



***In situ* Degradation Kinetics of Crop Residue Based Complete Rations in Murrah Buffalo Bulls**

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Abstract

The present investigation was carried out to determine the *in situ* degradation kinetics of crop residue based complete rations using Nylon bag technique. Three iso-nitrogenous complete rations comprising of maize stover (T₁), red gram straw (T₂) or black gram straw (T₃) and concentrate in 60: 40 proportion were prepared and evaluated for their rumen degradable DM, CP, NDF and ADF content using three adult male graded Murrah buffalo bulls (350 ± 9.36 kg) fitted with permanent rumen cannula. The slowly degradable fraction (b) of DM, CP, NDF (P<0.01) and ADF (P<0.05) and potential degradability (a+b) of DM, NDF, ADF (P<0.01) and CP (P<0.05) were higher in maize stover based complete ration (T₁) when compared to others. The coefficients of effective degradability (ED) of CP, NDF (P<0.05) and ADF (P<0.01) were higher in T₁ compared to other complete rations. However, the ED (%) of DM was higher in T₁ compared to other rations but the differences were not statistically significant. Hence, it is concluded that maize stover based complete ration was better utilized *in sacco* in terms of protein and fibre as compared to other crop residue based complete rations.

Keywords: Crop residues; Complete rations; Degradation kinetics

Introduction

The huge livestock population, depletion of grazing lands and escalating demand and cost of concentrate feed ingredients in India, has led to the utilization of non-conventional and non-competitive crop residues and agro-industrial by-products in livestock feeding (Waje *et al.*, 2010). Cattle need to be fed with balanced ration in order to obtain optimum production. Use of locally available crop residues can substantially reduce the maintenance of livestock (Saha *et al.*, 2002). Ramachandra *et al.* (2007) estimated that crop residues will provide more than 70% of the feed resources for Indian livestock by the year 2020. The concept of feeding complete ration comprising of locally available

crop residues is one of the best method to provide the balanced supply of nutrients. Improved performance and growth rates fed crop residue based complete rations were reported earlier (Anandan *et al.* (2010) in male Deccani sheep, Chopade *et al.* (2010) in kids, Pachauri *et al.* (2010) in female crossbred calves and Dhuria *et al.* (2009) in Magra lambs).

Different crop residues viz. maize stover, red gram straw and black gram straw is abundantly available in the coastal region of Andhra Pradesh. India occupies 7th position with a production of 21.28 MMT of maize, while Andhra Pradesh stands 5th with a production of 1.2 MMT in 2010-11 (US Department of Agriculture 2011) in India. The gram production in Andhra Pradesh is 0.72 MMT in 2011-12 contributing 8.76 % of the total production (8.11 MMT) (Ministry of Agriculture, 2011). This leads to the availability of large quan-

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tity of straws as byproducts after harvesting the crops for grain, thus can be utilized as animal feed. Less information is available on the rumen degradation kinetics of these crop residue based complete rations. It is essential to have data on the utilizability and incorporation of these crop residue based complete rations in the daily rations of livestock which can be better supported by preliminary animal experiments. Hence, the present investigation was undertaken to evaluate some potential complete rations prepared using locally available crop residues through *in situ* rumen degradability studies.

Materials and methods

Experimental rations

The present work has been carried out at Department of Animal Nutrition, NTR College of Veterinary Science, Gannavaram, Andhra Pradesh, India. Locally available crop residues such as maize stover, red gram straw and black gram straw were procured from the farmers' fields in nearby villages. Experimental concentrate mixtures were prepared at the feed mixing plant attached to the Department. Three iso-nitrogenous complete rations comprising of maize stover (T₁), red gram straw (T₂) or black gram straw (T₃) were prepared by mixing roughages and concentrates in 60: 40. The ingredient composition of complete rations is presented in Table 1.

Feeding Regimen

Three adult buffalo bulls used in the present study were fed daily a basal diet comprising of 5 kg hybrid napier, 4 kg paddy straw and 1.5 kg concentrate mixture to meet the maintenance requirements (ICAR, 1998). The experimental animals were housed in well ventilated and hygienic stalls with individual feeding and watering arrangements. All the animals were offered fresh, clean drinking water free of choice.

In situ degradation kinetics

Three adult rumen cannulated graded Murrah buffalo bulls (5 yrs, 350 ± 9.36 kg BW) were used to determine the *in sacco* degradability of dry matter (DM), crude protein (CP), neutral detergent fibre

Table 1. Ingredient composition of crop residue based complete rations.

Ingredient	T ₁	T ₂	T ₃
Roughage (Kg)			
Maize stover	60	-	-
Red gram straw	-	60	-
Black gram straw	-	-	60
Concentrate (Kg)			
Maize grain	5.5	6.5	8.5
DORB	5.5	6.5	7.5
Cottonseed cake	11.0	12.0	11.5
Gingelly cake	16.0	13.0	10.5
Mineral mixture	1.5	1.5	1.5
Salt	0.5	0.5	0.5
Overall CP (%)	12.77	12.62	12.82

Maize Stover (T₁)

Red gram straw (T₂)

Black gram straw (T₃)

(NDF) and acid detergent fibre (ADF) of complete rations in the rumen. The pre-weighed nylon bags (13.5cm x 7.5 cm), containing 5 g of air dried feed, ground through 2 mm screen, were incubated in the ventral sac of rumen of each buffalo bull. The experimental rations were incubated for 0, 3, 6, 9, 12, 24, 48 and 72 h in the rumen of three cannulated Murrah buffalo bulls. The bags containing samples for 0 h were washed without incubation in rumen. The *in sacco* degradability of DM, CP, NDF and ADF of complete rations were determined as per the procedure of Orskov and Mc Donald (1979). The bags with feed samples incubated in the rumen were drawn in a sequential removal method (Osuji *et al.*, 1993). After removal, the bags were washed under slow running tap water by rubbing between fingers and the thumb for ten minutes, oven dried at 70°C for 48 h to constant weight and DM loss during the incubation was calculated. The CP, NDF and ADF content in the residue was analyzed to determine their respective degradabilities. From the degradability data obtained at different intervals, the constant a, b and c from the expression $P = a + b(1 - e^{-ct})$ were obtained. Where, P is the degradability at time t, the constant, 'a' is the intercept or instantly degradable fraction, 'b' is the slowly degradable and 'c' is the degradation rate or rate constant. The effective nutrient degradability (%) of complete rations were calculated by time measurements and fitted values in NEWAY programme

(Model based on Mc Donald, 1981), assuming an outflow rate (K) of 0.05%/h.

Statistical Analysis

The samples were analyzed for proximate constituents (AOAC, 2007) and fibre fractions (Van Soest *et al.*, 1991). The data were analyzed statistically (Snedecor and Cochran, 1994) and tested for significance by Duncan's multiple range test (Duncan, 1955) using SPSS 17.0 version.

Results

The chemical composition and cell-wall constituents of crop residue based complete rations were presented in Table 2.

The *in sacco* degradability of DM, CP, NDF and ADF of complete rations in rumen fistulated buffalo bulls were presented in Table 3.

Table 2. Chemical composition (% DM basis) of crop residue based complete rations

Parameter	T ₁	T ₂	T ₃
Organic Matter	90.80	93.88	90.25
Total Ash	9.20	6.12	9.75
Crude Protein	12.77	12.62	12.82
Ether Extract	1.20	1.41	1.68
Crude Fibre	42.45	53.01	45.52
Nitrogen Free Extract	34.38	26.84	30.23
Neutral Detergent Fibre	58.86	66.17	55.37
Acid Detergent Fibre	33.73	44.29	37.94
Hemi-cellulose	25.13	21.88	17.43
Cellulose	24.70	32.83	25.22
Acid Detergent Lignin	8.38	12.34	11.50
Calcium	1.17	1.14	1.15
Phosphorus	0.74	0.73	0.72

Maize Stover (T₁)
Red gram straw (T₂)
Black gram straw (T₃)

Discussion

As shown in Table 2, the complete rations T₁ to T₃ were iso-nitrogenous with CP ranging from 12.62 to 12.82%. The maize stover based complete ration (T₁) contained less CF, ADF and ADL and more NFE and hemi-cellulose compared to either red gram straw (T₂) or black gram straw (T₃) based

complete rations. These results corroborated with the findings of Venkateswarlu *et al.* (2013).

Dry matter degradability values revealed that the instantly degradable fraction 'a' and rate constant 'c' were similar among the complete rations. The slowly degradable fraction 'b' and potential degradability (a+b) of DM were higher (P<0.01) in T₁ as compared to T₂ or T₃. The effective degradability (ED) of DM at an out flow rate of 0.05 per hour was similar among the complete rations. On the contrary, Venkateswarlu (2012) reported significantly lower EDDM (%) in red gram straw based complete ration when compared to either maize stover or black gram straw based complete rations. This might be due to variations in chemical composition of crop residues, stage of harvesting etc.

The *in sacco* degradation kinetics of CP revealed that fraction 'b' (P<0.01) and PD (P<0.05) were higher in T₁, while fraction 'a' is highest (P<0.01) in T₃ compared to others (Table 3). The higher fraction 'a' in T₃ might be attributed to the higher proportion of de-oiled rice bran along with maize grain when compared to T₁ or T₂. The EDCP at an out flow rate of 0.05 per hour was significantly higher (P<0.05) in T₁ when compared to T₂ and T₃. Similarly, Venkateswarlu (2012) reported higher EDCP (%) in maize stover based complete ration as compared to red gram or black gram straw based complete rations but the difference was not significant. The lower value for effective CP degradability in T₂ and T₃ compared to T₁ may be attributed to the higher proportions of de-oiled rice bran which is reported to have lower protein degradability as compared to other ingredients such as grains and oil cakes (Walli *et al.*, 1999). This indicated that the level of DORB and maize grain in the complete ration influenced rumen degradation kinetics. These results corroborated with the findings of Thakur and Tomar (2004) in wheat straw based complete rations in adult bulls.

Data on degradation kinetics of NDF revealed that the fractions 'b' and PD (P<0.01) were higher in T₁, while fraction 'a' and 'c' were highest (P<0.01) in T₃ compared to other complete rations. The ED of NDF at an out flow rate of 0.05 per hour was significantly higher (P<0.05) in T₁ compared to T₂ and T₃. The increased digestibility of T₁ as compared to other rations might have been a function of crop maturity, presence of more soluble nutrients and inherent difference between types of

Table 3. *In situ* degradation kinetics (%) of crop residue based complete rations

Attributes	T ₁	T ₂	T ₃	SEM	P Value
Dry Matter					
a	10.13	9.81	8.61	0.376	0.242
b**	52.01 ^a	45.80 ^b	47.20 ^b	0.990	0.004
c	0.0528	0.0712	0.0596	0.005	1.169
PD (a+b)**	62.14 ^a	55.61 ^b	55.81 ^b	1.118	0.002
ED (0.05 %)	35.40	34.97	35.27	0.691	0.971
Crude Protein					
a**	7.67 ^b	14.19 ^a	14.94 ^a	1.190	0.000
b**	58.52 ^a	48.54 ^b	49.68 ^b	1.707	0.001
c	0.051	0.068	0.0717	0.004	0.086
PD (a+b)*	66.19 ^a	62.73 ^b	64.62 ^b	0.639	0.020
ED (0.05 %)*	43.03 ^a	38.13 ^c	41.33 ^b	0.905	0.051
Neutral Detergent Fibre					
a**	9.66 ^b	12.64 ^a	13.21 ^a	0.622	0.010
b**	47.53 ^a	41.08 ^b	41.21 ^b	1.148	0.003
c**	0.0719 ^b	0.0874 ^b	0.1209 ^a	0.008	0.007
PD (a+b)**	57.19 ^a	53.72 ^b	54.42 ^b	0.588	0.009
ED (0.05 %)*	39.70 ^a	37.07 ^b	38.33 ^b	0.482	0.054
Acid Detergent Fibre					
a	5.12	4.41	5.54	0.350	0.475
b*	41.99 ^a	39.19 ^b	39.27 ^b	0.560	0.034
c	0.0637	0.1306	0.1069	0.014	0.493
PD (a+b)**	47.11 ^a	43.60 ^b	44.81 ^b	0.584	0.010
ED (0.05 %) **	30.73 ^a	27.33 ^b	30.00 ^a	0.577	0.009

abc Values in the rows bearing different superscripts differ significantly * (P<0.05) ** (P<0.01)

crop residue (Solaiman *et al.*, 1990).

Rumen degradability values for ADF showed no significant difference for fractions 'a' and 'c' among the complete rations under study. However, the fractions 'b' (P<0.05) and PD (P<0.01) were higher in T₁ compared to other rations. Similarly, Venkateswarlu (2012) also reported higher (P<0.01) values for fraction 'b' and PD in maize stover based complete ration when compared to red gram or black gram straw based complete rations. The EDADF at an out flow rate of 0.05 per hour was significantly lower (P<0.05) in T₂ compared to T₁ and T₃. This is in agreement with the findings of Venkateswarlu (2012). The fibrous portion of cereal straws was more digestible in ruminant than that of legumes and others due to presence of more soluble carbohydrates (Jung *et al.*, 1983). Incorporation of red gram straw in complete rations did not improve the degradation kinetics optimally. This may be attributed to thick and woody stem, higher

ADL and silica content in red gram straw leading to restricted fiber digestion in the rumen (Feng *et al.*, 1995) or bind to the cell wall and cell solubles that reduce the digestion of protein and microbial fermentation (Makkar *et al.*, 1995).

The variation in degradability values for DM, CP, NDF and ADF in feeds based on *In situ* nylon bag technique may be due to several factors. These can be categorized into animal characteristics, substrate characteristics, bag characteristics, other procedural aspects and mathematical components (Vanzant *et al.*, 1998). These variable results underline the need for caution while comparing degradability data among studies from different processing methods.

Conclusion

It can be concluded that complete rations incorporating locally available crop residues could be ef-

fectively included in the daily rations of livestock without any adverse effects. Among the complete rations studied, maize stover based complete ration was better utilized *in sacco* in terms of protein and fibre as compared to other crop residue based complete rations.

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