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Performance and Digestibility in Nubian Goats Fed Steam Treated Sorghum Stover

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Abstract: The effects of steam under pressure treatment on sorghum stover (Tabat variety) Dry Matter Intake (DMI), water consumption, body weight changes and digestibility were studied in the Gezira, Sudan. Sorghum stover was steam treated at 4 kg/cm^2 for 15 min (ST_1S) or 30 min (ST_2S) or not treated (US) as the control and fed to twelve female Nubian goats (four foreach treatment). Dry matter intakes (g/d, g/kg LW and g/kgW$^{0.75}$) were decreased with steam treatment with no significant differences among treatments. It was (55.81, 54.00 and 54.01) g/kgW$^{0.75}$ for US, ST_1S and ST_2S, respectively. Weekly weight loss (kg) was decreased by steam treatments and was 0.097, 0.062 and 0.0 kg/week for US, ST_1S and ST_2S, respectively. Water intake (g/d) was increased by steam treatment at 15 min (3405) and decreased at 30 min treatment (2948). Steam treatments decreased sorghum stover apparent digestibilities, except for CF and EE at 30 min.

Key words: Sorghum stover, digestibility, steam treatment, Nubian goats

INTRODUCTION

Nutrition is one of the main constraints for animal production in the Sudan, since most animals are reared in traditional systems based on natural pastures with seasonal migrations for feed and water (Elhag, 1984). The seasonal pattern of rainfall is associated with seasonal variations in available feeds and their nutritive value which are diminishing in the dry season with serious impacts on animals' health and performance.

Straws are important feed resources to fill the gap between animals' nutrient requirements and pasture yields (National Strategy, 2002). Straws are inferior in chemical composition with high fibres and low CP (Sundstol and Owen, 1984) limiting dry matter intake and performance when used untreated (Preston, 1986). The major constraint in using straws is their low digestibility due to the lignin component of the cell wall and its association with other cell wall carbohydrates (Kerley *et al*., 1987).

Many procedures are employed to upgrade the nutritive value of straws and to enhance Dry Matter Intake (DMI) using physical, chemical, biological methods and their combinations. Steam under pressure is conducted to upgrade the nutritive value and utilization of straws (He *et al*., 1989; Viola *et al*., 2008) and it increased DMD of maize cobs, bagasse and pith with no effect on *in vitro* DMD of rice straw (Abaza *et al*., 1981). Microbial growth in the rumen is generally limited by energy rather than N supply (Russell *et al*., 1992). Steam processing of low quality roughages has been recommended to increase energy availability (Bender *et al*., 1968). There is no information on the effects of steam treatment of sorghum stover on the digestibility and performance of Nubian goats in the Sudan. Consequently, this project was launched to investigate the effects of steam on the nutritive value of straw.

MATERIALS AND METHODS

Source of steam: Steam under pressure for treating stover was produced using boiler unit. The treatment was conducted at the laboratory of the Faculty of Engineering and Technology, University of Gezira, Wad Medani. The unit for steam production was manufactured by Falton in England. It was operated by diesel and electricity. The unit consists of a boiler, pipes and a steel container where the steam is injected.

Chopped sorghum stover (96% DM) was placed in the container and was steamed at required pressure (4 kg/cm^2) for different times (15 or 30 min). The time was calculated after reaching the desired pressure and the pressure was controlled by opening the valves. When the planed pressure and time were reached a tank valve was suddenly opened and the pressure was released and then the lid of the container was opened. Treated stover was removed manually from the container.

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Preparation of the experimental diets: In this experiment chopped sorghum stover (Tabat variety) was divided into three portions. The first part was not treated (control diet). The second was steam treated under pressure 4 kg/cm^2 for 15 min. The third part was treated with 4 kg/cm^2 steam for 30 min. The treatment was by direct steam injection in the boiler unit described before. The treated stover was spread on plastic sheets, sun-dried for 3 days and stored in plastic bags under room temperature.

Animals: Twelve female Nubian goats about 1.5-2 years old and with an average BW of 26.63±2.10 kg were used in this experiment. They were ranked according to body weight and randomly allocated to the three treatments with four animals for each treatment. The animals' treated against ecto (Amitraz) and endo (Albendazole) parasites, ear tagged and housed in individual pens (1 m x 1.5 m).

Feeding: The three rations were offered *ad libitum* in two equal meals at 9:00 am and 4:00 pm. The control group was offered Untreated Sorghum Stover (US). The second group was offered sorghum stover steam - treated for 15 min (ST_1S).The third group was given sorghum stover steam-treated for 30 min (ST_2S). A concentrate mixture was offered to all groups (235 g/head/day) in a separate feeder once daily before the roughage. The composition of the concentrates mixture is shown in Table 1. The experiment lasted 9 weeks with the first week as an adaptation period.

Table 1: The composition of the concentrate mixture offered to Nubian goats fed Steam treated sorghum stover

Ingredients (As fed)	%
Sorghum grain	48
Wheat bran	35
Groundnut cake	7
Molass	6.5
Limestone	1.5
Common salt	1.0
Mineral/vitamin mix	1.0
CP	15.5
ME (MJ/kg DM)	11.17

Parameters studied: The parameters studied were Dry Matter Intake (DM1), water consumption, body weight changes and digestibility.

Voluntary feed intake: The daily DM1 for each goat was calculated by the difference of the feed offered and the refusals on dry matter bases.

Water intake: The daily water intake for each animal in all groups was recorded daily for the last 7 days.

Body weight changes: The body weight of each goat was recorded at the beginning of the experiment. They were weighed weekly before the morning meal throughout the experiment.

Digestibility: A digestibility trial was conducted with the same animals at the last week of the experiment.

Dry matter intake: The offered feeds and their refusals were weighed daily for each animal to determine daily intake. Samples of feeds offered and refusals were collected for proximate analysis. Daily DMI for each animal was calculated.

Faecal output: The animals were fitted with nylon bags for faecal collection and were emptied daily. Faeces collected for each animal were weighed and representative 10% samples were taken for DM determination. Daily DM faecal output for each animal was calculated. The remaining faecal samples were separately stored for proximate analysis.

Statistical analysis: Results were analyzed by ANOVA for completely Randomized design using the general linear model procedure (SAS, 1997).Mean comparison was carried out by Scheffes test with an alpha level of 0.05.

RESULTS

Table 2 shows effects of steam treatment of sorghum stover on DMI, water intake and body weight changes in Nubian goats in the Gezira, Sudan.

Dry matter intakes (g/d, g/kg LW and g/kg $W^{0.75}$) were decreased by steam treatment for 15 and 30 min with no significant differences ($p>0.05$) among treatments. It was also decreased when expressed as percentages of live weight and metabolic body weight.

Water intakes (g/d, g/kg LW and g/kg $W^{0.75}$) were increased by steam treatment for 15 min and were decreased for 30 min which were lower than the untreated sorghum stover. Similar trends were observed when water intake was expressed as percentages of body weight and metabolic weight. Water intake expressed as part of DMI was increased by steam treatment for 15 min and decreased for 30 min which was lower than untreated stover. Weekly weight loss (kg) was decreased by steam treatments.

Table 3 shows *in vivo* digestibility of sorghum stover treated with steam under pressure in Nubian goats in the Gezira, Sudan.

Steam treatments generally decreased DM, OM and CP apparent digestibilities, but not significantly ($p<0.05$). Steam treatment for 15 min had the least DM, OM and CP digestibilities. Ether extract and CF digestibilities were increased with 30 min steam treatment and decreased by 15 min treatment. However, these effects were only significant for CF.

Table 2: The effects of steam under pressure treatments of sorghum stover (Tabat variety) on DMI, water intake and body weight changes in Nubian goats in the Gezira, Sudan

Treatment	US	ST_1S	ST_2S	SE	CV (%)
DMI					
g/d	647	640	627	8.02	4.59
g/kg LW	24.67	23.70	23.88	0.52	1.94
g/kgW^{75}	55.81	54.00	54.01	0.93	3.40
%LW	2.47	2.28	2.39		
% W^{75}	5.58	5.40	5.40		
Water intake					
g/d	3285	3405	2948	111.37	11.31
g/kg LW	125.34	125.91	111.90	4.38	15.04
g/kgW^{75}	283.54	287.04	253.31	9.43	31.61
%LW	12.53	12.59	11.19		
%W^{75}	28.35	38.27	25.33		
Kg/kg DMI	5.08	5.32	4.68		
LW loss (kg/wk)	0.097	0.062	0.00	0.056	19.79

US = Untreated Sorghum Straw. ST_1S = Steam-Treated Sorghum Stover, (4 kg/cm^2 for 15 min). ST_2S = Steam-Treated Sorghum Straw (4 kg/cm^2 for 30 min). SE = Standard Error of Mean. Means in same row with different superscripts are significantly ($p<0.05$) different

Table 3: *In vivo* digestibility (%) of steam under pressure treated sorghum stover in Nubian goats in the Gezira, Sudan

Treatments	DM	OM	CP	EE	CF
US	54.12	54.80	64.96	$62.71^{b,a}$	32.51^{a}
ST_1S	43.32	45.56	59.98	50.41^{b}	14.27^{b}
ST_2S	51.78	50.16	62.98	73.52^{a}	37.58^{a}
SE	2.323	2.253	1.641	3.754	3.669
CV (%)	14.28	14.84	9.34	15.06	28.42

US = Untreated Sorghum Straw; ST_1S = Steam Treated Sorghum Straw (4 kg/cm^2 for 15 min); ST_2S = Steam Treated Sorghum Straw (4 kg/cm^2 for 30 min); Means in the same column with different superscripts are significantly ($p<0.05$) different, SE = Standard Error of Mean

DISCUSSION

Dry matter intake: The dry matter intake of stover in this experiment (2.28-2.47% of the live body weight) was within the minimum range (2.1-6.3%) for goats (Devendra and Mcleroy, 1982). The low intake was mainly due to the fibre content and gutfil (Van Soest, 1982). Steam treatments had slightly, but not significantly depressed DMI. However, many workers (Rangnekar *et al*., 1982; Awadelkerim and Osman, 1993; Hou *et al*., 1997) reported improvements in DM1 for steam treatments. The variations in response could be due to differences in treatment conditions affecting chemical reactions and formation of browning compounds and the extent of nutrient solublization and losses. Many factors were reported affecting Maillard reaction products including temperature, duration, moisture content and type of substrates (Van Soest, 1982; Tipson and Horton, 1988). The duration of steam treatment had no significant effects on DMI indicating that it is better to treat for 15 min to reduce costs.

Water intake: Water intake of untreated sorghum stover in this study (3.3 L/day) was close to that reported by Awadelkariem and Osman (1993) for wheat straw (3.4 L/kg). Water intake was increased by steam treatment for 15 min and decreased after that, but not significantly. The increased water intake with steam treatment was similar to the findings of Rangnekar *et al*. (1982) and Awadelkerim and Osman (1993). Water intake was close for all feeds when expressed as L/Kg DMI and this was mainly due to non significant differences on DMI for steam treatment.

Weight loss: The higher weight loss when goats fed sorghum stover was expected due to the low N and higher CF depressing rumen fermentation and DMI. This is supported by the findings of Preston (1995) who suggested strategies for improving the soluble nutrients for rumen microbes. The reduced weight loss with steam treatment indicated the beneficial effects of the treatment and the response would have been better if effluents were added. The thirty min treatment prevented the weight loss although DMI was the least among treatments suggesting an improvement in nutritive value. The thirty min treatment significantly improved EE, CP and ash and significantly decreased CF and NFE indicating improved chemical composition and could be due to increased delignification. The 30 min treatment had also improved CF and EE digestibilities.

***In vivo* digestibility:** The least digestibility of sorghum stover steam-treated for 15 min was supported with the findings of Awadelkerim and Osman (1993) where more than 30% of steam-treated wheat straw at 125°C for 15 min had adversely affected OM, DM and CP digestibilities.

Dry matter, OM and CP digestibilities for 30 min steam treatment were close to the untreated straw. However, many workers reported improvements in apparent digestibility for steam treatment (Rangnekar *et al*., 1982; He, *et al*., 1989 and Hou *et al*., 1997). Furthermore, high steam pressure (30 kg/cm^2) had increased *in vitro* digestibility by 20% (Gugloz *et al*., 1971) and improved in vivo digestibility of straw by 25% at 1980c for 2-5 min (Viola *et al*., 2008). This could be because the pressure used in our experiment was not sufficient to exert marked effects. This agrees with the findings of Castro (1994) where mild steam treatment was ineffective in solubilizing hemicellulose. Steam treatment had decreased CP digestibility and could be due to browning reaction which is indigestible (Zahedifar, 1996). The improved EE and CF digestibilities at the higher duration were in line with the findings of Pearce (1982). This could be because steam treatment reduced lignin and cellulose, solubilized nutrients and increased reducing sugars.

The decreased digestibility at 15 min for all nutrients was mainly due to the lower pressure and duration and browning effect. Higher pressure and longer durations are required for optimum effects.

Conclusion: Tabat steam treatment (4 kg/cm^2 for 15 or 30 min) decreased DMI but it increased water consumption. Steam treatment of Tabat (4 kg/cm^2) not significantly decreased apparent digestibility except for EE and CF which were increased at 30 min. The increased in apparent digestibility for CF and prevention in weight losses at 30 min treatment indicating that the long duration of treatment had a better effect on fibre fraction.

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