EFFECT OF UREA TREATMENT OF SORGHUM STOVER
ON THE CHEMICAL COMPOSITION AND
IN RUMEN DEGRADABILITY

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DEDICATION

To my dear
Father and mother
To my son Abdelhafeez Mohamed Salih
To my husband
To my brothers
To my sister and her daughters and son

With love and gratitude

Selma Ali Bashir
ACKNOWLEDGEMENTS

My faithful thanks to Allah who gave me health and strength throughout this study.

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ABSTRACT

The objectives of the study were to estimate the effects of different levels of urea treatments on chemical composition, nutritional value and rumen degradability of sorghum Stover.

This experiment contained two: untreated sorghum Stover (sorghum) served as control. The other urea levels namely: 2% and 4% urea were used. Crude protein content of the treated sorghum was enhanced (P< 0.05) over the untreated control and ranks as 7.30, 6.05% CP for 4% and 2% respectively. NDF content was decreased (P< 0.05) from 92.5% (control) to 89.8 and 87.8 for 2% and 4% urea respectively.

EE content was decreased (P< 0.05) from 1.77 (control) to 1.63 and 0.82 for 2% and 4% respectively.

The rumen degradability was increased (P< 0.05) from 59.2% (control) and 64.2, 67.2 for 2, and 4% and among hours.
خلاصة الأطروحة

أجريت هذه الدراسة لمعرفة أثر معالجة الـذرة (قصب + أوراق) بواسطة البوريا على القيمة الغذائية والتحلل في الكرش.

استخدمت في هذه الدراسة مستويين مختلفين من البوريا المعالجة (2 و 4%) بالإضافة إلى الذرة (قصب + أوراق) غير المعالجة.

محتوي البروتين الخام أعطي معدلات متزايدة بالنسبة للذرة (قصب + أوراق) المعالج مقارنة بغير المعالج فكانت هناك فروقات معنوية (P<0.05).

الذرة المعالج بـ 2 و 4% بوريا أعطي 90.6 و 30% من البروتين الخام على التوالي مقارنة بغير المعالج 60% ب. كما كانت هناك فروقات معنوية NDF في معدل NDF (P<0.05). نقص معدل NDF مقارنة بالذرة غير المعالج، المعالج بـ 2 و 4% على التوالي.

بالمثل بالنسبة لدراسة معدل تحلل الكرش فقد أجريت في عجلتين مفتوحة الكرش، فقد وجد أن هناك زيادة في معدل تحلل الـذرة (قصب + أوراق) المعالج بـ 2 و 4% مقارنة بغير المعالج، كما وجدت فروقات معنوية (P<0.05) بين جميع المعاللات وأيضا بين عدد الساعات.

بالنسبة للتحليل التقريبي وجد أيضا فروقات معنوية (P<0.05) بين المعاللات في EE و Ash, DM.
CHAPTER ONE

INTRODUCTION

Ruminant in most countries rely on natural pastures for survival. However agricultural and agro-industrial byproduct contribute to high percentage of feed ingested by ruminant.

Most agricultural and agro-industrial byproducts such as sorghum Stover are low in protein content and digestibility. Their nutritive value, must be enriched by supplements to improve the feeding value of these low quality roughage.

Fiber is basically needed for fill of the animal and particular movement of gut. In addition fiber is essentially polysacharide containing cellulose, hemi-cellulose and lignin. It also plays an important role in ruminant nutrition, help to maintain the beneficial rumen flora which mainly produces acetate and prevents the enzymatic attachment of ruminal micro-organisms on cellulose and semi-cellulose particles.
The main objectives of this study is to see the effect of urea addition of chemical composition of sorghum Stover.

In addition degradability of the treated and untreated sorghum Stover.
2.1 Ruminal digestion:

Like other vertebrate, ruminal artiodactyla including (deer, cows and their relatives) are unable to digest plant material directly. They lack enzymes to breakdown crude fiber in the cell walls. They can digest cellulose, hemicellulose but hard to digest lignin. Digestion in ruminant occurs sequentially in a four chambered stomach (rumen reticulum, omasum, abomasums), (Church, 1988).

Types of microorganisms that can exist in rumen are constrained by temperature, oxidation-reduction and pH. Therefore ruminants have evolved a digestive system whereby they can utilize cell wall components by microorganisms synthesized enzyme complexes capable of degrading them.
Therefore, the digestion of straw, Stover by the rumen microorganisms is virtually synonymous with the digestion of straw cell wall (Chesson and Orkov, 1989).

2.1.1 Fiber digestion by microbial:

The ruminal microbial populations attach, degrade and ferment structural carbohydrates in forage cell walls and thereby provide volatile fatty acids and protein. Microbial digestion of fiber is quite rapid. However, the rate and extent to which fiber is degraded is determined to a considerable degree by factors such as microbial accessibility to substrate, physical and chemical nature of the forage kinetics of ruminal digestion (Gabriella et al., 1997).

Jurg and Allen (1995) showed that animal production and economic benefits from reduced cell-wall concentration and increased digestibility are significant because of the high cell-wall concentration and large digestible cell-wall fraction of grasses, reduction in cell wall concentration would
probably be of greater value than improving digestibility in these species.

2.1.2 Fibrolytic microorganisms:

2.1.2.1 Rumen microbes:

Bacteria: The major fibrolytic bacteria include *Fibrobacter succinogenes*, *Ruminococcus flavefaciens* and *Ruminococcus albus* (Cheng et al., 1991).

Fibrolytic bacteria tend to degrade the more readily digestible structure such as the mesophyl cell. Although *F. succinogenes* digest parenchyma bundle sheaths, epidermal cell walls and leaf sclerenchyma (Akin, 1989).

Fungi: Fungi account for approximately 80% of the microbial biomass in the rumen (Oprin and Joblin, 1988). The fungi seem to have an important role in fiber digestion because they are able to penetrate both cuticle and cell wall of lignified tissues (Akin, 1986).
Protozoa: *In vitro* studies have suggested that 19-28% of total cellulose activity can be attributed to protozoa (Gijzen *et al*., 1988).

2.1.3 Degradation of cell by wall microbial activity:

Microorganisms in the liquid environment of the rumen, in order to find the nutrient they require and to avoid being carried out of the rumen by the digestive flow, need to adhere to a particulate melter. Bacteria, protozoa and fungi colonize nearly all the plant particles that enter the rumen. The main colonization routes are lesions in the epidermis or through leaf stomata (Cheng *et al*., 1984).

2.1.4 Genetic manipulation and microbial species;

The potential of recombinant DNA technology to develop new strains of bacteria for improved fiber digestibility (Forsberg *et al*., 1986; Teather, 1985), remains largely unrealized. Strategies proposed have included the following: 1) increasing the competitiveness of cellulolytic organisms by conferring the ability to utilize xylose and
pectin, thereby allowing earlier colonization of particular matter. 2) Inserting the cellulose gene into numerically predominant species (B. rumincola): 3) Increasing the competitiveness of cellulolytic species present in the rumen in low numbers (C polysaccharolyticum) by the ability to adhere to feed particles, 4) Inserting an acid-tolerant cellulose gene into acid-tolerant bacteria (lactobacillus) to allow fiber fermentation at a ruminal pH less than 6; 5) Developing acutinase activity in predominant bacteria and 6) Allowing predominant species to degrade arabinose side chains, thereby overcoming the rate-limiting effect of lignin, reported (Wallace, 1994).

2.2 Factors of affecting microbial fiber digestion:

Animal and feeding systems can have a significant effect on the digestion of fiber. Notably, intake, dietary interactions, feeding strategies and feed additives will, to some degree, influence microbial growth and subsequent fiber digestion.
2.2.1 Intake:

The extent of fiber digestion is the result of competition between the rates of digestion and passage and, as such, is not a static value. Rumen liquid and particulate turnover rates are positively correlated with intake. Thus, as intake increases, the digesta flowing from the rumen will contain feed particles at earlier stages of digestion, and this will result in a lower dry matter digestibility (Russell et al., 1992). Because the rate of degradation of structural carbohydrate is of the same order as passage rate, at high levels of intake the depression in digestibility of structural carbohydrate can be two to three times greater than that of the faster degrading, nonstructural carbohydrate. Although a high level of intake may depress ruminal fiber digestion, compensation occurs through increases in gross energy intake and hindgut digestion (Bourquin et al., 1990).
2.2.2 Composition of dietary fiber:

Rumen liable energy normally limits growth of bacteria, and any additional organic matter fermented in the rumen as a result of changing the forage: concentrate ratio will probably increase microbial protein synthesis by providing more energy. Sniffen and Robinson (1987) suggested that the yield of bacteria was maximized with a forage content of 70% in the diet dry matter. Because structural carbohydrate-fermenting microbes are usually limited by a ruminal pH less than 6 (Hoover, 1986), the depression in fiber digestibility at higher inclusion rates of concentrate can most likely be explained by the rapid degradation of nonstructural carbohydrate. It is likely that fiber digestion will not be maximized at a single forage: concentrate ratio rather, it will depend on the various rates of digestion of structural and nonstructural carbohydrate supplied by the forage and the concentrate. This may be shown indirectly by the studies of Tamminga (1981), who
reported no relationship between forage:concentrate and bacterial yield. This study used byproduct ingredients with the a high fiber content, in contrast to the traditional cereal grains.

2.2.3 Particle size and chemical and biological treatments:

Although physical processing of forages by grinding and pelleting does provide a greater surface area for attack by enzymes, utilization of structural carbohydrate is not increased; rather, improvements in animal performance arise primarily from an increased digestible energy intake (Bourquin et al., 1990). In fact, fiber digestibility is reduced by 3.3% as a result of reduced residency time in the rumen. Chemical treatments such as sodium hydroxide, potassium hydroxide and ammonia will partially solubilize hemi-cellulose and lignin, as well as hydrolyze acetic, phenolic and uronic acid esters. Oxidative treatment of forage with sulfur dioxide or peroxide results in degradation of lignin and extensive solubilization or structural carbohydrate (Fahey
Potential improvements in fiber digestion could result from the use of alkaline hydrogen peroxide, which is a combined hydrolytic and oxidative process. The use of white-rot fungi for converting lignocellulosic materials to more digestible feedstuffs for ruminants has also been intensively investigated. In vitro dry matter digestibility was increased 30 and 13% for rice straw leaf and stem, respectively (Karunanandaa et al., 1995). Fungal treatment enhanced digestion of the mesophyll tissue and improved access for ruminal microorganisms by collapsing the vascular bundles.

2.2.4 Effective fiber:

Recent use of the term effective fiber (eNDF) acknowledges the different functionality of dietary fiber. Milk fat, chewing rate and particle size have all been used as an index of effective fiber. Currently, the Cornell Net Carbohydrate and Protein System (CNCPS) uses eNDF to adjust ruminal pH and passage rate (Sniffen et al., 1992). Factors other than particle size that influence eNDF include
the degree of lignification of the fiber, degree of hydration, and bulk density. The importance of eNDF can be seen in the reduced growth rate of structural carbohydrate-fermenting microorganisms and the reduction in total microbial yield when ruminal pH is lower than 6.2 (this being related to a dietary eNDF of 20%).

2.2.5 Feedings strategies:

Robinson (1989) indicated that fiber digestion may be limited by the order and frequency of substrate presentation to the rumen. A total mixed diet provides an optimal balance of nutrients to the microorganisms, thereby stabilizing fermentation. The potential to modify the ruminal environment is perhaps greater when separate, twice-daily feeding of forage and concentrate is practiced. Feeding diets, especially those that are highly fermentable, more frequently than twice a day is generally thought to stabilize the ruminal environment. This reduction in diurnal variation of fermentation end products, in conjunction with improved coupling of
protein and energy release in the rumen, can increase the rate of fiber digestion (Robinson, 1989).

2.2.6 Additives:

The addition of buffers and alkalinizing products (sodium bicarbonate, sodium sesquicarbonate, magnesium oxide, sodium bentonite) to the diet of lactating dairy cows can improve fiber digestion by reducing the period of time during the day that ruminal pH is less than 6. A buffer may overcome limitations to fiber digestion in diets that have a high proportion of low pH silages fermented feeds with a moisture content greater than 50%, an acid detergent fiber <19%, finely chopped haylage, a high proportion of concentrate, irregular feeding of high levels of concentrate, or finely ground concentrate (Hutjens, 1992).

2.3 Rumen protein digestion:

Ruminant animals can utilize non-protein nitrogen (NPN) sources to satisfy part of their protein requirement. In the rumen, microbial enzymes degrade dietary protein to
amino acids and then ferment the amino acid as energy source, excreting the nitrogen as ammonia (Peter, 2005).

According to McDonald (2002) some of the ammonia produced may be absorbed from the rumen into the blood carried to the liver and converted to urea. Some of the urea is returned to the rumen via the saliva and also directly through the rumen wall, but the greater part is excreted in the urine.

The ruminants derive their protein from microbes grown in the rumen and digested in the small intestine as well as from dietary protein not ruminally degraded (Klopfenstein et al., 1991).

2.3.1 Recycling of urea via saliva and blood:

Excess ammonia diffuse the rumen wall and enters the blood stream. The liver combines ammonia molecules into urea which is nitrogen transport form encountered in blood (McDonald, 2002).

Blood urea nitrogen may be recycled to the rumen via saliva as one of its natural buffering constituents and may
also urea diffuse directly out of the blood stream and back into the rumen.

**2.3.2 Non-protein nitrogen source:**

Non-protein nitrogen source can be utilized by ruminants if they can be converted to ammonia in the rumen. Ammonia nitrogen is used by the microbes for amino acid synthesis, in the same manner as ammonia from degraded amino acid is used (Peter, 2005).

The most common NPN source is urea. Urea is a normal product. It is produced in the liver from ammonia arising from amino acid metabolism and it is produced chemically from materials found in animal feeding.

For maximum utilization of NPN by rumen organisms two processes in the rumen should run simultaneously. The degradation of NPN to ammonia, and the fermentation of carbohydrate to supply energy for microbial protein synthesis (Chenost, 1995).
2.4 Sorghum Stover:

It is a hardy, drought-resistant crop adapted to environmental conditions too harsh for the production of corn. It requires less water and can survive dry conditions and then resume growth when moisture becomes available (Peter, 2005).

Like other roughage sorghum Stover contains lignocellulosic materials. The lignification degree represents a steric barrier that prevents the enzymatic attachment of ruminal microorganisms on cellulose and hemicelluloses.

Sorghum Stover like other byproducts containing high fiber, respond to various treatments. Chemical treatment has been reported as the most promising treatment to breakdown or disrupt the amount of lignin present in various byproducts thus increasing their digestibility.
2.4.1 Physical aspects of sorghum treated with urea:

2.4.1.1 Smell:

The criterion of smell can be applied equally well to forage treated by either anhydrous ammonia or urea. A strong pungent smell of ammonia should rise out of the forage mass and remain whilst a handful of forage is pulled and removed from the enclosure. Lack of smell or only a weak one points to total failure or only low efficiency in the treatment achieved. If one cannot detect a smell of ammonia, it is quite likely that one might notice an unpleasant smell of bad fermentation or of mould.

2.4.1.2 Colour:

Forages which have been well treated with urea take on a colour which is dark brown. This change of colour is particularly marked in straw as initially this much lighter than for other forage such as, for example, maize stalks. It is easy to judge treatment quality right inside the mass as the colour should be uniform. Lighter coloured zones show a weaker
reaction of the forage to the ammonia. This is due to a localized under-dosage of ammonia. This observation is often seen after urea treatment and indicated that the urea solution has not been sprayed on uniformly (Ghenost, 1995).

2.4.2 Effect of physical form:

Grinding, chopping or polluting Stover to small particle size resulted in an increment of voluntary intake (Walker, 1984). However Owen (1978) has pointed out that particle size reduction is a poorly defined term even when grinding takes place through a given a screen size. There is much evidence (Sundstol, 1988) that the increased intake seen following particle size reduction seems to arise essentially from increased rate of passage through the digestive tract. Also chewing time to reduce particle size to a size suitable for digestion is also very much reduced (Walker, 1984).

It may be noted that milling and chopping of Stover whilst increasing intake does not increase digestibility.
Indeed some reduction in digestibility may occur (Givens et al., 1995).

2.5 Effect of urea treatment on digestibility:

Nguyen et al. (2001) reported that urea and lime treatment of straw increased delignification, \textit{in vitro} gas production and in-saco degradability. Increased straw digestibility due to urea treatment has been well documented previously (Sundstøl and Xoxworth, 1984; Doyle et al., 1986; Schieve and Ibrahim, 1989; Chenost and Kayouli, 1997; Mardid et al., 1997). Improvements in straw apparent digestibility as a result of treatment with lime and urea in combination have also been reported by Zaman and Owen (1995); Sahoo et al. (2000).

Abd-El Kareem (1990) reported that digestibility and feeding value of urea treated diets depended upon the level of urea added, CP content of the diet, availability of carbohydrates and other nutrient materials.
Ahmed (1995) indicated that 2% urea did not improve CF digestibility of corn stalks, 5% urea-molasses decreased CF digestibility and 10% increased it without influencing dry matter digestibility.

2.5.1 Effect of urea treatment on NDF degradability:

The NDF degradability (dNDF) of roughages is an essential parameter in predicting their energetic value. The cell wall components in these feedstuffs are the main nutritive constituents and the extent of their rumen degradation is the main factor that influences the energetic value (NRC, 2001). Moreover dNDF has been used in models to estimate the physical fill of fibrous feeds in the rumen (Weisbjerg et al., 1990; Madsen and Hvelplund, 1994; Stensig et al., 1994a) and therefore the intake capacity of animals.

2.6 Chemical treatments:

The most common NPN compound and NPN supplementation feeds used in feeding ruminants are as follows:
Urea, ammonium salt, biuret:
- Mixed with concentrate feed
- Urea or urea mineral preparation.
- Liquid supplement consisting of molasses, urea, minerals, vitamins.
- NPN supplement to silage or to low protein green forage during ensiling.
- Pellets or briquettes of compound feed with a large proportion of ground straw, untreated or treated with alkali and supplement with NPN (Chenost, 1995).

One of the most effective methods to improve the nutritive value of straws is treatment with ammonia derived from anhydrous ammonia or urea (Chenost and Kayouli, 1997). Ammoniation of low quality feed with urea or ammonia solution increases levels in protein content (Nguyen et al., 2001).
2.6.1 Biological treatment:

The principle of this method is the splitting of the cellulose and lignin complex by extraction or decomposition of lignin. An ideal fermentation, digesting cellulose and lignin containing lignocellulose residues can be found in the rumen of both domestic and wild animals (Hungate, 1975; Prins and Clarke, 1979; Stewart, 1981). The main problem of biological treatment is to find suitable microorganisms (Zadrazil, 1984).
CHAPTER THREE
MATERIAL AND METHODS

3.1 Feed sample:

3.1.1 Sorghum Stover:

Sorghum Stover was purchased from Research Center of Animal Production (Kuku) The local name (Wad Akar).

3.1.2 Sample preparation:

Two hundred gram of small size sorghum Stover was weighed and placed in glass jars and then water was added at the rate of urea. Three replicates wee used per treatment. The treatments were:

1. Untreated sorghum (control).
2. Sorghum treated with 2% urea
3. Sorghum treated with 4% urea.

The jars were tightly secured and incubated for six weeks under sunlight. After six weeks samples were air dried, thoroughly mixed and ground in hammer mill to pass a
1 mm screen for chemical analysis and 2.5 mm screen for in situ degradability.

3.1.3 Chemical analysis:

The samples of feed were examined and residues were analyzed for their proximate components, DM, ash and CP according to AOAC methods (AOAC, 1990) and NDF was determined according to Georing and Van Soest (1970).

3.1.4 Degradability study:

Degradability study of sorghum Stover was carried out in the two cannulated steers according to the nylon bag technique of Mehrez and Ørskov (1980). Steers were fed at maintained level on a balance roughage concentrate diet with free access to water and mineral blocks.

Nylon bag (80 x 140 mm; pore, size 45 μ) weighing 1 – 25 g each were used for incubation of experimental sample. The empty bags were washed, oven dried at 105°C for overnight. Then they were individually weighed and their weights were recorded. Five grams of treated and untreated
sorghum Stover were put in the bag, tied with nylon ribbon and introduced into a plastic tube of 25 m length above the fistula level to ease the movement of the bags inside the rumen. The bags were incubated for different periods of time 4, 8, 16, 24, 48, 72 and 96 hrs. At the end of each period of time the bags were immediately removed and put in cold water to stop the rumen microorganisms activity then washed under tap water.

The dry matter disappearance at zero time (soluble fraction) was estimated as washing loss of sample weighed into the nylon bag and rinsed through running tap water.

The residues in the bags were oven dried at 105°C for overnight, cooled in a desiccator's and weighed. Dry residues in the bags were calculated, the percentage of dry matter loss was calculated as follows:

\[
\frac{\text{Wt. of sample incubated} - \text{wt. of residues} \times 100}{\text{Wt. of sample incubated}}
\]
Residual samples after incubation were mixed, pooled and made ready for analysis. The degradation kinetic of the incubated experimental diet may be described by curvilinear regression of NDF or CP loss from the bag with time.

\[ p = a + b \left( 1 - e^{-ct} \right) \]

Where

- \( p \) = Potential degradability
- \( a \) = Axis intercept at time zero represent soluble and completely degraded substrate that is rapidly washed out of the bag
- \( b \) = The difference between the intercept (a) and the asymptote, represent insoluble but potentially degradable substrate which is degraded by micro-organisms according first order kinetic
- \( t \) = Incubation time
- \( c \) = Constant rate.

\( a, b \) and \( c \) are constants fitted by an interactive least squares procedures.

Equation (1) provides curve constants that can be used in conjunction with predicted another rates for specified diet to estimate the effective degradability of the sample.

\[ \text{Effective degradability} = a \frac{bc}{c + k} \]
Where
\[ a, b & c = \text{Are constants as defined in equation (1)} \]
\[ K = \text{Rumen small particles outflow rate.} \]

Then a graph was plotted by the fitted values of NDF disappearance % against time of incubation in hrs to form a curve.

**3.1.5 Statistical analysis:**

Data were analyzed by analysis of variance for a completely randomize design (Steel and Torrie, 1980), where the F test was significant, the treatment means are compared using least significant differences (LSD).

The result from in-situ study was fitted to model \( p = a + p (1 - e^{ct}) \) of Ørskov and McDonald (1979) to determine the degradation characteristics of the incubated samples.
CHAPTER FOUR

RESULTS AND DISCUSSION

General appearance:

After treating sorghum Stover with 2% urea (sorghum 2%) and 4% urea (sorghum 4%), a dark brown colour with strong smell of ammonia, absence of mold and soft texture has been observed.

Chemical change:

Tables (1, 2) shows the chemical composition and proximate analysis of treated and untreated sorghum Stover. All treatments were significantly increased (P< 0.05) crude protein (CP) content from 5.6 for control sorghum to 6.05, 7.30 for sorghum 2% and sorghum 4% respectively. The cell wall fraction changed as follows: NDF content was significantly (P< 0.05) decreased for sorghum 2% and sorghum 4% compared to control.
Table (1): Chemical composition (%) of treated and untreated sorghum Stover.

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<tr>
<th>Urea level</th>
<th>DM</th>
<th>CP</th>
<th>EE</th>
<th>Ash</th>
<th>NDF</th>
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<tr>
<td>Sorghum 0%</td>
<td>93.7</td>
<td>5.60a</td>
<td>1.77</td>
<td>12.7a</td>
<td>92.9a</td>
</tr>
<tr>
<td>Sorghum 2%</td>
<td>93.0</td>
<td>6.06b</td>
<td>1.63</td>
<td>8.76b</td>
<td>89.9b</td>
</tr>
<tr>
<td>Sorghum 4%</td>
<td>92.3</td>
<td>7.35ce</td>
<td>0.82</td>
<td>7.53ce</td>
<td>87.6ce</td>
</tr>
<tr>
<td>SEM</td>
<td>1.7</td>
<td>0.40</td>
<td>0.02</td>
<td>1.40</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Sorghum 0 = Untreated sorghum Stover  
Sorghum 2% = Sorghum treated with 2% urea  
Sorghum 4% = Sorghum treated with 4% urea  
CP = Crude protein  
DM = Dry matter  
EE = Ether extract  
NDF = Neutral detergent fiber  
SEM = Standard error of means  
a, b, c = Values in the same column with different superscripts are significantly different (P< 0.05)
Table (2): Proximate analysis of treated and untreated sorghum Stover.

<table>
<thead>
<tr>
<th>Urea level</th>
<th>Moisture</th>
<th>EE (%)</th>
<th>CP (%)</th>
<th>CF (%)</th>
<th>Ash (%)</th>
<th>NFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum 0%</td>
<td>6.27</td>
<td>0.82</td>
<td>5.60</td>
<td>47.71</td>
<td>7.53</td>
<td>32.25</td>
</tr>
<tr>
<td>Sorghum 2%</td>
<td>6.99</td>
<td>1.63</td>
<td>6.06</td>
<td>46.53</td>
<td>8.76</td>
<td>30.03</td>
</tr>
<tr>
<td>Sorghum 4%</td>
<td>7.61</td>
<td>1.77</td>
<td>7.35</td>
<td>47.47</td>
<td>12.77</td>
<td>23.03</td>
</tr>
</tbody>
</table>

a, b, c = Values in the same column with different superscripts are significantly different (P< 0.05)
**Nylon bag degradability:**

In situ degradability of NDF increased significantly (P< 0.05) among all treatments compared to untreated sorghum Stover as shown in table (2). The soluble fraction (a) as shown in table (3) increased significantly for sorghum 4% and sorghum 2% compared to sorghum, while insoluble fraction but degradable in the rumen constant (b), lag time (LT) and rate (C) of degradability showed significant difference among all treatments (P< 0.05) as shown in table (3), while potential degradability was increased significantly (P< 0.05) for sorghum 4% than sorghum 2%, sorghum. The effective degradability increased significantly among all treatment and at different rate of outflow. While rumen degradability increased significantly among all treatment among hours as shown in figs. (1, 2 and 3) for sorghum, sorghum 2% and sorghum 4% respectively. Fig. (4) showed the disappearance of NDF for treated and untreated sorghum Stover.
Table (3): Rumen degradation of NDF (%) for treated and untreated sorghum Stover.

<table>
<thead>
<tr>
<th>NDF loss % (hr)</th>
<th>Sorghum 0%</th>
<th>Sorghum 2%</th>
<th>Sorghum 4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.4</td>
<td>16.8</td>
<td>21.6</td>
</tr>
<tr>
<td>4</td>
<td>16.1</td>
<td>18.9</td>
<td>23.8</td>
</tr>
<tr>
<td>8</td>
<td>22.7</td>
<td>27.8</td>
<td>30.7</td>
</tr>
<tr>
<td>16</td>
<td>25.6</td>
<td>32.2</td>
<td>37.5</td>
</tr>
<tr>
<td>24</td>
<td>32.2</td>
<td>39.4</td>
<td>42.0</td>
</tr>
<tr>
<td>48</td>
<td>42.5</td>
<td>44.3</td>
<td>46.6</td>
</tr>
<tr>
<td>72</td>
<td>49.7</td>
<td>52.2</td>
<td>54.6</td>
</tr>
<tr>
<td>96</td>
<td>59.2</td>
<td>64.2</td>
<td>67.0</td>
</tr>
</tbody>
</table>

Sorghum 0% = Untreated sorghum Stover  
Sorghum 2% = Sorghum treated with 2% urea  
Sorghum 4% = Sorghum treated with 4% urea
Table (4): Degradation kinetics (%) for treated and untreated sorghum Stover.

<table>
<thead>
<tr>
<th></th>
<th>Sorghum 2%</th>
<th>Sorghum 4%</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>13.7(^{a})</td>
<td>16.3(^{b})</td>
<td>20.5(^{c})</td>
</tr>
<tr>
<td>b</td>
<td>46.8</td>
<td>48.3</td>
<td>48.6</td>
</tr>
<tr>
<td>c</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>PD</td>
<td>60.5(^{a})</td>
<td>64.6(^{b})</td>
<td>69.1(^{c})</td>
</tr>
<tr>
<td>Lt (hr)</td>
<td>2.00</td>
<td>2.72</td>
<td>1.675</td>
</tr>
<tr>
<td>ED 2%</td>
<td>35.91(^{a})</td>
<td>38.31(^{b})</td>
<td>40.36(^{c})</td>
</tr>
<tr>
<td>ED 5%</td>
<td>25.33(^{a})</td>
<td>28.44(^{b})</td>
<td>31.05(^{c})</td>
</tr>
<tr>
<td>ED 8%</td>
<td>21.55(^{a})</td>
<td>24.71(^{b})</td>
<td>27.71(^{c})</td>
</tr>
</tbody>
</table>

\(a, b, c\) = Values in the same column with different super-scripts are significantly different (\(P<0.05\))
Fig. (1): Rumen degradation of untreated sorghum Stover
Fig. (2): Rumen degradation of 2% sorghum Stover
Degradation Curve

Fig. (3): Rumen degradation of 4% sorghum Stover
Fig. (4): The disappearance of NDF for treated and untreated sorghum Stover
The urea treatment of sorghum Stover in the present study enhanced its nitrogen content, which was obtained by the addition of nitrogenous substrate as reported by (Granzin and Dryden, 2003).

Crude protein (CP) content for sorghum control was significantly lower than sorghum 2% and sorghum 4%. This result is in agreement with result obtained by (Wambui, 2006) who reported that the urea treatment improved the CP content of maize Stover from 5.1 to 8.3%.

The NDF fraction for sorghum 4% and sorghum 2% was significantly lower than sorghum. These declines in concentration of NDF among treatments may be enhanced with generic action of alkali of feedstuff that disturbed the cell wall components resulting in increasing the soluble fraction (Fadel Elseed et al., 2003).

NDF degradability fraction was decreased significantly for sorghum 2% and sorghum 4% compared to untreated sorghum. This result is partially caused by alkali treatment
which converted insoluble fraction to the soluble fraction. This treatment makes the cell wall of fibrous material breakdown the bonds between lignin and structural carbohydrate making it easier for rumen cellulolytic bacteria to colonize and degrade ingested fibrous materials (Nguyen et al., 2001).

Nianogo (1999) indicated that the nutritional value and chemical composition improve when sorghum Stover is treated with urea.
Conclusion:

The present study showed that different levels of urea treatment of sorghum Stover 2 and 4% improved the nutritive value of fibrous material in term of increasing digestibility and chemical composition values.

Further research needs to be carried out using other levels of urea treatment and sorghum Stover.
REFERENCES


Church, D.C. (1988). The ruminant animal digestive physiology and nutrition Editor, Prentic hall, 121 – 130.


