Effect of feeding sorghum stover treated with Rabaa ash alkali on digestibility and performance of Nubian goats

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ABSTRACT

Ash from some plants in the Sudan was evaluated for alkalinity and used in upgrading straws since it is cheap and safe. Alkalinity varied greatly among plant species and was highest for Rabaa (*Trianthema pentandra* L.*)* and least in Buda *(Striga hermonthica* (Del) Benth.). Effects of Rabaa ash alkali on chopped sorghum stover (Tabat variety) dry matter and water intakes, digestibility and body weight changes in Nubian goats were studied. Sorghum stover was treated with 0%, 3%, 5% and 8% Rabaa ash solutions forming diet US, AT_1S, AT_2S and AT_3S, respectively. The alkali significantly ($p<0.05$) depressed dry matter intake (DMI) compared to untreated stover and the effect was 839, 688, 619 and 661 g/day for US, AT_1S, AT_2S and AT_3S, respectively. Water intake was 3303, 4164, 3752 and 3264 ml/day for US, AT_1S, AT_2S and AT_3S, respectively. The alkali increased DM, OM, CP, EE and CF apparent digestibilities and the effects were increased with alkali level. A non- significant weight gain was noticed in all treatments.

INTRODUCTION

Animal production in the Sudan depends mainly on natural pastures which are declining due to expansion of rainfed and irrigated schemes, successive droughts and over grazing. Natural pastures yield about 77.6 million tons DM or about 74.7% of animal feeds in the country (MAW, 2002).

Crop residues are important in filling this nutritional gap with about 19 million tons DM forming about 22% of animal feeds (MAW, 2002). Their low nutritive value due to high fibres and low crude protein (Sundstol and Owen, 1984) limited dry matter intake (DMI) and large amounts are wasted. Sorghum is the main straw in the Sudan and mostly used untreated.

The nutritive value and DMI of straws could be upgraded by physical, chemical and biological methods and combinations among them (Preston, 1995). Most of these procedures are expensive, tedious, hazardous and may not be feasible. Sudanese attempts in upgrading nutritive value of straws are conventional and limited by costs and producers are neither well informed nor trained.

Alkali from different sources is used in upgrading straws including NaOH, KOH, NH_3 and urea (Preston, 1995). Alkalis are generally expensive, corrosive and affect soil characteristics. Cheap and safe alkali was obtained from the ash of coca pods (Smith *et al*., 1988), wood dust (Ramirez *et al.*, 1992) and dung (Didier *et al.*, 2007). Rabaa (*Trianthema pentandra* L.) is a weed which is widely distributed in the country, reputed for high ash and used in traditional soap processing. Consequently, this study was executed to determine the nutritive value, DMI and digestibility of sorghum stover using Rabaa ash alkali in the Sudan.

MATERIALS AND METHODS

Evaluation of alkali in different plants

Plants used for determination of alkalinity consisted of sorghum (*Sorghum bicolor*), sesame (*Sesamum indicum* L.), pearl millet (*Pennisetum typhoides*), sunflower *(Helianthus annuus* L.*)*, Usher (*Calotropis procera* L.*)*, Tabar (*Ipomoea cordofana* choisy), Rabaa (*Trianthema pentandra* L.*)*, Buda (*Striga hermonthica* (Del) Benth.), Neem (*Azadirachta indica)* and Ramtouk (*Xanthium brasilicum* L.). They were dried and ashed in triplicates in a muffle furnace at 550 – 600^{o}C for 6 hours. Ash from each plant was dissolved in water to 50 ml volume and filtered through a filter paper. Alkalinity was determined by titration and the solution was titrated against HCl to calculate the percentage of (-OH). The pH for the solution was measured using a pH meter. Rabaa ash had the highest values and used in the main experiment.

Alkali preparation from Rabaa ash

The alkali was prepared by dissolving 3, 5 or 8 kg ash in 100 L of water.

Basal diets

Two tons of chopped sorghum stover (Tabat variety) were treated with 0, 3, 5 and 8% ash solutions forming diets US, AT_1S, AT_2S and AT_3S, respectively. The chopped stover was spread on a plastic sheet, sprayed with the alkali (2 L /kg straw) and thoroughly mixed with a fork. It was left for 24 hours and sun-dried for three days before feeding.

Animals

Sixteen female Nubian goats (average body weight of 30.27 ±2.07 kg) were housed individually and treated against ecto- and endo-parasites. They were randomly allotted to four treatments with four animals in each. Each animal had separate roughage and concentrate troughs.

Feeding

The basal diets were offered *ad-lib*itum in two equal meals at 09.00 am and 04:00 pm. Concentrates (0.3 kg/head/day) were offered before the roughages morning meal. The concentrates consisted of sorghum grain (48%), wheat bran (35%), groundnut cake (5%), molasses (6%), limestone (2.5%), common salt (1.5%), and mineral/vitamin mix (2%). Clean water was freely available to all animals. The trial lasted 71 days with 15 days adaptation period.

Dry matter intake (DMI), water intake and body weight changes

Daily DMI for each goat was determined by weighing the offered stover and the refusals each morning. Water intake was determined in the last 7 days by measuring offered and remaining water daily for each animal. Animals body weight was measured weekly for 8 weeks to determine changes in body weight.

Digestibility

Digestibility was determined using the same 16 animals. They were fitted with porous nylon faecal collection bags. They were divided into four groups of comparable live body weight and allocated randomly to the treatments. They were fed the diets *ad-libitum* in two equal meals. Clean water was freely offered in metal buckets fixed in the corner of the pens. They were allowed two weeks adaptation period followed by 7 days collection. Offered feeds and refusals were weighed daily for each animal to determine daily intake. Samples of feeds and refusals were collected for proximate analysis. Daily collected faeces for each animal were weighed and 10% representative samples were taken for chemical analysis. Samples of the diets, refusals and faeces were used for proximate analysis as described by A.O.A.C. (1995).

Statistical Analysis

Data were analyzed using the analysis of variance procedure (SAS, 1997).Mean comparison was carried out using Scheffe's test.

RESULTS

Plants alkalinity

Table 1 shows the alkalinity of some plants in the Sudan. It varies greatly among plants and was highest for Rabaa (10.54) followed by sorghum stover and was least in Buda.

Table 1. Ash (%) and alkalinity of some plants in the Sudan.

Scientific name	Local name	Ash (%)	Alkalinity (%wt OH)
Sorghum bicolor	Dura(Tabat)	6.73	7.92
Sesamum indicum L.	Simsim	7.00	5.28
Pennisetum typhoides	Dukhun	16.72	6.33
Calotropis procera	Usher	9.82	1.40
Ipomoea cordofana choisy	Tabar	9.88	6.30
Trianthema pentandra L.	Rabaa	23.00	10.54
Helianthus annuus L.	Zahret Elshams	7.67	4.84
Striga hermonthica (Del) Benth.	Buda	25.50	0.54
Azadirachta indica L.	Neem	6.16	1.00
Xanthium brasilicum L.	Ramtouk	6.92	4.00

DM intake, water intake and BW changes

Table 2 shows Rabaa alkali effects on sorghum stover DMI, water intake and body weight changes in Nubian goats in the Sudan. Dry matter intake as gram / day (g/d) was significantly ($p<0.05$) decreased by alkali and was least for AT_2S. Dry matter intake as g/kg live weight (LW), $g/kgW^{0.75}$ (metabolic weight), % LW and % $W^{0.75}$ decreased with alkali level.

Water intake (ml/d) was increased by treatments AT_1S and AT_2S and decreased by AT_3S compared to the untreated stover and the effect was significant ($p < 0.05$) for AT_1S. The alkali increased water intake as L/kg DMI and was highest for AT_1S and AT_2S. A non-significant weight gain increase with increasing alkali level was observed.

Apparent digestibility

Table 3 shows the effects of Rabaa ash alkali applied to sorghum stover on nutrients digestibility in Nubian goats in the Sudan. Increasing Rabaa alkali level generally increased dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and crude fibre (CF) apparent digestibilities and was highest for AT_3S. This effect was significant ($P<0.05$) for DM, OM and CF and non-significant ($P>0.05$) for CP between US, AT_1S and AT_2S. Ether extract apparent digestibility was significantly ($P<0.05$) decreased in AT_2S.

Table 2 Effects of sorghum stover treated with Rabaa ash alkali on DMI, water intake and body weight changes in Nubian goats in the Sudan.

Treatments	US	AT_1S	AT_2S	AT_3S	S.E.	C.V(%)
DMI: (g/d)	839[a]	688[b]	619[b]	661[b]	26.43	9.87
g/kg LW	26.94[a]	22.26[a]	20.34[a]	23.65[a]	0.99	3.46
$g/kgW^{0.75}$	63.64[a]	52.48[a]	47.76[a]	54.35[a]	2.21	7.28
%LW	2.7	2.22	2.04	2.37		
$\%W^{0.75}$	6.37	5.25	4.78	5.44		
Water intake: ml/d	3303[b]	4164[a]	3752[ba]	3264[b]	138.59	12.47
ml/LW	105.82[b]	134.75[a]	122.89b[a]	115.04[ba]	4.05	13.31
$ml/kgW^{0.75}$	250.13[b]	317.68[a]	288.75[ba]	265.4[b]	9.60	31.27
%LW	10.58	13.48	12.29	11.51		
$\%W^{0.75}$	25.01	31.77	28.88	26.54		
l/kg DMI	3.93	6.06	6.06	5.09		
LWchange (g/d)	0.555[a]	0.844[a]	0.867[a]	0.827[a]		18.02

US = Untreated sorghum stover. AT_1S, AT_2S and AT_3S stand for Rabaa alkali treated sorghum stover at 3 %, 5 % and 8 %, respectively. LW= Live weight. $W^{0.75}$ = Metabolic body weight. DMI= Dry matter intake

Means in the same row with different superscripts are significantly ($P<0.05$) different. S.E.= Standard error of means. C.V=Coefficient of variation.

Table 3**.** Effects of sorghum stover treated with Rabaa ash alkali on nutrients digestibility (%) in Nubian goats in the Sudan.

Treatment	DM	OM	CP	EE	CF
US	57.90[d]	59.71[d]	26.64[b]	53.86[ba]	68.60[d]
AT_1S	63.28[c]	64.30[c]	34.55[b]	58.52[a]	73.33[c]
AT_2S	73.46[b]	73.68[b]	36.65[ba]	30.15[b]	81.73[b]
AT_3S	82.54[a]	82.38[a]	46.42[a]	74.81[a]	88.06[a]
S.E.	2.46	2.28	2.10	4.78	1.97
C.V (%)	1.91	1.97	13.03	19.76	2.14

US = Untreated sorghum stover. AT_1S, AT_2S and AT_3S stand for Rabaa alkali treated sorghum stover at 3 %, 5 % and 8 %, respectively. Means in the same column with different superscripts are significantly ($p < 0.05$) different. S.E. = Standard error of mean. C.V=Coefficient of variation.

DISCUSSION

Dry matter intake, water intake and body weight changes

The decreased DMI (g/d) of Rabaa alkali treated sorghum stover was mainly due to reduced palatability and ash and this effect increased with increasing alkali level except for AT_3S. Similar results were found by Alawa and Owen (1984) and Kurdi (1984). Increasing alkali and ash may affect the taste and goats are known to distinguish between tastes (Devendra and Mcleroy, 1982). Didier *et al.* (2002) suggested that taste and smell were important in reducing DMI of dung ash alkali-treated paja brava hay. The decreased CF with increasing alkali level (Hamed and Elimam, 2008) was expected to increase DMI since it will decrease the gutfil. Van Soest (1982) and McDonald *et al*. (1994) reported that reduced gutfill increases DMI. The results indicated that expressing DMI as g/day is more sensitive and should be always adopted. Dry matter intake in our results was similar to the minimum for exotic dairy goats (2.8-4.9% and 62-142 $g/kgW^{.75}$) reported by Devendra and Burns (1983). Daily variations and variations among animals in DMI were similar to those reported by Devendra and Burns (1983).

Water intake

The increased water intake with 3% and 5% Rabaa alkali level was similar to that for NaOH (Osman, 1987).The results suggested that expressing water intake as L/kg DMI was more reliable than other expressions. The increased water intake with increasing alkali level was because animals need more water for alkali excretion in urine, rumen acid-base balance or stimulated by taste. Water intake in our study was close to that found for sheep (Osman, 1985; Alrahmoun, 1985).

Body weight changes

The increased weight gain with increasing alkali level was mainly due to improved digestibility and rumen degradation of the stover. Similar findings were reported by Van Soest (1982) and Ye *et al*. (1999).

Apparent digestibility

The improved apparent digestibilities of DM, OM, CP, EE and CF with Rabaa alkali indicated the effectiveness of the treatment. It is interesting that CF apparent digestibility was the highest at all alkali levels showing the effectiveness of the treatment since fibres are the limiting factor for the nutritive value of straws. Alkali treatment cleaves esterified bonds within the lignin-carbohydrate complex solubilizing inhibitory phenolic compounds, facilitating enzymes access (Chesson 1981; Fahey *et al.*, 1993) and microbial colonization of plant cell walls (Kerley *et al*., 1985). Crude protein apparent digestibility was generally least in all alkali levels and was mainly due to low CP in straws. Increasing straws CP is likely to enhance digestibility due to improved rumen fermentation.

The effects of Rabaa ash alkali on DM, OM, EE, CP and CF digestibilities of sorghum stover were similar to those reported for dung ash alkali and NaOH on paja brava where CP, neutral detergent fibre (NDF) and acid detergent lignin (ADL) digestibilities were more increased by dung ash than NaOH (Didier *et al*., 2002). In addition, 20% wood ash alkali improved corn stover fibre digestibility in goat and sheep to a degree comparable with that for NaOH (Ramirez *et al.*, 1992). This confirmed that alkalis other than NaOH are highly efficient and can replace NaOH, thus reducing costs and hazards.

CONCLUSION

It can be concluded that Rabaa alkali would be the alternative to NaOH for improvement of the nutritive value of straw and it is cheap and safe.

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تأثير التغذية على تبن الذرة الرفيعة المعامل بقلوي رماد نبات الربعة على الهضمية وأداء الماعز النوبي

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الخلاصة

تم تقييم قلوية رماد بعض النباتات بالسودان لاستخدامها في تحسين الاتبان لأنه رخيص ومأمون. تختلف القلوية في النباتات المختلفة. وجد أعلى قيمة قلوية في نبات الربعة وأقل قيمة في نبات البودا. تمت دراسة تأثير قلوي رماد الربعة على استهلاك المادة الجافة والماء والهضمية الظاهرية والتغير في الوزن في الماعز النوبي. تمت معاملة تبن الذرة بمستويات 0و 3 % و 5 % و8 % من محلول رماد نبات الربعة مكونا US, AT1S, AT2S, AT3S على التوالي. أدى القلوي إلى انخفاض معنوي للمادة الجافة المتناولة مقارنة بغير المعامل وكان الاثر839 و 688 و 619 و661 جرام /اليوم لكل من US و AT1S وAT2S وAT3S على التوالي. كان استهلاك الماء 3303 و 4164 و3752 و 3264 مل/اليوم لكل من US و AT1S وAT2S وAT3S على التوالي. أدى القلوي إلى زيادة الهضمية الظاهرية للمادة الجافة والمادة العضوية والبروتين الخام والدهن الخام والألياف الخام وازداد التأثير بازدياد مستوى القلوية. تلاحظ أن هناك زيادة غير معنوية في الوزن في كل المعاملات.