daily faecal output was weighed, sub sampled and oven dried at 600C for forty eight (48) hours for dry matter determination. This was later bulked for laboratory analysis. Daily urine output was collected into a plastic container with 100mls of 0.1N H2SO4 to prevent nitrogen loss by volatilization which was placed under the metabolic crates; the collected urine was strained through a layer of glass wool to remove detached hair fragments or other contaminants. Ten percent aliquot of total daily urine output was taken from each animal and stored in the refrigerator pending nitrogen determination (11).

Chemical Analysis

Samples of feed and faeces were analysed for dry matter (DM), nitrogen and total ash (12) and cell wall constituents (13).The urine samples were analysed for nitrogen content (12) only.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) in a one-way classification for completely randomized design (14). Means that were significant were separated using Least Significant Difference.

Results

Chemical composition of experimental diets are shown in Table 2. Urea treatment increased the crude protein content from 4.50% in untreated maize stover to 9.38% in treated stover. Organic matter, Neutral Detergent Fibre (NDF), hemicellulose and Acid Detergent Lignin (ADL) contents of maize stover decreased with urea treatment. The NDF and hemicellulose contents decreased from 76.65 to 68.80% and 29.0 to 18.32% respectively, while, organic matter and ADL contents decreased from 90.92 to 82.68% and 6.60 to 5.17% respectively. The Acid Detergent Fibre (ADF) and cellulose contents increased non-significantly (P>0.05) with urea treatment from 47.65 to 50.48% and 41.05 to 45.31% respectively. The organic matter, crude protein, NDF, ADF, ADL, cellulose and hemicellulose contents obtained for the concentrate mixture were 87.03, 13.88, 35.13, 23.68, 5.94, 17.74 and 12.07% respectively.

Table 2: Chemical composition of experimental diets

Parameters	Untreated maize stover	Urea treated maize stover	Concentrate mixtures
Dry matter	96.21	95.79	94.59
Organic matter	90.92	82.68	87.03
Crude protein	4.50	9.38	13.88
NDF	76.75	68.80	35.13
ADF	47.65	50.48	23.68
ADL	6.60	5.17	5.94
Cellulose	41.05	45.31	17.74
Hemicellulose	29.00	18.32	12.07

NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre, ADL=Acid Detergent Lignin

Table 3 shows the effect of urea treated maize stover supplemented with different levels of concentrate on feed intake and weight gain of crossbred heifers. The DM intake of concentrate was significantly lower (P<0.05) in heifers fed T4 than those on T3 which was also lower (P<0.05) than heifers on T1 and T2. There was no significant difference (P>0.05) in DM intake through maize stover between the dietary treatments; the values were, however higher in heifers fed T3. Total DM intake was similar between T1, T2 and T3 groups, but was significantly lower (P<0.05) in T4 compared to other treatments. Final weight (FWT), total weight gain (TWG), daily weight gain and feed conversion ratio (FCR) were not significantly different (P>0.05) across dietary treatments. Total weight gain and daily weight gain were similar between T1 and T4 treatments, however, total weight and daily weight gain were higher in heifers fed T2 and T3. Feed conversion ratio were similar between T2 and T4 treatments, however, feed conversion ratio was better in animals fed on T3.

Table 3: Effect of urea treated maize stover supplemented with different levels of concentrate on feed intake and weight gain of crossbred heifers

	Treatments					
Parameter	T1	T2	T3	T4	SEM	LOS
DMI (kg/day)						
Concentrate	1.29[a]	1.33[a]	0.96[b]	0.63[c]	0.07	*
Maize stover	1.66	1.56	1.75	1.66	0.11	NS
Total	2.96[a]	2.89[a]	2.71[a]	2.29[b]	0.19[b]	*
Body Weight (kg)						
IBW	79.75	84.50	81.75	80.75	5.43	NS
FBW	92.50	100.75	96.75	92.75	5.76	NS
T WG	12.75	16.25	15.00	12.00	2.42	NS
DWG	0.14	0.18	0.17	0.14	0.03	NS
FCR(kgDMI/kg gain)	25.19	21.54	20.48	21.19	3.61	NS

DMI=Dry Matter Intake, IBW=Initial body weight, FBW=Final body weight, TWG=Total weight gain, DWG=Daily weight gain, FCR=Feed conversion ratio,abc= Means within the same row with different superscripts are significantly different (P<0.05),NS= Non Significant (P>0.05), SEM=Standard Error of Means, LOS=Level of Significance

Table 4 shows the nutrients digestibility of crossbred bulls fed urea treated maize stover supplemented with different levels of concentrate. Dry matter digestibility was similar between bulls fed T2, T3 and T4. The values were significantly (P<0.05) higher in T3 and T4 than in T1, while there was no significant difference (P>0.05) between T2 and T1. Organic matter digestibility was similar between bulls fed T1, T2 and T3, but, the values were significantly (P<0.05) lower in T1 and T2 than in T4, while there was no significant (P>0.05) difference between T3 and T4 treatments. Bulls fed T2, T3 and T4 had significantly (P>0.05) higher crude protein digestibility than T4 treatment. NDF digestibility was similar between bulls fed

T1, T2 and T3, however, the values were significantly (P<0.05) lower in T1 and T2 compared to T4, while the difference between T3 and T4 treatments was not significant. ADF digestibility was significantly (P<0.05) lower in bulls fed T1 compared to T3 and T4 treatments, there was no significant (P>0.05) difference between T1 and T2. ADL digestibility was not significantly different (P>0.05) between bulls fed T2, T3 and T4, however, the values were significantly (P<0.05) higher than T1 treatment. Cellulose digestibility was not significantly different (P>0.05) between treatment means, but, the values were slightly lower in bulls fed T3 and T4. Hemicellulose digestibility was similar between bulls fed T1 and T4, but, the values were significantly (P<0.05) higher compared to T2 and T3 treatments.

Table 4: Effect of urea treated maize stover supplemented with different levels of concentrate on nutrients digestibility of crossbred bulls

	Treatments					
Digestibility Coefficient(%)	T1	T2	T3	T4	SEM	LOS
Dry Matter	47.49^{b}	49.68^{ab}	58.14^{a}	56.77^{a}	2.72	*
Organic Matter	53.65^{b}	51.98^{b}	56.42^{ab}	63.19^{a}	2.26	*
Crude Protein	63.19^{b}	75.52^{a}	71.24^{ab}	80.34^{a}	2.85	*
NDF	40.64^{b}	42.25^{b}	45.65^{ab}	51.27^{a}	2.27	*
ADF	32.49^{b}	37.54^{ab}	42.18^{a}	42.28^{a}	2.89	*
ADL	9.13^{b}	14.15^{a}	20.44^{a}	20.27^{a}	3.57	*
Cellulose	23.35	23.39	21.74	22.01	3.35	NS
Hemicellulose	8.15^{a}	4.71^{bc}	3.47^{c}	8.99^{a}	1.31	*

NDF=Neutral Detergent Fibre, ADF= Acid Detergent Fibre, ADL=Acid Detergent Lignin,SEM=Standard Error of Means, LOS=Level of Significance, NS= Non Significant (P>0.05), abc= Means within the same row with different superscripts are significantly different (P<0.05)

Table 5 shows the nitrogen balance of crossbred bulls fed urea treated maize stover supplemented with different levels of concentrate. Nitrogen intake was significantly (P<0.05) lower in bulls fed T4 compared to T2, while there was no significant (P>0.05) difference between T2, T3 and T4 treatments. Urinary nitrogen was significantly (P<0.05) higher in bulls fed T2 and T, compared to T1 and T4 treatments. Faecal nitrogen was similar between bulls fed T1, T2 and T3, but, the values were significantly (P<0.05) higher in T1 treatment compared to T4 treatment. Difference between T2, T3 and T4 were not significant (P>0.05). Total nitrogen output was similar between bulls fed T1, T2 and T3, however, the values were significantly (P<0.05) higher in T1 treatment compared to T4 treatment. Nitrogen absorbed was not significantly (P>0.05) different between T1, T3 and T4 treatments and the values were significantly (P<0.05) higher than T1 treatment. Nitrogen retained was similar between T2 and T4 treatments, however, the values were significantly (P<0.05) higher than T3 and T1 treatments. Nitrogen retained (%N-intake) was similar between bulls fed T2 and T3. The values were significantly (P<0.05) higher in T4 treatment than T1 treatment.

Table 5: Effect of urea treated maize stover supplemented with different levels of concentrate on nitrogen balance of crossbred bulls

	Treatments					
Parameters (%)	T1	T2	T3	T4	SEM	LOS
Nitrogen intake	41.42[ab]	46.97[a]	41.85[ab]	34.74[b]	2.48	*
Urinary Nitrogen	3.78[b]	6.49[a]	4.89[a]	3.02c	1.17	*
Faecal Nitrogen	32.65[a]	25.22[ab]	24.21[ab]	15.51[b]	3.24	*
Total Nitrogen Output	36.43[a]	31.71[ab]	29.09[ab]	18.53[b]	4.09	*
Nitrogen absorbed	8.93[b]	21.74[a]	17.64[a]	19.22[a]	2.78	*
Nitrogen retained	9.11[c]	15.26[a]	12.75[b]	16.21[a]	2.29	*
Nitrogen retained (%N-intake)	22.35[c]	32.84[b]	30.26[b]	46.99[a]	5.43	*

SEM=Standard Error of Means, LOS=Level of Significance, abc= Means within the same row with different superscripts are significantly different (P<0.05)

Discussion

Increase in CP content of straw as a result of urea treatment has been reported by several authors (15; 16 and 17). The increase in CP content is associated with the conversion of urea into ammonia during treatment period part of which may have been organically bound with treated straw (17). A reduction in NDF content from 76.7 to 68.8% and hemicellulose content from 29.0 to 18.3% are comparable to earlier reports (18; 19; 17). The decrease in NDF and hemicellulose contents was due to solubilisation or dissolving effect of urea on the hemicellulose fraction and its subsequent removal from cell wall constituents (20; 19). Increased concentration of ADF and lignin contents in urea treated barley and teff straw respectively were reported by (21) and (22). The possible reasons for differences in values of chemical composition in this study, when compared with previous studies might be due to variation in the method of processing the stover and stage of growth before harvesting the stover.

A study reported no significant difference (P>0.05) in DM intake of buffaloes fed untreated and urea treated wheat straw (23), while DM intake in goats was significantly improved (P<0.05) by treating ground maize stover with urea as compared to untreated ground maize stover with Lucerne hay (24). The variation in results reported by different researchers might be due to the amount of supplement, nutrient content and ratio given to the animals. Significantly higher daily weight gain in crossbred calves fed urea treated rice straw was also reported (15).

Better feed conversion ratio obtained in the present study might be associated with the pleasant taste, high dry matter and protein intake that encouraged the digestibility of the diet (25). Better utilisation of stover treated with both urea and molasses, when supplemented with concentrate feed was reported by (26) and (5). There was no improvement in feed conversion efficiency of Holstein calves fed wheat straw ammoniated with urea compared with the efficiency of calves fed the untreated straw (27).

High crude protein digestibility obtained in all treated maize stover group was in line with the findings of previous studies (28; 29). Increased digestibility of NDF and ADF observed in this study is in agreement with the results of (30) who reported increased digestibility of NDF and ADF due to urea treatment of straw. This could be attributed to the swelling of the hemicellulose-lignin complex (31) and loosening of ligno-cellulose bonds (32). These findings are in accordance with similar works of (33) and (34) in urea treated rice straw and barley straw respectively. Other workers (35; 36) have shown that digestibility of the fibre fractions of low quality residues have been improved by ammoniation and supplementation. If animals fed untreated straws or poor quality roughages are supplemented with substrates which increase the fermentation rate of cellulose, the rumen environment becomes similar to that of animals receiving ammonia treated straws (37). Urea treatment and concentrate supplementation tends to increase the digestibility of low quality roughages through its effect on plant cell walls (38). This also justifies the importance of concentrate supplementation in stover based diets to correct nutrient deficiencies in order to increase nutrient availability (39; 40; 41). However, (42) did not find any significant difference (P>0.05) in DM digestibility of bulls fed ammoniated rice straw.

The high nitrogen absorbed and nitrogen retained in groups receiving urea treated maize stover may reflect greater absorption of ammonia resulting from the hydrolysis of urea from the gastrointestinal tract of bulls in these groups and also an improvement in the crude protein content of the stover due to urea treatment. Nitrogen retention also depends on the intake of nitrogen and the amount of fermentable carbohydrate in the diet (43). Hence, the higher nitrogen retained observed in animals fed urea treated stover. This implies that feeding animals with urea treated stover with concentrate supplementation can improve weight gain, increase nutrient digestibility and improve immune response of animals; which are all advantages of feeding enough dietary protein to animals. However, all animals had a positive nitrogen balance, which implied that the animals utilised the diets offered effectively. These results are in tandem with the findings of (44) and (45) who reported that the nitrogen retention was increased by urea treatment when compared with untreated straw. In contrast with these results, (46) did not find any significant effect (P>0.05) on total nitrogen intake and faecal nitrogen excretion in Mithun (Bos frontalis) fed urea treated paddy straw. High concentration of nitrogen will be excreted when there is ammonia accumulation in the rumen or high levels of deamination occurring in the body, due to excess protein fed or an unbalanced amino acid profile (47).

Conclusion and Application

The technology involved in the treatment of maize stover with urea in this study is simple and can easily be carried out by smallholder ruminant farmers.

Urea treatment may be used to increase crude protein content of maize stover.

The results indicated that T2, T3 and T4 significantly improved the weight gain, nitrogen retention and digestibility of maize stover in cattle.

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