

## Eating Behaviour, VFA Production, Passage Rate and Nutrient Digestibilities in Cattle Fed on Wheat Straw Supplemented with Different Levels of Berseem

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**ABSTRACT** : Four ruminally fistulated crossbred (Sahiwal×Holstein Friesan) adult (~6 yr.) cattle of about 318±16 kg body weight were randomly assigned in an experiment based on 4×4 latin square design to study the effect of different level of berseem (*Trifolium alexandrinum*) supplementation to wheat straw based diet on intake, digestion, VFA production, eating behaviour and passage rate. Four dietary treatments were wheat straw *ad lib.* (I), supplementation to wheat either 15 (II), 30 (III) or 45 (IV)% of berseem. Mean total volatile fatty acids (TVFA) concentration in rumen liquor was 58.45, 66.14, 77.92 and 78.64 mmol/l. TVFA concentration in rumen liquor increased significantly ( $p<0.01$ ) with increased level of berseem supplementation upon 30% level of berseem. Two peaks of TVFA concentration was observed at 4 and 8 h post feeding. Berseem supplementation showed no significant effect on daily time spent for eating, ruminating or idling, chews per minute or number of rumination boli ingested per minute. Time spent for eating and ruminating one kg neutral detergent fibre (NDF) was significantly ( $p<0.05$ ) less in berseem supplemented groups. Animals in groups I, II, III and IV consumed 26, 34, 47 and 57% of DM within 1st 4 h and 64, 70, 70 and 77% of total DM within 1st 8 h of offering. All the animals consumed more than 90% of their DMI within 12 h. Active period of rumination was observed 8h post feeding reached the peak at 16 h post feeding, then declined and animals spend considerable time idling in last 4 h of 24 h feeding cycle. Berseem supplementation showed no significant effect on eating and rumination time. It is concluded that berseem supplementation upon 30% increases the efficiency of chewing during eating and rumination, which results in increase intake and TVFA production and nutrient digestibility. (*Asian-Aus. J. Anim. Sci. 1999, Vol. 12, No. 7 : 1040-1048*)

**Key Words** : Wheat Straw, Berseem, Supplementation, Eating Behaviour, VFA Production, Cattle

### INTRODUCTION

Wheat straw is the main basal feed for ruminants in India. However, wheat straw is characterized by low intake and digestion. Supplementation of wheat straw should aim at improving the intake of basal diet and total dry matter and overall digestibility of the diet. Nutritive value of low quality feeds is in addition to intake and digestion related to proportion of individual volatile fatty acids produced. It is generally accepted fact that green forage supplementation improves the digestibility of diet (Leng, 1990). However, the response on intake varies widely from negative impact on straw intake (Tharmaraj et al., 1989), to no impact (Mc Meniman et al., 1988; Sangawan et al., 1992) and more often than not an increase in straw intake (Moran et al., 1983; Suriyantratonong and Wiliapon, 1985; Bird et al., 1994). Such wide variation in results could be attributed to the nature of basal diet and supplement and also to the level of supplementation. Thus, how a specific supplement will interact with the basal diet needs to be studied.

Berseem is a green leguminous fodder grown during winter season in India, particularly in the milk

tract of Punjab, Haryana, Rajasthan and Uttar Pradesh. Berseem contains 15-20% CP and 4.1 kcal/g GE (Chauhan et al., 1992). Berseem is highly palatable and on sole feeding animals can consume as high as 7.5 kg DM/d (Nandra et al., 1989). The fodder is highly digestible and on sole feeding can support a growth rate of 550 g/d in calves (Chauhan et al., 1992). In practice, farmers in India feed wheat straw and berseem mixed together without considering the ratio. Berseem supplementation of wheat straw is reported to increase *in sacco* dry matter degradability of wheat straw based diet (Reddy et al., 1991). However, no information is available in the literature regarding effect of different levels of berseem supplementation on intake and digestion and factors regulating them i.e. time spend in eating and rate of eating (Biney and Davey, 1976), time spent in rumination (Welch, 1982), rumen fill (Compiling and Balch, 1961), fermentative digestion and passage from the rumen (Bosch et al., 1992). Hence, this experiment was undertaken to study the effect of different levels of berseem supplementation of wheat straw on intake, digestion, eating behaviour, passage rate of indigestible NDF and volatile fatty acid production in cattle.

### MATERIALS AND METHODS

#### Animal and design

Four ruminally fistulated crossbred (Sahiwal×Holstein Friesan) adult (~6 yr.) steers of about 318±16 kg body weight were randomly distributed to 4×4

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Received June 2, 1998; Accepted January 27, 1999

latin square design with experimental period lasting 35 d of which 14 d was adaptation period. Eating behaviour was studied on d 15 and 16, rumen liquor sampling was done on d 17, intake and digestion was measured through d 17 to d 22, rumen evacuation was conducted through d 26 to 32 of each period. Besides, particle dynamics was studied through d 22 to 26 and rate of communitation was studied through d 32-35 of each period, results of which are communicated elsewhere for publication.

### Feeding

The animals in group I were fed wheat straw *ad lib*. The diet of animals in groups II, III and IV contained about 15, 30 and 45% berseem, respectively. The amount of supplement to be offered was decided from intake of previous day to keep the level of berseem as close as possible to desired experimental levels. The supplement was offered once daily at 9.00. Wheat straw was also offered once daily, immediately after consumption of the supplement. All the animals consumed the supplement within 1st h of offering. The experiment was started from 1st Jan. 1995. Berseem used during the 1st experimental period was of 1st cut. However, in the subsequent periods berseem of 2nd, 3rd and 4th cut was used, respectively. Drinking water was freely available to all the animals. Besides, the animals in group I received I/V injection of 2 ml of propylene forte (containing 10000 IU of vit. A) once in a week.

### Measurements

**Eating behaviour** : On d 15 and 16 of each experimental period, time spent in eating and ruminating was measured by recording behaviour for 1min. at interval of 5 min. for 2 consecutive days. Number of chews during one minute eating and rumination was recorded. For recording the number of chews per minute eating observations were made during 5 eating bouts (2 for wheat straw, 3 for berseem) daily. Similarly, for recording the number of straw chews per minute rumination observations were made during 5 rumination period daily. Number of chews required to cud one rumination bolus was also recorded and from this number of rumination boli ingested per minute rumination was calculated. Eating pattern of the animals was measured by weighing the amount of feed left in front of the animals every 4 h after 1st offering the feed. The animals were trained to the procedure by removing the feed for 5 min. (without weighing) at 4 h intervals 2d prior to measurement.

**Rumen liquor sampling** : Rumen liquor samples were collected on d 17 of each period of 0, 2, 4, 6, 8, 12, 16 and 20 h post feeding. The pH was measured immediately, and samples for  $\text{NH}_3\text{-N}$  and

VFA analysis were stored frozen at  $-20^\circ\text{C}$  after acidification with conc.  $\text{H}_2\text{SO}_4$ . Rumen fluid outflow rate was estimated as per Hyden (1956).

**Intake and digestion** : A digestibility trial of 5 d collection was conducted through d 17 to 22 of each period to measure the intake and digestibility of nutrients.

**Rumen evacuation** : Each steer's rumen was evacuated once daily over d 26 to 32 of each periods either at 9, 12, 15, 18, 21 and 3 h. Total rumen content was removed by hand. The contents were weighed, mixed, sampled (500 g) and the remainder returned to the rumen. The feed remaining in front of the animals was weighed just prior to each evacuation. Animal I was evaluated on 12, 15, 18, 21, 3 and 9 h of d 26, 27, 28, 29, 31 and 32, respectively. Animal II was evacuated on 15, 18, 21, 3, 9, and 12 h of d 26, 27, 28, 30, 31 and 32 respectively. Animal III was evacuated on 18, 21, 3, 9, 12 and 15 h of d 26, 27, 29, 30, 31 and 32, respectively. Animal IV was evacuated on 21, 3, 9, 12, 15 and 18 h of d 26, 28, 29, 30, 31 and 32 respectively. Samples of rumen content were analyzed for DM and NDF. A portion of sample was incubated in nylon bags in rumen of steers fed on respective diet, as from where the rumen contents were collected for 336 h to determine the indigestible NDF (INDF). The residues were analyzed for NDF.

**Chemical analysis** : Wheat straw, berseem and their residues, and faeces were analyzed for DM, ash, N, NDF and ADF. Samples of rumen contents and nylon bag residues were analyzed for NDF. Estimation of proximate principles were done according to AOAC (1980) and cell wall analysis was done according to Goering and Van Soest (1970). PEG concentration in rumen fluid was measured by spectrophotometer at wavelength 540 nm.  $\text{NH}_3\text{-N}$  concentration in rumen fluid was determined by microdiffusion technique of Conway (1962). Total VFA (TVFA) concentration in rumen fluid was determined by Markhams distillation. Individual VFA was measured by gas liquid chromatography. For this samples were prepared according to the method of Erwin et al. (1961). The samples were analyzed on a Nucon Gas Chromatograph Series - 5700 fitted with dual flame ionization detector packed chromosorb 101 to serve as stationary phase,  $\text{N}_2$  was used as carrier gas.

### Calculation and statistics

**Liquid outflow rate** : Liquid outflow rate was estimated according to the method of Hyden (1956) using PEG-4000 as liquid phase marker.

**VFA production, turnover and absorption rate** :

VFA production, turnover and absorption rate were calculated according to the method described by Oosting (1993). VFA production was calculated from the apparently rumen degradable organic matter intake (ARDOMI) assuming a molecular weight of glucose in polymerized carbohydrate of 162 g/mole.

VFA production (mol/d) = ARDOMI/162 × (100/0.5 × (proportion of acetate + proportion of propionate) + proportion of butyrate). VFA production rate (mole/h) = VFA production/24. VFA turnover rate (%/h) = VFA production/VFA pool/24 whereas VFA pool was estimated from the rumen fluid volume (using rumen evacuation data) and concentration of VFA in it.

VFA absorption rate (%/h) = VFA turnover rate - liquid out flow rate

**Pool size and passage rate :** Pool size and passage rate was calculated using rumen evacuation data. Pool size of INDF was calculated from total amount of rumen content and proportion of INDF in it. Input of INDF was calculated from intake of feed and proportion of INDF in it.

Rate of passage was measured as reciprocal of mean retention time, (MRT), where as MRT was calculated according to Thiago et al. (1992), as follow:

$$\text{MRT (h)} = \frac{\text{Average weight of INDF in rumen}}{\text{Rate of intake of INDF (g/h)}}$$

Statistical analysis : Data obtained were analyzed statistically according to Snedecor and Cochran (1967).

## RESULTS

Chemical composition of wheat straw and berseem are presented in table 1. There was little variation in chemical composition of wheat straw across the experimental periods. However, CP content of berseem decreased and CF, NDF and ADF content increased significantly ( $p < 0.05$ ) with advancing of maturity. But these changes did not result any significant period effect in any of the parameters studied.

### Intake

On an average, animals in groups II, III and IV consumed 17, 30 and 45% berseem respectively. Total dry matter intake (DMI) increased significantly ( $p < 0.01$ ) with increased level of supplementation upto 30% level of berseem, however, 45% berseem supplementation did not show any effect on DMI as compared to 30% level of supplementation (table 2).

### Digestibility

Digestibility of DM, OM, CP and NDF is presented in table 2. Digestibility of DM, OM and NDF increased significantly ( $p < 0.01$ ) upon 30% level

of berseem supplementation, whereas, at 45% level of supplementation, digestibility of nutrients decreased. However, CP digestibility increased significantly ( $p < 0.01$ ) with increased level of berseem supplementation in the straw based ration.

**Table 1.** Chemical composition of wheat straw and berseem during four periods of experiment

Items	Chemical composition in the period of				
	21st Dec to 25th Jan	26th Jan to 1st Mar	2nd Mar to 5th April	5th April to 10th May	SEM
	% DM basis				
<b>Wheat straw:</b>					
OM <sup>NS</sup>	87.46	86.90	87.31	87.77	0.25
CP <sup>NS</sup>	3.64	3.39	3.33	3.23	0.27
CF <sup>NS</sup>	38.67	38.17	38.43	38.86	0.33
EE <sup>NS</sup>	1.67	1.46	1.31	1.34	0.11
NFE <sup>NS</sup>	43.48	43.88	44.24	44.34	0.53
NDF <sup>NS</sup>	81.44	81.35	81.05	81.58	0.12
ADF <sup>NS</sup>	56.32	56.89	56.24	56.78	0.30
<b>Berseem:</b>					
OM <sup>NS</sup>	85.8	86.14	85.67	85.98	0.76
CP <sup>**</sup>	20.83 <sup>a</sup>	17.69 <sup>b</sup>	15.86 <sup>c</sup>	14.42 <sup>d</sup>	0.31
CF <sup>**</sup>	17.17 <sup>a</sup>	19.04 <sup>b</sup>	22.57 <sup>c</sup>	27.57 <sup>d</sup>	0.37
EE <sup>NS</sup>	2.64	2.48	2.41	2.01	0.12
NFE <sup>NS</sup>	45.20	47.93	44.24	42.42	1.46
NDF <sup>**</sup>	43.93 <sup>a</sup>	45.87 <sup>ab</sup>	49.12 <sup>b</sup>	54.12 <sup>c</sup>	0.64
ADF <sup>**</sup>	36.21 <sup>a</sup>	38.72 <sup>b</sup>	43.66 <sup>c</sup>	46.56 <sup>d</sup>	0.52

**Table 2.** Intake and digestibility by animals fed on wheat straw supplemented with different levels of berseem

Items	Treatment <sup>†</sup>				SEM
	I	II	III	IV	
<b>DM intake</b>					
kg/d <sup>**</sup>	4.17 <sup>a</sup>	5.40 <sup>b</sup>	6.51 <sup>c</sup>	6.65 <sup>c</sup>	0.375
kg/100 kg BW <sup>**</sup>	1.42 <sup>a</sup>	1.74 <sup>b</sup>	1.99 <sup>c</sup>	2.02 <sup>d</sup>	0.004
<b>OM :</b>					
kg/d <sup>**</sup>	3.63 <sup>a</sup>	4.72 <sup>b</sup>	5.66 <sup>c</sup>	5.77 <sup>c</sup>	0.13
kg/100 kg BW <sup>**</sup>	1.23 <sup>a</sup>	1.52 <sup>b</sup>	1.73 <sup>c</sup>	1.75 <sup>d</sup>	0.035
<b>Digestibility (%)</b>					
DM <sup>**</sup>	39.85 <sup>a</sup>	45.61 <sup>b</sup>	52.97 <sup>c</sup>	47.52 <sup>b</sup>	1.09
OM <sup>**</sup>	42.31 <sup>a</sup>	48.13 <sup>b</sup>	56.18 <sup>c</sup>	50.28 <sup>b</sup>	1.21
CP <sup>**</sup>	12.12 <sup>a</sup>	31.30 <sup>b</sup>	45.93 <sup>c</sup>	56.51 <sup>d</sup>	1.61
NDF <sup>**</sup>	32.97 <sup>a</sup>	37.59 <sup>b</sup>	45.41 <sup>c</sup>	37.73 <sup>b</sup>	1.10

<sup>†</sup> Treatment : Wheat straw *ad lib.* (I), supplemental with either 15 (II), 30 (III) or 45% (IV) of berseem. Figures bearing different superscript in a row differ significantly.

\*\*  $p < 0.01$ .

### Mean rumen concentration of TVFA

Mean TVFA concentration, acetate, propionate and butyrate concentration, VFA production and its turnover rate are presented in table 3. Berseem supplementation

significantly ( $p < 0.01$ ) increased the TVFA concentration upto 30% level of supplementation, at 45% level of supplementation, there was no further improvement.

Acetate (mol/100mol) decreased significantly ( $p < 0.01$ ) with increased level of berseem supplementation upto 30%, however, acetate (mol/100 mol) in 45% berseem fed group was similar to that of 30% berseem fed group. Propionate (mol/100 mol) increased significantly ( $p < 0.05$ ) due to berseem supplementation, however, level of berseem did not show any significant effect on molar percentage of propionate. Butyrate concentration was significantly ( $p < 0.05$ ) higher in group III (10.72%) as compared to groups I, II and IV (7.80, 7.96 and 9.93%). The A/P ratio was significantly ( $p < 0.01$ ) higher in berseem supplemented group in comparison to group fed wheat straw alone (table 3). VFA production significantly increased ( $p < 0.01$ ) with increased level of berseem supplementation upon 30%, beyond which there was no significant change in moles of VFA produced per day. VFA turnover rate and VFA absorption rate were not significantly different among animals in different groups, but the mole VFA turned over and absorbed significantly ( $p < 0.01$ ) increased by increasing level of berseem upto 30%, whereas, the values in animals fed

30 and 45% berseem were similar.

#### Diurnal variation in VFA production pattern

Diurnal variation in rumen TVFA concentration is presented in figure 1. Both treatment and time of the day had significant ( $p < 0.01$ ) effect on ruminal TVFA concentration; however, the interaction between treatment and interval was non significant. Whereas TVFA concentration increased upto 30% level of berseem supplementation, beyond which there was no further improvement. Two peaks of TVFA concentration were observed, one at 4 h and other at 8 h post feeding. Then it declined gradually reaching to a minimum level just before feeding. The first peak of TVFA concentration corresponds to eating of supplement, whereas the second one corresponds to eating of maximum amount of wheat straw.

#### Passage and pool size of INDF

Within day variation in passage rate is presented in table 4. Proportion of INDF passage during eating increased significantly with increased level of berseem supplementation. Passage during rumination and idling was similar in all the groups.

**Table 3.** Total volatile fatty acid (TVFA) concentration and molar proportion of individual volatile fatty acids (VFA) in rumen liquor and calculated values of VFA production, turnover and absorption rate of animals fed on wheats straw supplemented with different levels of berseem

Items	Treatment <sup>†</sup>				SEM
	I	II	III	IV	
pH <sup>NS</sup>	6.78	6.82	6.80	6.80	0.017
NH <sub>3</sub> -N (mol/l)**	33.64 <sup>a</sup>	83.61 <sup>b</sup>	113.64 <sup>c</sup>	132.03 <sup>a</sup>	2.23
TVFA (mmole)**	58.45 <sup>a</sup>	66.14 <sup>b</sup>	77.92 <sup>c</sup>	78.64 <sup>c</sup>	1.34
Molar proportion (m mol/100 mol)					
Acetate**	74.47 <sup>a</sup>	71.37 <sup>b</sup>	68.53 <sup>c</sup>	68.69 <sup>c</sup>	0.59
Propionate*	16.48 <sup>a</sup>	20.67 <sup>b</sup>	20.75 <sup>b</sup>	21.39 <sup>b</sup>	0.84
Butyrate*	7.80 <sup>a</sup>	7.96 <sup>a</sup>	10.72 <sup>b</sup>	9.93 <sup>a</sup>	0.93
A/P ratio**	4.62 <sup>a</sup>	3.47 <sup>b</sup>	3.32 <sup>b</sup>	3.25 <sup>b</sup>	0.17
VFA production rate <sup>1</sup> (mol/d)**	12.00 <sup>a</sup>	16.86 <sup>b</sup>	22.95 <sup>c</sup>	21.14 <sup>c</sup>	0.77
VFA turnover rate <sup>2</sup>					
mol/h**	0.47 <sup>c</sup>	0.67 <sup>b</sup>	0.95 <sup>c</sup>	0.88 <sup>c</sup>	0.025
%/hNS	16.85	19.88	20.26	18.62	0.94
VFA absorption rate <sup>3</sup>					
mmol/h**	277.05 <sup>a</sup>	451.85 <sup>b</sup>	613.65 <sup>c</sup>	507.31 <sup>c</sup>	35.83
%/h	10.25	12.81	13.09	10.75	1.04

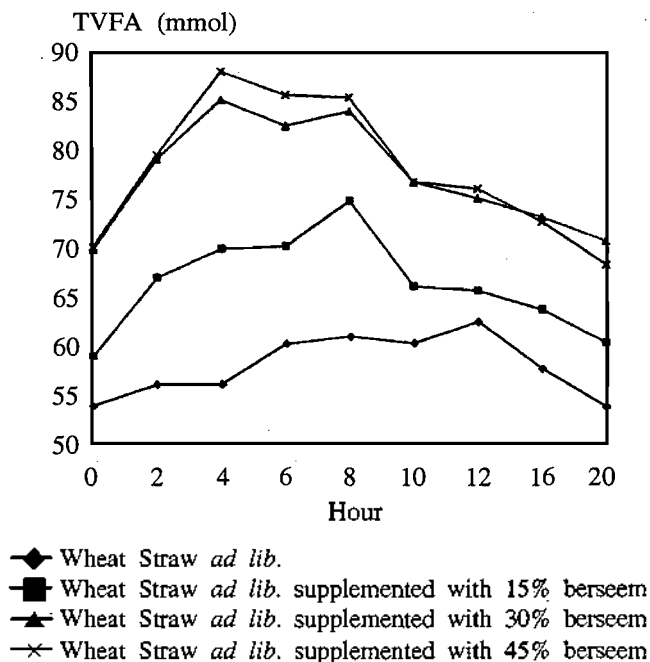
<sup>†</sup> Treatments : Wheat straw *ad lib.* (I) supplemented with either 15 (II), 30 (III) or 45% (IV) of berseem. Figures bearing different superscript in a row differ significantly.

NS = Non Significant, \*  $p < 0.05$ , \*\*  $p < 0.01$ , A/P acetate/propionate.

<sup>1</sup> VFA production (mol/d) = Apparent rumen degradable organic matter intake (ARDOMI)/162\*(100/(0.5\*(proportion of octetate+proportion of propionaye)+proportion of butylate).

<sup>2</sup> VFA turnover rate (%/h) = VFA production/VFA pool/24.

<sup>3</sup> VFA absorption rate (%/h) = VFA turnover rate - liquid outflow rate.



**Figure 1.** Diurnal variation in TVFA (mmol) concentration in rumen fluid of animal fed different proportion of berseem in diet

**Table 4.** Diurnal variation in pool sizes of indigestible neutral detergent fibre (INDF) and passage of INDF from the potentially removable INDF pool of rumen during eating (PEAT), rumination (PRUM) and idling (PID) in cattle fed on wheat straw supplemented with different levels of berseem

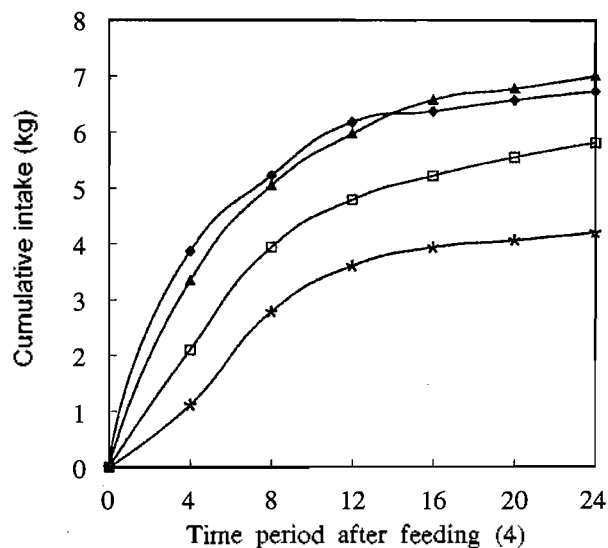
Items	Treatment <sup>†</sup>				SEM
	I	II	III	IV	
Passage rate (% of INDF intake)					
PEAT**	35.95 <sup>a</sup>	46.18 <sup>b</sup>	59.93 <sup>b</sup>	67.74 <sup>c</sup>	3.08
PRUM <sup>NS</sup>	46.32	33.26	26.73	23.24	8.73
PID <sup>NS</sup>	17.72	20.5	12.97	9.33	5.55
Pool size (kg)					
Post hour feeding (h)					
3 <sup>NS</sup>	2.95	3.03	3.18	3.23	0.18
6 <sup>NS</sup>	3.13	3.30	3.25	3.43	0.46
9 <sup>NS</sup>	3.20	3.25	3.03	3.25	0.43
12 <sup>NS</sup>	2.88	3.10	2.93	3.20	0.17
18 <sup>NS</sup>	2.73	2.85	2.88	3.10	0.20
24 <sup>NS</sup>	2.50	2.58	2.70	3.03	0.18

<sup>†</sup> Treatment : Wheat straw *ad lib.* (I), supplemented with either 15 (II), 30 (III) or 45% (IV) of berseem. Values bearing different superscript in a row differ significantly. NS = Non Significant; \*\* p<0.01.

#### Intake pattern

Daily intake pattern of animals in different groups

is illustrated in figure 2. Animals consumed all the supplement within first hour of offering. Animals in group III and IV consumed same amount and animals in group II consumed more straw than the animals in group I, in addition to their respective quota of berseem. As a result, DMI within first 4 h increased linearly with increased level of berseem in the diet. Animals in groups I, II, III and IV consumed 26, 34, 47 and 57% of their total DMI within first 4 h of offering. Animals in groups II consumed more straw than other groups in second 4 h period as well. Animals in groups I, II, III and IV had eaten 64, 70, 70 and 77% of their total DMI within first 8 h of offering, respectively. Animals in all the groups consumed 90% of total DMI 12 h after offering.



**Figure 2.** Eating pattern of animals fed on wheat straw supplemented with different levels of berseem

#### Eating behaviour

Berseem supplementation had no significant effect on daily time spent for eating (ET), rumination (RT) or idling (IT), chews per minute rumination (CRUM) or number of rumination boli ingested per minute (table 5). On an average animals spent 5.5 to 6 h for eating, 8 to 9.5 h for ruminating and rest of the time they spent on other activities, grossly considered as idling in this experiment. However, chews per minute eating (CEAT) was significantly (p<0.05) higher in groups III and IV in comparison to groups I and II. Eating time per kg NDF was significantly (p<0.01) less in berseem supplemented group, whereas, the

difference between the 3 levels of berseem was not significant. Rumination time per kg NDF was significantly ( $p < 0.01$ ) less in groups II, III and IV in comparison to group I. The difference between groups II and III was also significant, but the animals in group IV had value lying between groups II and III.

### Rumination pattern

Daily rumination pattern of animals fed different rations is illustrated in figure 3. Active period of rumination was observed 8 h post feeding, reached the peak at 12-16 h post feeding, and animals spent considerable time idling in last 4 h period of 24 h feeding cycle. An early onset of rumination was observed in berseem supplemented group. Animals in groups I, II, III and IV spent 28, 46, 64 and 87 min for ruminating, respectively, during first 8 h period after offering.

## DISCUSSION

### Nutrient intake

Supplementation of berseem in the wheat straw based diet increased the total DM intake. Increased DM intake as a result of green legume supplementation have been reported by other workers (McMeniman et al., 1988, Ash, 1990; Bird et al., 1994; Bonsi et al., 1994; Woodward and Reed, 1995). Findings of this experiment are in line with information available in the existing literature in general, but differ from the findings of Odwongo and Mugerwa (1980), and Ash (1990). Variation with Albezia supplementation is due to lower degradability of the supplement (Ash, 1990). Berseem, on the other hand, is highly degradable and supply the essential nutrients for optimum microbial activity. An ideal forage supplement should maintain or increase intake of the basal diet, rather than substitute for it, a phenomenon, that has been frequently observed in animals fed on legumes (Moran et al., 1983; Tharmaraj et al., 1989) or legume straws Ndlovu and Buchanan-Smith, 1987). In this experiment, 15 and 30% level of berseem supplementation increased the straw intake and intake of wheat straw was reduced only at 45% level of berseem supplementation.

### Digestibility

Berseem supplementation increased digestibility of nutrients upto 30% level, beyond which a negative associative effect was observed. Increased digestibility as a result of green forage supplementation have been reported by other workers (Bird et al., 1994, Bonsi et al., 1994). It is possible that increase in digestibility was partly due to additional  $\text{NH}_3$  generated in the rumen from the degradable N fraction of berseem. In this experiment rumen  $\text{NH}_3\text{-N}$  concentrations in all

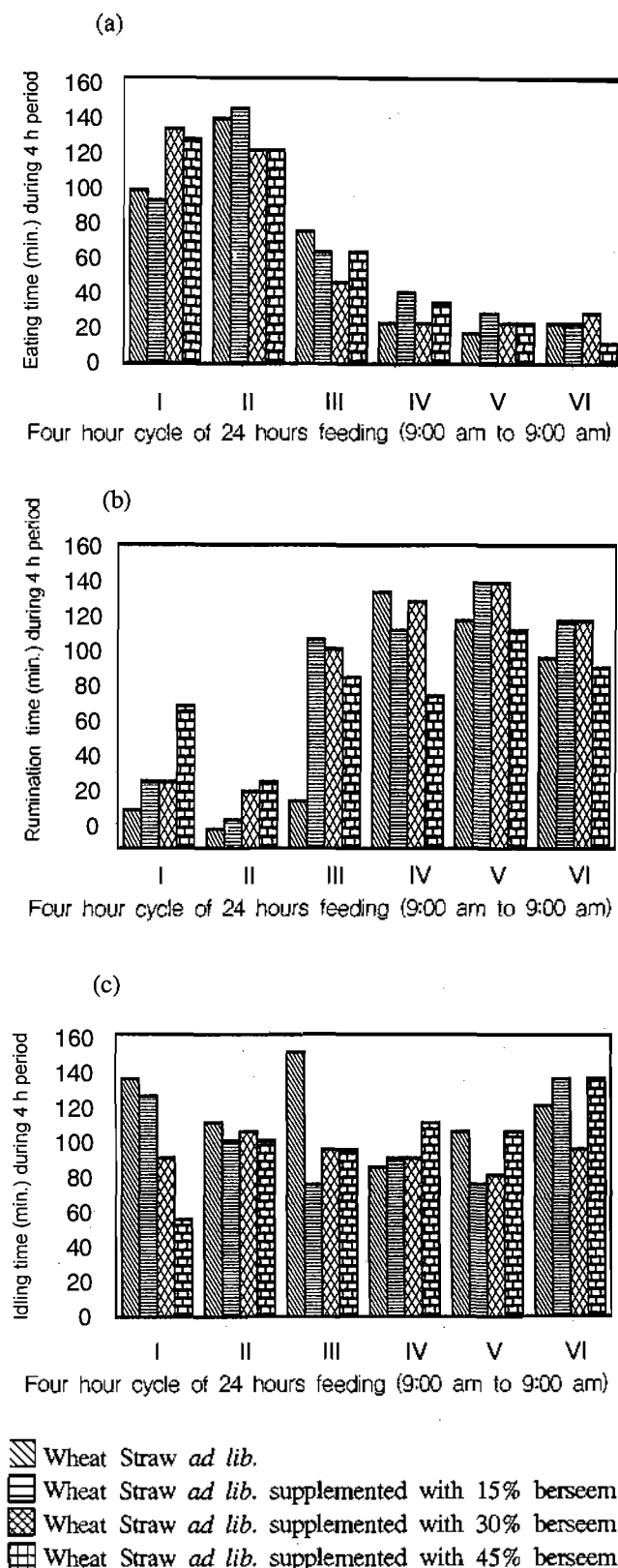


Figure 3. Daily pattern of eating (a), rumination (b) and idling (c) in cattle fed on wheat straw supplemented with different levels of berseem

**Table 5.** Eating time (ET), rumination time (RT), idling time (IT), chews per minute eating (CEAT), chews per minute ruminating and ingestion of rumination boli in cattle fed on wheat straw supplemented with different levels of berseem

Items	Treatment <sup>†</sup>				SEM	
	I	II	III	IV		
ET (min.):	Per day <sup>NS</sup>	354	361	346	339	11.82
	Per kg NDF intake <sup>**</sup>	98 <sup>a</sup>	75 <sup>b</sup>	64 <sup>b</sup>	48 <sup>b</sup>	7.73
RT (min.):	Per day <sup>NS</sup>	479	501	571	516	19.00
	Per kg NDF intake <sup>**</sup>	135 <sup>a</sup>	94 <sup>b</sup>	74 <sup>b</sup>	86 <sup>bc</sup>	4.69
Total chewing :	Time (min.) <sup>NS</sup>	833	862	917	855	28.41
	IT (min./d) <sup>**</sup>	607	578	523	585	23.73
Chews/min.:	CEAT <sup>**</sup>	61.44 <sup>a</sup>	64.20 <sup>a</sup>	74.34 <sup>ab</sup>	86.75 <sup>b</sup>	3.09
	CRUM <sup>**</sup>	55.70 <sup>a</sup>	64.80 <sup>b</sup>	64.90 <sup>b</sup>	64.00 <sup>b</sup>	1.34
	No. of rumination boli/ min. rumination	0.92	0.85	0.88	0.93	0.038

<sup>†</sup> Treatment : Wheat straw *ad lib.* (I), supplemented with either 15 (II), 30 (III) or 45% (IV) of berseem. Values bearing different superscript in a row differ significantly.

NS = Non Significant; \*\*  $p < 0.01$ ; NDF = Natural Detergent Fibre.

berseem supplemented groups were much higher than the range of 60-100 mg/l (Oosting, 1993), required for maximum digestibility of poor quality roughages. The increased rumen  $\text{NH}_3\text{-N}$  and TVFA concentration are indicative of improved rumen environment for microbial activity. In addition, berseem also provided fermentable cellulose and hemicellulose which are known to promote fibre digestion (Silva and Orskov, 1988), by ensuring greater degree of colonization of fibrolytic bacteria (Cheng et al., 1990) and fungi (Bauchop, 1979). Decrease in digestibility as a result of 45% berseem supplementation, as observed in this experiment, could be due to decreased mean retention time in the rumen which means an increased rate of passage from the rumen (Oosting, 1993) as the green forages are bulky in nature (Bonsi et al., 1994).

#### TVFA concentration

Increased TVFA concentration upto 30% level of berseem supplementation observed in this experiment are reflection of higher DOM intake (McMeniman et al., 1988; Bosch et al., 1992), are in line with the findings of Reddy et al. (1991) and Bonsi et al. (1995). Increased TVFA concentration could be attributed to the availability of essential nutrients required for optimal fibrolytic activity, (Hespell and Bryant, 1979; Hoover, 1986; Silva et al., 1989; Leng, 1990). Results of this experiment indicate that 30% level of berseem in the diet is optimum to ensure maximum microbial activity.

Molar proportion of acetate decreased and that of propionate increased as a result of berseem supplementation upto 30%. This is attributable to the fact that low rate of feed intake and fermentative process associated with roughage diet increased acetate production at the expense of propionate production (Van Houlert, 1993). Owing to low carbon flow

through electron accepting channels such as glycolytic acid propionate production pathways. Increased propionate production as a result of berseem supplementation can be due to higher rate of degradation of berseem in the diet (Bonsi et al., 1995). At 30 and 45% level of berseem supplementation reduced acetate production was associated with an increased proportion of butyrate. A/P ratio : Berseem supplementation reduced the A/P ratio. However, level of supplementation showed no significant effect on A/P ratio. At higher level of berseem supplementation reduced acetate production resulted in increased butyrate rather than propionate production. The wide A/P ratio in wheat straw alone fed group suggests poor utilization of ME. Because, increased acetate production results in increase  $\text{CH}_4$  production (Wollin and Miller, 1988). However, supplementation with berseem narrowed down the A/P ratio and thereby expected to improve utilization of ME. Increased butyrate production as observed in higher level of berseem fed group may reduce the A/P ratio, but at a smaller magnitude than propionate. Results of this experiment suggests that berseem supplementation reduces the A/P ratio by supplying adequate energy and protein for optimum microbial fermentation (Leng, 1990).

#### VFA production

Berseem supplementation increased moles of VFA produced in a day upto 30% level of supplementation. Reports indicate that other supplement like concentrate (Gupta et al., 1988) or UMMB (Garg, 1989) improved VFA production rate, owing to increased DOM intake. Low VFA production rate in animals fed on wheat straw alone, indicates insufficient availability of fermentable energy and nitrogen (Leng, 1990). Berseem supplementation at 30% level will be sufficient

to overcome this shortcomings. Berseem supplementation had no effect on VFA turnover rate or absorption rate (table 3). However, mole of VFA turned over and absorbed was increased by berseem supplementation owing to production of more VFA. Oosting (1993) found similar results in goat fed on wheat straw supplemented with sugarbeet pulp.

**Eating behaviour :** Berseem supplementation had no effect on eating and rumination time. The average rumination time was 8 to 9.5 h. This is about the maximum time animal can ruminate (Welch et al., 1982; Bosch et al., 1992; Oosting, 1993). However, berseem supplementation increased the efficiency of rumination and eating, as evident from the decrease in time required to ruminate or chew one kg NDF; owing to increased level of intake (Ho Bae et al., 1979; Faichney, 1986; Gheradi and Black, 1989). As rumination time was not different among the rations, it is unlikely that rumination time dictates eating time and thereby intake. Increased efficiency of rumination is explicable from the increased rate of communitation, observed in this experiment. In the present experiment, hemicellulose content in the diet decreased with increased level of berseem. Supplemental berseem provide optimal conditions to facilitate particle size reduction (Chai et al., 1984). Moreover, availability of readily digestible fibre source, facilitate colonization of fungi, known to assist in particle reduction (Bauchop, 1979).

Intake within first 4 h of offering increased with increased level of berseem supplementation, grossly considered to be as eating period of supplement. Straw intake was reduced, maintained and increased in 45, 30 and 15% level of berseem supplementation, respectively. The rate of intake during this period was 11.13, 20.10, 20.06 and 35.50 g/min in groups I, II, III and IV, respectively.

During the second 4 h period of feeding cycle, straw intake pattern was similar to period I. However, total DM intake changed, as the straw intake was equal to DMI in this phase. If we relate, this date with VFA concentration trend, the animal have already experienced the first peak of TVFA concentration. The decrease in straw intake being more sharp at 45% level correlating to the more rumen pool already observed within this period at around 3 h post feeding. Nevertheless, it is difficult to attribute the ceasation of intake only to pool size as increased pool size was also associated with increased rate of communitation and passage, At best pool size can limit intake, but not to regulate the intake.

At the third phase of 8 to 12 h post feeding, however, animals have experienced the 2nd peak of acetate and attained the maximum rumen pool size at around 9 h post feeding. All these factors combined together might have contributed to the ceasation of

intake as observed in this experiment; all the animals consumed more than 90% of their total DM intake within 12 h. This is similar to the observation made by Thiago et al. (1992) for less palatable silage, but different from highly palatable hay. Average total chewing time per kg DOMI was 541,379, 287 and 335 min in groups I, II, III and IV, respectively, much higher than the value of 99 min for lactating cattle fed concentrates and grass silage (Bosch et al., 1992) and 182 min as observed by Oosting (1993) in cattle fed on ammoniated straw and sugarbeet pulp supplemented with potato protein. This does indicate that the ME losses in eating and mastication were more as indicated for poor quality roughages (ARC, 1980).

Hence from the results of this experiment it is concluded that berseem supplementation had no effect on eating and rumination time. However, berseem supplementation increases the efficiency of chewing during eating and rumination, which results in increased intake and TVFA production.

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