THE POTENTIAL OF 'MAGADI' IN THE TREATMENT OF POOR QUALITY ROUGHAGES

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SUMMARY

A study was carried out to determine the effect of chemical treatment of rice straw (Oryza *sativa*) on in sacco % Dry Matter (DM) degradation using six rumen-fistulated cows. One kg of DM of straw was sprayed using 1 l of either of the following solutions; 50 g urea (U), 40 g sodium hydroxide (NaOH) (N), 250 g 'magadi' suspension (M), 25 g urea and 250 g 'magadi' suspension (½ U + M), 20 g NaOH and 250 g 'magadi' suspension (½ N + M). Solutions were made purposely to vary their pH, which would determine the degree of alkalinity/acidity of the solution. Untreated rice straw was used as control (C). The treated straws were placed in separate and tightly covered 20 l plastic buckets for 14 days after which samples for DM determination were taken and the rest sun dried for 12 h. Subsequently, 500 g of the sun-dried straws were ground by laboratory hammer mill to pass a 2.5 mm screen, of which 100 g of each sample was used for the determination of chemical composition and for in vitro organic matter digestibility. The 100 g ground sample was weighed into Dacron bags of standard pore size 36 µm x 36 µm measuring 7.5 cm x 10.0 cm and then incubated for 0, 2, 4, 8, 12, 24, 48, 72, 96 and 120 h. Incubated samples were removed according to the incubation schedule and immediately deep-frozen at -15 ^{0}C. After removing the 120 h incubated sample, all samples were manually washed until the washing water was clear. Samples were oven-dried at 100°C for 24 h. The residues in the bags were weighed to determine the DM left and the percentage degradation for each sample was calculated. This study showed that, NaOH treated sample had significantly, the highest ($P<0.05$) % DM degradation at all levels of incubation compared to other treatments. 'Magadi' solution treated samples had the highest degradability % compared to other solutions. Samples treated with the combination of 'magadi' and NaOH, 'magadi' and urea, and urea alone showed significantly ($P<0.05$) higher percentage degradation of DM compared to the control. The cost of the chemicals required to treat 1 kg DM of straws was cheaper with 'magadi' as compared to other chemical solutions used in the study. It is hereby concluded that treatment of poor quality roughage with 'magadi' alone and its combination with other sources of

alkali improved percentage DM degradation in the rumen. 'Magadi', which is locally available and cheap, can be used to replace industrial chemicals in the treatment of poor quality roughage but further in vivo study would be necessary to validate the effect of 'magadi'.

INTRODUCTION

The two major limiting factors in the ruminant productivity in Tanzania are diseases and poor nutrition especially during the dry season (Mgheni, 2000; Mlay *et al.*, 2005). The most important factor influencing production response of an animal is the total quantity of absorbed nutrients, which in turn is determined by intake, and digestibility of the ingested feed (Poppi *et al.*, 2000). Poor quality roughage is characterized with Neutral Detergent Fibre (NDF) above 75%, lignin content over 10%, crude protein content less than 5% and digestibility less or equal to 50% (Chesson, 1981; Leng, 1990). Thus, poor quality roughage which is abundant after harvesting of cereals, when used as the sole diet for ruminants may fail to meet the maintenance requirement of the animal let alone supporting a modest production (Mlay, 2001). Among roughages available as crop residues in Tanzania include maize stovers, rice straw, barley straw, sugarcane tops, and bean residues and collectively crop residues are about two million tons per year (Kategile et al., 1978). It is therefore pertinent to improve the digestibility and intake of such roughage through chemical treatment or giving supplementary rations in form of energy and protein rich concentrates (Sirohi and Rai, 1995; Mlay, 2001; Mlay *et al.*, 2003a).

To improve digestibility of straws a number of chemical compounds either singly or in combination have been used for years. These include sodium hydroxide, urea, sodium bicarbonate, ammonia, and calcium carbonate (Urio, 1981; Mira *et al.,* 1983; Salem *et al.,* 1994; Mgheni *et al.,* 1994; Masha, 2002). Of all chemicals used, alkalis have been proved most effective but are expensive and not readily available. Alkalis increase the digestibility of roughages by splitting the acetyl and methoxy groups from the indigestible part of lignin. Furthermore alkalis break the chemical bonds between cellulose and lignin. On lignocelluloses alkalis enhance saponification of the ester linkages of uronic acid associated with xylan chains. As a result there is increased accessibility of cellulose and hemicellulose components to microbial enzymes activity (Rexen *et al.*, 1975). Given the low economic base and scarcity of ingredients for compounding concentrates which would otherwise be used as feed supplement to cows by smallholder farmers in Tanzania (Mlay, 2001), the possibility of treating poor quality roughage using locally and cheaply available chemical substance could be an alternative.

'Magadi'is locally available in many parts of Tanzania including Kilimanjaro and Arusha in the northern zone. Its composition is very close to that of a commercial product called 'magadi soda' naturally harvested from Lake Magadi in Kenya, whose major ingredient is sodium sesquicarbonate. Beside its alkali content 'magadi soda' has 83.2% ash content making it an important mineral supplement as well. The percent dry matter content for the selected elements in 'magadi' locally available in Tanzania was14.3% Na, 1.3% K, 3.1% Ca, 2.3% Mg, 3.4% Fe, 0.3% P, 1.5% Cl^- , and 17.6% HCO_3^-(Mlay, 2001).

'Magadi' has been in use in many places in Tanzania for time immemorial, for both human and animal uses. In humans 'magadi' is added during cooking of dry food like beans and maize so as to hasten cooking time and add flavor to the food (Urio, 1981). 'Magadi' has wide application in animal industry as well. Some farmers spray 'magadi' powder or suspension on the feed to improve palatability due to its salty taste. Others add 'magadi' to drinking water offered to the animals.

Where condition allows, a combination of locally available ingredients like 'magadi' or ash (Katambala, 1997) be used in combination with a small amount of urea so as to improve both digestibility and nitrogen content of poor quality forage (Mlay *et al.*, 2003b, Mlay *et al.*, 2005).

Despite the proven fact that sodium hydroxide, sodium bicarbonate and urea are potential sources of alkali useful in the treatment of crop residues to improve their digestibility and hence utilization by ruminants, these industrial chemicals are expensive making them unaffordable to ordinary livestock keepers and also not readily available in rural areas. Therefore the aim of this study was to investigate further the potential of 'magadi', a locally available source of alkali when used alone or in combination with small amounts of conventional chemicals. The latter are used in treatment of poor quality rice straws for feeding ruminants in Tanzania. The expected outcome of this study is to reduce the treatment costs but maintain the efficacy of the treatment regime(s).

MATERIALS AND METHODS

Animals and feeding regime

Rumen fistulated cows (n = 6) approximately 5 - 6 years old and weighing between 350 - 400 kg, were used in this study. Cows were crosses of Friesian and Tanzania Short horn Zebu (TSZ) and belong to The Department of Animal Science and Production (DASP), Sokoine University of Agriculture in Morogoro Tanzania. Animals were fed *ad libitum* with elephant grass (*Pennisetum purpureum*) as a basal diet and supplemented with concentrates, which included maize bran 70% (CP = 12.6%), sunflower cake 27% (CP = 20%) all being locally available in Morogoro and maclick super 3% (Coopers'® Kenya) as mineral and vitamin supplement. The calculated CP in the concentrate mixture was 15%. Supplementation was done twice per day by offering 1 kg of concentrate mixture to each cow at 8.00 am and 4.00 pm daily.

Preparation of solutions used for treating rice straws

Five solutions as shown hereunder were prepared and used for treatment of rice straws, a post harvest residue of paddy in Morogoro.

a. 'Magadi' suspension

'Magadi' powder (250 g) was dissolved in 1000 ml of distilled water by thorough stirring and the resulting mixture was left to stand for 7 days. After this time it was decanted carefully to a clean container. Distilled water was added up into the remaining clear solution of the 'magadi' suspension to make a final 1000 ml and the pH of the solution was taken using a standard pH meter (Corning, model 17, UK).

b. Urea solution

Urea pellets (50 g) were weighed and put into a beaker and distilled water was added slowly while stirring and when all the crystals had dissolved the solution was made up to a 1000 ml level after which the pH was taken using a standard pH meter (Corning, model 17, UK).

c. Sodium hydroxide solution

The amount required to treat 1 kg DM rice straw was calculated basing on the treatment rate of 4 kg NaOH per 100 kg DM of poor quality roughage (Urio, 1981). Thus the treatment of 1 kg DM would require 40 g of NaOH. Forty grams of NaOH pellets were weighed into a beaker and distilled water was added slowly while stirring until the pellets had dissolved. The solution was made to 1000 ml level mark after which the pH was taken using a standard pH meter (Corning, model 17, UK).

d. Combination of sodium hydroxide and 'magadi'

Twenty grams of NaOH pellets (half the amount used in NaOH alone) were weighed into a beaker into which 1 l of 25% 'magadi' suspension was added and the mixture was stirred to dissolve the pellets. The pH of the solution was taken using a standard pH meter (Corning, model 17, UK).

e. Combination of urea and 'magadi'

Twenty-five grams of urea (half the amount used in urea alone) were weighed into a beaker to which 1 l of 25% 'magadi' suspension was added and the mixture was stirred to dissolve the pellets. The pH of the solution was taken using a standard pH meter (Corning, model 17, UK).

Straw treatment procedure

Five 2 m x 2 m nylon sheets were spread on the floor. Dry matter of straw was weighed and 1 kg was spread on each of the nylon sheets. A 1000 ml hand spray pump was filled with the respective solution and sprayed on the rice straw bundle while turning manually from time to time to ensure uniform mixing of the chemical solution with rice straws. After thorough spraying and mixing, each bundle of treated straw was put in labeled plastic buckets and covered tightly with a lid. Buckets were put at room temperature for 14 days after which buckets were opened and duplicate samples of about 200 g weighed onto large aluminum pans and dried to constant weight at 60^{0}C in a hot air oven. The remaining straws were sun dried for 12 h and then ground with a laboratory hammer mill to pass through a 2.5 mm sieve. The ground samples were used for in sacco incubation, chemical analysis and for in vitro digestibility determination by the method of Tilley and Terry (1963).

Procedure for straw DM determination

The DM of samples were determined following the AOAC (1990) where 200 g of wet samples were weighed in large aluminum pans (in duplicates) and dried in a hot air oven to constant weight at 60 °C. DM (%) was calculated using the formula:

$$\frac{W1-W2}{W1} \times 100$$

Where: W1 = Initial weight

W2 = Final weight after drying

Procedure for in sacco degradability

An in-sacco degradability was carried so as to determine the % DM degradation of the straw in the cows' rumen. The sun-dried straws were milled to pass through a 2.5 mm screen. The ground straw weighing 1 g were put into nylon bags measuring 7 cm x 10 cm and of 36 x36 ɥm pore size. For each incubation time, each sample was replicated 3 times and all were inserted into the rumen through the fistulum. The bags had their open ends sealed by tying them strongly around rubber bongs (5 cm diameter and 4 cm long) using nylon cable ties (TYRAP® nylon 66 186 mm, Thomas and Betts, UK). The bongs were arranged at 4 cm distance from each other such that one tube hanged 8 bongs. Nylon strings were attached at each end of the tube with big knots at 25 cm distance from the tube. The knots were guided to ensure that the bongs are in the ventral sac of the rumen through the canulla lid edges. All were left in the rumen to mimic normal rumen digestion of food which is hereby referred to as incubation. The incubation times in hours were: 0, 2, 4, 8, 12, 24, 48, 72, 96 and 120 h from the time samples were put into the rumen. All the bags were inserted at the same time during morning feeding and taken out as scheduled and frozen at −15°C to arrest further microbial activity. After the longest incubation (120th hour) time all samples were thawed and manually washed using running water until the washing water from samples was clear. The bags with washed samples were oven-dried for 24 h at 100°C. After cooling the weight of residues was measured and DM content of the ground straw was determined using the standard procedures outlined by AOAC

Calculations

***In sacco* degradation**

Degradation of DM from bags was calculated from the disappearance of the fractions from Dacron bags after washing (zero hour) and for respective incubation times. This was done according to equation:

$$Df = \frac{(Wi - Wr)}{Wi} *100.$$

Where;

Df = Percentage degradation fraction after incubation

a = water soluble part

b = non-water soluble but potentially digestible fraction,

c = degradation rate constant per hour

t = incubation time in hours.

Effective degradation (ED)

This was calculated using the equation below:

$Y = a + [b (c/ (c+ k)].$

Where:

Y = Effective Degradation

a = Water soluble part

b = Non-water soluble but potentially digestible fraction,

c = Degradation rate constant per hour

k = Fraction passage rate

(1990) where 2 g of samples were weighed into crucibles of known weight (duplicate) that were oven-dried for 24 h at 100°C. The DM (%) was calculated as previously described.

Wi = Weight DM incubated bags

Wr = Weight of the fraction in the residues

Degradation characteristics

Rumen degradability characteristics was calculated using the exponential equation by Ørskov and McDonald (1979) as shown below:

$Y(t) = a+b\ (1-e^{-c}),$

Where;

Y(t) = degradation at time t,

Statistical analyses

Data were analysed using the General Linear Model (GML), Statistical Analysis System (SAS, 1990), to test the differences between the means of various parameters for each incubation time. Means were compared by Duncan Multiple range test. The model of the analysis was;

$Y = I + T + C + P + \varepsilon;$

Where;

Y = dependent variable

I = intercept

T = treatments (U, M, N, Control, ½ N +M and ½ U +M)

P = period (first and second run)

C = cows (1-6)

ε = random error variation.

RESULTS

The 'magadi' solution had an alkaline pH of 8.8 which was lower than pH of 11.5 observed in a 4% NaOH solution. It was also lower than pH of 10.7 observed in solution made from a mixture of 20 g NaOH and 250 'magadi' in 1 l of distilled water. The pH in the solution made from, 250 g 'magadi' and 25 g urea was 8.3 while urea solution had an acidic pH of 6.5. The more alkaline the solution the more effect on straw degradability in the rumen.

Table 1. Degree of alkalinity/acidity in treatment solutions as reflected by pH

Treatment solutions	pH
'Magadi' solution (M)	8.80
5% Urea solution (U)	6.5
4% NaOH solution (N)	11.50
2% NaOH solution and 25% 'magadi' (½ NaOH + 'maga	10.70
2.5% Urea solution and 25% 'magadi' (½ Urea + 'maga	8.30

Table 2. Estimated costs of chemicals for treating 1 kg DM straw

Chemicals	Quantity	Price (Tsh)	Amount used (g)			Cost to treat 1 kg DM straw
			'magadi' Powder	Urea	NaOH	
NaOH	500 g	40,000	-	-	40	3,200
'Magadi'	100 kg	3,000	250	-	-	1.88
Urea	1 kg	450	-	50	-	22.50
20 g NaOH + 'magadi'			250	-	20	1,601.88
25 g Urea + 'magadi'			250	25	-	13.12

Cost estimate for treating one kilogram of rice straw based on market prices in Morogoro for the year 2003.

Treating 1 kg DM of rice straws by 25% 'magadi' solution would cost Tsh 1.88 which was very cheap compared to the cost for treating straw with 4% NaOH (Tsh. 3,200). It was also cheaper than treating rice straw using a solution made from a mixture of 2% NaOH and 250 g 'magadi' which would cost Tsh 1,601.88/kg DM. With a mixture of 2.5% urea and 250 g 'magadi' the cost was Tsh13.12/kg

DM of rice straw and that of Urea alone was Tsh 22.50/kg DM.

The DM, IVOMD, NDF, ADF, CP, EE, and ASH contents of rice straw samples treated with different alkalis did not differ significantly (P<0.05). 'Magadi' treated rice straw sample had an IVOMD level of 85% followed by 83% in the 2.5% urea and 250 g 'magadi' mixture in 1 l of distilled water. IVOMD of 80% was obtained in a solution made from 2% NaOH and 250 g 'magadi' in 1 l distilled water. Urea treated sample had crude protein of 3.74 which was slightly higher compared to other alkali treated samples. Ether extract content of 3.72 was slightly higher in NaOH treated sample compared to other alkalis. The observed CP content of 5.64% in the control sample was higher compared to CP in other treatments.

Table 3. Chemical composition of the treated and untreated straw

Parameter (%)	Treatments					
	U	M	N	½ U +M	½ N +M	Control
DM	91.55	89.95	90.56	91.07	90.34	94.40
IVOMD	59.0	85.0	73.0	83.0	80.0	61
NDF	65.96	65.57	68.93	68.27	65.51	70.59
ADF	56.90	55.40	54.46	56.62	55.08	56.35
CP	3.74	2.01	2.34	2.55	1.56	5.64
EE	1.87	2.22	3.72	2.21	2.04	1.98
Ash	20.67	24.72	23.93	22.95	27.06	19.56

IVOMD: in vitro organic mater digestibility

Table 4: Degradation constants for DM of samples incubated in Dacron bags in the rumen of cows

Parameter	TREATMENTS						SEM	P value
	U	M	N	½ U+M	½N +M	C		
Fraction 'a'	6.36^{b}	8.30	12.40^{a}	9.81^{ab}	8.48^{b}	6.76	1.078	0.0001
Fraction 'b'	60.17^{bc}	62.97^{ab}	64.29^{a}	57.92^{c}	61.17^{ab}	52.76^{d}	1.047	0.0001
'c' Degr rate (%/h)	4.32	4.01	4.22	3.94	3.87	3.34	0.004	0.5220
ED (2%/h)	47.93^{b}	49.39^{b}	55.23^{a}	47.96^{b}	48.56^{b}	39.38^{c}	0.966	0.0001

Means within rows with different superscript letters are significantly different (P<0.05).

The straw DM degradation kinetics characterized by water solubility (a), insoluble but fermentable fraction (b), the maximum potentially fermentable material (a + b), the rate constant (c) and effective degradation at a 2% passage rate (ED 2% h^{-1}) are given in Table 5. The degradation rate (c) of DM ranged between 3.34 to 4.32% $^{h-1}$. Highest rate was observed in NaOH treated straw and the lowest was in the control untreated diet. 'Magadi' treated straw had a degradation constant of 4.01 which was not different (P>0.05) compared to other treatments. The effective degradation rate at passage rate of 2% ranged between 39.38 and 55.23%. The ED varied (P < 0.0001) greatly among treatment with 'magadi' treated straw coming next to NaOH treated straw.

Table 5. The Least Square Means for percentage degradation at different hours of incubation in the rumen

In-cuba-tion Time (h)	TREATMENTS						SEM	P value
	U	M	N	½ U+M	½ N+M	Control		
0	8.69^{c}	10.95^{cb}	15.91^{a}	12.43^{b}	9.98^{cb}	8.30^{c}	0.999	0.0001
2	10.59^{c}	13.83^{b}	17.2^{a}	14.79^{ab}	14.02^{b}	10.94^{c}	0.9342	0.0001
4	12.52^{cd}	14.74^{cb}	19.25^{a}	15.68^{b}	15.04^{b}	11.33^{d}	0.8106	0.0001
8	19.99^{b}	21.85^{b}	25.71^{a}	21.73^{b}	19.96^{b}	15.20^{c}	1.0733	0.0001
12	38.00^{a}	40.11^{a}	42.44^{a}	39.36^{a}	36.76^{a}	27.56^{b}	2.3168	0.0001
24	47.49^{ab}	42.01b^{c}	52.28^{a}	44.51^{b}	43.97^{b}	35.54^{c}	2.4241	0.0001
48	53.76^{dc}	62.79^{ab}	67.96^{a}	58.84^{bc}	62.00^{b}	48.72^{d}	1.8477	0.0001
72	64.23^{cb}	66.47^{b}	71.33^{a}	61.32^{c}	63.77^{cb}	52.99^{d}	1.0263	0.0001
96	66.93^{cb}	67.80^{b}	74.06^{a}	64.86^{c}	67.45^{cb}	56.27^{d}	0.9095	0.0001
120	69.40^{cb}	71.11^{b}	76.41^{a}	67.98^{c}	69.95^{cb}	59.46^{d}	0.9714	0.0001

Means with different superscripts ($^{a, b, c}$) within rows are significantly different at P<0.05.

The % disappearance from Dacron bags ranged between 8 and 76 for zero and 120 hours of incubation respectively. There was a very high statistically significant ($P<0.0001$) difference in % degradation rate between all treatments at all incubation periods. 'Magadi' solution treated straw had higher degradation rates compared to other sources of alkali except NaOH alone, but closely similar to (½NaOH + 'magadi') solution.

DISCUSSION

In this study, the cost of treating 1 kg DM of straw using either NaOH only, 'magadi' only, Urea only, a combination of urea and 'magadi' and a combination of 'magadi' and sodium hydroxide was Tsh. 3200, Tsh.1.88, 33, 22.50 and 13.12 and 1601.88 Tsh respectively. From these costs it can be argued that 'magadi' is the cheapest source of alkali for treating poor quality roughage and is locally available. Sodium hydroxide seems to be very expensive and cannot be afforded by smallholder dairy farmers. Moreover, the chemical is corrosive and requires extreme care in handling. Urea is reasonably cheap possibly due to government subsidy being used as fertilizer as well for agricultural production. Interestingly, most farmers still find the price of urea too high and, at any rate prefer to use it for crop farming rather than treating poor quality roughage. The other disadvantage is that urea if not carefully used is highly toxic to animals with reported mortality of cows among smallholder farmers in Morogoro who overfed urea-molasses blocks to their animals (Mlay, 2001).

From the results of this study and from other literature findings (Urio, 1981; Kimario, 2003) it is evident that chemical treatment of poor quality roughage improves the digestibility and therefore nutrient availability to the animal. However, the choice of the appropriate chemical must take into consideration the cost, availability, easiness of application and prevailing social-economic local conditions.

The crude protein (CP) content obtained in this study was lower than in control sample except for the urea treated straw. A slight higher level of crude protein in urea treated straw agrees with (Masha, 2002) who observed an increase in nitrogen content when rice straw was treated with urea. Apparently nitrogen content in urea may contribute to such a slight increase in CP content as compared to other alkalis used in this study. CP was lower in the treatments involving sodium hydroxide and 'magadi' compared to the control possibly due to losses of N due to leaching during the incubation stages (Musimba, 1981; Silayo, 1998). Nonetheless the CP of rice straws can vary from 2.5 to 4.8% (Kimario, 2003).

The NDF or cell wall content of treated straws was slightly lower compared to the untreated straws possibly due to solubilization of total phenolics, arabinoxylans and cellulose when the alkali labile lignin-structural carbohydrate bonds are broken down. This finding concurs with those of Urio

(1981), Meeske *et al.*, (1993), and Moss *et al.*, (1994) who reported a reduced NDF content in alkali treated straws. NDF is that part of the feed necessary to stimulate chewing, saliva production and eructation. Cell wall components in variable proportions would include lignin, fibrous carbohydrates, heat damaged proteins and silica. The chemical composition of rice straw can vary due to rice variety, stage of harvest, proportion of leaf stem, soil fertility, weather condition at maturity and diseases and in this case the chemicals used in the treatment. The increase in ash content in the treated straws was consistent with the findings of other workers (Katambala, 1997; Kimario, 2003). The rise in ash content with treatment could most likely be due to the minerals from the treatment solutions.

The differences in the extent of digestibility of the DM from the Dacron bags between the various treatment regimes in this study could have been attributed to the varying strength of the alkali from each solutions used where sodium hydroxide alone had the highest pH (11.5), followed by the mixture of sodium hydroxide with 'magadi' (10.7), then 'magadi' suspension alone (8.8), then the mixture of 'magadi' and urea (8.3) and finally urea alone (6.5) (Table 2). However, it is worth noting that the initial pH of urea solution changes during the incubation period due to urease forming microbes that convert urea into ammonium hydroxide (Masha, 2002). Urea treatment has an added advantage over the other chemicals due to its contribution to N availability in the rumen (Sirohi and Rai, 1995; Mlay *et al.*, 2003a). The observed significantly higher ($P<0.05$) washing losses from sodium hydroxide treated straw compared to the other treatments was consistent with the finding that the strong alkali is so efficient in breaking down the lignin bonds that even cell wall bound N is leached and most of it escapes with the washing fluid (Msimba, 1981; Meeske *et al.*, 1993; Moss *et al.*, 1994).

The degradation constants a, b and c and the ED 2%/h obtained in this study were of nearly similar order as those reported by Mgheni (2000) and Mlay (2001) and Masha, (2002) for poor quality roughages that ranged between 2.0 - 4.5%/h and 40 - 55% at 48 h incubation respectively. This study proved that chemical treatment of straws improves both the potentially degradable fraction (a + b) as well as the rate of degradation. This was possibly due to increased efficiency of microbial fermentation of treated straws with less tough lignin-structural carbohydrates bonds that not only hinder attachment of the microbes but also shield the digestible cell wall components (Chesson, 1981). In this study the % increase in ED compared to the control was highest with sodium hydroxide (40.2), followed by 'magadi' only suspension (25.0%), then the mixture of 'magadi' and sodium hydroxide (23.3%), then urea mixed with 'magadi' (21.8%) and finally urea alone (21.7%). Farmers of low income who cannot afford the more superior NaOH solution can use 'Magadi' solution and its mixture with other cheap alkalis.

CONCLUSION

'Magadi' could be a rational choice in the treatment of poor quality roughage in Tanzania. This study showed that it would still be reasonably cheap when a small amount of urea is mixed with 'magadi' so as to improve both digestibility and nitrogen availability in the rumen. Furthermore, an in vivo digestibility trial for straws treated with 'magadi' alone or combination with other cheaper alkalis at varying concentrations would be necessary for tangible results that farmers can adopt easily.

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