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Relative intake, nutrients utilization, nitrogen balance and fermentation pattern in sheep fed stay-green and go-brown sorghum silage

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ABSTRACT

Based on 2 years evaluation of 6 stay green and 4 go brown sorghum cultivars for nutritional and morphological attributes, 2 promising cultivars each of stay green (M35–1 and CSV–15) and go brown sorghum (HD–20 and J Sel–10) were gown, harvested 1 month after grain collection and then conserved as silage. Silage was fed *ad lib.* to 16 crossbred sheep divided equally to silage of each cultivar. Metabolism trial was conducted to assess intake, nutrients utilization and N balance, and rumen liquor samples were collected at 0 h to determine the rumen fermentation pattern. The intake of stay green sorghum was higher than go brown. Similarly $w^{0.75}$ intake of DE, TDN and DCP was higher in sheep fed stay green sorghum silage. Sheep fed stay green sorghum silage had 4–5 units more nutrients digestibility. OM and hemicellulose digestibility was higher in animals fed stay green. N absorption and retention was higher in sheep stay green than go brown sorghum silage. DCP, TDN and DE contents of stay green sorghum were higher than go brown sorghum silage. Mean NH_3–N contents were higher in rumen liquor of sheep fed stay green than go brown sorghum silage. Results indicated that silage from stay green sorghum cultivars is more palatable and nutritious than go brown cultivars.

Key words: Fermentation pattern, Nitrogen balance, Sheep, Silage, Stay green sorghum

Sorghum, a major multifunctional C_4 cereal crop, is used for feed food, fodder and fabrication. Due to moisture stress, sorghum genotypes tend to be dried by grain harvesting resulting in poor yield and poor nutritional value. Stay green is a trait associated with moisture stress resistance and retains their leaves in an active photosynthetic state. Stay green genotypes have also been reported to contain more cytokinin (McBee 1984) and basal stem sugars (Duncan 1984) compared with go-brown cultivars. Stay green sorghum had higher fodder yield under limited water conditions (Borrell *et al.* 2000) and have higher number of green leaves due to reduced senescence than go brown (Borrell *et al.* 2000). Introduction of drought resistant, stay green sorghum stover which retains nutritional superiority for longer time into the dry period than conventional go brown types has the potentiality to improve ruminant feed quality/quantity. This will help to utilize the significance of stay green characteristics in sorghum is to be evaluated in relation to sustainability of livestock production, with this; it was hypothesized that the silage prepared from stay green cultivars would be more nutritious.

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MATERIALS AND METHODS

From 2 years study with 6 stay green (M35–1, A2267–2, SPV1284, CSV–15, GSS–21, B–24) and 4 go brown (IS4859, HD–20, J Sel–10, IS2179) cultivars of sorghum, 2 varieties each of stay green (M 35–1 and CSV–15) and go brown (J Sel–10 and HD–20) were selected based on their nutritional (CP, NDF, ADF, cellulose, sugar contents and IVDMD) and morphological (green fodder yield, number of leaves, leaf width, leaf length etc.) traits for *in vivo* studies. These varieties were grown on larger area under similar agronomic practices during *kharif* in Crop Improvement Division at IGFRI, Jhansi, India.

Silage preparation

Both types (stay vs. go brown) of cultivars harvested 1 month after grain collection were chopped with electrically operated chaff cutter and ensiled in big size polythene sheets (bags). The DM contents were 41.54, 38.71 and 48.8, 42.11% for stay green (M35–1, CSV15) and go brown (Jsel–10,

HD20) cultivars at the time of chopping for silage making. After 40 days of ensiling, bags were opened and silage was evaluated both for biochemical (pH, NH_3, VFA, lactic acid) and physical (colour, odor/smell etc) traits.

Animals, feeding and metabolism trial

Sixteen crossbred sheep (local × Corridale) with average body weight of 25.70±1.99 kg were randomly alloted to silage of 4 different cultivars with 4 animals in each. The animals were fed sole silage *ad lib.* for more than 1 month and then 7 days metabolism trial was conducted by keeping animals in metabolic cages. At the end of metabolism trial rumen liquor samples were also collected before feeding using stomach perforated tube to estimate rumen metabolites.

Analytical and statistical techniques

DM and total-N of silage, faeces, residue and urine were determined as per AOAC (1992). For estimation of pH and NH_3–N 10 g sample of silage was macerated with 100 ml of distilled water for 3 min in a blender and then filtered. The pH of the filtrate was measured using electronic pH meter, and NH_3–N as per Conway (1957). For VFA 50 g of silage sample was used and VFA were estimated as per Daniel (1970). Lactic acid in silage was estimated as per Barker and Summerson (1962).

Fibre contents of silage and faeces samples were estimated as per Goering and Van Soest (1970), and gross energy as per of Oshea and Maguire (1962). Total volatile fatty acids and total-N, TCA-soluble-N and NH_3–N were estimated as per Briggs *et al.* (1957) and McKenzie and Wallace (1954), respectively.

Data for silage quality, intake, nutrients utilization, N-balance, DCP, TDN, DE and rumen metabolites were statistically analyzed using GLM of SPPS 10.0. Duncan's multiple range test was used to differentiate the means at $P<0.05$ level of significance.

Table 1. Biochemical characteristics of stay green and go brown sorghum silage

Sorghum cultivars	DM	pH	VFA	NH_3–N	Lactic acid
Stay green					
CSV–15	34.24	4.81	12.41	13.25	1.73
M 35–1	38.07	4.57	10.83	8.20	2.32
Mean	36.15	4.69	11.62	10.72	2.03
Go brown					
J sel–10	36.96	4.70	6.16	10.58	1.05
Hd–20	38.24	4.32	11.50	10.63	2.08
Mean	37.40	4.51	8.83	10.60	1.94
SEM	0.93	0.10	1.39	1.03	–

SEM, Standard error of means.

RESULTS AND DISCUSSION

Silage quality

Mean pH of stay green and go brown silage was 4.69 and 4.51, respectively (Table 1) that corroborates with NRC (1985) pH values. Mean NH_3 (% of total N), TVFA concentration (Meq/100g DM) and lactic acid (%), values are given in Table 1 respectively. The production of NH_3 and lactic acid during ensiling depends on the protein content and its solubility and water-soluble carbohydrates, respectively. Well-preserved silage should have ammonia-N concentration less than 10 g/kg total nitrogen and this value is close to the values of present study. Ali *et al.* (2004) reported higher lactic acid (6.27) and low pH of sorghum silage than values of present study. This might be due to low DM (27.9) and higher water-soluble carbohydrates in sorghum at ensiling than stay green and go brown silage of present study (40.12 -stay green and 45.45%-go brown) as more soluble carbohydrates results in higher lactic acid production during fermentation.

Chemical composition and nutrients intake

CP in stay green and go brown sorghum silage offered to sheep was comparable, while NDF and ADF (units) were lower in former than later sorghum silage (Table 2). Chemical constituents of normal sorghum silage were reported earlier (Madibela *et al.* 2002, Ali *et al.* 2004). Relatively low CP

Table 2. Chemical composition of stay-green and go-brown sorghum silage

Sorghum cultivars	DM	OM	CP	NDF	ADF	Cellulose	Hemi-cellulose	Lignin	EE	GE
Stay green										
CSV15	46.51	87.7	5.4	68.43	41.02	31.98	25.41	4.55	1.1	3.74
M35–1	50.0	89.5	5.8	67.43	41.75	31.63	25.68	4.68	1.0	3.86
Mean	48.22	88.6	5.6	67.93	41.38	31.80	25.54	4.61	1.05	3.80
Go brown										
Jsel–10	46.16	89.8	5.4	69.86	42.62	32.13	27.24	4.00	1.17	3.65
HD–20	44.15	88.8	5.0	73.11	42.58	31.36	30.53	4.00	1.23	3.79
Mean	45.15	89.3	5.2	71.48	42.60	31.74	28.88	4.00	1.20	3.72
SEM	1.21	0.46	0.16	1.24	0.38	0.17	1.17	0.18	0.005	0.04

SEM, Standard error of means.

Table 3. Dry matter intake in sheep fed stay-green and go-brown sorghum silage

Intake	g/d	% Body weight	g/kg $w^{0.75}$
Stay green			
CSV–15	856.6	3.32	74.55
M 35–1	1001.6	4.04	89.98
Mean	929.1	3.68	82.26
Go brown			
Jsel–10	875.6	3.39	76.41
HD–20	765.6	3.08	68.67
Mean	820.6	3.24	72.54
SEM	48.59	0.20	4.50
Significance	NS	NS	*

NS, Nonsignificant; SEM, standard error of means.

Table 4. Nutrients intake (g/kg $W^{0.75}$) in sheep fed stay-green and go-brown sorghum silage

Nutrients intake	DE	TDN	DCP
Stay green sorghum			
CSV–15	1.50	36.19	2.11
M 35–1	2.04	49.04	3.08
Mean	1.77	42.61	2.59
Go brown sorghum			
Jsel–10	1.54	34.57	2.29
HD–20	1.30	32.75	1.74
Mean	1.42	33.60	2.01
Significance	*	*	*
SEM	0.15	3.31	0.28

*Significant at P<0.05; SEM, standard error of means.

and high fibre of stay green and go brown sorghum silage of present study may be partly due to ensiling of sorghum at more mature stage as with the advancing maturity cell contents decline and cell wall contents increases (Siegal 1986).

In animals fed stay green g/kg $w^{0.75}$ intake was significantly (P<0.05) higher than go brown sorghum silage (Table 3). This variation in intake may be attributed to low NDF in stay green than go brown. Hanzell *et al.* (1992) reported higher DMI of stay green than go brown sorghum. Allen (2000) summarized 15 studies and showed a general decline in DMI with increasing NDF concentration in diets when diets exceed 25% NDF. Steen *et al.* (1998) reported significant effect of fibre and nitrogen concentration, forage digestibility and DM content on grass silage intake in cattle. Nutrients (DE, TDN and DCP) intake on g/kg $W^{0.75}$ weight was significantly (P<0.05) higher in sheep fed stay-green silage than animals fed go-brown sorghum silage (Table 4). This variation in DCP, TDN and DE intake between stay green and go brown silage may be due to higher nutrients digestibility and DMI in sheep fed stay green sorghum silage.

Nutrients utilization: Sheep fed stay-green had higher DMD than animals fed go-brown sorghum silage (Table 5). OM and hemicellulose digestibility was significantly higher in animals fed stay green than go brown sorghum silage. Sheep fed stay green silage had 6 units more CP digestibility than go-brown. Higher IVDMD of stay green sorghum cultivars than go brown sorghum was reported by Singh *et al.* (1999). Digestibility of DM, OM, NDF and ADF of sorghum silage in sheep observed by Ali *et al.* (2004) corroborates to the nutrients digestibility of go brown silage but lower by 3–4 units than stay green sorghum silage of present study.

Nitrogen balance: Mean N intake (g/day) was more in sheep fed stay-green than go-brown silage fed sheep (Table 6). Urinary N excretion (g/d) was almost 2 times in sheep fed go brown than stay green silage fed animals. N retention and absorption (g/d) was (P<0.05) higher in stay green than in go brown silage fed sheep. This variation in N utilization may be partly due to higher intake and lower urinary N excretion in sheep fed stay green sorghum silage.

Nutritive value: DCP, TDN and DE values of stay green

Table 5. Nutrient utilization in sheep and goat fed stay-green and go-brown sorghum silage

Nutrients digestibility	DM	OM	CP	NDF	ADF	Cellulose	Hemicellulose
Stay-green							
CSV–15	57.70	60.6	54.5	58.1	54.8	69.23	61.0
M 35–1	57.26	60.74	55.68	58.8	53.32	67.16	67.51
Mean	57.5	60.67	55.09	58.45	54.06	68.19	64.25
Go brown							
J sel–10	53.75	56.4	52.14	54.15	51.88	65.99	58.17
HD–20	50.64	53.17	46.18	55.36	47.36	61.99	58.65
Mean	52.19	54.78	49.16	54.75	49.62	63.99	58.41
Significant at P<0.05		*	NS	NS	NS	NS	*
SEM	1.65	1.82	2.13	1.14	1.67	1.52	2.10

NS, Nonsignificant; SEM, standard error of means.

Table 6. Nitrogen balance of animals fed stay-green and go-brown sorghum silage

Nitrogen balance/	Stay green			Go brown			
Cultivars	CSV–15	M 35–1	Mean	Jsel–10	HD–20	Mean	SEM
Intake g/d	7.8	9.81	8.80	7.98	6.64	7.31	0.65
Faecal out put	3.14	4.34	3.74	3.76	3.62	3.69	0.24
Retention*	4.66	5.47	5.06	3.22	3.02	3.12	0.58
Urinal output	0.35	0.78	0.56	1.23	0.84	1.03	0.18
N absorbed*	4.30	4.68	4.49	2.15	2.17	2.16	0.67

*Significant at P<0.05.

sorghum silage were (P<0.05) higher compared to go brown sorghum silage (Table 7). However, highest and lowest nutritive values were recorded in M35–1 and HD-20 sorghum silage, respectively. Higher nutrients digestibility and more DMI in sheep fed stay green silage may be partly responsible for its higher nutritive value

Rumen fermentation: Total volatile fatty acid concentration (meq/l) was higher in rumen liquor of sheep fed stay green silage than go-brown silage offered sheep (Table 8). Mean

Table 7. Nutritive value stay-green and go-brown sorghum silage fed to sheep

Nutritive value	DCP	TDN	DE
Stay green			
CSV–15	3.1	52.70	2.19
M 35–1	3.42	55.70	2.28
Mean	3.26	54.2	2.23
Go brown			
J Sel–10	3.01	49.83	1.91
HD–20	2.54	47.67	1.90
Mean	2.77	48.75	1.90
SEM	0.18	1.74	0.01
Significant at P<0.05	*	*	*

SEM: Standard error of means.

Table 8. Rumen metabolites concentration in rumen liquor of sheep fed stay-green and go-brown sorghum silage

Rumen metabolites	pH	TVFA	Total-N	NH_3–N	TCA-N
Stay green					
CSV–15	6.91	138.6	49.2	9.38	21.0
M 35–1	7.21	171.1	61.4	9.80	22.5
Mean	7.06	154.8	55.30	9.56	21.75
Go brown					
Jsel–10	7.02	134.6	56.6	8.17	19.3
HD–20	6.62	146.6	48.4	7.0	18.9
Mean	6.82	140.6	52.50	7.58	19.1
SEM	0.12	8.18	3.10	0.63	0.82
Significant at P<0.05	NS	NS	NS	*	NS

NS: Nonsignificant; SEM: Standard error of means.

NH_3–N concentration was significantly (P<0.05) higher in rumen liquor of sheep offered stay green sorghum silage (9.56) than go brown sorghum silage (7.58 mg/100 ml). The concentration of total-N, NH_3–N and TCA soluble -N was the highest in rumen of animals fed M 35–1 stay green sorghum silage while the lowest value of these N-metabolites was observed in animals fed HD–20 go brown sorghum silage. The higher TVFA and nitrogen metabolites in rumen of sheep fed stay green sorghum silage may be due to more nutrients digestibility particularly the fiber and protein.

Evaluation of stay green vis-à-vis go brown sorghum cultivars revealed that DM and nutrients intake along with their digestibility is relatively more for stay green sorghum silage. More DCP, TDN and DE contents along with higher metabolites in sheep fed stay green silage indicates nutritional superiority of stay green cultivars over conventional go brown cultivars.

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