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IN SITU RUMEN DEGRADATION KINETICS OF FOUR SORGHUM VARIETIES IN *NILI RAVI* BUFFALOES

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ABSTRACT

Different sorghum varieties are introduced in practice to ensure the provision of good quality fodder for ruminants. Limited information is available on *in situ* rumen degradation characteristics of dietary nutrients of sorghum varieties. This study was planned to evaluate the chemical composition and *in situ* rumen degradation kinetics of four sorghum varieties in *Nili* Ravi bulls. Four sorghum varieties (Viejin 4003, Viejin 4005, Viejin 4006 and Viejin 4571) were harvested at 80th day after sowing. Samples of fresh fodders were taken and used for the determination of chemical composition. These sorghum varieties were evaluated using *in situ* nylon bag technique. The fresh samples were filled in nylon bags and incubated in the rumen of four rumen cannulated buffalo bulls for 0, 2, 4, 6, 12, 24, 36, 48, 72 and 96 h. Rumen incubated residues were analyzed for dry matter (DM), neutral detergent fiber (NDF) and acid detergent fiber (ADF). Chemical analysis showed that the crude protein and ADF contents were found higher ($P<0.05$) for Viejin 4003 compared to other varieties, whereas, the higher values of NDF and hemicellulose contents were found for Viejin 4005. Results showed that significant ($P<0.05$) higher effective rumen degradation (ED) and extent of degradation of DM were found for Viejin 4571. The extent of degradation and ED of NDF and ADF were found higher ($P<0.05$) for Viejin 4006 variety compared to other varieties. It is concluded that Viejin 4006 variety has the good nutritive profile and better values for rumen degradation characteristics compared to other varieties.

Keywords: Sorghum varieties, rumen degradation kinetics, effective rumen degradation, buffalo bulls.

INTRODUCTION

Feed is an integral part of livestock farming which contributes about 60-70% in cost of production. The nutrient availability for ruminant animals is greatly hampered due to non-availability of land for fodder production resulting from their competition with cash crops as well as increasing demand of cereal grains as food for human consumption (Raghuvansi *et al.,* 2007). From available feed resources, livestock sector in Pakistan is getting about 62% of crude protein and 74% of total digestible nutrients (Sarwar *et al.,* 2002). Manipulation of excessive fodder can fill the gap between supply and demand for livestock. The agricultural economy of developing countries is greatly aided by utilizing fodder crops as least cost source of nutrients for livestock. In Pakistan, livestock is primarily raised on seasonal fodders and range lands, generally having high fiber contents, lower feed intake and digestibility (Khan *et al.,* 2006). It is necessary to ensure the supply of high quality forages for better production and increased profit throughout the year (Garcia *et al.,* 2008). Livestock is getting 89% nutrients from roughages and rest of nutrients from other feed resources. High quality fodders are required for better livestock production. Consequently, the serious constraint in commercial livestock farming is the inadequate supply of good quality fodder in developing countries (Sarwar *et al.,* 2002).In Pakistan, sorghum is the major fodder crop during Kharif season and is grown over a wide range of soil types, providing food grain for humans and forage for livestock. New varieties of sorghum have 5 to 7 tons/acre average yield, less water requirements and better nutritional value that may assist livestock farmers to fulfill the nutrient requirements of animals (Miller and Stroup, 2004). However, limited information is available about nutrient bioavailability from different varieties of sorghum. Therefore, the present study was conducted to evaluate the nutritive profile and *in situ* rumen degradation characteristics of four sorghum varieties (Viejin 4003, Viejin 4005, Viejin 4006 and Viejin 4571).

MATERIALS AND METHODS

Forage sowing and harvesting: Four different sorghum varieties (Viejin 4003, Viejin 4005, Viejin 4006 and Viejin 4571) were sown at experimental field, Department of Agronomy, University of Agriculture, Faisalabad. Forage was harvested at day 80 after sowing. Fresh chopped sorghum fodder samples were oven dried at 60ºC for 72 h and ground to 2 mm size.

Experimental animals and *in situ* rumen incubations: The experiment was conducted at Raja Muhammad Akram Animal Nutrition Research Center, University of Agriculture Faisalabad, Pakistan to determine the

chemical composition and *in situ* rumen degradation kinetics of four sorghum varieties. Four ruminally cannulated *Nili Ravi* buffalo bulls of approximately the similar age and body weight (average weight 475 kg) were used to evaluate the *in situ* rumen degradation characteristics. Bulls were housed on a concrete floor in separate pens. Fresh and clean water was made available round the clock. The bulls were fed on the sorghum fodder. The trial consisted of four periods of 11 days each. The first 7 days were allowed for adjustment followed by 4 day incubation period for each variety. The fresh fodder sample was harvested, chopped and then size of fodder particles was 2 mm by Wiley mill. Samples of each sorghum variety (5 g on DM basis) were filled in nylon bags (10 cm × 25 cm, pore size 60µm) and incubated in the rumen of three buffalo bulls for 0, 2, 4, 6, 12, 24, 36, 48, 72 and 96 h. Nine bags of each variety were incubated in the rumen of three bulls for each incubation period (3 bags per bull per incubation period). The bags were placed in the rumen in a reverse order and all the bags were removed at the same time to reduce variation associated with the washing procedure. After removing these bags from the rumen, these bags were washed in running tap water. The 0 h bags were rinsed under tap water without incubation in the rumen.The washed bags were dried in hot air oven at 60ºC for 72 h and dried residues were again ground to 2 mm for chemical analysis.

Chemical analysis: The DM content was determined by oven drying the sample at 60°C for 72 h and ash content was determined by incineration at 550°C (AOAC, 2000) for 4 h. The nitrogen (N) was determined by Kjeldahl method and CP was calculated as N × 6.25 (AOAC, 2000). The NDF was determined by a modified method of Van Soest *et al*. (1991) with the use of sodium sulfite and expressed with residual ash. The ADF was determined by boiling NDF residue with ADF reagent and expressed with residual ash. Acid detergent lignin (ADL) was determined by boiling ADF residue with sulfuric acid (ISO 13906:2008).

Calculations: The degradation rate (k_d), lag time and extent of degradation were calculated using the exponential model of Ørskov and McDonald (1979);

$$Y_t = W + D_t(1 - exp^{-k_d(t-L)})$$

Where, Y_t is degradation at time t; D_t is potentially degradable fraction in the rumen at time t; L is lag time. The lag time is the initial phase during which either no degradation occurs or it occurs at a greatly reduced rate. Extent of degradation is the part of nutrient degraded in the rumen.

The effective rumen degradation (ED) of DM, NDF and ADF was calculated according to the equation of Ørskov and McDonald (1979). The k_p value of 0.02 h^{-1} and 0.040 h^{-1} were used for NDF and ADF of grasses, respectively, based on the results of Pellikaan (2004). The ED_{DM} in the present study were calculated using a k_p value of 0.05 h^{-1}.

Statistical Analysis: The data collected were analyzed using Analysis of Variance Technique under 4 × 4 Latin Square Design and means were compared by least significant difference test (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Chemical composition: Chemical composition of sorghum varieties was significantly (P<0.05) different among all the sorghum varieties (Table 1). The results of current study revealed that the OM content of Viejin 4571 variety was significantly higher (P<0.05) than that of other varieties. These results are consistent to the findings of Mahanta and Pachauri (2005). They found that the OM varied among varieties of sorghum. Fadel *et al*. (2007) also reported that Himaecy variety of sorghum contained higher (P<0.05) OM content than the other varieties of sorghum stover. These differences might be due to the genetic makeup of the varieties. The CP content of Viejin 4003 variety was higher (P<0.05) than that of other varieties. These results are similar to the findings of Mahanta and Pachauri (2005). They reported that CP contents of sorghum varieties varied between the ranges of 5.4 to 8.2%. The results of current study for NDF and ADF are within the ranges reported by Singh *et al.* (2002) for sorghum varieties. The ash content of Viejin 4006 was found higher (P<0.05) compared to other varieties. Mahanta and Pachauri (2005) also reported that ash contents of sorghum varieties *i.e.* HC-135, HD-15 and JS-10 were within the ranges of 5.9 to 9.1%.

Dry matter degradation kinetics: The ED, lag time, k_d and extent of degradation for DM were significantly differed (P<0.05) among all the sorghum varieties (Table 2). Highest values (P<0.05) of ED, lag time and extent of degradation were observed in Viejin 4571 compared to other varieties whereas, higher k_d value was observed for Viejin 4005. The results of present study supported the findings of Fadel *et al.* (2007) who reported that higher ED value for DM of CR 35-18 and Feterita than the other sorghum varieties. This difference in the ED values of DM might be due to the variation in the NDF and ADF contents. Awad El Kareem *et al.* (2009) reported different k_d values for sorghum varieties. The k_d value of CSH-5 was higher (P<0.05) than Feterita cultivar of sorghum. This might be due to the high DM and CP contents of CSH-5. The results of present study showed that the extent of DM degradation was higher (P<0.05) for Viejin 4571 variety compared to other varieties. These results were consistent with the finding of Wedig *et al.* (1987) who reported higher extent of degradation for brown

midrib mutants than normal genotypes of sorghum and Sudan grass hybrids. Contrary to these, Wedig *et al.* (1987) reported non-significant differences in DM digestibility among the sorghum varieties.

Neutral detergent fiber degradation kinetics: The ED, k_d and extent of degradation for NDF were significantly different (P<0.05) among all the sorghum varieties. However, non-significant difference (P>0.05) in the lag time was observed among all the varieties (Table 3). The results of present study showed that the higher ED value of NDF for Viejin 4006 due to lower ADL content. The difference in degradation values was probably due to lignification and maturity which interferes the degradation of structural carbohydrates by acting as a physical barrier to rumen microbial enzymes (Moore and Jung, 2001). In contrast to this, Mustafa and Seguin, (2003) observed non-significant difference in NDF degradability among legume-cereal. Similarly, non-significant difference in lag time of NDF was reported by Wedig *et al.* (1987) for different sorghum varieties. Higher k_d for Viejin 4006 was found that is contrary to the finding of Aydin *et al.* (1999), they reported that the rate of NDF degradation were similar among conventional sorghum, bmr-sorghum and corn silage. The results of present study were in agreement with the findings of Oliver *et al.* (2004). It was reported that extent of NDF degradation was greater for bmr-6 sorghum, bmr-8 sorghum and corn silage compared with the conventional sorghum varieties.

Acid detergent fiber degradation kinetics: The ED, k_d and extent of degradation for ADF were significantly different (P<0.05) among all the sorghum varieties. However, non-significant differences (P>0.05) in the lag time and k_d was observed among all the varieties (Table 4). The results of present study showed that higher ED value of ADF was found for Viejin 4006 sorghum variety than other varieties. These values were in agreement with the values reported by Oliver *et al*. (2004) that the total tract digestibility of ADF for bmr-6 sorghum was greater than that for bmr-18 sorghum. These findings are contrary to the findings of Wedig *et al*. (1987). They reported degradability of ADF was similar in bmr and non-bmr variety of sorghum. The results of current study for lag time and k_d also supported the finding of Aydin *et al*. (1999), they reported that the lag time and degradation rate of ADF were similar among conventional sorghum, bmr sorghum and corn silages. Oliver *et al.* (2004) observed that extent of degradation of ADF was greater in bmr-6 sorghum than that of bmr-18 and corn silage. Wedig *et al*. (1987) also reported that extent of degradation was higher for bmr mutants than the normal genotypes of sorghum and Sudan grass hybrid sorghum.

Table 1. Chemical compositions of sorghum varieties.

Parameters	*Viejin* 4003	*Viejin* 4571	*Viejin* 4006	*Viejin* 4005	*SEM	Significance Level
Organic matter	93.17^{c}	95.36^{a}	92.03^{d}	94.00^{b}	0.36	***
Dry matter	18.16	17.16	17.27	17.06	1.13	NS
Ash	6.83^{b}	4.64^{d}	7.97^{a}	6.00^{c}	0.37	***
Crude protein	7.34^{a}	6.7^{bc}	6.77^{b}	6.64^{d}	0.08	**
Neutral detergent fiber	61.50^{a}	52.00^{b}	53.83^{b}	62.17^{a}	1.38	*
Acid detergent fiber	31.00^{a}	24.50^{b}	23.33^{b}	30.83^{a}	1.14	***
Hemicellulose	29.83^{b}	27.50^{c}	30.50^{ab}	31.33^{a}	0.46	**
Acid detergent lignin	5.01^{b}	5.35^{a}	3.05^{c}	3.35^{c}	0.31	*

* Standard error of mean.
Means in same row with different superscripts (a, b, c, d)differ significantly (P<0.05).
NS, non-significant; *, P<0.05; **, P<0.01; ***, P<0.001.

Table 2. Rumen degradation kinetics and effective rumen degradation (ED) of dry matter of four sorghum varieties.

Parameters	*Viejin* 4003	*Viejin* 4571	*Viejin* 4006	*Viejin* 4005	*SEM	Significance Level
Extent of degradation	50.99^{b}	51.82^{a}	49.47^{c}	47.61^{d}	0.42	***
Degradation rate (%/ h)	2.22^{b}	2.26^{b}	2.28^{b}	2.58^{a}	0.04	**
Lag time (h)	7.14^{a}	7.44^{a}	6.08^{b}	4.51^{c}	0.31	**
ED (%)	65.55^{c}	71.80^{a}	69.45^{b}	65.70^{c}	0.69	***

* Standard error of mean.
Means in same row with different superscripts (a, b, c, d) differ significantly (P<0.05).
The ED was calculated by using passage rate (*kp*) value of 0.05 h^{-1}.
**, P<0.01; ***, P<0.001.

Table 3. Rumen degradation kinetics and effective rumen degradation (ED) of neutral detergent fiber of four sorghum varieties.

Parameters	*Viejin* 4003	*Viejin* 4571	*Viejin* 4006	*Viejin* 4005	*SEM	Significance Level
Extent of degradation	44.50^{bc}	43.57^{bc}	47.17^{a}	46.24^{ab}	0.45	***
Degradation rate (%/h)	3.31^{ab}	2.98^{b}	3.59^{a}	2.99^{b}	0.08	*
Lag time (h)	7.07	7.02	7.37	8.28	0.48	NS
ED (%)	59.90^{c}	67.12^{a}	67.74^{a}	61.65^{b}	0.90	***

* Standard error of mean.
Means in same row with different superscripts (a, b, c) differ significantly (P<0.05).
The ED_{NDF} was calculated by using passage rate value of 0.020 h^{-1}.
NS, non-significant; *, P<0.05; ***, P<0.001.

Table 4. Rumen degradation kinetics and effective rumen degradation (ED) of acid detergent fiber of four sorghum varieties.

Parameters	*Viejin* 4003	*Viejin* 4571	*Viejin* 4006	*Viejin* 4005	*SEM	Significance Level
Extent of degradation	58.34^{c}	64.88^{b}	71.65^{a}	66.30^{b}	1.36	**
Degradation rate (%/h)	5.93	5.54	5.53	5.53	0.55	NS
Lag time (h)	4.39	4.47	4.37	4.72	0.36	NS
ED (%)	51.57^{b}	52.40^{b}	57.22^{a}	52.79^{ab}	0.86	*

* Standard error of mean.
Means in same row with different superscripts (a, b, c) differ significantly (P<0.05).
The ED_{ADF} was calculated by using passage rate value of 0.040 h^{-1}.
NS, non-significant; *, P<0.05; **, P<0.01.

Conclusion: The results of present study show that Viejin 4006 sorghum variety has the good nutritive profile and better values for rumen degradation kinetics and effective rumen degradability. The Viejin 4006 variety can be used as good forage source to fulfill animal requirements and to obtain optimum animal performance in terms of maintenance, health and production.

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