



In Situ Nutritional Evaluation of Maize Varieties Harvested at Different Growth Stages

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Abstract | Three rumen cannulated buffalo bulls were employed to evaluate 3 maize varieties i.e., Sa2000, Sa2001 and GI2000 harvested at 40 and 60 days were nutritionally evaluated according to completely randomized design with 3x2 factorial arrangements. After drying, samples of maize varieties were crushed to 2mm size for chemical analyses through standard techniques. Dry matter (DM) and Neutral detergent fiber (NDF) digestion kinetics were determined in ruminally cannulated male buffalo bulls. As fodder aged, the degradability, disappearance rate and extent of DM and NDF declined. However, varieties did not affect the in-situ DM and NDF disappearance, but it reduced as plant matures. Lag time for DM and NDF was shorter ($p < 0.05$) in early harvest varieties than late ones.

Keywords | Maize varieties, Harvest stage, Digestion kinetics, Buffalo bulls

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INTRODUCTION

Ruminants can rely exclusively on forages as their major feed resource; hence, fodder crops have received vital importance in livestock production. In developing countries due to urbanization and trend of agriculture towards cash crops there is insufficient fodder available and animals are deficient in essential nutrients. Moreover, it is well documented that the performance of ruminants depends upon their ability to consume and digest fibrous portion of the diet (Sarwar and Iqbal, 2002).

In south East Asian sub-continent, poor inputs, low genetics potential of fodder varieties, lack of agriculture research and extension services and orthodox agronomic practices leads to low production per acre and lower the quality of fodders. These facts forced for immediate remedies like introduction to high yielding, multi-cut and improved fodder varieties. Under these circumstances efficient utilization of existing feed resources can be an

important gizmo to conduit the fissure between nutrients demand and requirements.

For efficient utilization, nutritive illustration of local fodders is required to be used as base line data. Among local fodders, maize (*Zea Mays*) is of vital significance as it is cultivated on large scale for fodder production. Although wheat, cotton and rice are cultivated at large scale in Pakistan but maize still is the 4th important grown crop. It is cultivated over one-million-hectare area at about 4.0 million metric tons valuable food production (Anonymous, 2010). It is highly palatable and plays an immense part in fattening of livestock. The quantity and quality of maize fodder is exceptionally variable depending upon variety, ago-chemical conditions and management factors. One of the major and vital factors affecting the nutritive value of maize is the choice of harvest time and physiological maturity of crop at harvest (Cherney et al., 1993, Harrison et al., 1996). While, the nutritive value may also differ among varieties of the same fodder (Estrada-Flores et al.,

2006). So, its utilization can be improved by perception of fodder harvest stage with minimum lignification and maximum DM content and the appropriate variety suitable for ruminant feeding.

Limited scientific information is available on the issue; hence, the existing experiment was planned to establish the feeding value of three maize fodder varieties harvested at 40 and 60 days of maturity and their breakdown kinetics in rumen cannulated Nili Ravi buffalo bulls in situ.

MATERIALS AND METHODS

Three buffalo bulls fitted with rumen cannula were used to evaluate maize varieties Sa 2000, G1 2000 and Sa 2001, harvested at 40 and 60 days of age. Maize fodder was offered to cannulated bulls to avoid any variation due to feed on rumen fermentation pattern. Same feed was given to animals for 10 days as an adaptation prior to incubation of samples in nylon bags for 4 days. Chopped fodder samples were dried in hot air oven at 60°C and ground to 2mm mash size for analysis of dry matter (DM), CP, ether extract (EE) and total Ash (AOAC, 1995), Neutral Detergent Fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) by the methods of (Van. Soest et al., 1991). Ten-gram sample of each variety was taken separately in nylon bags measuring 10×23cm having pore size of 50µm for incubation in the rumen. Bags clipped with nylon thread were placed separately in the rumen for 1, 2, 4, 6, 10, 16, 24, 36, 48 and 96 hours (in triplicate for each interval; 2 bags replicate and 3rd blank). Nylon bags were placed in the distilled water at room temperature for 10 minutes before incubation into the rumen (Sarwar and Nisa,

1999). Nylon bags were placed in the rumen in converse arrangement to remove at a same time (Sarwar et al., 1995). Bags were washed in running tap water until the rinse was clear. After washing till clear rinse, bags were placed in hot air oven at 60°C for drying till constant weight. The residual materials were analyzed for DM and NDF fractions. Digestion coefficient of DM and NDF was calculated at 48 hours of incubation. Disappearance rate, lag per hour and extent of degradation of DM and NDF were investigated by the procedures defined by Sarwar et al. (1991).

STATISTICAL ANALYSIS

The data for lag time, rate and extent of DM and NDF digestion were analyzed according to Completely Randomized Design through 2x3 factorial design. Following statistical model used for data analysis;

$$Y_{ijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{ijk}$$

In this equation, μ was overall mean, α_j represents varieties effect (3 varieties), β_k represents harvest period (40 and 60 days), $(\alpha\beta)_{jk}$ denotes the interactions amongst α and β and ϵ_{ijk} was the variance within means (error term). Duncan's Multiple Range test was applied to estimate extent of significance ($p < 0.05$) across means (Steel et al., 1997).

RESULTS

CHEMICAL COMPOSITION

Chemical composition of maize varieties harvested at 40 and 60 days is presented in Table 1. Dry matter and fiber fractions augmented but protein content reduced with advancing stage of harvest.

Table 1: Chemical composition of different maize varieties harvested at different growth stages.

Parameters	G12000		Sa2000		Sa2001	
	40 days	60 days	40 days	60 days	40 days	60 days
Dry matter, %	20.00	28.00	19.60	28.20	20.00	28.00
Crude protein, %	8.40	6.90	8.10	6.40	8.60	6.50
Neutral detergent fiber, %	67.00	76.50	68.00	75.90	67.00	75.00
Acid detergent fiber, %	43.00	49.80	42.10	49.50	42.00	48.50
Acid detergent lignin, %	7.00	8.95	7.40	9.52	7.00	9.57
Cellulose, %	36.00	40.85	34.75	39.98	40.00	38.93
Hemicellulose, %	24.00	26.70	25.90	26.40	25.00	26.50

IN SITU DM AND NDF DEGRADABILITY

Table 2 illustrates that variety and harvesting stage had significant effect on in Situ DM degradability (at 48 hours of incubation) and extent of degradation (at 96 hours to incubation) of different varieties of maize fodder. The interaction between harvest stage and variety was also significant statistically (Table 2). All parameters (DM and

NDF degradability, rate of degradation, lag and extent of degradation) were significantly affected by variety of the maize fodder (Tables 2 and 3). Stage of harvest of maize varieties linearly ($p < 0.05$) effected DMD and DM extent of degradation in situ (Tables 2 and 4). In Situ Dry matter degradability (DMD, %) at 48 hours of incubation of different varieties of maize (66.99, 66.33 and 66.85%, respectively)

Table 2: In Situ DM and NDF Digestion Kinetics of maize varieties harvested at 40 and 60 days of maturity.

Parameters	GL 2000		SA 2001		SA 2000		SE	Main effects		Variety X Harvest
	40 days	60 days	40 days	60 days	40 days	60 days		Variety	Harvest	
Dry Matter										
Digestibility ₁ , %	66.99	55.71	66.33	56.64	68.55	58.43	0.31	**	**	*
Rate of degradation, % hour ⁻¹	4.49	3.04	4.54	3.09	4.59	3.13	0.17	NS	**	NS
Lag, hour	1.56	3.19	1.59	3.18	1.59	3.09	0.19	NS	**	NS
Extent ₂ , %	73.65	72.94	72.54	64.88	65.08	64.88	0.70	**	**	**
Neutral Detergent Fiber										
Digestibility ₁	61.71	52.36	60.31	52.97	60.40	52.16	0.63	NS	**	NS
Rate of degradation, % hour ⁻¹	4.12	2.61	4.14	2.60	4.12	2.71	0.26	NS	**	NS
Lag, hour	1.91	3.60	1.90	3.62	1.91	3.62	0.23	NS	**	NS
Extent ₂ , %	70.57	61.34	71.46	62.13	70.96	61.34	0.52	NS	**	NS

Means within row bearing different superscripts differ significantly ($p < 0.05$); 1Degradability was determined at 48 hours of incubation; 2Extent of digestion was determined at 96 hours of incubation.

Table 3: In Situ DM and NDF digestion kinetics of maize varieties.

Parameters	Varieties			SE	Linear	Quadratic
	GL 2000	SA 2001	SA 2000			
Dry matter						
Digestibility ₁ , %	61.40	61.49	63.49	0.22	**	**
Rate of degradation, % hour ⁻¹	3.76	3.81	3.86	0.12	NS	NS
Lag, hour	2.37	2.38	2.34	0.13	NS	NS
Extent ₂ , %	73.30	68.71	64.98	0.50	**	NS
Neutral Detergent Fiber						
Digestibility ₁	57.03	56.64	56.28	0.45	NS	NS
Rate of degradation, % hour ⁻¹	3.37	3.37	3.41	0.19	NS	NS
Lag, hour	2.75	2.76	2.77	0.16	NS	NS
Extent ₂ , %	65.96	66.80	66.15	0.37	NS	NS

Means within row bearing different superscripts differ significantly ($p < 0.05$); 1, Degradability was determined at 48 hours of incubation; 2, Extent of digestion was determined at 96 hours of incubation.

were higher ($p < 0.05$) when harvested at 40 days of maturity than those (55.71, 56.64 and 58.43, respectively) harvested at 60 days of maturity (Table 2). Neutral Detergent Fiber degradability (NDFD) in different varieties of maize harvested at 40 days of maturity were higher ($p < 0.05$) than those harvested at 60 days of maturity (Table 2). Similar trend was also observed for rate and extent of NDFD for all the varieties in the current study. Lag time (hour) of NDF exhibited an opposite trend as was perceived in rate and extent of NDF degradation for all treatments. The linear trend was observed with respect to harvest stage for all parameters of in situ experimentation (Table 4).

The effect of variety was similar for DM rate of degradation and lag time while NDF degradability, rate, lag and extent of degradation were similar ($p > 0.05$; Table 2). Whilest, the effect of variety was linear in case of DMD and extent of degradation (Table 3). Lag time (hour) showed reverse

tendency like it was observed in rate of degradation and extent of digestibility across all treatments.

DISCUSSION

CHEMICAL COMPOSITION

Dry matter and fiber fractions increased but CP content decreased with advancing age of maturity. This increase in fiber fractions and reduction in CP contents with advancing maturity was ascribed a decline in ratio between leaf and stem along with the rate of accretion of structural elements (Messam et al., 1991). Kim et al. (1989) reported increased NDF from 51.9 to 59%, ADF from 30.6 to 39.7% and ADL from 7.2 to 14.6% with advancing plant age. Boddroff and Ocumpangh (Boddroff and Ocumpangh, 1986) reported similar trend in the growth of fibrous fractions of the Mott grass when harvested at varying growth stages. Neutral detergent fiber increased from 40 to 65%, ADF from 20

to 38% while CP contents decreased from 13 to 10.5% in ryegrass (*Lolium Multiflorum*) as plant age progressed (Cherney et al., 1993). The reason for low CP content of soft dough stage was that with increasing maturity, cell content decreased and cell wall contents increased (Acosta et al., 1991).

Table 4: In Situ DM and NDF Digestion Kinetics of maize harvested at 40 and 60 days.

Parameters	Harvest		SE	Linear
	40 days	60 days		
Dry Matter				
Digestibility ¹ , %	67.29	56.93	0.18	**
Rate of degradation, % hour ⁻¹	4.54	3.08	0.10	**
Lag, hour	1.58	3.15	0.11	**
Extent ² , %	70.42	67.57	0.41	**
Neutral Detergent Fiber				
Digestibility ¹	60.81	52.50	0.36	**
Rate of degradation, % hour ⁻¹	4.13	2.64	0.15	**
Lag, hour	1.91	3.61	0.13	**
Extent ² , %	71.00	61.60	0.30	**

Means within row bearing different superscripts differ significantly ($p < 0.05$); ¹Degradability was determined at 48 hours of incubation; ²Extent of digestion was determined at 96 hours of incubation.

IN SITU DM AND NDF DEGRADABILITY

Increased cell wall components and decreased cell contents of forages with increasing maturity were the possible reason for lower NDFD with advancing age of maturity (Givens et al. 1989; Rinne et al., 1999; Rinne et al., 2002). Buxton and Hornstein (1986) and Miller et al. (1991) reported inverse function of lignification for both *in vivo* and *in vitro* digestion which might be owed to mature lignification and structural carbohydrates. It was opined previously that rumen microbes favorably use starch or cell soluble over fiber. The decline in rate of disappearance might be ascribed to augmented concentration of NDF and lignin in matured fodders. Cleale and Bull (1986) explored that potentially digestible DM of early cut grasses/ legumes silage was digested faster than late cut silage. Results of present study have supported the findings of Bowman et al. (1991) who suggested that ADL contents of forage increased with the advancement in maturity of forages thus reduced the potential extent of NDF disappearance. Similarly, Cherney and Lucey (1993) conveyed that effect of forage maturity on the DM digestibility is a variation in fiber content across premature and mature cut maize, as well as in ruminal milieu.

CONCLUSION

The maize varieties harvested at 40 days of maturity had

higher CP contents and better *in situ* DM and NDF digestion kinetics in Nili-Ravi buffaloes.

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AUTHORS CONTRIBUTIONS

Nasir Ali Tauqir conducted research. Fayyaz Ahmad helped in conduct of research, Asim Faraz wrote the paper, Abdul Waheed analyzed the data, Rana Muhammad Bilal helped in write-up.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

- Acosta YM, Stallings CC, Polan CE, Miller CN (1991). Evaluation of barley silage harvested at boot and soft dough stages. *J. Dairy Sci.* 74: 167. [https://doi.org/10.3168/jds.S0022-0302\(91\)78158-7](https://doi.org/10.3168/jds.S0022-0302(91)78158-7)
- Anonymous (2010). Economic Survey of Pakistan, 2010-2011. Government of Pakistan, Economic Adviser's Wing, Finance Division, Islamabad.
- AOAC (1995). Official methods of analysis, association of official analytical chemists, Arlington, Virginia, USA.
- Boddroff D, Ocumpangh WR (1986). Forage quality of pearl millet x Napier grass hybrids and dwarf Napier grass. *Soil Crop Sci. Soc. Fla. Proc.* 45: 170.
- Bowman JGP, Hunt CW, Kerly MS, Paterson JA (1991). Effect of grass maturity and legume substitution on large particle size reduction and small particle flow from the rumen of the cattle. *J. Anim. Sci.* 69: 369-375. <https://doi.org/10.2527/1991.691369x>
- Buxton OR, Hornstein JS (1986). Cell wall concentration and components in stratified canopies of alfalfa birds foot trefoil and red clover. *Crops Sci.* 26: 180-184. <https://doi.org/10.2135/cropsci1986.0011183X002600010043x>
- Cherney DJR, Jones JS, Pell AN (1993). Technical note: Forage *in vitro* dry matter digestibility as influenced by fiber source in the donor cow diet. *J. Anim. Sci.* 71: 1340. <https://doi.org/10.2527/1993.7151335x>
- Cherney JH, Lucey RF (1993). *In vitro* digestion kinetics and quality of perennial grasses as influenced by forage maturity. *J. Dairy Sci.* 76: 790-797. [https://doi.org/10.3168/jds.S0022-0302\(93\)77402-0](https://doi.org/10.3168/jds.S0022-0302(93)77402-0)
- Cleale RM, Bull LS (1986). Effect of forage maturity on ration digestibility and production by dairy cows. *J. Dairy Sci.* 69: 1587-1594. [https://doi.org/10.3168/jds.S0022-0302\(86\)80575-6](https://doi.org/10.3168/jds.S0022-0302(86)80575-6)
- Estrada-Flores JG, Gonzalez-Ronquillo M, Mould FL, Arriaga-Jordan CM, Castela'n-Ortega OA (2006). Chemical composition and fermentation characteristics of grain and different parts of the stover from maize land races harvested at different growing periods in two zones

- of central Mexico. Anim. Sci. 82: 845-852. <https://doi.org/10.1017/ASC2006094>
- Givens DI, Everinton JM, Adamson AH (1989). The nutritive value of spring grown herbage produced on farms throughout England and Wales over four years, I. The effect of stage of maturity and other factors on chemical composition, apparent digestibility and energy values measured *in vivo*. Anim. Feed Sci. Tech. 27: 157-172. [https://doi.org/10.1016/0377-8401\(89\)90140-5](https://doi.org/10.1016/0377-8401(89)90140-5)
 - Harrison JH, Johnson L, Riley R, Xu S, Loney K, Hunt CW, Sapienza D (1996). Effect of harvest maturity of whole plant corn silage on milk production and component yield, and passage of corn grain and starch into feces. J. Dairy Sci. 79(Suppl. 1): 149.
 - Kim DJ, Kim YK, Maeng WJ (1989). Study on the dry matter digestibility of domestic herbage by pepsin cellulase technique. 2. cell wall constituents and dry matter digestibility in wild legumes. Korean J. Anim. Sci. 31: 385 - 393.
 - Messam MA, Weiss WP, Erickson DO (1991). Effect of nitrogen fertilizer and Maturity of bromegrass on in situ ruminal digestion kinetics of fiber. J. Anim. Sci. 69: 1151-1161. <https://doi.org/10.2527/1991.6931151x>
 - Miller PS, Garrett WN, Hinmsn N (1991). Effect of alfalfa maturity on energy utilization by cattle and nutrient digestibility by cattle and sheep. J. Anim. Sci. 69: 2591-2600. <https://doi.org/10.2527/1991.6962591x>
 - Rinne M, Huhtanen P, Jaakkola S (2002). Digestive processes of dairy cows fed silages harvested at four stages of grass maturity. J. Anim. Sci. 80: 1986-1998. <https://doi.org/10.2527/2002.8071986x>
 - Rinne M, Jaakkola S, Kaustell K, Heikkilä T, Huhtanen P (1999). Silages harvested at different stages of grass growth vs. concentrate foods as energy and protein sources in milk production. J. Anim. Sci. 69: 251-263. <https://doi.org/10.1017/S1357729800051286>
 - Sarwar M, Nisa MU (1999). Effect of nitrogen fertilization and stage of maturity of mott grass (*Penisetum perpureum*) on its chemical composition, dry matter intake, ruminal characteristics and digestibility in buffalo bulls. Asian-Aust. J. Anim. Sci. 12: 1040 - 1041. <https://doi.org/10.5713/ajas.1999.1035>
 - Sarwar M, Sial MA, Abbas W, Mahmood S, Bhatti SA (1995). Ruminal digestion kinetics of forages and feed by products in Sahiwal calves, Indian J. Anim. Nutr. 12: 141-147.
 - Sarwar M, Firkin JL, Eastridge ML (1991). Effect of replacing neutral detergent fiber of forage with soy hull and corn gluten feed for dairy heifers. J. Dairy Sci. 74: 1006. [https://doi.org/10.3168/jds.S0022-0302\(91\)78250-7](https://doi.org/10.3168/jds.S0022-0302(91)78250-7)
 - Sarwar M, Khan MA, Iqbal Z (2002). Feed resources for livestock in Pakistan. Int. J. Agric. Biol. 4: 186.
 - Steel RGD, Torrie JH, Dicky DA (1997). Principles and procedures of statistics. A biometric approach 3rd Ed. McGraw Hill Book Co., New York, USA.
 - Van Soest P, Robertson JJB, Lewis BA (1991). Methods for dietary Fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 4083 - 4097. [https://doi.org/10.3168/jds.S0022-0302\(91\)78551-2](https://doi.org/10.3168/jds.S0022-0302(91)78551-2)