

# Effect of Urea-treatment on Nutritive value of Sugarcane Bagasse

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## ABSTRACT

This study was conducted to enhance the nutritive value and improve digestibility of sugarcane bagasse by alkali treatment method using urea. Urea at a level of 10% dry matter of bagasse was dissolved in water and mixed with bagasse. The mixture was divided into four equal portions and was stored in sealed plastic bags for 1, 2, 3 and 4 weeks. Crude protein increased significantly in the treated bagasse compared with raw and ensiling for 28 days increased crude protein to 10.4% compared with 2.18% of the raw bagasse. Neutral Detergent Fiber (NDF) degradation of treated bagasse increased significantly ( $P < 0.05$ ) compared with raw bagasse. The increase in degradation rate was maximum for the ensiling period of four weeks. Cell wall compounds decreased with the increase of the ensiling period, and reached a maximum at day 28 of ensiling.

**Keywords:** Alkali treatment, Digestibility, lignocelluloses.

## 1. INTRODUCTION

Sugarcane bagasse is one of a highly fibrous residue remaining after extraction of juice from cane stem which can be used as a source of roughages for ruminants. Sugarcane bagasse annual production in Sudan is more than three million tons. Small proportions of these quantities are burnt during the production cycle of sugar and the rest creates problems of its disposal. Utilization of Sugarcane bagasse for animal feeding is limited due to their bulkiness that hinders their transport to areas of consumption and their poor digestibility due their high content of fiber which contain more than 60% of its dry matter in the form of cellulose, hemicellulose and lignin. [9] and [18] found that sugarcane bagasse contained about 50% cellulose, 27.9% hemicellulose, 9.8% lignin and 11.3% cell content that included 1.3% CP. The limitation in availability of energy to the ruminant animals from ligno-cellulose of agricultural by-products is due to physical and chemical association between structural carbohydrate and lignin and the crystalline arrangement of the cellulose polymer in plant cell wall [12], [7] and [19]. It is clear that, with respect to animal feeding, the major biological constraints the use of sugarcane bagasse are the vast amount of lingo-cellulose material which has a very low digestibility. A potential for the use of sugarcane bagasse as a ruminant feed may be realized through the development of physical, chemical and biological treatments to disrupt the lingo-cellulose complex. Alkali, acid and oxidative reagent treatments are kinds of chemical treatments for roughages [21] and [20]. Ammoniation of low quality roughages with urea or ammonia solution improved digestibility and nutritive value [14]. Urea is an interesting alternative to anhydrous ammonia in the treatment of ligno-cellulose foodstuff due to its low cost, easy handling, danger-free and non toxic for animals [3]. The urea treatment is based on adequate ureolysis due to the effect of enzyme urease

to release ammonia from urea and the effect of ammonia on the cell wall of straw. The ammonia thus generated provokes the (alkaline) reaction which gradually spreads and treats the mass of forage. The aim of this work is to improve the digestibility of sugarcane bagasse using urea and raw sodium bicarbonate (atruon).

## 2. MATERIALS AND METHODS

### 2.1 Bagasse Preparation and Ensiling

The following components, 7% molasses, 10% urea, 2% limestone, 0.5% common salt and 1% sodium bicarbonate (atruon) were dissolved in one liter of water  $\text{kg}^{-1}$  DM and mixed with raw bagasse. Two polyethylene sacs were used to form one silo, by inserting one into another with sealed sides of both sacs opposite to one another for extra strength and to avoid rupturing of the sacs along the sealed sides. Twelve silos were made and each was filled with treated bagasse compressed and tightly closed. Silos were randomly divided into four ensilage periods of 7, 14, 21 and 28 days with three replicates each and stored under shade. At the end of each ensilage period samples were drawn, sun dried and prepared for chemical analysis and degradability studies.

### 2.2 Chemical Composition

Samples of raw and ensilaged bagasse were analyzed for proximate composition (CP, EE, DM and Ash) according to [1]. Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and hemicellulose (HC) were determined according to [5].

### 2.3 In Situ Degradability

Degradability study of bagasse was carried out in a cannulated steer according to the nylon bag technique described by [16]. Samples were air dried and ground through 2.5 mm sieve before rumen incubation. Duplicate

samples of about 5g each were placed in nylon bags (bag size 18×140mm, pore size 45µm) which were then suspended in the rumen of a steer for 4, 8, 16, 24, 48, 72 and 96 hrs. After removal from the rumen, the bags were dipped into cold water to stop microbial activity, washed with tap water to remove rumen matter from outside the bags and then cleaned by rubbing and rinsed under running water for about 30 minutes. Samples of 0 hr were prepared by washing the bags containing the test samples for 30 minutes. The residues in the bags were overnight oven dried at 105°C. The bags were then cooled and their weights were recorded and used to calculate percent dry matter loss. The results from in-situ study were fitted to model  $P=a+b(1-e^{-ct})$  of [15] to determine the degradation characteristics of the incubated samples.

#### 2.4 Statistical Analysis

Data were analyzed by analysis of variance (ANOVA) according to [6] for a complete randomized design. When the F test was significant, the means were compared using least significant difference (LSD).

### 3. RESULTS

#### 3.1 Chemical Analysis

Table (1) shows the chemical composition of raw and treated sugar-cane bagasse. Protein content improved significantly ( $P<0.05$ ) in all treatments. The ensiling raised CP from 2.18% of raw sugar-cane bagasse to 10.40% for the ensiled for 28 days. The ash content was significantly ( $P<0.05$ ) lower for raw bagasse than for ensiled bagasse. The cell wall compounds as determined by NDF, ADF, ADL and HC decreased with increasing the period of ensiling. The decrease was only significant ( $P<0.05$ ) between raw bagasse and the different ensiling periods. The maximum decrease was between raw bagasse and bagasse ensiled for 28 days.

#### 3.2 Degradability Study

Table (2) and figure (1) show in-situ degradability for NDF. Ensiling significantly ( $P<0.05$ ) increased NDF degradability compared to raw bagasse. NDF degradation increased but not significantly with time up to 8 hours, there after the increase was significant and maximum at 96 hours. According to Table (3) the soluble fraction (a) increased significantly ( $P<0.05$ ) for treated bagasse compared with raw bagasse, while slow degradable fraction (b) and potential degradability (PD) increased but not significantly ( $P>0.05$ ) for treated than for raw bagasse. The rate of degradation (c) showed no change between treated and raw bagasse. The effective degradability (ED) increased among all treatments and in the different rates of outflow. However the effective degradability (ED) decreased with increase in outflow rates for all treatments and the decrease was only significant ( $P<0.05$ ) for the control and treatment one ( $T_1$ )

## 4. DISCUSSION

#### 4.1 Chemical Composition

The chemical composition of the raw and treated sugar-cane bagasse indicated that urea treatment improved all the parameters studied. The urea treatment enhanced nitrogen content of ligno-cellulosic materials and the increase was significant with the increase of storage period. This finding was similar to that obtained by [8] and [2] in their studies on Sugar-cane bagasse. The present study suggested that the added nitrogen existed initially in the form of urea and consequently free ammonia was released. The same phenomena was observed in wheat straw by [13] and in other grasses [17]. The cell wall components (NDF, ADF, ADL and HC) decreased with urea treatment and the decrease was significant ( $P<0.05$ ) only between raw sugar-cane bagasse and the different ensiling periods. Treatment of agricultural by-products by urea released ammonia which reacted with the lignocelluloses materials and improved their feeding values [22]. The cell wall components were affected by alkali treatment which disturbed the cell wall components that caused a decline in these components [2]. The NDF content of treated sugar-cane bagasse decreased as the treatment period increased. This decrease was mainly due to a decrease in HC content. The fall in NDF content of lignocelluloses materials was due to hemicellulose degradation by ammonia [24]. The decrease in NDF agreed with [8] and [20] who found that the NDF decreased with urea treatment for different ensiling periods. The ADF fraction also decreased significantly ( $P<0.05$ ) with urea treatment, while with increasing period of ensiling the enhancement was not significant among treated sugar-cane bagasse. The findings by [2] and [10] showed the same trend in bagasse and that ADF decreased when urea treated and ensiled for seven weeks. [23] stated that saponification of ester linkages between acetic acid and phenolic acids and polysaccharides and or lignin as well as such linkages between uronic acids residues of xylans in hemicelluloses and lignin would be expected to occur during the alkaline treatment of straw material. High temperature and alkaline condition causes cleavages in the lignin and formation of other linkages between phenyle propane units and free phenolic groups. As a result of the accompanying decrease in the molecular weight and cleavages of linkages to the hemicellulose an increased solubility of lignin in the alkaline solution will occur.

#### 4.2 Degradability Study

The results showed that in-situ degradability of NDF increased significantly for treated sugar-cane bagasse among all treatments compared with raw bagasse. The effective degradability (ED) in different outflows also increased with increasing ensiling period of sugar-cane bagasse. This result might be due to partial solubilization of hemicellulose by alkali treatment. Urea treatment was reported to cause partial break down of the bond between the lignin and other cell wall components that lead rumen bacteria to degrade fibrous material in the

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rumen [14]. [11] stated that ammonia treatment of roughages might affect the lignin itself or its linkage that might increase cell wall degradation. The important change during alkali treatment was a swelling of plant cell wall and its rupture allowing the rumen microbes to have better access to the structural carbohydrate and consequently the digestibility would be enhanced. The readily degradable fraction (a) of raw bagasse was less than that of treated one. The degradability values of treated sugar-cane bagasse observed were not affected significantly by treatment periods. This could be due to urease generation in great amount in the first two weeks depending on high temperature. Atta [2] also found the

same trend when he treated sugar-cane bagasse with urea and ammonia solution in comparison with raw bagasse. [4] stated that the increase of DM and NDF degradation of alkali treated fibrous materials with addition of a nitrogen source was partially due to increased degradation of crude protein. High supply of nitrogen immediately after incubation might result in increasing degradation rate of fibrous by-products up to 48 hrs than that in the late time. From this degradability study it was clear that urea treatment of sugar-cane bagasse improved its nutritive value.

**Table 1:** Chemical composition of raw and treated bagasse (%)

	CP	EE	DM	Ash	NDF	ADF	ADL	HC
R	2.18 <sup>d</sup>	0.84 <sup>a</sup>	96.1 <sup>abc</sup>	2.70 <sup>b</sup>	84.5 <sup>a</sup>	60.0 <sup>a</sup>	13.4 <sup>a</sup>	24.4 <sup>a</sup>
T <sub>1</sub>	8.46 <sup>c</sup>	0.61 <sup>b</sup>	96.6 <sup>a</sup>	7.50 <sup>a</sup>	69.3 <sup>b</sup>	54.1 <sup>b</sup>	10.7 <sup>b</sup>	15.1 <sup>b</sup>
T <sub>2</sub>	9.28 <sup>b</sup>	0.77 <sup>ab</sup>	95.6 <sup>c</sup>	6.35 <sup>a</sup>	69.3 <sup>b</sup>	54.6 <sup>b</sup>	10.8 <sup>b</sup>	14.7 <sup>b</sup>
T <sub>3</sub>	9.76 <sup>ab</sup>	0.84 <sup>a</sup>	95.7 <sup>bc</sup>	6.66 <sup>a</sup>	69.2 <sup>b</sup>	54.3 <sup>b</sup>	10.3 <sup>b</sup>	14.9 <sup>b</sup>
T <sub>4</sub>	10.4 <sup>a</sup>	0.86 <sup>a</sup>	96.4 <sup>ab</sup>	6.96 <sup>a</sup>	67.6 <sup>b</sup>	53.9 <sup>b</sup>	10.0 <sup>b</sup>	13.7 <sup>b</sup>
SE	0.25	0.07	0.20	0.53	0.71	0.61	0.47	0.80

R: Raw bagasse.

T<sub>1</sub>-T<sub>4</sub>: bagasse ensiled for one to four weeks.

SE: Standard Error.

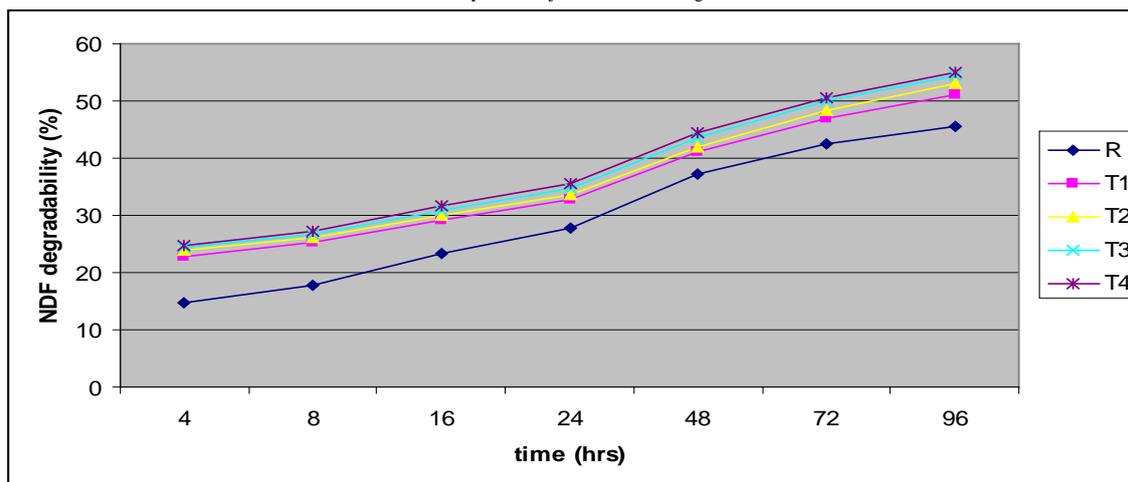
a, b, c, d Means with different superscript in the same column were significantly different (P<0.05).

(CP) crude protein, (EE) ether extract, (DM) dry matter, (NDF) neutral detergent fiber, (ADF) acid detergent fiber, (ADL) acid detergent lignin, (HC) hemicelluloses.

**Table 2:** Rumen degradation of NDF (%) for raw and treated bagasse

NDF loss% (hr)	R	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	SE
0	12.59 <sup>b</sup>	20.71 <sup>a</sup>	20.18 <sup>a</sup>	20.75 <sup>a</sup>	21.97 <sup>a</sup>	1.11
4	14.92 <sup>b</sup>	22.50 <sup>a</sup>	22.62 <sup>a</sup>	22.74 <sup>a</sup>	22.68 <sup>a</sup>	0.58
8	18.74 <sup>b</sup>	26.40 <sup>a</sup>	27.85 <sup>a</sup>	27.94 <sup>a</sup>	28.17 <sup>a</sup>	1.15
16	21.40 <sup>d</sup>	27.44 <sup>c</sup>	28.52 <sup>c</sup>	31.17 <sup>b</sup>	33.24 <sup>a</sup>	0.63
24	27.85 <sup>c</sup>	33.37 <sup>b</sup>	35.03 <sup>ab</sup>	35.29 <sup>ab</sup>	35.54 <sup>a</sup>	0.96
48	39.22 <sup>c</sup>	43.03 <sup>b</sup>	43.25 <sup>b</sup>	45.09 <sup>a</sup>	45.64 <sup>a</sup>	0.67
72	40.86 <sup>b</sup>	44.79 <sup>a</sup>	45.32 <sup>a</sup>	46.34 <sup>a</sup>	46.41 <sup>a</sup>	1.04
96	45.84 <sup>b</sup>	52.14 <sup>a</sup>	54.56 <sup>a</sup>	56.55 <sup>a</sup>	56.58 <sup>a</sup>	2.64

a, b, c, d Means with different superscript in the same row were significantly different (P<0.05).



**Fig 1:** Degradation of NDF (%) for treated and raw bagasse.

R: Raw bagasse, T<sub>1</sub>-T<sub>4</sub>: bagasse ensiled for one to four weeks

**Table 3:** Rumen degradation kinetics (%) of NDF for treated and untreated bagasse

	R	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	SE
a	11.27 <sup>b</sup>	20.43 <sup>a</sup>	21.70 <sup>a</sup>	21.87 <sup>a</sup>	21.93 <sup>a</sup>	0.91
b	38.27	44.57	54.80	44.40	43.13	13.31
c	0.02	0.02	0.01	0.02	0.02	0.006
PD	49.53	65.03	73.27	66.30	65.07	12.37
ED2	32.03 <sup>c</sup>	37.90 <sup>b</sup>	39.17 <sup>ab</sup>	40.20 <sup>a</sup>	40.60 <sup>a</sup>	0.75
ED5	23.70 <sup>d</sup>	29.70 <sup>c</sup>	30.80 <sup>b</sup>	31.73 <sup>a</sup>	32.30 <sup>a</sup>	0.34
ED8	20.23 <sup>d</sup>	27.00 <sup>c</sup>	27.90 <sup>b</sup>	28.60 <sup>ab</sup>	29.17 <sup>a</sup>	0.39

(a) Readily degradable fraction, (b) slow degradable fraction, (c) rate of degradation, (PD) potential degradability, ED2, ED5, ED8 effective degradability at outflow rate of 0.02, 0.05 and 0.08/hrs.

a, b, c, d Means with different superscript in the same column were significantly different (P<0.05).

## REFERENCES

- [1] AOAC. (2000). Official methods of analysis, 17<sup>th</sup> ed. Association of official analytical chemists. Washington. DC.
- [2] Atta Elmanan, B. A. Fadel Elseed, A. M. A, and Salih, A. M. (2007). Effect of ammonia and urea treatments on the chemical composition and rumen degradability of bagasse. *J. of Applied Sc. Res.* 3(11): 1359-13-62.
- [3] Caneque, S. Velasco, S. and Sancha, J. L. (1998). Nutritional value and use of ligno-cellulosic feed treated with urea in the ruminant diet. In: Exploitation of Mediterranean roughage and by-products. Antongiovanni M. (Ed). Options Mediterraneenes 32-17:17, (CIHEAM). Serie B: Etudes et Recherches n.
- [4] Fadel Elseed, A. M. A. Sekine, J. Hishinuma, M. and Hamana, K. (2003). Effects of ammonia, urea plus calcium hydroxide and animal urine treatments on chemical composition and in sacco degradability of rice straw. *Asian-Aust. J. Anim. Sc.* 16(3): 368-373.
- [5] Goering, H. K. and Van Soest, P. J. (1970). Forage fiber analysis (Apparatus, Procedure and some Application) agricultural Hand Book No. 379. Agricultural Research Services. USDA, Washington, DC.
- [6] Gomez, K. A. and Gomez, A. G. (1984). Statistical procedures for agricultural research. John Wiley and Sons, USA.
- [7] Hartley, R. D. and Jones, E. C. (1978). Phenolic components and degradability of the cell walls of the brown mibrid mutant, bm3, of *Zea mays*. *J. Sci. Food Agric.* 29, 777-789.
- [8] Hassoun, P. Geoffroy, F. Saminadin, G. Prior, P. and Beramis, M. (1990). Studies on the ammoniation of sugar-cane bagasse by urea. Effects of moisture, urea levels, urease source and treatment periods on composition, in vitro dry matter digestibility and evolution of ureolytic bacteria. *Anim. Feed Sci. and Technol.* 29: 113-129.
- [9] Kewalramani, N. Kamra, D. N. Lall, D. and Pathak, N. N. (1988). Bioconversion of sugar-cane

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- bagasse with white rot fungi. *Biotechnology letters*. 10 (5): 369-372.
- [10] Kraidees, M. S. (2005). Influence of urea treated and soybean meal (urease) addition on the utilization of wheat straw by sheep. *Asian-Aust. J. Anim. Sci.* 18(7): 957-965.
- [11] Mason, V. C. Cook, J. E. Dhanoa, M. S. Keene, A. S. Hoadley, C. J. and Hartley, R. D. (1990). Chemical composition, digestibility in vitro and bio degradability of grass hay oven-treated with different amounts of ammonia. *Anim. Feed Sci. Technol.* 29: 237-249.
- [12] Morris, E. J. and Bacon, J. S. D. (1977). The fate of acetyl groups and sugar components during the digestion of grass cell walls in the sheep. *J. Agric. Sci.* 89:327-340.
- [13] Nair, P. V. Verma, A. K. Dass, R. S. and Mehra, U. R. (2002). Growth and nutrient utilization in buffalo calves fed urea-ammoniated wheat straw and hydrochloric acid plus urea treated wheat straw. *Asian-Aust. J. Anim. Sci.* 15(5): 682-686.
- [14] Ngyuen, X. T. Dan, C. X. Ly, L. V. and Sandsle, F. (2002). Effect of urea concentration, moisture content and duration of treatment on chemical composition of alkali treated rice straw. *Livest. Res. Rural Devel.* 10 (1).
- [15] Ørskov, E. R. and McDonald, I. (1979). The estimation of protein degradability in the rumen of incubation measurement weighted according to rate of passage. *J. Agric. Sci., Camb.*, 92: 499-503.
- [16] Ørskov, E. R. Hovell, F. D. and Mould, F. (1980). The use of nylon bag technique for evaluation of beef stuff. *Trop. Anim. Prod.* 5: 195-213.
- [17] Ramirez, G. R. Aguilera-Gonzalez, J. C. Garcia-Diaz, G. and Munez-Gonzalez, A. M. (2007). Effect of urea treatment on chemical composition and digestion of *Cenchrus ciliaris* and *Cynodon dactylon* hays and *Zea mays* residues. *J. Anim. Vet. Advances.* 6(8):1036-1041.
- [18] Ramli, M. N. Imura, Y. Takayama, K. and Nakanishi, Y. (2005). Bioconversion of sugarcane bagasse with Japanese Koji by solid-state fermentation and its effects on nutritive value and preference in goats. *Asian-Aust. J. Anim. Sci.* 18 (9): 1279-1284.
- [19] Scalbert, A. Monties, B. Lallemand, J. Y. Guitte, E. Rolando, C. (1985). Ether linkages between phenolic acids and lignin fractions for wheat straw. *Phytochemistry.* 24: 1359-1362.
- [20] Suksombat, W. (2004). Comparison of different alkali treatment on bagasse and rice straw. *Asian-Aust. J. Anim. Sci.* 17 (10):1430-1433.
- [21] Sundstol, F. (1988). Straw and other fibrous by-products. *Livest. Prod. Sci.* 19: 137-158.
- [22] Sundstol, F. Coxworth, E. Mowat, D. N. (1978). Improving the nutritive quality of straw and other low-quality roughages by treatment with ammonia. *World Anim. Rev.* 26: 13.
- [23] Theander, O. and Aman, P. (1984). In: F. Sundstol and E. Owen (Editors) *Straw and other by-products as feed*. Elsevier, Amsterdam. Pp. 45.
- [24] Van Soest, P. J. Mascarenhas Ferreira, A. and Hartley, R. D. (1984). Chemical properties of fiber in relation to nutritive quality of ammonia-treated forages. *Anim. Feed Sci. Technol.*, 10: 155-164.