

# The Potential of Urea Treated Maize Stover for Growth Performance of Weaned Crossbred Calves

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## ABSTRACT

The effects of urea treatment on chemical composition, intake and digestibility of maize stover and the potential of such a stover for growth performance of weaned calves were investigated using 21 crossbred (50% Borana and 50% Friesian) calves of 9 to 12 months of age and an average initial live weight of 138.9 kg. The animals were divided into three groups each of which were individually fed to appetite on basal diets of either untreated maize stover (UNMS), or 5 % urea treated maize stover (UTMS), or natural pasture hay (NPH) for 99 days. In addition, all animals were given 1 kg concentrate mixture per head per day. Urea treatment increased the CP content of maize stover by 3.8 and 2.7 folds over the untreated stover and the natural pasture hay, respectively. Besides, compared with the untreated stover, urea treatment brought an improvement of 9% in *in vitro* dry matter digestibility and 22% in dry matter intake. These improvements in terms of chemical composition, intake and digestibility led to higher ( $p < 0.05$ ) live weight gain of animals fed on the urea treated stover diet compared with those fed on the untreated stover diet. However, there was no difference ( $p > 0.05$ ) in weight gain between the animals fed on the urea treated stover diet and those fed on the hay based diet. Generally, with the added advantage of being more cost effective than hay, feeding urea treated maize stover may be considered as one of the strategies that bring about an efficient utilization of crop residues for livestock feeding. However, its economic advantage over other alternatives must carefully be examined under the prevailing price conditions before it is implemented.

**Key words:** urea treatment, maize stover, natural pasture hay, weaned calves, growth performance

## INTRODUCTION

The shortage of grazing land as a result of the expansion of crop land is a visible phenomenon in the East Shoa Zone of Oromiya Regional State, Ethiopia. Hence the dependence on crop residues for livestock feeding is very high and is increasing from time to time. Maize stover is one of the important crop residues constituting the major feed resource in low to medium altitude

areas where maize is grown abundantly. According to the information obtained from the East Shoa Zone (personal communication), maize covered about 25% of the total land cropped to cereals and pulses during the 2003/4 cropping year, and the grain production was estimated at 0.33 million tons. Taking the grain to residue ratio already established by Kossila (1988), this annual grain yield would be equivalent to about 1 million tons of maize stover.

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Though the annual production of maize stover in the zone is said to be high, its utilization for livestock feeding is constrained by its physical nature (its stalk) and nutritional characteristics. Maize stover is one of the available energy sources for ruminants. However, the availability of this energy to animals is generally limited by the low voluntary intake, the chemical association between lignin and cell wall carbohydrates and the physical limitation of the cell wall components for microbial fermentation.

There are various physical and chemical processing methods that are known to improve the feeding value of low quality feeds such as crop residues. Of the chemical methods, ammoniation (using urea) is currently a popular one in upgrading crop residues as it has several advantages over caustic soda treatment (Brand *et al.*, 1991). These include easiness of application, nitrogen addition and absence of undesirable residues. According to these authors, ammoniation (55 g urea/kg straw) of wheat straw improved ( $p < 0.01$ ) the voluntary dry matter intake of the total diet by 27% in comparison with the untreated diets. Straw dry matter intake was also improved by similar percentage units.

In Ethiopia, the potential of urea treatment of tef and barley straws for crossbred dairy cows has been investigated by Rehraie (2001). However, the potential of such treatment in upgrading the nutritive value of maize stover and in improving the growth performance of animals fed on such stover was not so far assessed. Therefore, this work was initiated to investigate the potential of urea treatment of maize stover in terms of improving the nutritive value of the stover and the growth performance of weaned calves.

## MATERIALS AND METHODS

This experiment was conducted at Adami Tullu Agricultural Research Center, Ethiopia. The center is located at an elevation of 1650 m above

sea level, and it receives a mean annual rainfall of 800 mm. Its mean maximum and minimum temperature range from 25 to 28°C and 8 to 12°C, respectively.

Twenty one weaned crossbred (50% Borana and 50% Friesian) calves of 9 to 12 months of age and an average initial weight 138.9 kg were used for this study. The animals were drenched for internal parasites and sprayed against external parasites after which they were assigned to one of the following three dietary treatments designed in a Completely Randomized Design having seven animals in each treatment. The three dietary treatments were:

Diet 1: Untreated maize stover (UNMS) *ad libitum* plus 1 kg concentrate mixture per head per day

Diet 2: Urea treated maize stover (UTMS) *ad libitum* plus 1 kg concentrate mixture per head per day

Diet 3: Natural pasture hay (NPH) *ad libitum* plus 1 kg concentrate mixture per head per day

Maize stover of improved maize varieties was purchased from the surrounding farmers and machine chopped into 3 to 5 cm length. Urea treatment was conducted by dissolving 5 kg urea and 10 kg cane molasses in 65 kg water to be sprayed over 100 kg air dried maize stover in a pit. The soaked straw was pressed by trampling. Then it was covered with a plastic sheet and loaded with sacks full of sand to make it air tight. The straw treated in such a way was kept for two weeks after which the daily required amount was taken out of the pit, aerated for overnight and fed to the animals in two meals. Natural pasture hay which was dominated by *Cynodon*, *Andropogon*, *Pennisetum* and *Trifolium* species was purchased from the neighboring zone. The concentrate mixture was formulated from 59% wheat bran, 40% linseed cake and 1% salt and has DM, CP, NDF and ash contents of 89.0, 20.6, 51.5 and 7.8%, respectively with an *in vitro* DM digestibility of 68.8%.

The basal diets were fed to each animal individually at a rate of 20 to 25% and 25 to 30% in excess of the previous daily intake of hay and maize stover, respectively. The concentrate mixture was given every day prior to offering the basal diet. The animals were watered to appetite once per day around 1200 hour. Every morning, feed refusals were collected and weighed before feeding. The animals were weighed fortnightly. The experiment lasted for 21 days adaptation and 99 days experimental periods. Finally 4 representative animals from each treatment were transferred to metabolic crates where faeces and urine were collected for 7 days to determine apparent digestibility of the diets.

Economic analysis was based on comparison of feed costs. The current feed costs, calculated on per kg DM basis, were 0.72, 0.30, 0.50 and 0.88 Birr for natural pasture hay, untreated maize stover, urea treated maize stover and the concentrate mixture, respectively.

Samples of feed, orts and faeces were dried and analyzed for dry matter (DM), nitrogen and ash (AOAC, 1990) and neutral detergent fiber (Goering and Van Soest, 1970). Total nitrogen of the urea treated maize stover and the faeces samples were analyzed before drying according to the Kjeldhal method. *In vitro* dry matter digestibility (IVDMD) was determined using the two stage methods of Tilley and Terry (1963).

### Statistical analyses

The effects of dietary treatments on different parameters were analyzed using the

generalized linear model procedure of SAS (2000) for a completely randomized design with three treatments. While analysing live weight change and feed intake data, initial live weight was used as covariant. Differences among treatment means were evaluated using Duncan Multiple Range Test. The statistical model used was:

$$Y_{ij} = \mu + T_i + b(x_{ij} - \bar{x}) + e_{ij}$$

Where,  $Y_{ij}$  = Response variables (feed intake, growth rate, and feed cost)

$\mu$  = Overall mean

$T_i$  = Effects of  $i^{\text{th}}$  dietary treatment ( $i = 1, 2, 3$ )

$b(x_{ij} - \bar{x})$  = Covariate effect,  $b$  is the regression coefficient for initial weight  $x$

$e_{ij}$  = Random error

## RESULTS AND DISCUSSION

### Chemical composition

The effect of urea treatment on chemical composition of maize stover as compared to the untreated stover and natural pasture hay is shown in Table 1. Crude protein (CP) content of the urea-treated maize stover was close to 3.8 and 2.7 folds higher than that of the untreated stover and the natural pasture hay, respectively. In studying the effects of urea treatment of maize stover on the performance of growing steers and heifers, Munthali *et al.* (1992) also observed a four fold (2.8 vs. 14.4%) increase in CP content due to 4% urea treatment of maize stover compared with the water treated stover. Jackson (1978), Klopfenstein

**Table 1** Chemical composition and IVDMD of the urea treated maize stover versus the untreated stover and natural pasture hay.

Items	DM (%)	Chemical composition (% of DM)				IVDMD (%)
		OM	CP	NDF	Ash	
Untreated maize stover	91.58	93.41	4.02	82.24	6.59	55.7
Urea treated maize stover	65.47	92.10	15.40	76.15	7.92	60.6
Natural pasture hay	91.43	92.21	5.70	78.32	7.79	45.03

(1978) and Sundstol *et al.* (1978) also found similar increments in CP content of treated straws.

The IVDMD of the urea treated stover was 8.8% higher than that of the untreated maize stover. This, however, is lower than the 27% increase in apparent dry matter digestibility obtained by Saadullah *et al.* (1982) for 5% urea treated straw fed to 18 months old calves. If seen from the point of view of making efficient use of the low quality and yet the abundantly available feed resources, the small increment such as the one found in this study would mean a lot to livestock owners. With this regard Orskov *et al.* (1990) stated that in areas where straw is the main feed for ruminants, a proportional increase of 0.1 in digestibility can have enormous implication for resource availability and thus animal performance.

Compared with the untreated stover, urea treatment has reduced Neutral Detergent Fiber (NDF) content of the stover by about 6 percentage units. Nguyen (2000) reported urea to be effective in delignifying rice straw thus reducing its NDF content. The author stated that the changes in NDF were mainly determined by treatment effect on hemicellulose. This is in accordance with the findings of Males (1987) who described hemicellulose as the cell wall component most sensitive to delignification treatment.

### Feed intake

Feed intake of the calves, calculated as the difference between the amount of feed offered and refused, is given in Table 2. The daily DM intake (DMI) of the basal diet varied from 3.1 kg in untreated maize stover to 3.8 and 4.4 kg in urea treated stover and natural pasture hay, respectively. Urea treatment has significantly ( $p < 0.05$ ) increased DMI of the stover. The intake of animals fed on the treated stover was 22% higher than that of the animals fed on the untreated stover. FAO (1986) stated that urea treatment may increase voluntary intake of the treated straw as compared to the untreated one by as much as 25 to 30%. Smith *et al.* (1989) also reported a significant increase in DMI of urea-treated maize stover compared with dry fresh maize stover. On the other hand, Saadullah *et al.* (1982) observed no trend of intake increment for urea treated rice straw fed to calves. Also according to Munthali *et al.* (1992), urea treatment of maize stover did not increase dry matter intake compared with the water treatment of maize stover.

### Apparent digestion and digestible nutrient intake

The DM, OM and CP digestibility coefficients of the three experimental diets are

**Table 2** Feed intake of calves fed the three experimental diets.

Parameter	Experimental diets <sup>1/</sup>		
	1	2	3
Roughage DM intake (kg/d)	3.13 <sup>c</sup>	3.83 <sup>b</sup>	4.35 <sup>a</sup>
Concentrate DM intake (kg/d)	0.89	0.89	0.89
Total DM intake (kg/d)	4.02 <sup>c</sup>	4.72 <sup>b</sup>	5.24 <sup>a</sup>
Roughage DM intake (% BW)	2.07 <sup>b</sup>	2.49 <sup>a</sup>	2.65 <sup>a</sup>
Concentrate DM intake (% BW)	0.60 <sup>a</sup>	0.58 <sup>a</sup>	0.54 <sup>b</sup>
Total DM intake (% BW)	2.66 <sup>b</sup>	3.10 <sup>a</sup>	3.20 <sup>a</sup>
Total DM intake (g/kg W <sup>0.75</sup> /d)	93 <sup>b</sup>	108 <sup>a</sup>	114 <sup>a</sup>
Total CP intake (g/d)	320 <sup>c</sup>	781 <sup>a</sup>	442 <sup>b</sup>

<sup>abc</sup> In a row means followed by different letters are different ( $p < 0.05$ ).

<sup>1/</sup> 1 = Untreated maize stover *ad libitum* + 1kg concentrate/hd/d.

2 = Urea-treated maize stover *ad libitum* + 1kg concentrate/hd/d.

3 = Natural pasture hay *ad libitum* + 1kg concentrate/hd/d.

shown in Table 3. Calculated based on these coefficients, the digestible DM, OM and CP intakes as well as metabolizable energy intake of the calves are also given in the same Table. Though the DMI of animals fed on hay based diet was significantly higher than that of animals fed on urea treated maize stover, there was no difference between these two diets in digestible dry matter intake (DDMI) and digestible organic matter intake (DOMI). This is attributed to the superiority in digestibility of the diet containing urea treated stover compared to the hay based diet. With regard to protein, the animals fed on urea-treated stover diet had higher ( $p < 0.05$ ) digestible crude protein intake (DCPI) than those animals fed on either untreated stover or hay diets. Even if the daily DMI of animals fed the diet containing untreated maize stover was within the recommended values (Kearl, 1982), the daily DCPI of the animals was slightly below the amount required to ensure a daily gain of 250 g. This concurs with the lower CP content of the untreated stover. On the other hand, animals on the diet containing hay obtained lesser ( $p < 0.05$ ) DCP than those animals fed the diet containing urea treated maize stover. This is attributed to the lesser CP content of hay compared with the urea

treated stover and the lower CP digestibility of the diet containing hay.

Metabolizable energy intake (MEI) of the calves, estimated as  $\text{kg DOMI} \times 15.56$  (ARC, 1980), generally followed the trends of DDMI. Calves fed on hay and urea treated maize stover diets obtained higher ( $p < 0.05$ ) ME than those fed on the untreated stover diet. However, even the daily MEI of calves fed on the latter diet was within the recommended range for animals of similar live weight to show some gain. This is likely to be due to the high energy concentration (2.3 Mcal/kg DM) of the diet. On the other hand, even if the energy concentration of the hay diet was lower than that of the urea treated maize stover diet, the daily MEI of animals on these two diets did not vary significantly ( $p > 0.05$ ) following the absence of difference in their DOMI. While evaluating the effectiveness of ammonification through urea in improving the feeding value of rice straw in ruminants, Saadullah *et al.* (1981) found that urea treatment increased the ME concentration in terms of MJ/kg DM of the straw from 6.93 in the untreated straw to a maximum of 9.51 in straw treated with 5% urea. In the current study it was not possible to exactly tell the effect of urea

**Table 3** Apparent digestion and the digestible nutrient intake of calves fed the three experimental diets.

Parameter	Experimental diets		
	1	2	3
Apparent digestibility, %			
- Dry matter	62.5 <sup>a</sup>	65.7 <sup>a</sup>	56.4 <sup>b</sup>
- Organic matter	65.6 <sup>a</sup>	67.9 <sup>a</sup>	59.4 <sup>b</sup>
- Crude protein	65.6 <sup>b</sup>	77.4 <sup>a</sup>	60.4 <sup>b</sup>
Dig. DM intake (kg/d)	2.51 <sup>b</sup>	3.10 <sup>a</sup>	2.96 <sup>a</sup>
Dig. DM intake (g/kg W <sup>0.75</sup> /d)	58 <sup>c</sup>	71 <sup>a</sup>	65 <sup>b</sup>
Dig. OM intake (kg/d)	2.46 <sup>b</sup>	2.95 <sup>a</sup>	2.88 <sup>a</sup>
Dig. CP intake (g/d)	210 <sup>c</sup>	604 <sup>a</sup>	267 <sup>b</sup>
ME energy intake (MJ/d)	38.3 <sup>b</sup>	46.0 <sup>a</sup>	44.7 <sup>a</sup>
ME energy intake (KJ/kg W <sup>0.75</sup> /d)	887 <sup>b</sup>	1053 <sup>a</sup>	976 <sup>a</sup>
Energy concentration (MJ/kg DM)	9.5 <sup>b</sup>	9.7 <sup>a</sup>	8.5 <sup>c</sup>

<sup>abc</sup> In a row means followed by different letters are different ( $p < 0.05$ ).

treatment on energy concentration as the values obtained represent the energy concentration of the whole feed (basal diet plus concentrate). However, it is very likely that the higher ( $p < 0.05$ ) energy concentration of the diet containing the urea treated stover, compared with the other two diets could be due to the basal feed of urea treated stover as the amount of concentrate offered with all the diets was the same.

### Growth performance and feed efficiency

Live weight changes of animals fed the experimental diets are given in Table 4. In accordance with their similarity in digestible nutrient and energy intakes, animals fed on urea treated stover diet and those fed on hay diet did not differ ( $p > 0.05$ ) in their live weight gains. This is in line with the findings of Tran and Nguyen (2000) who concluded that urea treated maize stover could be used to replace grass for ruminant feeding as cattle had acceptable weight gains. In the current study, the slightly higher live weight gains of animals fed on the urea treated stover than those fed on the hay diet could be attributed to the higher CP content of the urea treated stover which in turn resulted in higher CPI of the animals. The gain of animals fed on the diet containing the untreated stover was inferior. This was concomitant with their lower feed and hence lower nutrient intakes than animals fed the other two diets.

Bui and Le (2001) found considerably higher growth rate of cattle fed ammoniated rice straw than those fed untreated straw plus molasses-urea block. They attributed such improvements in growth rate, which was 25%, to a 50% increase in DMI of the ammoniated straw. From their study on the effects of urea treatment of maize stover on performance of growing steers and heifers, Munthali *et al.* (1992) also concluded that the increased intake of energy and an accompanying improvement in the utilization of non protein nitrogen in the treated straw resulted in improvement of live weight gain of the animals.

With regard to feed efficiency, though the differences were not significant ( $p > 0.05$ ), animals fed on urea treated stover diet were relatively more efficient than those fed on the other two diets in converting feed to live weights. Gao (2000) also found animals on urea ammoniated wheat straw consumed 25.8% less straw DM than those on untreated straw. In the current study, for every kg live weight gain, animals on urea treated stover diet consumed 1.8 kg (12.7%) less DM than those animals fed on the diets containing either hay or untreated stover. This is in agreement with the works of Li *et al.* (1993) who, from their study on the effect of untreated and treated wheat straw and maize stover on performance of crossbred cattle, observed an improvement of 13.3% (from 2.33 to 2.02) in feed conversion ratio as a result of ammonia treatment of maize stover.

**Table 4** Live weight changes and feed conversion efficiency of growing calves fed the experimental diets.

Parameter	Experimental diets		
	1	2	3
Initial weight (kg)	137.9	133.7	145.1
Final weight (kg)	165.7 <sup>b</sup>	171.4 <sup>b</sup>	181.7 <sup>a</sup>
Total weight gain (kg)	27.9 <sup>b</sup>	37.7 <sup>a</sup>	36.6 <sup>a</sup>
Daily weight gain (g)	284 <sup>b</sup>	385 <sup>a</sup>	377 <sup>a</sup>
Feed conversion ratio (kg. DM/ kg weight gain)	14.2	12.4	14.2

<sup>ab</sup> In a row means followed by different letters are different ( $p < 0.05$ ).

### Cost analysis

Costs of feeding the experimental feeds are summarized in Table 5. Hay was so expensive that both the total cost and cost per kg live weight gain were higher ( $p < 0.05$ ) for this diet than the corresponding costs for the stover based diets, whether treated or untreated. The difference between the two stover based diets was not significant ( $p > 0.05$ ). In studying the effects of ammoniated wheat straw on growth of beef cattle, Gao Tengyun (2000) reported 16.4% lower cost of 1 kg weight gain for steers fed 5% urea ammoniated wheat straw compared with that of the animals fed the untreated straw. In the current study, though the cost per kg weight gain of feeding urea treated maize stover diet was about 16% higher than the corresponding cost of feeding the untreated stover diet, it was 33% lower than the cost of feeding the hay based diet. This indicates that feeding treated maize stover could be a possible alternative to hay feeding enabling the realization of more weight gains with reasonably higher costs than feeding untreated stover diet and lower costs than hay feeding.

### CONCLUSION AND RECOMMENDATIONS

Besides significantly increasing CP content of the stover, urea treatment of maize stover improved the IVDMD and DMI of the stover by 9 and 22%, respectively over the

untreated one. Accordingly there was a higher CPI by animals fed the diet containing the treated stover than those fed either the untreated stover or the hay based diets. These improvements in terms of chemical composition, intake and digestibility led to a higher ( $p < 0.05$ ) live weight gain of animals fed on the urea treated stover diet compared with the gain of those animals fed on the untreated stover diet. However, there was no difference ( $p > 0.05$ ) in daily weight gain between the animals fed on the urea-treated stover diet and those fed on the hay diet. Generally, with the added advantage of being more cost effective than hay, feeding urea treated maize stover may be considered as one of the strategies that bring about an efficient utilization of crop residues for livestock feeding especially in arid and semi-arid areas where crop residues constitute the major ruminant feeds and natural pasture hay is not easily available. However, its economic advantage over other alternatives must carefully be examined under the prevailing price conditions before it is implemented.

### ACKNOWLEDGEMENTS

The authors would like to acknowledge The Oromiya Agricultural Research Institute for financing this study through the Agricultural Research and Training Project. The Adami Tullu Agricultural Research Center is also acknowledged for every service it rendered in facilitating this work.

**Table 5** Costs of feeding the three experimental diets to the calves.

Parameter	Experimental diets		
	1	2	3
Roughage feed cost (Birr/d) <sup>1</sup>	0.94 <sup>c</sup>	1.91 <sup>b</sup>	3.13 <sup>a</sup>
Concentrate cost (Birr/d)	0.78	0.78	0.78
Total cost (Birr/d)	1.72 <sup>c</sup>	2.70 <sup>b</sup>	3.92 <sup>a</sup>
Total cost/kg weight gain (Birr/hd)	6.09 <sup>b</sup>	7.08 <sup>b</sup>	10.61 <sup>a</sup>

<sup>1</sup> Birr = Ethiopian currency (1 USD = 8.60 Birr at the time).

<sup>abc</sup> In a row means followed by different letters are different ( $p < 0.05$ ).

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