Impact of Three Categories of Supplements on *In Sacco* Ruminal Degradation of Urea-Treated and Untreated Straw Substrates

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ABSTRACT : The objective of this study was to examine the impact of three categories of supplements on intake and diet induced difference on degradation of straw substrates. Sixteen crossbred cattle fitted with rumen cannula were randomly divided into 4 equal groups. Animals were fed on wheat straw *ad libitum* without any supplement except mineral mixture (control; T_1) or supplemented with concentrate mixture (CS; T_2) or green Lucerne (GLS; T_3) or urea-molasses block lick (ULS; T_4). Total dry matter intake in T_2, T_3 and T_4 was increased by 70, 54 and 49%, respectively compared to T_1 which was only 1.55 kg/100 kg B.Wt. Other than control animals, straw intake was less on T_3 than T_2 or T_4. *In Sacco* degradation of untreated and urea treated wheat or paddy straw in different treatments indicated that the supplements had a significant ($p<0.01$) impact on rapidly soluble (A) and insoluble but potentially degradable (B) fractions of straw. Urea treatment increased fraction-A but, provision of supplement improved fraction-B also. Effective degradation (ED) of OM was better on T_2. Rate of degradation (C) of OM and CWC was dependent on diet and type of straw but hemicellulose and cellulose were related to latter factor only. ED of cell wall carbohydrates (CWC) was similar in T_2 and T_4 but higher than T_3. CS was more effective in improving the degradation of both untreated and urea treated straw while ULS was effective on the former only. CS had more impact on superior quality straw while contrary was true with ULS. Although GLS improved intake and degradability of untreated and urea treated straws, its bulkiness affected the straw intake compared to other supplements. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 2 : 195-204)***

Key Words : Supplements, Intake, Rumen, Cell Wall Degradation, Wheat Straw, Paddy Straw, Urea Treatment

INTRODUCTION

Feed utilization is a multi-step process that takes place in a specific rumen environment. Extent of degradation of diet varies due to fluctuations in rumen environment that was transcribed by the diet itself (Sutherland, 1988). Defining the optimal rumen environment is not easy particularly where rations based on crop residues are fed to the animals. It is frequently cited in the literature that the combination of factors like low palatability, essential nutrients inadequacy, high resistance to structural degradation by chewing and deleterious secondary components of crop residues create imbalance in rumen environment (Leng, 1990; Weston, 1996). Creating an efficient rumen ecosystem for fermentative digestion of crop residues and balancing its end products with supplement have been emphasized in order to optimize productivity of the ruminants in tropics (Preston and Leng, 1987; Leng, 1990; Bhat and Bansil, 1999). A large number of supplements have been tried to improve rumen environment of the animals when fed on straw based diets (Ndlovu and Buchanan-Smith, 1985; Silva and Orskov, 1988; Fondevila et al., 1994; Mgheni et al., 1994; Prakash et al., 1996; Bonsi and Osuji, 1997). Different supplements in use in developing countries for feeding of ruminants can be generalized into three categories such as concentrate, hays and green forage, and non-protein nitrogen (NPN). This study compared the influence of three categories of supplement on rumen environment to degrade cell wall constituents of untreated and urea treated straw samples. The hypothesis (null) tested was that the degradation of cell walls in the rumen is independent of type of supplement fed to the animals on straw based diet.

MATERIALS AND METHODS

Animals and diets

Sixteen crossbred (Brown Swiss × Sahiwal) adult male cattle fitted with flexible rumen cannula were divided into four equal groups of comparable age and body weight (31±0.8 months, 248±16 kg). Animals were fed on *ad libitum* wheat straw as basal roughage. Treatments (T) were (1) without any protein or energy supplement but supplementation of mineral mixture (control; T_1), (2) concentrate mixture supplementation (CS; T_2), (3) green Lucerne supplementation (GLS; T_3) and, (4) urea-molasses-mineral block (UMMB) lick supplementation (ULS; T_4). Though the diet in T_1 did not meet the maintenance requirement, it was a negative control to differentiate relative improvement in degradation kinetics (RID) in other

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diets (ARC, 1990). Concentrate mixture was formulated with maize 35, groundnut cake 27, wheat bran 35, mineral mixture 2 and common salt 1 part. UMMB lick was a compressed block with a total weight of 3 kg. The ingredients of UMMB licks were selected with an objective to augment rumen fermentation (Srinivas and Gupta, 1997). It comprises of urea 15, molasses 40, mineral mixture 8, common salt 3, sodium bentonite 3, calcite powder 3, cottonseed cake 14 and groundnut extractions 14 parts. Nitrogen content of the CS, GLS and ULS was 3.67, 3.42 and 8.40%, respectively. The ratio between metabolizable and gross energy of T_2, T_3 and T_4 was 0.4. Though the 3 supplements fed to meet the maintenance need of the animals, they were vary in bulkiness with different levels of dry matter content (table 1). Green Lucerne was harvested between 8:30 to 9:00 h. Both CS and GLS were offered to the animals at 9:30 h. UMMB licks were placed in a plastic tray and fitted adjacent to the feed trough. Animals in T_3 were accessible to UMMB licks throughout the day to encourage its licking at free of choice. On fresh basis, animals were consumed 1.17, 4.95 and 0.52 $kg \cdot d^{-1}$ concentrate mixture, green Lucerne and UMMB lick, respectively. The bulkiness of the GLS was 4 times higher than CS and that of the CS was 2 times higher than ULS. Daily roughage and supplement intake were recorded throughout the study.

Sampling for measuring degradation attributes of different straw

Wheat and paddy straw samples of untreated (WS and PS) and urea treated (UTWS and UTPS) were used to study the pattern of degradability of cell walls in rumen. WS and PS were treated with 4% urea and 40% moisture (Dias-da-Silva and Sundstol, 1986). Both untreated and treated samples were milled in a willey mill through 2.5 mm sieve. Degradation of straw samples in rumen was studied using nylon bag technique (Orskov et al., 1980).

A sample of 4-5 g was taken in a 5×10 cm nylon bag having a pore size of 50-60 μm. After a preliminary period of feeding for 45 d, samples were suspended in rumen. Bags in triplicate were taken for each incubation time per animal in each treatment. Bags were removed at 12, 24, 48, 72, 96 and 120 h, washed with tap water and washing losses estimated. Bags were dried to a constant weight in hot air oven at 70°C. Final weights were recorded with correction for washing losses. Straw samples were analysed for organic matter and cell wall constituents before and after incubation in rumen (Goering and Van Soest, 1970).

Estimation of rumen degradation kinetics

The percent disappearance of dry matter (DM) was calculated as the difference between the feed and the residue remaining in nylon bag. These values were fitted to the following non-linear regression equation (McDonald, 1981):

$$P=A+B[1-\exp(-Ct)] \quad \text{----------} \quad (1)$$

Where A and B are different fractions denoting soluble and insoluble but potentially degradable portion of the feed component, respectively and C is fractional rate of disappearance of B. Effective degradability (ED) of feed was calculated from A, B and C values by using following equation:

$$P=A+B\times C/(C+K)\times\exp[-(C+K)\times T] \quad \text{------} \quad (2)$$

Where K is the out flow rate of digesta from the rumen. It was assumed as 0.03 h^{-1} since the diets were based on crop residues and fed at maintenance level (ARC, 1990).

Rumen attributes and digestibility trial

Rumen liquor samples were collected through a cannula with the help of specially made stainless steel probes with a large number of small holes drilled in them and covered with fine nylon cloth (pore size 50-60 μm). Probes were kept at four different sites in rumen to draw a representative sample of rumen liquor at 0, 2, 4, 6, 8 and 10 h interval after offering the feed. Rumen liquor was strained (SRL) through double layer cheese cloth. Rumen liquor pH, total nitrogen (Total-N; AOAC, 1984), ammonia nitrogen (NH_3-N; Conway, 1962) and total volatile fatty acids (TVFA; Barnett and Reid, 1977) were estimated.

A digestibility trial for 7 d was conducted at the end of the study. Daily collections of faeces were weighed, mixed thoroughly and 1% sub-samples was taken. Fecal samples were kept acid by adding 4 M H_2SO_4. Feed and faeces samples were analysed for proximate principles (AOAC, 1984) and cell wall constituents (Goering and Van Soest, 1970).

Table 1. Chemical composition of straw substrates and diet supplements

Variable	Wheat straw		Paddy straw		Concentrate mixture	Green lucerne	UMMB lick
	Untreated	Urea treated	Untreated	Urea treated			
Dry matter	94.32	52.76	90.80	49.52	93.66	24.32	94.27
Organic matter	87.92	85.44	86.21	86.38	93.89	88.16	78.89
Neutral detergent fibre	82.23	81.68	79.34	79.58	40.90	51.14	11.26
Acid detergent fibre	54.74	54.32	52.96	53.05	22.65	38.72	3.90
Hemicellulose	27.49	27.36	26.38	26.53	18.25	12.42	7.36
Cellulose	39.21	39.84	33.54	33.48	15.07	29.10	1.82

Statistical analysis

Effect of diet, type of straw and interaction between both the factors on degradation characters were analysed using randomized complete block design for factor α (Diet) at four levels with factor β (Type of Straw) a split plot on α with 4 levels using following model.

$X_{ij\,k}=\mu+\rho_i+\alpha_j+\gamma_{ij}+\beta_k+I_{jk}+e_{ijk}$

$X_{ij\,k}$ is the observation variable corresponding to the observation $X_{ij\,k}$ coming from the k^{th} subplot treatment of the jth main plot treatment in the i^{th} replication. μ is the general mean. ρ_i, α_j, β_k are the fixed effect of the i^{th} replication, j^{th} main treatment and k^{th} subplot treatment, respectively. I_{jk} is the interaction effect between diet and type of straw. γ_{ij} is error component for diet and replication and e_{ijk} are the error components that are assumed to be independently and normally distributed with zero mean and constant variance. The relative effective degradability (RED) was calculated as ratios between treatment means and grand mean of all the treatments. Ranking for degradation attributes between diet was done using nearest neighbor analysis (Snedecor and Cochran, 1967; Das and Giri, 1991).

RESULTS

The chemical composition of the untreated and urea treated straw samples and feed is given in table 1. It was similar between untreated and treated straw samples. Three supplements in T_2, T_3 and T_4 were distinctly different in organic matter (OM) and cell wall composition. Cell wall carbohydrates (CWC) in the supplement of T_2 were less than T_3 but higher than T_4.

Straw intake was significantly ($p<0.01$) different between diets. Total dry matter intake (kg/100 kg body weight) was increased by 70, 54 and 49% in T_2, T_3 and T_4 than that of T_1, respectively (table 2). When compared between supplemented groups, straw intake was less in T_3 than in other two treatments. Whole tract digestibility coefficient for DM and OM were significantly different ($p<0.01$) between treatments. However, digestibility coefficients of CWC were similar. Fluctuations in rumen parameters tested at different intervals after feeding was shown in figure 1. Rumen pH in T_2 was below 6.5 and significantly less ($p<0.01$) than other treatments that were above 6.6. In particular, rumen pH in T_3 was higher ($p<0.01$). Total-N and NH_3-N were significantly ($p<0.01$) higher in T_2 and T_4, respectively compared to other treatments. TVFA concentration in T_2, T_3 and T_4 were similar but substantially less ($p< 0.01$) on T_1.

Influence of treatment on A of OM and CWC degradation is presented in table 3. Diet, type of straw and their interaction were significantly influenced A of OM or CWC. Response of different kinetic attributes (A, B, C or

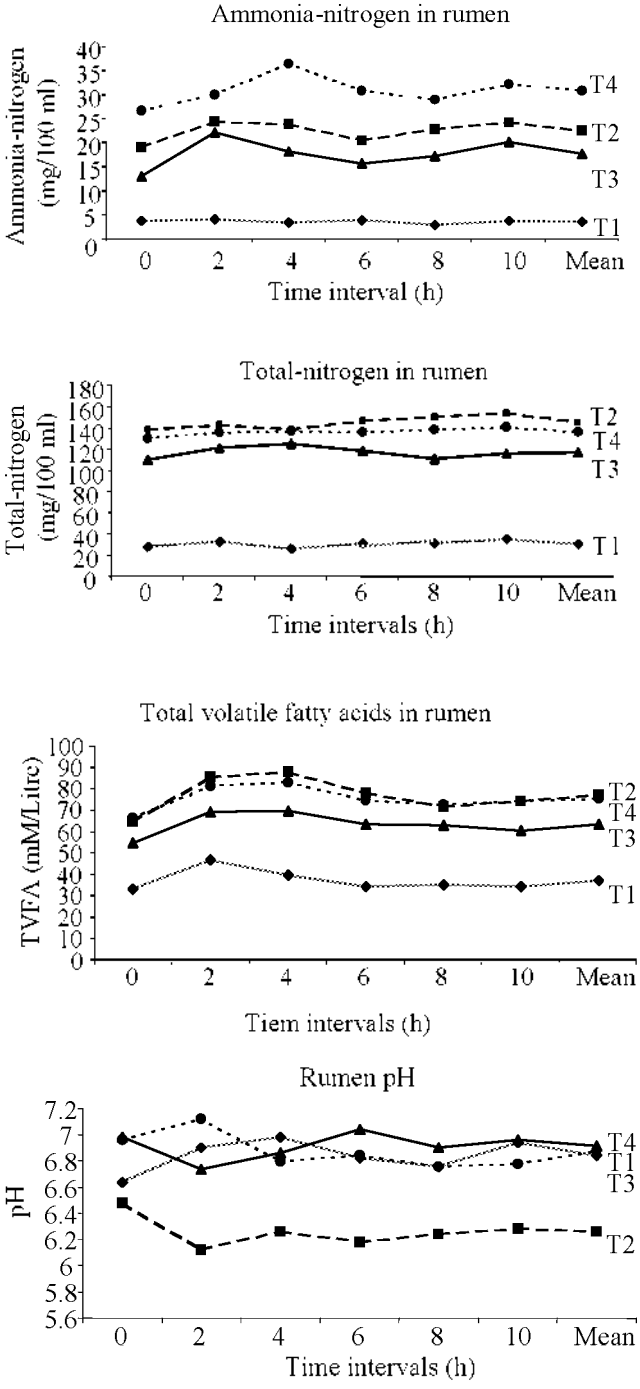

Figure 1. Rumen parameters on unsupplemented and supplemented diets at different intervals

ED) to the supplement was described as relative improvement over T_1. Impact of T_2 was higher and T_4 was less on A of OM for WS whereas higher in T_3 and less in T_2 in case of PS. A of UTWS was improved two fold compared to UTPS (19-35%) in T_2, T_3 and T_4. Supplements had more impact on A of neutral detergent fibre (NDF) of WS or UTWS, and A of hemicellulose or cellulose of PS or UTPS. T_4 had better impact on the A of NDF irrespective of

Table 2. Intake and digestibility of diets in different treatments

Component	Wheat straw *ad lib* & no supplement	Wheat straw *ad lib* + supplementation of Concentrate mixture	Green Lucerne	UMMB lick	Mean ±SE	LSD
Initial body weight (kg)	251.8	252.5	252.8	253.0	9.64	21.80
Final body weight (kg)	244.3	253.8	253.2	253.8	9.91	22.42
Straw intake (kg/d)**	3.87^{a}	5.54^{b}	4.82^{c}	5.32^{bd}	0.36	0.40
($g/kg_W^{0.75}$)	61.23^{a}	87.68^{b}	76.00^{c}	84.15^{bd}	1.40	3.17
Supplement intake (kg/d)	0.02^{a}	1.10^{b}	1.20^{b}	0.49^{c}	0.05	0.12
($g/kg_W^{0.75}$)	0.3^{a}	17.38^{b}	19.05^{b}	7.79^{c}	0.36	1.39
Total dry matter intake						
kg/100 kg body weight	1.54^{a}	2.64^{b}	2.38^{c}	2.31^{cd}	0.05	0.09
g/kg $M^{0.75}$**	61.55^{a}	105.08^{b}	95.05^{c}	91.95^{cd}	0.89	3.11
Digestible dry matter intake ($g/kg_W^{0.75}$)**	28.16^{a}	54.35^{b}	47.67^{c}	47.49^{c}	0.67	1.52
Digestible organic matter intake ($g/kg_W^{0.75}$)**	26.77^{a}	52.04^{b}	46.11^{c}	45.71^{c}	0.66	1.49
Degradable cell contents intake from basal roughage						
(g/100 kg B.Wt)	97.35	127.81	140.04	116.73	6.27	60.16
($g/kg_W^{0.75}$)	3.89	5.09	5.58	4.66	1.05	2.38
Degradable cell walls intake from basal roughage						
(g/100 kg B. Wt)**	268.26^{a}	379.16^{b}	296.79^{c}	367.00^{b}	9.07	25.28
($g/kg_W^{0.75}$)**	10.64^{a}	15.06^{b}	11.83^{c}	14.60^{b}	0.40	0.91
Digestibility coefficients						
Dry matter**	43.72^{a}	49.52^{b}	48.51^{b}	49.71^{b}	0.67	4.43
Organic matter**	46.00^{a}	51.72^{b}	50.15^{b}	51.59^{b}	0.68	2.10
Neutral detergent fibre	48.55	51.55	50.35	50.83	0.46	1.62
Acid detergent fibre	40.77	44.42	41.90	45.79	0.67	2.50
Hemicellulose	56.14	59.36	57.54	57.97	0.79	2.86
Cellulose	49.37	50.19	51.43	52.29	0.61	1.95
Rumen parameters						
pH**	6.84^{a}	6.26^{b}	6.91^{a}	6.78^{a}	0.02	0.07
Ammonia nitrogen** (%)	3.60^{a}	23.20^{b}	18.16^{c}	30.30^{d}	1.08	2.28
Total nitrogen** (%)	30.40^{a}	146.00^{b}	130.24^{c}	136.30^{c}	6.52	5.83
Total volatile fatty acids** (mM L^{-1} SRL)	38.50^{a}	73.80^{b}	70.26^{b}	69.90^{b}	7.62	6.16

^{a,b,c,d} Values bearing different superscripts differ significantly ($p<0.01$).

straw sample while the impact of T_2 was lesser. T_3 could induce less impact on the A of hemicellulose or cellulose compared to T_2 and T_4.

Diet, type of straw and their interaction had significant effect on B of OM or NDF but not on that of the hemicelluloses or cellulose (table 4). Although B of OM in WS due to supplements was unaltered, it was enhanced by 20-30% after urea treatment than T_1. Improvement in B of NDF in PS was two fold less than that of the WS in T_2, T_3 and T_4 but increased three fold in the latter after urea treatment. Impact of T_2, T_3 and T_4 on the B of hemicellulose and cellulose was higher in T_4 and less in T_2.

C of OM and NDF were significantly affected by the diet and type of straw (table 5). However, only type of straw had significant influence on the C of hemi cellulose and cellulose. Except C of OM or NDF in PS, urea treatment enhanced C of OM or CWC. C of hemi cellulose or cellulose was relatively improved more in T_4 than T_2 or T_3.

Diet, type of straw and their interaction significantly ($p<0.01$) influenced the ED of OM and CWC. The ED of straws were higher in T_2 and less in T_3. ED of straws in T_4 was more comparable with T_2 rather with T_3 (table 6).

The principle aim of the work is to differentiate the impact of diets on the qualitative degradation of straws rather than comparison between type of straws, grouping of RED values of OM and cell wall constituents were considered between untreated and treated straw. The RED below 1.0 in T_1 and some extent in T_2 indicate relatively poor response of the degradation of straw to the diets compared to other diets. RED of urea treated straw in T_3 was moderately 1.0 (table 7). RED values on T_2 and T_4 were much higher than 1.0 for both untreated and treated straw. The overall ranking from nearest neighbour analysis indicated that ED of straws was higher on T_2, T_4, T_3 and T_1 as in the order given.

Table 3. Rapidly soluble fraction (A) of organic matter and cell wall components of urea treated and untreated straw in different rumen environments

Diet	Type of straw	Organic matter	Neutral detergent fibre	Hemicellulose	Cellulose
Wheat Straw	WS	4.69	4.71	5.50	3.55
ad lib and	PS	2.95	6.82	5.37	4.85
No supplement	UTWS	6.76	8.34	10.35	8.40
	UTPS	10.31	10.33	8.08	8.84
Wheat Straw	WS	8.14	5.28	13.41	4.78
ad lib +	PS	4.74	7.53	15.79	10.02
Concentrate	UTWS	12.29	10.98	17.19	8.76
Supplement	UTPS	12.30	11.94	15.89	14.39
Wheat Straw	WS	6.97	8.11	10.07	4.87
ad lib + Fresh	PS	7.00	8.16	12.36	8.47
Green Berseem	UTWS	11.71	11.53	12.95	8.29
Supplement	UTPS	13.80	11.37	12.36	12.47
Wheat Straw	WS	6.26	7.25	12.40	4.83
ad lib +	PS	4.85	10.89	17.29	9.12
UMMB Lick	UTWS	10.00	12.52	15.54	9.54
Supplement	UTPS	12.26	11.92	17.18	14.34
SEM	Factor	0.79	0.40	0.50	0.34
	Interaction	1.59	0.79	1.01	0.68
Critical difference#	Factor $^{D/S}$	1.25**/**	0.72**/**	1.43**/**	0.97**/**
Difference#					
	Interaction	2.25*	1.14*	2.86*	1.94**

'D' at the left of the slash indicates significance of diet factor and 'S' at right of the slash indicates significance of straw factor. Statistical Significance: ** p<0.01, * p<0.05, NS: p>0.05.

Table 4. Slowly degradable fraction (B) of organic matter and cell wall components of urea treated and untreated straw in different rumen environments

Diet	Type of straw	Organic matter	Neutral detergent fibre	Hemicellulose	Cellulose
Wheat Straw	WS	60.61	37.96	50.35	53.28
ad lib and	PS	53.03	48.10	56.98	58.06
No supplement	UTWS	52.66	68.03	54.46	62.69
	UTPS	50.23	68.52	57.90	51.50
Wheat Straw	WS	59.67	54.89	56.62	55.07
ad lib +	PS	58.03	59.24	65.90	59.85
Concentrate	UTWS	60.97	71.67	72.08	61.44
Supplement	UTPS	68.08	84.40	65.40	57.91
Wheat Straw	WS	61.42	58.02	67.57	55.75
ad lib + Fresh	PS	53.05	64.51	67.59	65.85
Green Berseem	UTWS	61.53	71.89	66.05	60.55
Supplement	UTPS	60.62	66.60	67.59	60.94
Wheat Straw	WS	58.71	66.65	69.18	55.51
ad lib +	PS	59.19	60.80	71.80	57.66
UMMB Lick	UTWS	61.38	72.48	69.29	61.93
Supplement	UTPS	77.76	80.07	69.07	62.00
SEM	Factor	1.58	1.74	1.77	1.64
	Interaction	3.16	3.49	3.54	3.29
Critical Difference#	Factor$^{D/S}$	4.49**/*	4.95**/**	5.03**/^{NS}	4.68$^{NS/NS}$
	Interaction	8.98*	9.91*	10.06^{NS}	9.36^{NS}

'D' at the left of the slash indicates significance of diet factor and 'S' at right of the slash indicates significance of straw factor. Statistical significance: ** p<0.01, * p<0.05, NS: p>0.05.

Table 5. Rate constant of degradation (C) of organic matter and cell wall components of urea treated and untreated straw in different rumen environments

	Type of straw	Organic matter	Neutral detergent fibre	Hemicellulose	Cellulose
Wheat Straw	WS	0.91	1.44	1.75	0.55
ad lib and	PS	2.13	0.97	1.69	0.98
No supplement	UTWS	2.31	0.64	1.55	0.54
	UTPS	1.52	0.60	1.64	1.20
Wheat Straw	WS	1.65	1.42	1.37	0.59
ad lib +	PS	2.49	1.16	1.21	0.92
Concentrate	UTWS	1.69	0.96	1.02	0.65
Supplement	UTPS	1.52	0.79	1.21	1.04
Wheat Straw	WS	1.26	0.95	1.07	0.61
ad lib + Fresh	PS	1.73	0.72	1.07	0.90
Green Berseem	UTWS	1.53	1.00	1.21	0.60
Supplement	UTPS	1.43	0.79	1.07	1.01
Wheat Straw	WS	1.69	1.05	0.99	0.72
ad lib +	PS	2.45	1.26	0.94	1.03
UMMB Lick	UTWS	1.83	0.95	1.16	0.72
Supplement	UTPS	1.29	0.85	1.00	1.14
SEM	Factor	0.13	0.05	0.07	0.04
	Interaction	0.27	0.11	0.15	0.08
Critical Difference#	Factor $^{D/S}$	0.38**/*	0.15**/**	$0.21^{NS/NS}$	$0.12^{NS/**}$
	Interaction	0.76^{NS}	0.31**	0.41^{NS}	0.24^{NS}

'D' at the left of the slash indicates significance of diet factor and 'S' at right of the slash indicates significance of straw factor. Statistical significance: ** $p<0.01$, * $p<0.05$, NS: $p>0.05$.

DISCUSSION

Chemical composition of untreated and urea treated straw could not yield a definite inference against the existing two contrary opinions on its influence on altering the cell wall composition (Ibrahim et al., 1995). Generally difference in chemical composition may be possible due to variation in the proportions of leaf blade in the straws. Leaf blade in wheat straw was reported to digest more than that of the paddy straw (Capper. 1988). In any case, variation in solubility of CWC and their response to chemical treatment could be explained by the difference in leaf and stem proportion of the straws (Capper, 1988). Higher silica content in rice straw compared to wheat straw reported to make its leaves less digestible than stems (Walli et al., 1988). Positive associate effects of supplements on dry matter intake was confirmed in the earlier recommendation to feed supplement with straw based diet (Silva and Orskov, 1988; Prakash et al., 1996; Bonsi and Osuji. 1997). Intake and digestibility of forage feeds by cattle are positively related (Baile and Forbes. 1974). In this experiment no significant difference in dry matter digestibility (DMD) coefficient between supplemented diets reflected that the difference in intake could be attributed to other factors like body weight. physiological state. energy value and method of conservation (ARC. 1990).

However. uniform physical state of the experimental animals in the supplemented diets and the significant difference in intake between treatments per unit of metabolic body size which otherwise should be. tend to count on rest other factors. The predicted value of metabolizability (q) of diets from the DMD coefficient by the factor suggested by ARC (1990) was 0.35. 0.40. 0.39 and 0.40 in T_1. T_2. T_3 and T_4. respectively. It was significantly different between diets but not between T_2, T_3 and T_4. This then indicated that the variability in intake could be attributed to physical form of the supplements because its bulkiness has been reported to affect the intake (Preston. 1982). The 1:4 ratio between GLS and basal roughage in the present study also appeared to limit the intake of the latter. Increased intake with lucerne content more than 25% has been reported to associate with linear increase in particulate passage rate and physical change in particle size in rumen digesta rather than change in fermentative degradation of the particulate matter (Hunt et al., 1988). The closed arrangement of lignified tissues of Lucerne imparts an advantage of greater ease of breakdown in rumen (Grenet, 1989) besides the animal inclination in chewing fresh forage effectively than dried ones (Ulyatt et al., 1986). Bowman and Asplund (1988) also reported lower intake of CWC when lucerne hay was supplemented to caucasian bluestem hay. Quantitative DM intakes per unit

Table 6. Effective degradation (ED) of organic matter and cell wall components of urea treated and untreated straw in different rumen environments

Diet	Type of straw	Organic matter	Neutral detergent fibre	Hemicellulose	Cellulose
Wheat Straw	WS	20.45	16.93	23.88	16.88
ad lib and	PS	21.93	16.90	25.85	19.05
No supplement	UTWS	25.35	19.28	28.28	19.23
	UTPS	26.98	20.70	28.40	23.45
Wheat Straw	WS	28.43	22.88	30.93	24.73
ad lib +	PS	29.88	23.90	34.15	25.23
Concentrate	UTWS	35.00	27.00	34.83	28.25
Supplement	UTPS	36.18	28.43	34.15	28.30
Wheat Straw	WS	24.33	18.33	26.98	20.58
ad lib + Fresh	PS	26.05	19.98	29.78	21.90
Green Berseem	UTWS	31.90	25.75	30.73	23.28
Supplement	UTPS	34.09	24.85	29.78	26.63
Wheat Straw	WS	27.18	22.25	29.05	24.35
ad lib +	PS	28.23	23.70	34.73	25.20
UMMB Lick	UTWS	34.28	27.38	34.25	26.83
Supplement	UTPS	34.93	28.30	33.78	28.38
SEM	Factor	0.25	0.19	0.25	0.23
	Interaction	0.50	0.38	0.50	0.46
Critical Difference#	Factor $^{D/S}$	0.71**/**	0.54**/**	0.71**/**	0.65**/***
	Interaction	1.42**	1.08**	1.41**	1.30**

'D' at the left of the slash indicates significance of diet factor and 'S' at right of the slash indicates signifcance of straw factor. Statistical Significance: ** p<0.01, * p<0.05, NS: p>0.05.

Table 7. Relative effective degradability (RED) of cell wall components of untreated and urea treated straw substrates in different diet

Diet	Untreated Straw				Urea Treated Straw			
	OM	NDF	Hemicellullose	Cellulose	OM	NDF	Hemicellullose	Cellulose
I	0.818	0.809	0.848	0.813	0.809	0.803	0.872	0.833
	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
II	1.118	1.146	1.101	1.113	1.101	1.095	1.078	1.112
	(1)	(1)	(1)	(1)	(1)	(2)	(1)	(1)
III	0.972	0.928	0.976	0.965	1.027	1.004	0.977	0.989
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
IV	1.092	1.116	1.074	1.109	1.063	1.097	1.073	1.067
	(2)	(2)	(2)	(2)	(2)	(1)	(2)	(2)

Values in parenthesis indicate relative ranking of diets.

of metabolic body weight from CS and GLS was same but stimulation in straw intake was higher for former than for the latter. This supports the view that diets based on coarse roughages would be eaten in greater quantity with higher concentrates (ARC, 1990). CS effect on straw intake was greater than other two types of supplement. CS generally has an advantage of providing performed amino acids, peptides and bypass protein those have an influence on fibre digestion in the rumen of cattle (Smith et al., 1987, Mc Allan et al., 1988) and voluntary intake (Preston, 1982). Variation in the particle size of CS, GLS or ULS and their chemical composition; such as fractions of cell contents or cell walls, makes them to behave differently while fermenting in rumen. Low cell wall fractions, particle size and shape were the peculiar advantageous of CS in kinetics rate of digestion (Murphy and Kennedy, 1993). The rate of fermentation of concentrate ingredients as determined from the gas production per unit time appears to be higher than meadow hay and oat straw (krishnamoorthy et al., 1991). Differential rate of fermentation of ingredients in the CS, may presumed to maintain a gradual and steady rate of fermentation compared to GLS which may not have such an advantage.

Variations in rumen pH between diets testify the

differential impact of supplements on rumen environment. Generally rumen environment defined by pH and concentration of fermentation end products affect the rate and extent of rumen degradation of food (Ranilla et al., 2000). Taking into consideration the fact that the level of NH_3-N needed in rumen is dependent on the pH of the rumen (Smith, 1989), NH_3-N concentration corresponding to pH on GLS was lower compared to either CS or ULS. Substantially lower concentration of TVFA in control and supplemented diet again ascertained energy deficiency on straw diets. As suggested by Leng (1990), higher NH_3-N and TVFA concentration on supplemented diets may probably induce an impact on the microbial cell synthesis that lead to the improved voluntary intake.

Degradation of WS or PS was increased significantly ($p<0.01$) after urea treatment. It is well known that the NH_3 released from urea by hydrolysis will have an partial impact on the solubilization of cell walls of straws/stovers (Dias-da-silva and Sundstol, 1986). Improvements in degradation attribute of A, B and ED of OM or CWC after urea-ammoniation were in agreement with the earlier reports (Nakashima and Orskov, 1990; Fondevila et al., 1994). PS, which had a less degradation than WS, was improved to more extent after urea treatment than the latter. Tuah et. al. (1986) reported that the ammonia treatment tended to improve poor varieties of straws to a greater extent than those varieties having better nylon bag disappearance values. Significant influence of diet and type of straw on the kinetic attributes between treatments and type of straw indicated that both rumen environment and physical structure of straw are important factors (Orskov et al., 1990). When the quality of straw was inferior as in PS, the impact of CS was less but the impact of GLS or ULS was comparatively higher. Contrary impact of CS compared to GLS or ULS on OM and NDF with regard to A, B or ED indicated that it supported more of the degradation of cell contents.

It is evident from the earlier studies that the growth of non-structural carbohydrate fermenting microorganism is maximized when diet contained natural protein source (Russel et al., 1992; Meng et al., 2000). Concurrently it is also probable that the specific effect of comparatively less pH on CS along with non-specific effect of carbohydrates source from grain may have contra-impact on the growth of cellulolytic organism (Leng, 1990). Comparatively better kinetic attributes of hemi cellulose and cellulose degradation on ULS than other two supplements may probably due to higher pH and NH_3-N concentration in rumen. Earlier studies have shown an increase in the utilization of low-N and low-digestible forage at higher ruminal NH_3-N concentration (Leng, 1990). Despite the fact that addition of high digestible forage along with straw induces the colonization effect of rumen bacteria on the latter (Krebs et al., 1989; Leng, 1990), improvement in degradation of hemi cellulose or cellulose over control on GLS was either average or poor than CS and ULS. Presumably this may be due to lack of adequate quantity of NH_3-N in rumen on GLS to satisfy the requirement of poor fermentability of straw because NH_3-N required for maximum digestion is a function of fermentability of the diet (Erdman et al., 1986). The studies of Silva and Orskov (1988) have clearly shown that when the NH_3-N in rumen was below 200 mg l^{-1}, potential degradability of barley straw was effected. Studies from Australia showed that 200 mg l^{-1} is a minimum level of rumen fluid NH_3-N for optimum voluntary intake of straw (Krebs and Leng, 1984; Boniface et al., 1986). Lower intake of WS observed on GLS may also thus attributable to below 200 mg l^{-1} NH_3-N and less rate of degradation of CWC (Manyuchi et al., 1992).

Type of straw had a significant effect on the content of hemicellulose and cellulose but diet did not have any impact on it. Generally C is largely dependent on physico-chemical characteristics of substrate (Van Soest, 1994) but C of OM or NDF was dependent on both diet and type of straw. It was also observed that the C of hemi cellulose was higher than cellulose. Such variation could be expected because the potentially-digestible cell wall can have more than one rate constant characteristic of the different cell wall components (Smith et al., 1987). Urea treatment had no significant affect on the C and agrees with the observations reported by other workers (Nakashima and Orskov, 1990; Fondevila et al., 1994). C of OM on GLS or ULS was decreased and NDF was increased after supplementation and vice-versa was true with CS. Presumably such changes could be due to influence of diet on the composition of microbial species in rumen (Russel et al., 1992).

The overall effects of supplements on the RED of OM and CWC of untreated and treated straw were remarkable. CS had superior ranking for RED of both untreated and treated straw. ULS was ranked to be better than GLS. RED values less than 1.0 in GLS indicated its under impact on the degradation of straws. However, GLS coupled with urea treatment appears to bring changes in RED of OM and NDF but not in the RED of hemicellulose and cellulose. Although ULS along with urea treatment was appeared to improve RED of NDF but it was not an accountable improvement as the ranking of hemicellulose and cellulose were unchanged.

CONCLUSIONS

Straw diets categorically require supplements to improve conditions in the rumen for optimum fibre degradation. Different supplements viz., concentrate, green

leguminous fodder and urea-molasses based supplements were found effective to increase the total dry matter intake but their impact on the extent of degradation of straw was variable. CS was found to be a better choice among all the categories of supplements. However, it had a more impact on superior quality straw. ULS was observed to be better choice on inferior quality straw e.g., paddy straw. CS along with urea treated straw enhanced the degradation of fraction-A besides fraction-B unlike urea alone without any supplements. GLS was not as effective as CS or ULS to enhance the degradation of either untreated and treated straw. While supplementing green fodder for straw diets care should be taken for its level of inclusion in the diet. It should be included in the ration along with basal roughage at the ratio of 1:4 or less to avoid impact of its bulkness on the consumption of basal roughage. GLS or ULS may not have much impact on the degradation of hemi cellulose or cellulose of treated straw.

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