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Comparison between levels of sodium hydroxide and urea in hay guinea grass haylage

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ABSTRACT

The experiment was carried out with the objective of evaluate the effect of increasing levels of sodium-hydroxide (NaOH) and urea in the nutritive attributes of haylage Guinea grass (*Panicum maximum*) haylage for 36 hours in the sun. Guinea grass hay samples were randomly assigned to 7 treatments whit 10 repetitions (n=10). The treatments were: T1 - Guinea grass haylage, T2 - Guinea grass haylage plus 1.5 % NaOH, T3 - Guinea grass haylage plus 2.5 % NaOH and T4 - Guinea grass haylage plus 3.5 % NaOH, T5 - Guinea grass haylage plus 1.5 % urea, T6 - Guinea grass haylage plus 2.5 % urea and T7 - Guinea grass haylage plus 3.5 % urea dry matter based. The greatest crude protein (CP) values were obtained with the highest dose of NaOH and urea. Urea or NaOH addition reduced NDF, FDA and HEM values ($P<0.05$). In Vitro Dry Matter Digestibility (IVDMD) was affected by the chemical treatments. with greater responses at the highest doses ($P<0.05$). Non-structural carbohydrates (NSC) increased whit NaOH and urea application while total carbohydrates (TC) suffer a reduction as a response to the treatments ($P<0.05$). The nutritive values of Guinea grass improve with both chemical treatments. expressed as a reduction in structural carbohydrates and an increase in IVDMD. Choose the chemical method to improve forage quality would depend on management strategies and cost.

1. Introduction

Seasonal forage production it's a well known fact in Brazilian tropical regions, where the mean grass production concentrates in the rainy season. causing great losses in the national grassland production systems. mainly because a vast number of Brazilian farmers aren't habituated to prepare for the lack of forage in the dry season (Candido et al., 1999). One of the existing options as an interesting and useful instrument it's the supplementation with chemical treated hay.

The use of urea (ammonia source) and/or sodium hydroxide has been study as a grass conservation technique (Neiva and Garcia, 1995; Gobbi et al., 2005; Zanine et al., 2006a) in favor of their low costs and easy management. Given the positive results evidenced by using these chemical treatments on forage conservation (Reis et al., 1995; Zanine et al., 2006b). find the optimal levels of application. adequate water content and nutritional attributes of treated forages still needs research for a good adjustment of this technology.

This technology it's based on increase cellulose and hemicellulose digestibility by expanding cellulose molecules caused by the rupture of hydrogen bonds and elevates fiber hydration, which allows a faster and easier access of microorganisms. resulting in an increase of dry matter digestibility (Dolberg, 1992; Schiere and Nell, 1993; Berger et al., 1994). There are different factors that affect the alkalinization process such as dose concentration, forage quality, humidity levels, duration of the treatment and environmental temperature.

Reis et al., (2001) experimenting with hay of tropical grasses cropped in physiological maturity, compared non-treated (control) vs treated (5% urea) hay and observe an increase of IVDMD of 22.97% for Brachiaria decumbens, 31.43% for Brachiaria brizantha and 20.5% for Hiparhenia rufa, Pries et al., (2004) with similar premises study the effect of NH3 application on sugarcane bagasse in potential dry matter degradability. increasing from 38.3% up to 65.5% for the treated sugarcane bagasse whit 4% of NH_3, This authors concluded that treated sugarcane bagasse improve dry matter, NDF and ADF degradability. Research with sugarcane bagasse treated whit sodium hydroxide and urea. Zanine et al., (2006a) and Zanine et al., (2006b) concluded that the use of sodium hydroxide inhibit the development of fungus and yeasts beside improving fiber quality of hay.

Under this context. there is a lack of information regarding the sodium hydroxide and/or urea quantities that maximize these processes and which of these tow products it's the most efficient. mainly in Panicum maximum hays.

With this in mind. the objective of this experiment was to compare the chemical and bromatologic al composition and in vitro digestibility of dry matter of Guinea grass haylage with different levels of sodium hydroxide and urea.

2. Materials and methods

2.1. Study site

The experiment was carried out at the Department of Animal Science at the Federal University of Viçosa, located in the municipality of Viçosa-MG, Brazil during the summer season, Viçosa, is situated at 20° and 4l'atitude south, 42° and 51' longitude west and at 657 m altitude. with 1341 mm mean annual rainfall, 86% of which falls from October to April, average temperature of 25°C and relative humidity average of 80%.

2.2. Data collection and soil chemical characteristics

An established approximately 1.0 ha Guinea grass (*Panicum maximum*) pasture was used, After a standardizing cut. it was fertilized with nitrogen and potassium using ammonia sulfate and potassium chloride, respectively. The Guinea grass was cut 65 days after uniformity and harlage in the sun for 36 hours in January 2010. The soil chemical characteristics are shown at Table 1, It wasn't requires any corrective fertilization at sowing, since the elevated fertility of the soil, high pH level and low aluminum content.

2.3. Treatment of Guinea grass hay

Were tested in Guinea grass haylage, being assigned to 7 treatment, T1 – Guinea grass haylage, T2 - Guinea grass haylage plus 1.5 % NaOH, T3 - Guinea grass haylage plus 2.5 % NaOH and T4 - Guinea grass haylage plus 3.5% NaOH, T5 - Guinea grass haylage plus 1.5 % urea, T6 - Guinea grass haylage plus 2.5% urea and T7 - Guinea grass haylage plus 3.5% urea dry matter based, in a completely randomized design with 10 repetition per treatment.

Table 1
Soil chemical characteristics from 0-20 cm and 20-40 cm horizons of Guinea grass the experimental plots.

Chemical characteristics	Results	
	0 – 20 cm	20 – 40 cm
pH (H2O)	6.6	6.6
Calcium (cmolc/dm3)	4.9	4.5
Magnesium (cmolc/dm3)	1.1	0.9
Aluminium (cmolc/dm3)	0.0	0.0
H + Al (cmolc/dm3)	1.6	1.6
*CEC (cmolc/dm3)	9.5	7.6
Effective CEC (cmolc/dm3)	7.9	6.0
Base saturation (%)	83	79
Phosphorus – Mehlich-1 (mg/dm3)	53.4	32.3
Potassium – Mehlich-1 (mg/dm3)	360	250

*Cation exchange capacity

2.4. Chemical treatment haylage

The cut hay was mixed. followed by the addition of 15. 25 or 35 g of NaOH or urea per Kg of fresh haylage, using as a vehicle 50 ml of water per Kg of haylage, including the control treatment. The materials were homogenized and approximately 2 Kg of haylage of each treatment were stored in polyethylene bags of 0.60 x 0.90 meters and 0.20 millimeters of thickness, closed with adhesive tape and stored in a warehouse for 45 days as was described by Sundstol et al., (1978). Subsequently the samples were dried to constant weight in a ventilated stove at 65o C per 72 hours; the dry material was ground in a Wiley mill and stores in glass jars for subsequent chemical analysis.

2.5. Chemical analyze

Dry matter content was determined putting the samples in a stove at 65º C per 24 hours. crude protein (PC) was determined by Kjeldadhl method, neutral detergent (NDF) and acid detergent fiber (ADF) was measured by autoclave method described by Pell e Schofield (1993). Hemicellulose content was calculated by the difference between NDF and ADF, ash content determined by a muffler furnace at 550o C per 4 hours, organic matter (OM) was calculated by the difference between DM and ashes (Table 2).

Non-structural carbohydrates (NSC) and total carbohydrates (TC) were calculated by the following equations: NSC= (100 - %apNDF - %CP - %EE - %ashes) and TC=100-(%CP + %EE + %ashes), were apNDF its NDF value corrected by ash and CP. and EE its ether extract, determined by the Goldfish fat extracting method (Sniffen et al., 1992; Silva and Queiroz, 2002).

Table 2
Average dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose (HEM) of Guinea grass haylage treated with NaOH or urea before storage.

NaOH and urea levels	DM (%)	CP (% DM)	NDF (% DM)	ADF (% DM)	HEM (% DM)
Guinea grass haylage	35.55	8.83	66.36	35.68	30.68
1.5% of NaOH	34.62	8.85	65.78	35.57	30.21
2.5% of NaOH	34.45	8.86	65.74	35.55	30.19
3.5% of NaOH	34.12	8.68	65.61	35.09	30.52
1.5% of Urea	34.87	9.26	66.02	35.67	30.35
2.5% of Urea	34.58	9.53	66.11	35.55	30.56
3.5% de Urea	34.27	9.73	65.78	35.35	30.43

2.6. In vitro digestibility procedures

In vitro dry matter digestibility (IVDMD) was determined following the methods of Tilley and Terry (1963), by incubating in a thermostatically controlled water circulating bath, Sub-samples of 25g were taken for pH analysis, adding 100 milliliters of water and measuring with a potentiometer after 2 hours of infuse.

2.7. Statistical analysis

Chemical composition of the different treatments with NaOH and urea before storage are presented in Table 2. The chemical components, pH and digestibility data were compared by using Tukey test at the 0.05 significance level using SAS software (2001).

3. Results and discussion

3.1. Chemical composition

The chemical treatments results of pH, dry matter, crude protein, mineral content and organic matter in Guinea grass haylage are exposed in Table 3. There were no significant effects in the average pH values between NaOH, urea and control treatments (P>0.05). These results were similar to those obtained by Zanine et al., (2006a) who register pHs of 3.45, 4.01 and 3.74 in treated sugarcane bagasse with 1, 2 and 3% of NaOH.

Dry matter values were positively affected by the chemical treatments (P<0.05), diminishing DM contents with the addition of NaOH and urea. The control treatment presented the highest DM values (Table 3). Dry matter reductions of ammonized materials could take place as a result of the urea high hygroscopic power, causing environmental humidity absorption (Candido et al., 1999).

The lowest DM content was obtained with the highest dose of NaHO (50.41%), this reduction it's provably given by a hydrolysis of the fiber fraction, caused by the addition of a strong alkaline source, which in this particular case was stronger that the 3% urea treatment (47.96%). Oliveira et al., (1985) reported values of 88.20% of DM in Hyparrhenia rufa treated with 4% of NaOH, the higher DM content in this experiment was given since the grass was cut in a more advanced stage of maturity and dehydration.

The addition of NaOH and urea increased crude protein values (Table 3), where the greatest responses were observed with the 3.5% NaOH and 3.5% urea treatments (10.57% and 12.47% respectively). The control treatment shows the lowest value of CP.

This results might be explained by a DM diminish. as a consequence of NDF and ADF reduction (Table 4), highly correlated to the increasing levels of NaOH and urea on this experiment. Another possible explanation for the CP increase could be related to an increase of insoluble nitrogen caused by the chemical treatment. Reis et al., (2001) working with Brachiaria decumbens and Hyparrhenia rufa hay, obtained an increase of 6.8 and 8.2 percentage points in CP respectively for each species, by an ammonization treatment with urea (5.4% of DM).

Table 4
Average pH. dry matter (DM), crude protein (CP), ether extract (EE), ashes (ASH) and organic matter (OM) of Guinea grass haylage treated with NaOH or urea.

Treatment	pH	DM (%)	CP (% DM)	EE (% DM)	ASH (% DM)	OM (% DM)
Control	3.57±0.05[a]	55.50±1.22[a]	9.23±0.51[c]	3.17±0.16[a]	7.39±0.36[a]	92.61±0.42[a]
2.5 %NaOH	3.30±0.07[a]	50.23±0.38[b]	10.14±0.53[b]	3.35b±0.10[a]	6.99±0.27[a]	93.01±0.33[a]
3.5 %NaOH	3.41±0.09[a]	47.96±1.09[c]	10.57±0.71[ab]	3.24b±0.17[a]	6.23±0.38[a]	93.77±0.47[a]
1.5 %Urea	3.65±0.14[a]	52.09±0.47[b]	10.09±0.29[b]	3.20a±0.15[a]	7.15±0.39[a]	92.85±0.54[a]
2.5 %Urea	3.63±0.10[a]	51.54±0.27[b]	10.47±0.47[ab]	3.28a±0.13[a]	7.45±0.46[a]	92.55±0.64[a]
3.5 %Urea	3.53±0.12[a]	50.34±1.08[b]	12.47±0.42[a]	3.38±0.19[a]	7.03±0.59[a]	92.97±0.38[a]
VC(%)1	2.54	4.02	3.98	2.74	4.85	5.77

[1]Coefficient of variation.
Means followed by the same letter in the same column do not differ statistically by the Tukey test at the level of 5% probability.

Bertipaglia et al., (2005) found the greatest values of CP in Brachiaria brizantha hay with 15% of humidity and urea. Oliveira et al., (2005) working with *Panicum maximum* and *Pennisetum purpureum* hay, using 5% of urea, obtained an increase of 6.5% and 4% in CP respectively compared whit the control treatment. In agreement, Zanine et al., (2006a) and Zanine et al., (2006b) researching with increasing levels of NaOH and urea in sugarcane bagasse obtained a positive response in CP contents.

The urea and NaOH addition did not modify ($P>0.05$) EE, OM or Ash contents (Table 3). Oliveira e Viera (1994) reported a linear effect of ammonia treatment in the ashes content for sugarcane bagasse. Meanwhile Zanine et al., (2006ab) reported no differences on these fractions for sugarcane bagasse treated whit NaOH and urea.

3.2. Fiber and in vitro digestibility

The average values of neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEM) and in vitro digestibility of DM (IVDMD) of Guinea grass haylage treated with levels of NaOH and urea are shown in Table 4 and, in Figure 1 the behavior in the distinct levels of the chemical treatments.

The addition of urea or NaOH provided a reduction in content of NDF, ADF and HEM ($P>0.05$) (table 4 and Fig. 2). There was no statistical differences between the two sources ($P<0.05$). For FDA the highest levels of sources (3%) provided in an average reduction approximately 5 percentage points compared to the hay without chemical treatment. The HEM presented a reduction with the application of the sources in relation to haylage without chemical treatment. However, there were no differences between doses and sources ($P<0.05$).

According to Van Soest (1994), this reduction in the contents of fiber can be attributed to partial solubilization of the fraction of hemicelluloses, cellulose and lignin of cell wall. These assumptions are based on the fact that most forage subjected to such treatment do not show decrease in other cell wall constituents, and when it occurs, is proportionally, in smaller in scale (Klopfenstein, 1978; Van Soest and Ferreira, 1994; Van soest and Mason, 1991; Jackson, 1997; Garcia and Smith, 1998; Rose and FadeL, 2001).

Candido et al., (1999) observed a decrease in NDF content with urea application. with reductions of 4.3 percentage points of control in relation to dose of 8% of urea. Others works using urea with source for ammoniation showed effeciency in reducing of NDF (Reis et al., 1995; Paiva et al., 1995, Fischer et al., 1996; Rosa et al., 1998;Rosa et al., 2000).

In experiment testing the effect of levels varying between 0 and 4% of NaOH Oliveira et al., (1985) reported reduction in the NDF, ADF and HEM contents, for Hiparrhenia Rufa hay. Similarly, Zanine et al., (2006b) observed that the addition of NaOH provided a reduction in NDF, ADF and HEM contents of sugarcane bagasse. Worth mentioning that the changes caused by alkali products in the cell wall constituents vary according some factors such as levels to be applied. forage quality, moisture content. treatment time and ambient temperature.

Table 4
Average values and respective standard deviation of neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEM) and dry matter in vitro digestibility (DMIVD) of Guinea grass haylage treated with sodium hydroxide and urea.

NaOH and urea level	NDF (% DM)	ADF (% DM)	HEM (% DM)	DMIVD (% DM)
Guinea grass haylage	68.52 ± 0.53^{a}	41.63 ± 0.39^{a}	26.88 ± 0.19^{a}	58.97 ± 1.37^{e}
1.5% of NaOH	65.97 ± 0.50^{b}	40.40 ± 0.30^{bc}	24.56 ± 0.71^{b}	60.22 ± 0.31^{c}
2.5% ofNaOH	63.62 ± 0.46^{c}	38.89 ± 0.57^{dc}	23.72 ± 0.09^{b}	62.97 ± 1.01^{b}
3.5% of NaOH	61.55 ± 0.47^{d}	36.65 ± 1.25^{d}	24.89 ± 1.74^{b}	64.32 ± 0.47^{a}
1.5% of Urea	65.18 ± 0.45^{b}	40.12 ± 0.21^{bc}	25.05 ± 0.55^{b}	58.97 ± 0.40^{d}
2.5% of Urea	63.70 ± 0.28^{c}	38.06 ± 0.55^{dc}	25.63 ± 0.11^{b}	60.59 ± 1.04^{c}
3.5% of Urea	60.09 ± 0.31^{d}	36.21 ± 1.24^{d}	23.87 ± 1.69^{b}	62.36 ± 0.37^{b}
CV1(%)	2.88	3.01	3.14	4.51

[1]Coefficient of variation.
Means followed by same letters in column do not differ by Tukey test at 5%.

The IVDMD was affected by the chemical treatments ($P<0.05$), being the higher doses provided better answers. In this aspect. feature the treatment of 3.5% with NaOH that resulted in the highest digestibility value (5.45 percentage points) toward the hay without chemical treatment. and (3.49 percentage points) toward the hay treated with 3% of urea. Although there was no difference between the level of 3.5% urea (62.36%) compared to the level of 2.5% NaOH (62.97%).

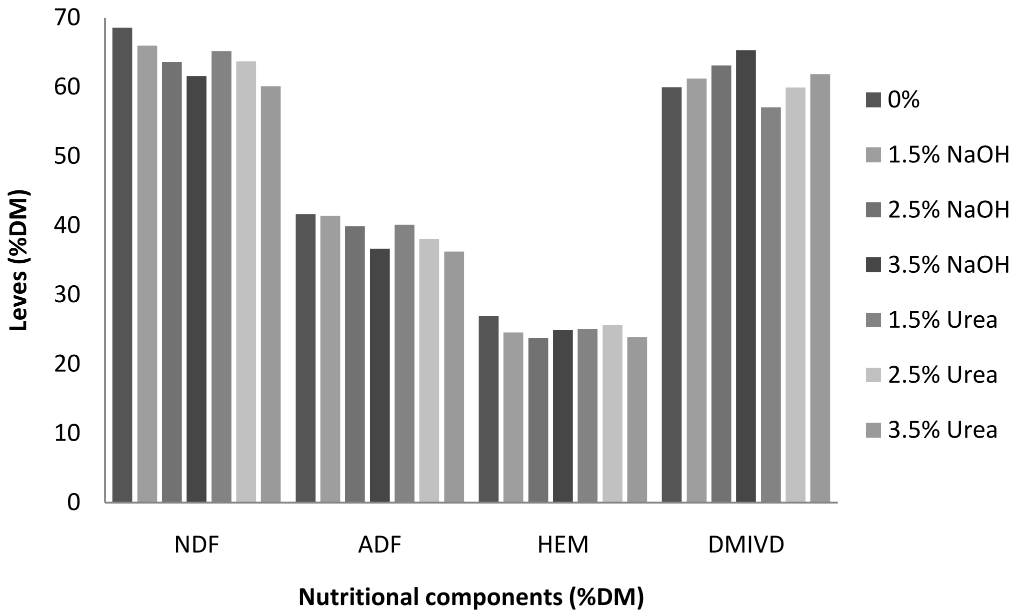

Fig. 1. Behavior of values of neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEM) and dry matter in vitro digestibility (DMIVD) of Guinea grass haylage treated with sodium hydroxide and urea.

What can be explained by the action of alkaline compounds from the NaOH, which occurs through the disruption of lignocellulosic complex. solubilizing the fiber and increasing the digestibility of cellulose by the expansion of the fibrous fraction (Jackson, 1997; Klopfenstein, 1978). Oliveira et al., (1985) observed values of 53.03% in DMIVD in the Hyparrhenia rufa hay treated with 4% of NaOH. The lower value observed in the present study can be explained by the higher value of fiber, because the hay had been harvested too late.

Meanwhile, Rose et al., (1998) evaluated the nutritive value of *Brachiaria decumbens* hay untreated or treated with urea (3.6 and 5.4% of DM), observed that ammoniation increased the DMIVD in 3.35 and 4.4% for reported urea levels.

3.3. Non fibrous carbohydrates and total carbohydrates

Non fibrous carbohydrates (NFC) and total carbohydrates (TC) were affected by the addition of urea and NaOH; however, the TC suffered decreased proportionately the inclusion of chemicals products and NFC, increased ($P > 0.05$) (Figure 2). As the CP content increased by the addition of non-protein nitrogen and with the treatment of NaOH (table 3), and the ether extract and ashes did not suffer alteration (Table 3), was expected reduction in the level of TC. In its turn, the reduction of fibrous components in ammoniated material (REIS et al., 1991), especially hemicelluloses, resulting in reduction of the NDF fraction, as more pronounced is the reduction of this fraction, higher will be the content of NFC, since, the NDF is subtracted in the obtainment of CNF.

Comparatively in this study based on the greater inclusion of urea or NaOH, the highest value of NFC was observed in the hay treated with 3.5% in NaOH (19.38%) and the lowest value of TC (14.60%) (Fig. 2). Carvalho et al., (2006) in experiments with sugarcane bagasse ammoniated with 2.5. 5.0 and 7.5% of urea, reported average increases of 15.97, 18.86, 21.74 and 24.63% DM for the NFC.

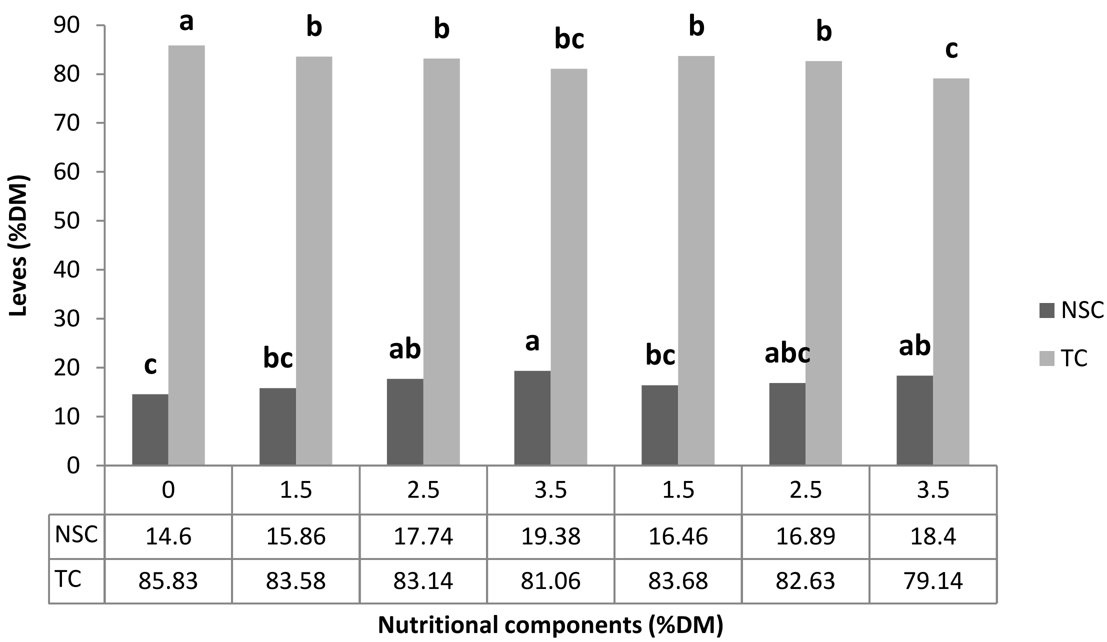

Fig. 2. Average values of non-structural carbohydrates (NSC) and total carbohydrate (TC) of Guinea grass haylage treated.

4. Conclusion

There was a similarity of reply between urea and/or sodium hydroxide, through improvement of nutritional value of Guinea grass haylage, by means of reduction of the fibrous fraction, and increased contents of crude protein and non-structural carbohydrates.

The highest values of digestibility occurred in treatments with urea NaoH over. Overall, in view of the proximity nutritional between urea and sodium hydroxide in the treatment of Guinea grass haylage, the relation management and cost: benefit can point to the best choice.

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