THE DIGESTIBILITY AND INTAKE OF SODIUM HYDROXIDE OR LOCAL ALKALI-TREATED STRAW BY GOATS

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ABSTRACT

An experiment to compare the effects on digestibility of alkali treated Gamba grass (*Andropogon gayanus*) straw was conducted with four Borno white male goats (22.25 ± 1.0 kg body weight) in a 4 x 4 Latin square design. Treatments were (A) untreated straw (control), (B) Sodium hydroxide (NaOH) treated straw, (C) Kanwa-treated and (D) Kantu-treated straws. Straw was treated separately with solutions (8%) of NaOH, Kanwa and Kantu for 10 minutes prior to ensiling for 20 days. In treatment A, straw was soaked in water before ensiling. Alkali treatment increased the ash and crude protein, but decreased the crude fibre, nitrogen free extract and energy contents of the silage diets. The ether extract content of the diets was not affected by treatment. Dry matter intake ($\text{g/day/W}_{\text{kg}}^{0.75}$) of alkali treated diets was significantly higher ($P < 0.05$) than the control. The NaOH-treated diet was consumed less ($P < 0.05$) than the Kantu-treated diet, but to the same extent as the Kanwa diet. Nitrogen balance was positive in animals consuming the alkali-treated diets and negative for those in the control group. Apparent N-digestibility were similar in the alkali treated diets and better ($P < 0.05$) than in the control. Digestibility coefficients of dry matter, crude protein and crude fibre were not significantly different among the alkali treated diets. However, they were markedly improved ($P < 0.05$) than in the control diet (A). The results indicated that the natural alkali sources (Kanwa and Kantu) compared favourably with NaOH in improving the nutritive value of Gamba grass hay. Further

work however should be undertaken to ascertain the optimal level of their application under the semi-arid environment of Borno State.

INTRODUCTION

One major factor militating against livestock production in the semi-arid region of Borno State is inadequate feed resources. During the 7-8 months of the dry season there is virtually any grazeable pasture available to livestock. The feed situation is always critical at this period for the over 30 percent of the nation's livestock within the State (Alaku and Igene, 1983). What is readily available and cheap as feed substitutes are farm wastes such as straws and agro-industrial by-products. In this region, straw constitutes a very important livestock feed, but it is often not used to its maximum potential because of the low feeding value. Straw is low in energy, very low in protein and high in fibre. The dry matter digestibility is less than 50 percent and intake is generally low.

Highly lignified poor quality feeds have been improved considerably by treatment with such chemicals as sodium hydroxide, calcium hydroxide, sodium hypochlorite, metallic acids, ammonia and urea (Jackson, 1977; Saadullah *et al.*, 1982; El-Shazly and Naga, 1981; Adebowale, 1983). Sodium hydroxide (NaOH) treatment has been the most effective (Jackson, 1977; Klopfenstein, 1978) and the most extensively used for low quality roughage (Sundstol and Owen, 1984). However, the problem with sodium hydroxide is the high cost of importation making it unavailable to village livestock farmers. Furthermore, the caustic nature of NaOH does not make it an ideal chemical to be handled by ignorant farmers.

Therefore, there is a need to look for possible alternatives to NaOH that could be easily within

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the reach of local farmers. There are two types of locally available natural salts usually referred to as 'Kanwa' and 'Kantu'. These are found in appreciable quantities in most parts of northern Nigeria. They are mostly the carbonates, bicarbonates, sulphates and chlorides of sodium and potassium (Peers, 1959). The Fulani nomadic cattle rearers usually administer them to their cattle claiming them to possess nutritive and curative properties.

This paper aims to compare the effects of digestibility and voluntary intake of straw treated and ensiled with NaOH or local natural alkali salts by goats.

MATERIALS AND METHODS

Source of Alkalies

Commercial caustic soda, product of the Imperial Chemical Industry (ICI), was used. The native alkali salts, 'Kanwa' and 'Kantu', were purchased from a local market in Maiduguri, the Borno State capital. Kanwa, the native name for trona, is an outgrowth very much like moss growing out of the ground during the rains (Gbodi and Ikwuegbu, 1982). The growth is scrapped off, sun-dried, and sold without further treatment. On the other hand, Kantu is prepared by burning sorghum and millet straws, maize stover and certain grasses and wood. The ashes are collected and suspended in water. The suspension is then filtered and the filtrate subjected to

gradual evaporation by either gentle heat application or sun-dried. The residue is left to solidify. This residue serves as a source of mineral nutrients for both human and livestock. The two natural salts look very much alike and vary widely in composition (Table 1). In the case of Kantu, the composition depends on the materials used in the preparation, whereas the place of origin of Kanwa accounts for its composition. The composition of Kanwan has been reported (Von Kaufmann *et al.*, 1985).

Experimental Diets

The grass hay (*Andropogon gayanus*) was collected as straw from areas around the University Livestock and Research Farm. This was later chopped into bits (5cm long). Four treatment diets were prepared:- (A) hay plus water, (B) hay plus NaOH solution, (C) hay plus Kanwa solution and (D) hay plus Kantu solution. three 240-litre capacity drums each containing 200 litre of 8% weight/volume of NaOH, Kanwa and Kantu solutions were prepared as described (Kategile *et al.*, 1981). Jute bags containing (15kg) chopped hay were treated by soaking in solutions of the respective chemicals for 10 minutes. For treatment A, a jute bag containing hay was soaked in ordinary water to serve as the control. The bags were then drained and the contents emptied into four 200-litre size drums lined on the inside with polythene sheets to serve as silos. The drums were then sealed tightly and weights

TABLE 1. CHEMICAL COMPOSITION OF SOME LOCAL ALKALI SALTS (g/100g DM)

	Kunwa Nguru (Kano)	Kanwa (Kano)	Beza Kantu (Jos)	Kantu Foga (Sokoto)
Moisture and Organic matter	23.5	0.0	1.8	1.2
Free silica + Silicates	9.1	0.0	16.5	2.6
Sodium carbonate	36.2	0.0	0.8	2.1
Sodium bicarbonate	20.7	0.0	2.1	1.9
Sodium sulphate	0.0	0.0	40.9	1.7
Sodium chloride	6.3	99.5	28.1	89.8
Potassium carbonate	1.6	0.5	7.6	0.2
Phosphorus and trace elements	2.6	trace	2.2	0.5

Source: Peers (1959)

placed on top to exclude air. The treated materials remained ensiled for 20 days.

Digestibility Trial

Four Borno white bucks weighing between 15 and 20 kg were selected from the goat unit of the University Livestock and Research Farm. The animals were confined separately in metabolism cages (Oyenuga, 1961) and each randomly assigned to one of the four diets in a 4 x 4 Latin square design to determine nutrient digestibility. Water and salts were provided *ad libitum*. The animals were weighed before and after each experimental period. A 14-day preliminary feeding was followed by a 7-day total collection

period. The dried samples were ground to pass through a 1 mm sieve and stored in plastic bags.

Chemical Analysis

All the feed and faecal samples were analysed for their proximate composition while urine samples were analysed for nitrogen (A.O.A.C., 1980). The gross energy content of the diets and faecal samples were estimated (Harris *et al.*, 1964). The data obtained from these analyses were used in the calculation of digestibility, total digestible nutrients (TDN), nitrogen balance and percentage nitrogen retention by goats.

TABLE 2. CHEMICAL COMPOSITION OF DIETS FED TO BORNO WHITE GOATS (g/100g DM)

Nutrients (%)	Diets			
	A	B	C	D
Dry matter	77.00	63.30	67.70	65.71
Organic matter	69.86	57.26	64.19	61.10
Crude protein	3.42	4.65	4.44	4.39
Crude fibre	46.40	30.60	32.52	32.51
Ether extract	0.94	1.02	0.94	0.95
Total ash	7.14	8.24	10.77	9.67
Nitrogen-free extract	19.10	18.79	19.03	18.19
Total Digestible Nutrients(TDN)				
(g/100g DM)	35.88	30.34	32.54	30.24
Gross energy (Kcal/100g)	379.53	307.37	290.79	302.50

period. Urine and faeces were collected separately each morning before feeding. Urine from each buck was collected in a polythene bucket wetted with 5ml concentrated sulphuric acid to prevent urine ammonia loss. The daily urine volume was measured immediately after collected and 10% saved and stored in a deep freezer at -5°C until required for chemical analysis. A representative sample (10%) of the daily faecal output was dried in a force-draught oven at 70°C for 48 hours. The daily samples were then bulked at the end of each collection period, milled in a Christy-Norris Hammer-Mill using a 2mm sieve and stored in airtight bottles until required for analysis. The diet samples were oven-dried at 60°C for 72 hours (Harris,

Statistical Analysis

Data on digestibilities and balances were subjected to analysis of variance and mean differences were tested by Duncan's New Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The mean proximate composition of the experimental diets are given in Table 2. The dry matter (DM) of the diets varied from 63.3 (B) to 77.0% (A). Alkali treatment markedly decreased the dry matter, organic matter and crude fibre content of the straw. This is in line with other reports (Kategile, 1981; Kagegile *et al.*, 1981). In this study, the alkali-treated diets contained comparable amounts of dry matter.

The crude protein values were 3.42, 4.65, 4.43 and 4.39% respectively for diets A, B, C, and D. Thus, the alkali treated diets (B, C, D) contained 36.0, 29.5 and 28.4% more crude protein respectively than the control. The observed increase could probably be a contribution by microorganisms involved in the ensiling process. The low content of ether extract in the diets is generally the characteristics of low quality forage hay (Adu and Adamu, 1982). The present organic matter percent for NaOH-treated hay (57.3%) is less than the value (76.3%) reported for NaOH-treated *Hyparrhenia* silage (Kategile *et al.*, 1981). The disparity could probably be due

crude fibre and energy digestibility followed closely the trend of DMD. No significant differences ($P > 0.05$) existed among the treatments in the digestion of ether extract and nitrogen free extract by goats. Considerable improvements in digestibility and intake levels of highly fibrous feedingstuffs have resulted following treatment with alkali (Jackson, 1977; Klopfeinstein, 1987; Adebawale, 1985; Baber *et al.*, 1988). Generally, alkali treatment enhances fibre digestion through delignification or swelling of plant cell walls thereby rendering it easy penetration by rumen cellulolytic enzymes (Spencer and Akin, 1980; Elshazly and Naga, 1981; Theander, 1981).

TABLE 3. APPARENT DIGESTIBILITY COEFFICIENT (%) OF DIETS FED TO GOATS

Nutrients (%)	Diets				SEM
	A	B	C	D	
Dry matter	48.79 ^b	55.96 ^a	59.31 ^a	54.76 ^a	1.62*
Organic matter	48.30 ^b	59.71 ^a	62.56 ^a	59.37 ^a	1.25*
Crude protein	42.77 ^b	54.44 ^a	56.55 ^a	53.15 ^a	1.32*
Crude fibre	49.73 ^b	53.48 ^a	56.53 ^a	52.85 ^a	1.34*
Ether extract	40.15	45.73	47.14	48.55	1.46 ^{ns}
Nitrogen-free extract	54.92	55.31	55.98	53.24	1.41 ^{ns}
Gross energy	54.50 ^b	69.90	72.30 ^a	69.23 ^a	2.06*

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

SEM = Standard error of mean

ns = Not significant ($P < 0.05$); * = ($P < 0.05$)

to differences in the concentration of the alkali and stage of maturity of the forages. As would be expected, the ash content of the treated diets were higher than in the control. The natural alkali-treated diets were higher than the NaOH-treated diet. The high values could be contributed by free silica and trisilicate present in Kanwa and Kantu (Gbodi and Ikwegbu, 1982).

The apparent digestibility coefficients (%) of the nutrients in the diets are presented in Table 3. The apparent dry matter digestibility (DMD) of the treated diets were markedly improved ($P < 0.05$) than the untreated diet (A). The DMD values of NaOH, Kanwa and Kantu treated hay were similar. The crude protein,

A natural alkali salt deposit or trona ("Magadi") comparable to the present natural alkali salts was reported by Said *et al.* (1982) to show considerable improvement in the digestion of maize stover and rice straw in laboratory experiments. Several other workers (Musimba, 1980; Kategile *et al.*, 1981; Saadullah and Hague, 1981) have previously confirmed the effectiveness of Magadi salt and urea in improving the digestibility and intake of straws.

The data on feed intake and nitrogen balance are shown in Table 4. The daily total DM intake (g/W_{kg} 0.75) was significantly less ($P < 0.05$) DM than those on the treated diets. Alkali treatment of roughages in the form of NaOH (Pirie and

TABLE 4. MEAN FEED INTAKE AND NITROGEN BALANCE VALUES FOR GOATS FED FOUR TREATMENT DIETS.

Parameters	Diets				SEM
	A	B	C	D	
Average Liveweight ($W_{kg}^{0.75}$)	10.11	9.47	9.33	10.04	
Dry matter intake (g/day)	196.50 ^b	245.95 ^a	256.50 ^a	256.50 ^a	17.62*
Dry matter intake (g/day/ $W_{kg}^{0.75}$)	19.43 ^b	27.97 ^a	27.49 ^a	30.03 ^c	6.53*
Nitrogen utilization					
N-Intake (g/day)	1.08 ^c	1.83 ^a	1.80 ^a	2.13 ^b	0.26*
Faecal-N (g/day)	0.65 ^b	0.65 ^b	0.60 ^b	0.76 ^a	0.18*
Urinary-N (g/day)	0.49 ^b	1.15 ^a	0.97 ^a	1.26 ^a	0.05*
N-Retained (g/day)	-0.06 ^d	0.03 ^c	0.23 ^a	0.11 ^b	0.10*
N-Absorbed (%)	-39.81 ^b	64.48 ^a	66.67 ^a	64.32 ^a	0.35*
N-Retained (%)	-5.56 ^d	1.64 ^c	12.78 ^a	5.16 ^b	0.91*
Apparent N-digestibility (%)	39.81 ^b	64.43 ^a	67.89 ^a	64.66 ^a	0.53*

a,b,c,d Means in rows with different superscripts are significantly different ($P < 0.05$)

* ($P < 0.05$)

SEM = Standard error of mean.

Greenhalgh, 1978; Kategile *et al.*, 1981; Sunstol, 1981), anhydrous ammonia (Sunstol, 1984), urea-NH₃ (Williams *et al.*, 1984) and organic ashes (Adebawal, 1985) has been shown to increase dry matter intake. In this study Kantu diet (D) was consumed more ($P < 0.05$) than the NaOH-treated (B) or Kanwa-treated (C) diets.

Nitrogen intake, faecal nitrogen and urinary nitrogen differed significantly ($P < 0.05$) among animals in the treatment groups. These parameters followed similar trend as the daily DM intake (g/ $W_{kg}^{0.75}$). Animals fed the alkali diets lost more ($P < 0.05$) nitrogen in urine than those on the control. Faecal nitrogen output was higher ($P < 0.05$) for animals on treatment D than those in the other treatment groups. Retained nitrogen was slightly negative for animals on diet A (control) while those fed the treated diets were on positive nitrogen balance. This could be an indication that animals on the control diet were breaking down body tissue to meet their protein requirements. Topps and Elliot (1965) reported that negative nitrogen retention might perhaps indicate poor utilization

as a result of poor energy supply. In this study energy digestibility value for the untreated hay was significantly less ($P < 0.06$) than for the treated diets. Apparent nitrogen digestibility (%) was significantly different ($P < 0.05$) among treatments. Nitrogen in the treated diets were similarly digested and better ($P < 0.05$) than in the control. In this study, nitrogen intake was low due to the low crude protein content of the diets. Comparable low nitrogen digestibility values from treated wheat straw fed to steers has been reported (Zorrila-Rios *et al.*, 1989). It has been suggested (Mason, 1981) that depressed apparent N digestibility associated with large intakes of fibrous materials could be the result of either impaired reabsorption of endogenous N or by increased faecal output of nitrogenous compounds of ruminal and/or caecal bacteria.

It is appreciable that the local naturally occurring alkali salts used in this study were as good as sodium hydroxide in improving the nutritive value of *Anandropogon gayanus* straw. The local alkali treated straws were readily consumed as the NaOH treated hay and there were no meta-

bolic problems. These salts have a cost advantage over NaOH which is imported. However, more research is needed to develop a practical and cost-effective technology applicable at the farm level. These salts hold a lot of promise as possible alternatives to other forms of imported and hazardous chemicals employed in forage improvement.

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