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ORIGINAL RESEARCH ARTICLE

Chemical composition and acceptability of different alkali-treated *Pennisetum purpureum* hays by West African dwarf goats

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ABSTRACT
The dry season in the tropics is characterized by inadequate nutrition for ruminants due to poor feeds and highly fibrous forages. Alkali treatment of forages has been identified as a means of improving their utilization by ruminant animals. Pennisetum purpureum hays were subjected to four alkali treatments as follows, T1: untreated Pennisetum purpureum hay (UPPH), T2: Pennisetum purpureum hay treated with wood ash (PPHWA); T3: Pennisetum purpureum hay treated with cow dung ash (PPHCDA) and T4: Pennisetum purpureum hays treated with poultry litter ash (PPHPLA). Treated hays were assessed for their nutritive value (chemical and mineral composition) and acceptability by West African Dwarf (WAD) goats in a cafeteria experiment. Ash value ranged from 11.90 (UPPH) to 16.55g/100g DM (PPHWA). Crude fibre was (P<0.05) higher in the control (UPPH) than all the alkali treated PPH. Ether extract and Crude protein content of forages were significantly (P<0.05) improved in the PPHPLA than the control. Na content of Pennisetum purpureum hays was not affected by the alkali treatments. P (Phosphorus), Mg (Magnesium) and S (Sulphur) values of the forage were significantly (P<0.05) improved in the PPHCDA. PPHWA showed highest (P<0.05) values for Zn (Zinc), Cu (Copper) and Mn (Manganese) (57.00, 3.23 and 1.42 mg/kg respectively) while lowest (P<0.05) values were observed in the PPHCDA (3.20, 0.04 and 0.01 mg/kg respectively). UPPA and PPHWA were preferred by WAD goats while PPHCDA and PPHPLA were rejected by WAD goats. Results suggest that alkali treated PPH were improved in terms of their chemical and mineral compositions. Wood ash treated PPH was preferred by WAD goats while PPHCDA and PPHPLA were rejected by goats. Further research to improve acceptability of other forms of alkali treatment of PPH by WAD goats should be conducted.

Keywords: Ash, Alkali solution, dry season, Elephant grass, Preference, WAD goats,

INTRODUCTION

In tropical zones, ruminants depend on year-round grazing of natural pastures or fed with cut and carry grass and crop residues. Most of these areas face seasonal dry periods in which the availability of pasture decreases and also its quality by a reduction in the content of digestible energy and nitrogen [Sarnklong et al., 2010]. *Pennisetum purpureum* also known as Napier grass or elephant grass, has high biomass production, however, at the peak of the dry season, they are highly lignified and dry suggesting a need for improving their intake and digestibility in animals. One of the ways to achieve this is through alkali treatment: Alkali treatments of high fiber roughages have been investigated extensively, and there are numerous reviews of their effect in increasing feeding value for ruminants (Jackson, 1978; Wanapat et al., 1985). Alka1i treatment reduced the amount of fiber unavailable for digestion and stimulated increased feed intake, milk production, and digestibility of NDF and ADF (Canale et al., 1990). The most common alkalis used are NaOH, $Ca(OH)_2$ and urea-ammonia but these alkali sources have been found to have one disadvantage or the other ranging from high cost, scarcity to corrosiveness and legislative laws against their use (Preston, 1995). One economical alkaline source is wood ash. Alkalis from plants ash including coca pods (Smith and Osafo, 1987), wood dust (Ramirez *et al*., 1992), from dung ash (Didier *et al*., 2002) and Rabaa (Hamed and Elimam, 2008) are cheap and safe. Rabaa (*Trianthema pentandra* L.) is a widely distributed weed in the Sudan and is high in ash and alkalinity and is used in traditional soap manufacturing (Asma and Mohmed, 2009). Treatment of wheat straw with a 30% solution of wood ash for 6 h significantly increased dry matter digestibility (DMD) for goats (Nolte et al., 1987). - Unfortunately, wood is becoming very scarce and further felling of trees is being discouraged due to the campaign against desertification and its effect on climate change phenomenon. Genin et al. (2002) hypothesized that ash from camel dung could have similar effects to wood ash due to their high pH values. In the southern part of Nigeria, where Napier grass grows well, camels are not as popular as cattle. Cattle dung and poultry litter are easily available on farms where these animals are kept. Accumulation of dung on the farms has become a nuisance where they are not used for agriculture or for fuel. The idea of using poultry litter to treat crop residues originated from alkali treatment aimed at breaking the lignin bond in such residues and straws thus releasing the energy contained in them for use by the animal fed such material (Baba et al., 2010). Baba et al. (2010) recommended that an extra protein supplement might be needed in order to meet the protein requirements of animals in the dry season, hence the need to treat hay with urea solution after treatment with ash from different sources.

This work was therefore designed to evaluate the comparative effect of wood ash, cow dung ash and poultry litter ash on chemical and mineral composition of *Pennisetum purpureum* hay and their acceptability by WAD goats.

MATERIALS AND METHODS

Forage preparation

The experiment was carried out at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. Cattle dung was collected from heaps within the resting areas of cattle on the Teaching and Research farm. It was burnt completely to ashes after drying for 4-5 days. It was sieved using a sieve of pore size 0.6 mm (0.024 inches) to remove sand and other unburnt materials. The ash was stored in large polythene bags until required for forage treatment. Wood ash was collected from a kitchen within the campus of the University, and stored the same way as described above. Poultry litter was also collected from the poultry unit of the University, dried, and burnt to produce ash which was stored as described earlier. Fertilizer based urea was purchased from an open market within Ile-Ife metropolis. *Pennisetum purpureum* grass was harvested at the matured stage (14 weeks) in the mid-dry season (December-January). The availability of this forage at this stage and time was possible only along the tributaries leading to the Opa dam in Ife. They were air-dried, chopped to lengths of approximately 10cm and stored in a dry area for further treatment. Due to its low nitrogen content, *Pennisetum purpureum* hay was supplemented after alkali treatment with urea in order to increase the crude protein *(CP)* content.

Treatment of forages

The treatment of the *Pennisetum purpureum* hay with dung ash, wood ash and poultry litter followed the procedures of Nolte et al. (1987). The hay was soaked in a solution containing 20 *(w/v)* cow dung ash, wood ash and poultry litter ash respectively. *Pennisetum purpureum* hay (of about 10kg/batch) was soaked for 6 hours. After soaking, the *Pennisetum purpureum* hay was removed and sundried for 3-4 days and 3% urea (DM basis) was later added following the procedures of Oluokun (2005). Four diets were prepared viz: (a) Untreated *Pennisetum purpureum* (UPPH) hay (b) wood ash treated *Pennisetum purpureum* hay (PPHWA) (c) cow dung ash treated *Pennisetum purpureum* hay (PPHCDA) (d) poultry litter ash treated *Pennisetum purpureum* hay (PPHPLA).

Laboratory analysis of different alkali treated hays

Crude protein, crude fibre, ether extract and ash contents of the treated and untreated PPH were determined (AOAC). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to the methods of Van Soest et al. (1999). The concentration of minerals (Macro and micro) in the untreated PPH and differently treated PPH were determined by atomic absorption spectrophotometry.

Acceptability trials

Fifteen WAD goats were used in a cafeteria experiment to evaluate the acceptability of the alkali treated PPH for 7 days after 5 days of adaptation. About 4kg of each diet was introduced daily on cafeteria basis in eight different concrete feeding troughs according to the methods of Babayemi and Bamikole (2006). Each animal had free access to each of the diet in the trough. The positioning of the feeds was changed daily to prevent bias by the animals in recognizing part of the pen for a particular diet. The amount of feed consumed was monitored for six hours per day after which dried cassava peels was served to the animals. Feed preference was determined from the coefficient of preference (CoP) (Karbo et al.1993; Falola et al, 2013). A feed is adjudged to be relatively preferred if the CoP is greater than unity (1).

$$CoP = \frac{\text{Intake of individual feed offered}}{\text{Mean intake of all the feed offered}}$$

Statistical analysis

In a completely randomized design, data were collected and subjected to one way analysis of variance (ANOVA) procedure of SAS (2002). Significant means were separated using Duncan's multiple range test of the same package.

RESULTS AND DISCUSSION

Table 1 shows the result of the proximate composition of different alkali treated *Pennisetum purpureum* hays (PPH). DM values ranged between 88.71 g/100g DM (PPHWA) and 89.80 g/100g DM (UPPH), but were not significant (P>0.05). These values were however lower than DM values reported by Asma and Mohmed (2009) for Rabaa ash alkali treatment of sesame straw. This may be attributed to the differences in plant structure and stage of growth at harvest.

Table 1: Proximate Composition (g/100g DM) of different alkali treated *Pennisetum purpureum* hay

Parameters	T1	T2	T3	T4	Probability
DM	89.80±0.55	88.71±1.17	89.13±0.29	88.81±0.70	0.3692
Crude Protein	$10.98±0.53^{b}$	$l1.86±0.05^{ab}$	$11.81±0.01^{ab}$	$12.62±0.07^{a}$	0.0525
Crude Fibre	$32.83±0.07^{a}$	$28.93±0.08^{c}$	$30.81±0.34^{b}$	$21.54±0.10^{d}$	0.0001
Ether Extract	$1.63±0.13^{b}$	$1.24±0.04^{c}$	$1.17±0.07^{c}$	$2.05±0.05^{a}$	0.0046
Ash	$11.90±0.00^{c}$	$16.55±0.15^{a}$	$12.45±0.15^{b}$	$11.90±0.00^{c}$	0.0001
NFE	$32.46±1.13^{bc}$	$30.14±0.95^{c}$	$33.89±0.70^{b}$	$42.70±0.81^{a}$	0.0023

^{abcd}:Means within column with different super-script indicate significant difference at p<0.05

Note: DM = Dry Matter, NFE= Nitrogen Free Extract; TI= Untreated *Pennisetum purpureum* Hay (UPPH); T2= *Pennisetum purpureum* hay treated with wood ash (PPHWA); T3= *Pennistum purpureum* Hay treated with Cow dung Ash (PPHCDA); T4= *Pennisetum purpureum* hay treated with Poultry litter ash (PPHPLA).

Table 2: Macro mineral composition (mg/kg) of different alkali treated *Pennisetum purpureum hays*

Minerals	T1	T2	T3	T4	Probability
Na	$1.50±0.00^{c}$	$3.00±0.00^{a}$	$1.23±0.03^{d}$	$1.70±0.00^{b}$	0.0369
K	$5.28±0.03^{d}$	$30.08±0.03^{b}$	$39.08±0.03^{a}$	$6.63±0.03^{c}$	0.0001
Ca	$63.05±0.05^{b}$	$122.50±0.50^{a}$	$11.05±0.05^{d}$	$30.00±0.00^{c}$	0.0001
P	$10.50±0.02^{a}$	$9.36±0.01^{c}$	$10.35±0.05^{b}$	$8.51±0.01^{d}$	0.0046
Mg	$10.50±0.02^{b}$	$48.82±0.32^{a}$	$6.17±0.02^{d}$	$14.43±0.01^{c}$	0.0052
S	$5.06±0.02^{b}$	$8.16±0.01^{a}$	$0.93±0.02^{d}$	$3.27±0.02^{c}$	0.0023

^{abcd}:Means within column with different super-script indicate significant difference at P<0.05

Note: Na = Sodium, K= Potassium, Ca = Calcium, P = Phosphorus, Mg = Magnesium, S = Sulphur. *Pennisetum purpureum* Hay (UPPH); T2= *Pennisetum purpureum* hay treated with wood ash (PPHWA); T3= *Pennistum purpureum* Hay treated with Cow dung Ash (PPHCDA); T4= *Pennisetum purpureum* hay treated with Poultry litter ash (PPHPLA).

Crude fibre was highest in the control (untreated PPH) 32.8g/100g DM and significantly reduced in all the alkali treated PPH (30.81, 28.93 and 21.54 in PPHCDA, PPHWA, and PPHPLA respectively). This observation corroborates the report of Genin et al. (2002) when they observed significant reduction in the fibre fractions (NDF and ADL) of alkali treated Paja brava hay. Crude protein, ether extract and NFE values were highest in T4 (PLPPH). This may be as a result of feed particles which may have dropped on the litter and eventually enriching its ether extract and the crude protein contents. Poultry litter has uric acid which under high pressure is hydrolyzed to ammonia thereby acting on the lignin bond (Sundsol and Worth, 1984). Micro-organisms in the rumen have a unique ability of utilizing uric acid and other forms of non protein nitrogen (NPN) contained in animal waste to make body protein which is subsequently digested in the lower gut for use by the host animal (Baba et al., 2010). Ether extract contents of PPHWA and PPHCDA were similar but lower than those for UPPH. The reduction in the ether extract values for the alkali treated *P. purpureum* hays apart from the PPHPLA may be attributed to increased oil extraction as a result of the alkaline treatment (Asma and Mohmed, 2009). Values for ash ranged between 11.90 g/l00g DM (UPPH and PPHPLA) to 16.55 g/l00g DM (PPHWA). Ash was significantly (P<0.05) highest in the Wood ash treated forage and least (P<0.05) in PPHPLA. Ash content of UPPH and the alkali treated PPH in this study were higher than ash values of 8.13 g/100g DM reported for ash treated Rhodes hay (Kebede et al., 2012). This could be due to species differences or genetics, however, they were similar to those reported for Rabaa grass ash treated straw (Asma and Mohmed, 2009). The high content of ash observed in the PPHWA could be as a result of contamination with soil and also the type of wood used in making the ash.

Table 2 shows the macro mineral content of alkali treated *Pennisetum purpureum* hays (PPH). Na content of PPH was significantly (P<0.05) affected by the alkali treatments as Na content of PPHWA was doubled compared to UPPH. K contents in hays were improved (P<0.05) by alkaline treatment. Calcium was highest (P<0.05) in the PPHWA and lowest in the PPHCDA. The values of calcium observed for untreated and treated PPH in this study were lower than values of 0.98 ppm and 0.42ppm Ca reported for Mexican sun flower leaf meal and *Panicum maximum* (Ekeocha and Fakolade 2012). Phosphorus (P), Magnesium (Mg) and Sulphur (S) values of the forage were all significantly (P<0.05) improved in the cow dung ash treated PPH.

Table 3 shows the micro mineral composition of different alkali treated *Pennisetum purpureum* hays. Wood ash treated PPH showed highest (P<0.05) values for Zn, Cu and Mn (57.00, 3_23 and 1.42 mg/kg respectively) while lowest values were observed in the cow dung ash treated PPH (3.20, 0.04 and 0.01 mg/kg respectively). These values are lower than wood ash values of 465 mg/kg and 106 mg/kg for Zn and Cu respectively reported earlier by (Van Ryssen and Ndlovu (2004). The high differences may be due to location and specie difference. Zn and Cu play major roles as cofactors in enzymes like arginase, enolase, and peptidase, synthesis and metabolism of RNA and protein, blood and bone formation and also pigmentation, hence their importance in goat diets.

Table 3: Micro mineral composition (mg/kg) of different alkali treated *Pennisetum purpureum hays*

Minerals	T1	T2	T3	T4	Probability
Zn	41.10±0.10^{b}	57.00±0.20^{a}	13.20±0.00^{d}	18.43±0.03^{c}	<0.0001
Cu	1.31±0.03^{b}	3.23±0.03^{a}	0.04±0.00^{d}	0.76±0.0l^{c}	<0.0001
Mn	0.36±0.01^{b}	1.42±0.02^{a}	0.0l±0.00^{d}	0.23±0.03^{c}	<0.0001

^{abcd}: Means within column with different super-script indicate significant difference at P<0.05
Note: Zn = Zinc, Cu= Copper Mn = Manganese; TI= Untreated *Pennisetum purpureum* Hay (UPPH); T2= *Pennisetum purpureum* hay treated with wood ash (PPHWA); T3= *Pennisetum purpureum* Hay treated with Cow dung Ash (PPHCDA); T4= *Pennisetum purpureum* hay treated with Poultry litter ash (PPHPLA).

Table 4: Mean dry matter intake (MDI kg/DM) and coefficient of preference (CoP) of different alkali treated *Pennisetum purpureum* hays

Treatments	MD1(kg/DM)	CoP	Rank
T1	0.213	1.41	1st
T2	0.155	1.02	2nd
T3	0.123	0.82	3rd
T4	0.113	0.75	4th

^{abcd}: Means within column with different superscript indicate significant difference at P<0.05
TI= Untreated *Pennisetum purpureum* Hay (UPPH); T2= *Pennisetum purpureum* hay treated with wood ash (PPHWA); T3= *Pennistum purpureum* Hay treated with Cow dung Ash (PPHCDA); T4= *Pennisetum purpureum* hay treated with Poultry litter ash (PPHPLA).

Acceptability of the alkali treated *Pennisetum purpureum* hays by WAD goats are as shown in Table 4. Generally, the dry matter intake was low and this must have been as a result of the coarse texture of the hays since they were harvested in the dry season. Low dry matter intake of elephant grass silage with cassava peels was reported earlier (Olorunnisomo and Fayomi, 2008). The untreated *Pennisetum purpureum* hay and wood ash treated *Pennisetum purpureum* hay were acceptable by WAD goats. However, cow dung ash and poultry litter ash treated PPH were rejected by WAD goats. The rejection was probably due to smell and the appearance of the treated forages.

CONCLUSION AND APPLICATION

These results reveal that wood ash confer higher levels of macro and micro minerals on forages and hence improve their mineral profile and nutritive value. However, in terms of protein, NFE and ether extract content, PPHPLA was superior to others. Further studies are recommended to find solution to the offensive odour from poultry and cow dung ash that resulted in animals rejecting hays treated with them.

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