Nutritional Evaluation of Two Promising Varieties of Forage Sorghum in Sheep Fed as Silage

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ABSTRACT : Two promising varieties of forage sorghum viz. HD-15 and J. Sel-10 were identified for their higher forage yield (350-400 quintals per hectare) compared to traditional/existing variety, HC-136 at Indian Grassland and Fodder Research Institute, Jhansi. Silage of these three forage sorghum varieties viz., HD-15, J.Sel-10 and HC-136 were prepared in three concrete silos for their nutritional evaluation in sheep. Twelve adult Muzaffarnagari Ewes, divided into three equal groups of 4 each, were offered a particular variety of sorghum silage *ad libitum* over a period of 30 days followed by a 6 day metabolism trial and a collection of rumen liquor and blood samples. The HD-15 variety of forage sorghum silage contained higher crude protein (CP) than both the J.Sel-10 and HC-136. Average daily dry matter (DM) intake (% of live weight) differed significantly ($p<0.05$) in sheep that were fed the different varieties of silage, with the maximum amount in HD-15 (2.55) followed by J.Sel-10 (2.49) and HC-136 (1.84). The average apparent digestibility of all the nutrients was low in the sheep that were fed the HC-136 variety of sorghum silage when compared to both HD-15 and J.Sel-10. However, digestibility of organic matter ($p<0.05$) and crude protein ($p<0.01$) was significantly low in the HC-136 variety. The average daily nitrogen retention was-0.19, 2.15 and 0.42 g in HC-136, HD-15 and J.Sel-10, respectively which differed significantly ($p<0.01$). The average digestible crude protein and total digestible nutrient (TDN) contents (%) of the silage varieties were higher in HD-15 (3.14 and 55.3) than HC-136 (0.25 and 58.6) and J.Sel-10 (1.58 and 55.3) varieties. On comparing to the maintenance requirements (ICAR, 1985) for dry matter, crude protein and total digestible nutrients, both the improved varieties (HD-15 and J.Sel-10) almost met the requirements except crude protein, which met only 73.3% of the requirement by J.Sel-10, while the HC-136 variety was unable to meet the requirements. The average rumen pH and total volatile fatty acids concentrations were comparable among the groups. However, concentrations of nitrogen metabolites were higher in the animals fed the HD-15 variety of silage. Varieties of sorghum silage also did not have any influence on the concentration of the blood metabolites. It was concluded that the HD-15 variety of sorghum silage was nutritionally superior to both J.Sel-10 and HC-136 silage. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 12 : 1715-1720)***

Key Words : Nutritional Evaluation, Forage Sorghum Varieties, Silage, Sheep

INTRODUCTION

Sorghum (*Sorghum bicolor*) is the most important crop during *Kharif* (short duration rainy, hot and humid crop growing period) season and is grown over a wide range of soil types, providing food grain for humans and forage for their livestock in arid and semi-arid regions (Narayanan and Dabadghao, 1972). Sorghum for forage is grown over 2.6 million hectares in India, which contributes about 60-70% of the total green forage supply during *Kharif*. It is palatable to the ruminants and can be fed as green, dry or in the silage form (Gupta et al., 2000). During recent years, different varieties of sorghum have been developed but the problem associated with the existing varieties of forage sorghum is their low nutritional value. Again achieving consistency in animal production throughout the year is a major challenge in India. In tropical countries including India, it is accepted that the disadvantages of seasonal deficits can considerably be reduced by the conservation of excess forage produced in an earlier season and feeding back in periods of the deficiency. Green forage is not available during lean/summer months of April, May and June and conserved forage like silage may be fed to the animals during this period (Ranjhan, 1993).

While concerted effort in the sorghum breeding program has led to identifying two promising varieties of forage sorghum viz. HD-15 and J.Sel-10 because of their higher green forage yield (350-400 quintals per hectare) at Indian Grassland and Fodder Research Institute, Jhansi (Anon. 1998). Such genetically improved and location specific varieties of forage with higher yields are essential to achieve sustainable productivity of livestock (Swaminathan, 1991). But the quality of a forage along with its yield is also important to meet the nutritional requirement of livestock. (Reid, 1973). Hence, the present investigation was undertaken to evaluate the newly developed and promising sorghum forage varieties (HD-15 and J.Sel-10) and compared against the existing national check/ traditional variety (HC-136) for their nutritional quality in sheep fed as silage during the summer months.

MATERIALS AND METHODS

Sorghum cultivation and ensiling

Three varieties of forage sorghum viz. HD-15, J.Sel-10

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Table 1. Chemical composition and IVDMD (% DM basis) of three varieties of sorghum as green and silage

Attributes	Variety		
	HC-136	HD-15	J.Sel-10
Green			
OM	94.14	90.90	93.99
CP	5.38	8.20	6.09
EE	1.69	1.78	1.52
NDF	65.53	66.18	67.19
ADF	36.54	35.35	37.50
Cellulose	31.28	29.14	32.32
ADL	4.32	3.83	4.48
Total ash	5.86	9.10	6.09
IVDMD	54.30	61.43	56.89
Silage			
OM	92.35	89.82	86.37
CP	5.24	7.43	5.87
EE	2.13	2.16	2.03
NDF	80.87	81.96	79.89
ADF	48.96	51.00	50.35
Cellulose	39.38	39.27	38.84
ADL	7.35	7.36	8.27
Total ash	7.65	10.18	13.63
pH	4.2	3.8	4.1
Lactic acid	6.12	7.30	6.88
TVFA (meq/100 g)	17.62	23.70	19.55
NH_3-N (as % of total N)	8.41	7.36	9.10

OM = Organic matter, CP = Crude protein, EE = Ether extract.
NDF = Neutral detergent fibre, ADF = Acid detergent fibre.
ADL = Acid detergent lignin, IVDMD = *in vitro* dry matter digestibility.
TVFA = Total volatile fatty acids.

and HC-136 were grown on the sandy loam soil in a randomized block design with three replications under the uniform recommended agronomic practices (Hazra, 1995) at the Central Research Farm of Indian Grassland and Fodder Research Institute. These sorghum varieties were harvested after 75 days of sowing, chopped into pieces of 3-5 cm in length and ensiled separately into three cemented square pits (1.5×1.5×1.5 m) lined with plastic. The silage was manually packed into each silo. The pits were opened after 120 days to start the feeding trial with the sheep. The silages of all three varieties were good with sweet/pleasant aroma and greenish colour and were readily consumed by the sheep. The representative samples of forage from each variety were also collected for their nutritional evaluation as green feed.

Animals and experimental feeding

Each variety of conserved silage was then fed *ad libitum* to 12 adult, non-pregnant Muzaffarnagari Ewes consisting of 3 groups of 4 each. In addition, about 10 g of common salt and *ad libitum* clean drinking water were offered to each ewe daily. After 30 days of preliminary feeding, a digestion-cum-metabolism trial (Schneider and Flatt, 1975) consisting of a 6-day duration was conducted for the collection of feed, feces and urine samples. During the trial, DM offered, residues, feces and urine voided over a period of 24 hours were recorded. Representative samples of the feces collected were then dried in a hot air oven and pooled over a period of 6 days. For the analysis of N, aliquots of feces and urine were preserved in sulphuric acid and pooled over the same period.

Chemical analysis

Representative samples of green sorghum, feeds offered (silage), residues and excreta (feces/urine) were analyzed for proximate principles like moisture/dry matter, crude protein, ether extracts and total ash contents (AOAC, 1990), and cell wall fractions (Goering and Van Soest, 1970). The *in vitro* dry matter digestibility (IVDMD) of the green sorghum samples were also determined using the two-stage technique (Tilley and Terry, 1963) for a period of 72 hours. Samples (10 g) of sorghum silage varieties were macerated with 100 ml of distilled water for 3 minutes in warring blender and filtered. The filtrates were used for pH measurement and ammonia nitrogen analysis (Conway, 1957). Silage samples (50 g) were also taken and made up to 500 ml volume with distilled water and the contents were filtered after 24 h. The filtrates were analyzed for total volatile fatty acids (Daniel, 1970) and lactic acid (Barker and Summerson, 1941).

Rumen liquor and blood samples analysis

At the end of the metabolism trial, rumen liquor samples were collected through a stomach tube from each animal before feeding and watering, and then strained through nylon cloth. The pH was determined immediately and part of the strained rumen liquor (SRL) was preserved using a few drops of saturated mercuric chloride solutions for analysis of total volatile fatty acids (TVFA; Barnet and Reid, 1957). Also the total amount of nitrogen and trichloro acetic acid (TCA) soluble nitrogen was estimated by the Kjeldahl method (AOAC, 1990) and ammonia nitrogen (NH_3-N) was estimated by the micro-diffusion technique (Conway, 1957).

Blood samples were also collected via a jugular vein puncture from the experimental animals into sterilized glass tubes (with cap) containing sodium fluoride (5 mg/ ml) and heparin (0.2 mg/ml) for the preparation of plasma. The blood and plasma samples were then analyzed for haemoglobin (Wong, 1928), glucose (Cooper and McDaniel, 1970), protein (Biuret method; Reinhold, 1953) and urea nitrogen (Ralunutulla and Boyde, 1980).

Statistical analysis

The data was subjected to a statistical analysis of variance in a one-way classification for a completely randomized design as described in Snedecor and Cochran (1989). The test of significance among the treatment differences was also analyzed (SPSS, 1999).

Table 2. Nutrient utilization and N balance in sheep fed three varieties of sorghum silage

Attributes	Variety/group		
	HC-136	HD-15	J.Sel-10
Daily feed (DM) intake			
Total (g)	399±30.94	500±13.37	476±20.48
kg/100 kg B.Wt.*	1.84±0.07^{b}	2.55±0.21^{a}	2.49±0.21^{a}
g/ kg W $^{0.75}$ *	39.6±1.22^{b}	53.6±3.12^{a}	51.9±3.23^{a}
Digestibility (%)			
DM	58.5±1.91	66.0±2.90	62.8±0.52
OM*	61.8±2.21^{b}	70.5±2.53^{a}	63.0±0.48^{a}
CP**	4.9±0.79^{c}	42.3±4.33^{a}	26.1±2.86^{b}
EE	48.3±1.69	56.6±3.27	50.7±1.24
NDF	62.0±2.21	70.1±2.77	66.1±0.46
ADF	59.9±2.24	69.3±2.89	66.0±0.57
Cellulose	71.8±2.15	78.8±2.21	72.9±0.73
Nitrogen balance (g/d)			
N intake**	3.34±0.26^{c}	5.90±0.15^{a}	4.46±0.19^{b}
Faecal out-go	3.18±0.25	3.41±0.27	3.28±0.11
Urinary out-go**	0.36±0.04^{b}	0.34±0.03^{b}	0.75±0.07^{a}
Balance**	-0.19±0.04^{c}	2.15±0.27^{a}	0.42±0.12^{b}

Means bearing different superscripts in a row differ significantly (* $p<0.05$; ** $p<0.01$).

DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre.

RESULTS AND DISCUSSION

Chemical composition and utilization of nutrients

The chemical composition of three varieties of forage sorghum is presented in Table 1. There seems to be little difference with regards to the chemical constituents, except CP when compared among the varieties either as green or silage. The average CP content was comparatively higher in the HD-15 variety (8.20%) of green sorghum than that of both J.Sel-10 (6.09%) and HC-136 (5.38%). Similar was the trend with respect to CP content of sorghum silage varieties. The average *in vitro* dry matter digestibility (%) of green sorghum was also higher in HD-15 (61.43) when compared to J.Sel-10 (56.89) and HC-136 (54.30). However, the chemical composition, in general, was also similar to that reported earlier (Pachauri and Mojumdar, 1994; Gupta et al., 2000). It was again observed that irrespective of variety, there was loss of around 5.64% of CP when green sorghum was conserved as silage for lean period feeding. This was likely to be due to fermentation loss. Ether extract (EE) content increased from 1.66 to 2.10% in silage making. This increase EE content on ensiling indicated the possibilities of transformation of carbohydrates and other nutrients into fat. Similarly, there was an increase (37.41%) in ADF content on ensiling of green sorghum. These results thus indicated that green sorghum was superior to other forms like silage as observed earlier (Patel et al., 1968).

The chemical characteristics like pH, total volatile fatty acids (TVFA), lactic acid and NH3-N as percent of total nitrogen of all the silage varieties were also studied (Table 1) on opening of pits after 120 days of ensiling, since silages can even be stored for more than 180 days (Suksombat and Lounglawan, 2004) and remained stable upon aerobic exposure (Tai et al., 2002). The average pH, lactic acid and TVFA contents of all the silages remained fairly constant and varied from 3.8 to 4.2, 6.12 to 7.30% and 17.62 to 23.70 meq per 100 g, respectively. These were considered to be the normal in good quality silage (Johnson and Mc Clure, 1968; Upadhyay and Mojumdar, 1991). However, better fermentation quality in silage of forage is always not a clear indicator of its better palatability and intake in animals. Direct cut napier grass (*Pennisetum purpureum*) silage had better fermentation quality compared to wilted napier grass silage, but wilted silage was more ($p<0.01$) preferable to sheep.

On exclusive feeding of different varieties of sorghum silage to sheep, average daily dry matter intake (DMI) was 399, 500 and 476 g in HC-136, HD-15 and J.Sel-10, respectively and the differences were statistically nonsignificant ($p>0.05$) among the varieties (Table 2). However, DMI expressed as kg/100 kg body weight as well as g/kg W $^{0.75}$ was significant ($p<0.05$) among the varieties. Average DMI (% of live weight) was maximum in HD-15 (2.55) followed by J. Sel-10 (2.49) and HC-136 (1.84). Average DMI to a similar extent (2.25% of the body weight) was also recorded in milch cows fed on *ad libitum* sorghum silage as basal roughage (Pachauri and Mojumdar, 1994). This lower DMI in silage-based rations is associated with the longer time of retention of silage in the rumen, which appears to be caused by the difficulty of animals in regurgitating the partially digested silage (Minson and Wilson, 1994). Although there was wide variation (1.60 to 3.20 kg/100 kg body weight) in DMI of sorghum forage depending upon the species of animals and their physiological stages of maturity, physical form and nutrient contents (Patel et al., 1968; Panwar et al., 2000).

Average apparent digestibility of all the nutrients was low in sheep fed HC-136 variety of sorghum silage when compared to both HD-15 and J. Sel-10 (Table 2) and this might be associated with lower CP and higher fibre contents in HC-136 variety of sorghum silage. However, average digestibility of OM ($p<0.05$) and CP ($p<0.01$) was significantly low in HC-136 variety of sorghum silage. Apparent digestibility of CP was maximum in HD-15 (42.3%) followed by J. Sel-10 (26.1%) and HC-136 (4.9%), being attributed to different levels of nitrogen consumption in sheep fed different varieties of silage. The lower level of nitrogen/ protein consumption in HC-136 variety sorghum silage resulted in lower ($p<0.01$) apparent digestion coefficient of CP. This was due to increase in the ratio of metabolic fecal nitrogen to the undigested nitrogen of the feed in sheep (Ranjhan, 1993). While digestibility of EE

Table 3. Nutritive value and level of nutrition in comparison to requirement in sheep fed three varieties of sorghum silage

Attributes	Variety/group		
	HC-136	HD-15	J.Sel-10
Nutritive value (%)			
DCP**	0.25±0.04 0^{c}	3.14±0.32 ^{a}	1.58±0.16 ^{b}
TDN**	58.6±2.08^{b}	68.3±2.27^{a}	55.3±0.35^{b}
Level of nutrition vs. requirement			
Weight (kg)	21.8±1.95	20.3±2.34	19.7±2.26
DM			
Requirement (g/d)	533.8	506.3	496.0
Consumption (g/d)	399.3	500.5	475.9
Deficiency (%)	25.19	1.14	4.05
CP			
Requirement (g/d)	40.96	38.85	38.06
Consumption (g/d)	20.90	36.90	27.90
Deficiency (%)	48.97	5.01	26.69
TDN			
Requirement (g)	256.1	242.9	238.0
Consumption (g)	234.2	342.9	263.2
Deficiency/excess (%)	8.55	41.16	10.58

Means bearing different superscripts in a row differ significantly (** $p<0.01$).
DM = Dry matter, CP = Crude protein, DCP = Digestible crude protein, TDN = Total digestible nutrients.

and fibre fractions (NDF, ADF and cellulose) were comparable among the varieties of sorghum silage and with their similar nutrient contents. The digestibility of various nutrients to the similar extent was also reported in various species of animals fed on sorghum forage exclusively or mixed ration of forage and concentrates (Pathak and Jakhmola, 1983; Ward et al., 2001). The average daily nitrogen intake differed significantly ($p<0.01$) among the varieties of sorghum silage fed to sheep, being maximum in HD-15. This was due to comparatively higher DMI as well as higher nitrogen content in HD-15 variety of silage. Average daily nitrogen retention also varied significantly ($p<0.01$) among the varieties of sorghum silage fed to sheep, being maximum in HD-15. Animals fed HC-136 variety of sorghum silage were in negative nitrogen balance, which indicates the requirement of nitrogen supplement in this group of adult sheep for maintenance. There was also variation in the retention of nitrogen expressed as a percent of nitrogen intake (9.46 to 36.44%), indicating a difference in utilization of nitrogen from the varieties of silage in sheep. Similarly low nitrogen retention (as percent of nitrogen intake) was also recorded in cattle fed sorghum silage *ad libitum* (Patel et al., 1968).

Level of nutrition in comparison to requirement

The animals were on a different level of nutrition (Table 3) consuming different ($p<0.01$) quantities of CP/DCP and TDN. HD-15 variety (36.9 and 342 g) of sorghum silage supplied the maximum amount of CP and TDN, followed by J.Sel- 10 (27.9 and 262 g) and HC-136 (20.9 and 234 g). On comparing the maintenance requirements (ICAR, 1985) for DM, CP and TDN, both the improved varieties (HD-15 and J. Sel-10) almost met the requirements except CP, which was met only 73.3% of the requirement by J. Sel-10. However, ewes fed on J. Sel-10 variety of silage were also on positive nitrogen balance, probably through better utilization of nitrogen with higher TDN consumption. On the contrary, HC-136 variety of sorghum silage was unable to meet the requirements of the above-mentioned nutrients.

The sorghum varieties fed as silage differed significantly ($p<0.01$) with respect to their DCP and TDN contents (Table 3). The DCP content was maximum in HD-15 variety (3.14%) when compared to both HC-136 (0.25%) and J. Sel-10 (1.58%) and was attributed to both higher CP content as well as digestibility in HD-15 variety. Similarly TDN content was maximum in HD-15 variety (68.3%) of sorghum silage and was attributed to higher OM digestibility. Thus HD-15 variety of sorghum was found superior to both J. Sel-10 and HC-136. However, all the values corroborated well with the earlier reports in different species of animals fed either as green or silage (Gupta et al., 2000; Panwar et al., 2000). A lower DCP content to the extent of 1.14% was also reported in cattle fed sorghum silage (Pathak and Jakhmola, 1983).

Rumen and blood metabolites

The average pH and TVFA concentrations of rumen liquor samples were similar among the groups fed different varieties of sorghum silage (Table 4), even though there were significant differences in OM digestibility. However, the concentration of various nitrogen metabolites (total N, NH_3-N and TCA soluble-N) in the rumen were comparatively higher in animals fed HD-15 variety of sorghum silage, which might be due to higher ($p<0.01$)

Table 4. Rumen and blood metabolites in sheep fed three varieties of sorghum silage

Attributes	Variety/group		
	HC-136	HD-15	J.Sel-10
Rumen metabolites (unit/dl)			
pH	6.20±0.06	6.00±0.14	6.15±0.07
TVFA (meq)	11.5±0.05	12.7±0.76	12.0±0.61
Total N (mg)*	44.8±1.97^{b}	57.4±2.10^{a}	50.4±2.76^{ab}
NH_3-N (mg)	10.8±0.30	14.7±1.75	13.3±1.26
TCA-sol- N (mg)	33.6±1.97	40.6±3.05	36.4±1.40
Blood metabolites (unit/dl)			
Hemoglobin (g)	9.24±0.59	9.11±0.45	9.42±0.47
Glucose (mg)	45.26±1.18	45.60±3.12	48.66±2.44
Plasma protein (g)	7.36±0.41	7.50±0.48	7.51±0.53
Plasma urea-N (mg)	14.72±1.94	14.39±1.30	14.62±1.03

Means bearing different superscripts in a row differ significantly (* $p<0.05$; ** $p<0.01$).
TVFA = Total volatile fatty acids, Total N = Total nitrogen, NH_3-N = Ammonia nitrogen.
TCA-sol-N = Trichloro acetic acid soluble nitrogen. Plasma urea-N = Plasma urea nitrogen.

nitrogen intake from HD-15 variety (Table 2).

On the contrary, different varieties of sorghum silage did not have any influence on concentration of blood metabolites (Table 4) in sheep. Blood hemoglobin, glucose, plasma protein and urea-N levels were comparable among the groups, ranging from 9.11 to 9.42 g, 45.26 to 48.66 mg, 7.36 to 7.51 g and 14.39 to 14.72 mg per dl, respectively. Plasma urea-N reflects the dietary CP intake, the ratio of dietary CP to ruminally fermentable OM, and also serves as an indicator of ruminal protein supply. Thus, similar plasma urea-N and protein in the present study among the groups indicated that protein utilization was not disturbed due to silage feeding. Although animals fed HC-136 variety of sorghum silage were in negative nitrogen balance and deficient in both CP and TDN intakes when compared to the maintenance requirements (Table 4). This contradictory finding in transformation/utilization of metabolites might be due to short-term (36 days duration) nature of this study. However, all the values were within the normal range as reported earlier (Mahanta et al., 1999) in sheep.

Hence, the genetic characterization/ variability of these sorghum varieties had significant influence on chemical constituents and nutrient utilization of sorghum. This genetic variability in sorghum forage quality must be exploited to improve the availability of nutrients to animals through this forage. Thus, it may be inferred that HD-15 variety of sorghum was superior in nutritional quality to both J. Sel-10 and HC-136 when grown as rainfed forage crop during *Kharif* season and fed to sheep as silage during summer months.

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