Evaluation of rations supplemented with fibrolytic enzyme on dairy cows performance 2- *In situ* ruminal degradability of rations containing different roughages at two concentrate to roughage ratios

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ABSTRACT: This experiment was conducted to study the effect of fibrolytic enzymes supplementation on *In Situ* degradability of DM, CP and CF of different rations consisted of concentrate feed mixture (CFM) + berseem hay (BH), dried sugar beet tops (DSBT), corn silage (CS), rice straw (RS) or wheat straw (WS) in different ratios 60:40 or 40:60. The fibrolytic enzyme (fibrozyme) was added to the ground rations at the levels of 0, 1 and 1.5 g/kg DM diluted with distilled water (1:10 w/v) and sprayed with 10 ml per kg of ground feedstuffs overnight and samples incubated in canulated multiparous Friesian cows for 2, 4, 8, 16, 24, 48 and 72 hours. Rations contained DSBT showed the highest values of *in situ* DM, CP and CF disappearance followed by rations contained BH, while rations contained RS or WS had the lowest values (P<0.05). The percentages of *in situ* DM, CP and CF disappearance for rations contained 60% concentrate: 40% roughage was higher than rations contained 40% concentrate: 60% roughage for different feedstuffs (P<0.05). Added fibrolytic enzyme at the level of 1g/kg DM showed the highest DM and CF disappearance in DSBT rations and CP disappearance in BH and DSBT rations, while, the level of 1.5 g/kg showed the highest DM and CF disappearance in BH, CS, RS and WS rations and CP disappearance in CS, RS and WS rations (P<0.05). Rations contained DSBT showed the highest rapid degradable fraction (a) for DM, CP and CF, rations contained BH showed the highest potential degradable fraction (b), rations contained CS had the highest degradation rate (c), while, rations contained RS or WS had the highest undegradable fraction (u) (P<0.05). The rapid degradable fraction (a), the potential degradable fraction (b) and the degradation rate (c) were higher, the undegradable fraction (u) was lower for rations contained 60% concentrate: 40% roughage compared with those contained 40% concentrate: 60% roughage for different feedstuffs (P<0.050. Moreover, rations contained DSBT showed the highest outflow rate of degradable DM at 2, 5 and 8%/ hour from the rumen and increased with increasing concentrate level (P<0.05). The highest rapid and potential degradable fractions, degradation rate and the outflow rate at 2, 5 and 8%/ hour from the rumen and the lowest undegradable fraction detected with added fibrozyme at level of 1g/kg for of DM and CF in DSBT rations and CP in BH and DSBT rations and at level of 1.5 g/kg for DM and CF in BH, CS, RS and WS rations and CP in CS, RS and WS rations (P<0.05).

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INTRODUCTION

In the different regions of the world, forages are used as a unique of feed source for ruminants due to their abundance and low cost, however, their availability and quality are not constant throughout the year. Moreover, the digestion of forages in the rumen is relatively slow and incomplete, limiting animal performance and increasing feed cost of livestock production. Tropical forages are particular have limited energy value and its cell wall contents are rich in lignin, silica and cut in that limiting carbohydrates fermentation and therefore the VFA's production and microbial mass in the rumen (Dominguez Bello and Escobar 1997).

Recent studies indicated that, adding fibrolytic enzymes to ruminant diets improved nutrient digestibility (kung et al 2000 and Murillo et al 2000), growth rate (Ali 2006) and milk production (Rode et al 1999 and Zheng et al 2000). Eun et al (2007) indicated that using fibrolytic enzymes lead to improve ruminal fiber digestion resulting in an increase of digestible energy intake. Furthermore, enzyme application was more effective with lower forage to concentrate ratio (38:62) than higher ratios (55:45, 57:43 and 60:40). Therefore, the effect of the dietary component to which the enzyme is added may depend on the forage to concentrate ratio and the uniformity of enzyme application to these components (Adesogan 2005).

The nylon bag technique has been used for many years to provide a useful means for estimating rates of disappearance and potential degradability of feedstuffs. This technique also provides an opportunity to fractionate feedstuffs into water soluble, potentially degradable, and indigestible fractions, which gives some idea about the extent of degradation of feedstuffs in the rumen. These fractions may provide an opportunity to develop better regression equation for predicting forage intake and digestibility. The cell wall components of forages represent major source of energy for cattle, even though less than 50% of this fraction is readily digested and utilized (Hatfield et al 1999).

The objective of the present study was to investigate the effect of fibrolytic enzyme (Fibrozyme) additive on *in situ* ruminal DM, CP, CF degradability of rations containing different roughages at two concentrate to roughage ratios.

MATERIALS AND METHODS

The experimental work of this study was conducted at Sakha Animal Production Research Station, Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture in co-operation with the Department of Animal Production, Fac. of Agric., Kafrelsheikh University during the period from July to November 2008.

This trial was conducted to study the effect of fibrozyme additive on *in situ* ruminal degradability of DM, CP and CF of the different rations consisted of concentrate feed mixture (CFM) + berseem hay (BH), dried sugar beet tops (DSBT), corn silage (CS), rice straw (RS) or wheat straw (WS) in different ratios 60:40 or 40:60 as follows: R1: 60% CFM: 40% BH, R2: 40% CFM: 60% BH, R3: 60% CFM: 40% DSBT, R4: 40% CFM: 60% DSBT, R5: 60% CFM: 40% CS, R6: 40% CFM: 60% CS, R7: 60% CFM: 40% RS, R8: 40% CFM: 60% RS, R9: 60% CFM: 40% WS, R10: 40% CFM: 60% WS.

CFM consisted of 32% undecorticated cotton seed cake, 24% wheat bran, 22% yellow corn, 12% rice bran, 5% linseed cake, 3%molasses, 1% limestone and 1% common salt

Fibrolytic enzyme (fibrozyme) ingredients are Aspergillus Niger, Trchodema Longibrchiatum, fermentation extracts and fermentation soluble. Also, it contains 20% CP, 8% ash and 100 U xylanase / g (International Free Trade Co., Cairo, Egypt). The fibrozyme were added to the ground rations at the levels of 1 and 1.5 g/kg DM. The fibrozyme was diluted with water at 100 and 150 g/liter for the levels of 1 and 1.5 g/kg, respectively and sprayed with 10 ml per kg of ground rations overnight according to the procedure stated by Kung et al (2000).

Three multiparous Friesian cows were used for studying degradability of the different rations in a 3×3 Latin Square Design. The ruminal degradability of DM, CP and CF for three samples of different rations were determined by *in situ* technique (Mehrez and Ørskov 1977). Samples of different rations were ground and 5 gm weighed into 7x12 cm nylon bags with mean pore size 50 µm, bags were tied near the end of 60 cm nylon cord anchored by a 70 gm steel weight and incubated in the rumen (in triplicate for each silage) for different extends times (0, 2, 4, 8, 16, 24, 48 and 72 hrs). Zero hour bags were washed to estimate the disappearance due to both solubility and washing procedure. The bags after incubation in the rumen were also washed. All bags then dried at 60 ^{o}C for 48 hrs to determine DM. The results of DM, CP and CF disappearance were fitted to the following exponential models of Ørskov and McDonald (1979) and the degradation was calculated by using the NAWAY computer programme with the following exponential model: $P = a + b\ (1 - e^{-ct})$, Where, P = percentage disappearance at time t. a = rapidly soluble fraction. b = slowly degradable fraction. a + b = potential degradability. c = fractional rate constant at which b will be degraded. t = time. u = undegradable fraction.

Effective degradability of DM, CP and CF were calculated using the rumen outflow rate (K), P and the constants a, b and c from the above model. K was assumed to be 0.02, 0.05 or 0.08 per h. Effective degradability (ED) in the rumen was calculated as: $ED = a + [(b \times c)/(c + k)]$, where a is the water soluble fraction, b is the potentially degradable (insoluble) fraction, c is the degradation rate of b, and k is the fractional passage rate out of the rumen.

The representative samples of the different rations before and after incubation were chemically analyzed for DM, CP, CF, EE and ash determinations according to the official methods of AOAC (1990). Fiber constituents, neutral detergent fiber (NDF) was determined according to Van Soest and Marcus (1964). While, acid detergent fiber (ADF) and acid detergent lignin (ADL) was determined according to Van Soest (1963).

The obtained data were subjected to statistical analysis using general linear models procedure adapted by SPSS (2008) for user’s guide with one-way ANOVA. Duncan test within program

SPSS was done to determine the degree of significance between the means (Duncan 1955).

RESULTS AND DISCUSSION

Chemical composition of experimental rations

Calculated chemical composition of experimental rations is shown in Table 1. Results revealed that OM content was lower and ash content was higher in rations contained DSBT. The content of CP was higher in rations contained BH and DSBT and lower in rations contained RS and WS. While, CF content was higher in rations contained RS and WS and lower in ration contained DSBT. Moreover, the contents of OM, CP, EE and NFE content decreased, but CF, NDF, ADF and ADL contents increased with decreasing concentrate mixture and increasing roughage levels in the rations.

In Situ disappearance of different rations

Dry matter disappearance

Dry matter disappearance of different experimental rations is shown in Table 2. Rations contained DSBT had the highest DM disappearance followed by rations contained BH, while rations contained both RS and WS had the lowest values ($P<0.05$). The percentage of *in situ* DM disappearance was higher for rations contained 60% concentrate: 40% roughage than rations contained 40% concentrate: 60% roughage for different feedstuffs ($P<0.05$). Moreover, added fibrozyme at the level of 1g/ kg recorded the highest the percentage of *in situ* DM disappearance for rations contained DSBT at all the different incubation times ($P<0.05$). While, the level of 1.5 g/kg recorded the highest DM disappearance for rations contained BH, CS, RS and WS ($P<0.05$). The results also showed a positive correlation between DM disappearance and NFE content ($r = 0.59$), while there was a negative correlation between DM disappearance and CF content ($r = - 0.63$). The level of added enzyme should be increased with increasing fiber content of the rations. These results are in accordance with those obtained by Giraldo et al (2008) who reported that enzyme supplementation increased in situ DM disappearance of grass hay, which may attributed to enhanced colonization and digestion of the slowly degradable fiber fraction by ruminal microorganisms. Gaafar et al (2008) found that enzyme treated corn stover silage increased *InSitu* DM disappearance. Also, Pinos-Rodriguez et al (2002) indicated that fibrolytic enzymes increased the ruminal in situ disappearance of DM in lambs. Eweedah (2007) found that DM disappearance increased with increasing NFE content and found the DSPT recoded the highest DM disappearance value due to the lower CF content.

Ruminal DM degradation

The effect of fibrozyme on the degradation fractions and effective degradability of DM for different rations are shown in Table 3. Ration contained DSBT showed the highest rapid degradable fraction (a) followed by ration contained BH, while rations contained CS, RS and WS had the lowest values ($P<0.05$). Ration contained BH recorded the highest potential degradable fraction (b) followed by ration contained DSBT, while ration contained RS and WS had the lowest values ($P<0.05$). Ration contained CS had the highest degradation rate (c) followed by ration contained DSBT and WS, while ration contained RS had the lowest values ($P<0.05$). However, rations contained RS and WS showed the highest undegradable fraction (u) followed by ration contained CS, while ration contained DSBT had the lowest values ($P<0.05$). Moreover, ration contained DSBT showed the highest outflow rate of degradable DM at 2, 5 and 8%/ hour from the rumen followed by ration contained BH, while rations contained RS and WS had the lowest values ($P<0.05$). The degradable fractions (a&b), degradable rate (c) and outflow rate ($k=0.02$, 0.05 and 0.08) increased, but undegradable fraction (u) decreased with increasing concentrate level and decreasing roughage level ($P<0.05$).

Fibrozyme treated different rations led to increase the rapid and potential degradable fractions, degradation rate and the outflow rate of degradable DM at 2, 5 and 8%/ hour from the rumen and decrease the undegradable fraction ($P<0.05$). The highest rapid and potential degradable fractions, degradation rate, the outflow rate of degradable DM at 2, 5 and 8% from the rumen and the lowest undegradable fraction for rations contained DSBT recorded with added fibrozyme at the level of 1 g/kg, while in rations contained BH, CS, RS and WS were fond with added the level of 1.5 g/kg. These results are in agreement with those obtained by These results are in accordance with those obtained by Giraldo et al (2008) who reported that enzyme supplementation increased the insoluble potentially degradable fraction (b) and its fractional rate of degradation (c). Gaafar et al (2008) indicated significant increased degradation fractions and outflow rates of DM in the rumen with enzyme treated corn stover silage. For DM, enzyme treatment significantly ($p<0.01$) increased the rapidly soluble fraction a, the potentially degradable fraction b, and effective degradability (Jalilvand et al 2008).

Crude protein disappearance

Crude protein disappearance of different experimental rations is shown in Table 4. Ration contained DSBT showed the highest values of CP disappearance followed by ration contained BH, while rations contained both RS and WS had the lowest values (P<0.05). The percentage of *in situ* CP disappearance was higher for rations contained 60% concentrate: 40% roughage than rations contained 40% concentrate: 60% roughage (P<0.05). Moreover, the percentage of *in situ* CP disappearance for different rations increased with added fibrozyme (P<0.05). The level of 1 g/kg showed the highest CP disappearance for rations contained BH and DSBT, while the level of 1.5 g/kg had the highest values for rations contained CS, RS and WS. The results also showed a positive correlation between CP disappearance and CP content (r = 0.45). These results are in accordance with those obtained by Gaafar et al (2008) who found that enzyme treated corn stover silage increased *in situ* CP disappearance. Eweedah (2007) reported that the CP disappearance was lower for CS than BH and DSPT at period of incubation.

Ruminal CP degradation

The effect of fibrozyme on the degradation fractions and effective degradability of CP for different rations are shown in Table 5. Rations contained DSBT showed the highest rapid degradable fraction (a) followed by ration contained BH, while rations contained RS and WS had the lowest values (P<0.05). Rations contained CS recorded the highest potential degradable fraction (b) followed by ration contained BH, while ration contained DSBT had the lowest values (P<0.05). The degradation rate (c) for DSPT was significantly compared to the rations followed by rations contained CS and RS, while rations contained BH and WS had the lowest values (P<0.05). However, rations contained RS and WS showed the highest undegradable fraction (u) followed by ration contained CS, while ration contained DSBT had the lowest values (P<0.05). Moreover, rations contained DSBT showed the highest outflow rate of degradable CP at 2, 5 and 8%/ hour from the rumen followed by ration contained BH, while ration contained WS had the lowest values (P<0.05). The degradable fractions (a&b), degradable rate (c) and outflow rate (k=0.02, 0.05 and 0.08) decreased, but undegradable fraction (u) increased with decreasing concentrate level and increasing roughage level (P<0.05).

Fibrozyme treated different rations led to increase the rapid and potential degradable fractions, degradation rate and the outflow rate of degradable CP at 2, 5 and 8%/ hour from the rumen and decrease the undegradable fraction (P<0.05). The level of enzyme at 1 g/kg showed the highest CP degradation for rations contained BH and DSBT, while the level of 1.5 g/kg had the highest values for rations contained CS, RS and WS. These results are in agreement with those obtained by Jallilvand et al (2008) who found that the soluble CP fraction a was higher for both alfalfa hay and maize silage than for wheat straw, whereas the potentially fermentable fraction b was higher for maize silage than for the other forages and parameter c for alfalfa hay was significantly higher than for the other forages. Gaafar et al (2008) reported that enzyme treated corn stover silage increased degradation fractions and outflow rates of DM in the rumen.

Crude fiber disappearance

Crude fiber disappearance from different experimental rations is shown in Table 6. Ration contained DSBT showed the highest values of CF disappearance followed by ration contained BH, while rations contained both RS and WS had the lowest values (P<0.05). The percentage of *in situ* CF disappearance was higher for rations contained 60% concentrate: 40% roughage than rations contained 40% concentrate: 60% roughage (P<0.05). Moreover, the percentage of *in situ* CF disappearance for different rations increased with added fibrozyme and the level of 1g/ kg recorded the highest values for rations contained DSBT and the level of 1.5 g/kg showed the highest values for rations contained BH, CS, RS and WS at all the different incubation times (P<0.05). The differences in CF disappearance among the different feedstuffs might be due to the differences in chemical composition as shown in Table 1. The level of added enzyme should be increased with increasing fiber content of the rations. These results are in accordance with those obtained by Gaafar et al (2008) who found that enzyme treated corn stover silage increased *in situ* DM disappearance.

Ruminal CF degradation

The effect of fibrozyme on the degradation fractions and effective degradability of CF for different rations are shown in Table 7. Rations contained DSBT showed the highest rapid degradable fraction (a) followed by rations contained CS, while rations contained RS and WS had the lowest values (P<0.05). Rations contained BH recorded the highest potential degradable fraction (b) followed by ration contained CS, while ration contained WS had the lowest values (P<0.05). Rations contained DSBT had the highest degradation rate (c) followed by rations contained CS and RS, while rations contained BH, RS and WS had the lowest values (P<0.05). However, rations contained WS showed the highest undegradable fraction (u) followed by rations contained CS, while rations contained BH had the lowest value (P<0.05). Moreover, rations contained

DSBT showed the highest outflow rate of degradable CP at 2, 5 and 8%/ hour from the rumen followed by ration contained BH, while rations contained WS had the lowest values (P<0.05). The degradable fractions (a&b), degradable rate (c) and outflow rate (k=0.02, 0.05 and 0.08) decreased, but undegradable fraction (u) increased with decreasing concentrate level and increasing roughage level (P<0.05).

Fibrozyme treated different rations led to increase the rapid and potential degradable fractions, degradation rate and the outflow rate of degradable CF at 2, 5 and 8%/ hour from the rumen and decrease the undegradable fraction (P<0.05). The level of 1 g/kg showed the highest CF degradation for rations contained DSBT, while the level of 1.5 g/kg had the highest values for rations contained BH, CS, RS and WS. These results are in agreement with those obtained by Pirmohammadi (2006) who found that degradation fractions and outflow rates of CF in the rumen for different forages significantly increased with enzyme supplement. Gaafar et al (2008) reported significant increased degradation fractions and outflow rates of CF in the rumen with enzyme treated corn stover silage.

Table 1: Calculated composition of experimental rations.

Item	Experimental rations									
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
DM %	90.8	90.5	90.9	90.7	68.4	56.9	91.5	91.5	91.7	91.8
Composition of DM %:										
OM	89.3	88.1	85.5	82.4	92.0	92.1	88.2	86.4	89.4	88.3
CP	15.0	14.5	15.4	15.1	13.1	11.7	10.8	8.2	10.5	7.7
CF	19.9	23.7	12.3	12.3	17.9	20.7	21.6	26.3	23.2	28.6
EE	2.7	2.5	2.5	2.3	2.8	2.7	2.3	1.9	2.3	1.9
NFE	51.8	47.4	55.3	52.7	58.2	57.0	53.4	49.9	53.5	50.1
Ash	10.7	11.9	14.5	17.7	8.0	7.9	11.9	13.7	10.6	11.7
Fiber fractions %:										
NDF	34.9	38.8	29.0	30.0	38.3	44.0	46.0	55.5	46.7	56.7
ADF	18.2	21.2	12.7	12.9	18.7	22.0	25.3	31.8	26.0	32.8
ADL	4.2	4.4	3.2	2.9	4.3	4.6	3.5	3.9	4.6	5.0

Table 2: *In situ* ruminal DM disappearance (%) of different rations.

Enzyme Level	Incubation times (hours)							
	0	2	4	8	16	24	48	72
R1 (60% CFM : 40% BH)								
0	30.2	31.1^{b}	38.0^{c}	44.0^{b}	55.6^{b}	61.3^{b}	76.0^{b}	80.4^{b}
1	30.9	35.8^{a}	39.3^{b}	44.7^{ab}	56.5^{b}	62.4^{b}	76.1^{b}	81.3^{b}
1.5	31.3	36.9^{a}	40.6^{a}	46.2^{a}	59.0^{a}	65.4^{a}	79.4^{a}	82.9^{a}
Mean	30.8^{A}	34.6^{A}	39.3^{A}	45.0	57.0^{A}	63.1	77.2^{A}	81.5^{A}
R2 (40% CFM : 60% BH)								
0	22.5	28.4^{b}	31.5^{b}	42.7^{c}	47.0^{b}	61.2^{b}	68.3^{b}	76.0^{b}
1	23.2	31.2^{a}	35.7^{a}	43.9^{b}	55.9^{a}	63.2^{a}	73.5^{a}	80.2^{a}
1.5	23.9	32.0^{a}	37.0^{a}	45.1^{a}	56.6^{a}	64.2^{a}	74.1^{a}	81.2^{a}
Mean	22.9^{B}	30.5^{B}	34.8^{B}	43.9	53.2^{B}	62.9	72.0^{B}	79.2^{B}
Overall mean	26.9^{F}	32.6^{F}	37.0^{F}	44.4^{F}	55.1^{F}	63.0^{F}	74.6^{F}	80.4^{F}
R3 (60% CFM : 40% DSBT)								
0	36.9	40.7^{b}	44.7^{b}	48.4^{c}	59.7^{b}	67.2^{b}	74.8^{b}	85.1
1	38.7	42.9^{a}	46.3^{a}	55.1^{a}	63.5^{a}	72.0^{a}	81.9^{a}	85.4
1.5	38.2	42.0^{b}	45.1^{ab}	51.6^{b}	59.8^{b}	67.3^{b}	81.2^{a}	85.3
Mean	38.0^{A}	41.9	45.3	51.7	61.0	68.8	79.3	84.3
R4 (40% CFM : 60% DSBT)								
0	32.1	38.4^{c}	41.4^{c}	49.3^{b}	57.2^{b}	64.4^{c}	77.6^{b}	79.3^{c}
1	32.5	42.4^{a}	47.1^{a}	53.8^{a}	64.9^{a}	72.2^{a}	82.3^{a}	86.6^{a}
1.5	32.8	40.6^{b}	43.9^{b}	52.4^{a}	63.1^{a}	69.3^{b}	78.0^{b}	85.3^{a}
Mean	32.9^{B}	40.4	44.4	51.9	61.7	68.6	79.3	83.8
Overall mean	35.4^{E}	41.2^{E}	44.7^{E}	51.8^{E}	61.4^{E}	68.7^{E}	79.3^{E}	84.0^{E}

R5 (60% CFM : 40% CS)								
0	23.1	27.9^{b}	33.7	42.3^{b}	53.6^{b}	61.0^{c}	69.2^{c}	73.9^{b}
1	23.2	28.5^{ab}	34.2	43.0^{ab}	55.3^{ab}	62.7^{b}	71.8^{b}	76.0^{a}
1.5	23.6	30.0^{a}	35.8	44.0^{a}	56.0^{a}	64.3^{a}	73.9^{a}	76.3^{a}
Mean	23.3^{A}	28.8^{A}	34.5^{A}	43.1	55.1	62.7	71.6	75.4^{A}
R6 (40% CFM : 60% CS)								
0	19.1^{b}	26.3^{c}	30.5^{b}	41.2^{b}	52.3^{b}	59.4^{b}	69.4^{b}	71.5^{b}
1	20.9^{a}	27.4^{b}	32.1^{ab}	42.4^{ab}	54.9^{a}	62.2^{a}	70.5^{ab}	72.2^{b}
1.5	21.3^{a}	28.8^{a}	33.4^{a}	43.8^{a}	55.7^{a}	63.0^{a}	71.0^{a}	73.9^{a}
Mean	20.4^{B}	27.5^{B}	32.0^{B}	42.5	54.3	61.6	70.3	72.5^{B}
Overall mean	21.9^{G}	28.1^{G}	33.3^{G}	42.8^{F}	54.5^{F}	62.1^{F}	71.0^{G}	74.0^{G}
R7 (60% CFM : 40% RS)								
0	22.0^{b}	28.4	31.8^{c}	38.1^{c}	47.7^{c}	53.8^{c}	64.3^{b}	67.2
1	22.4^{b}	28.6	34.1^{b}	42.5^{b}	52.8^{b}	57.9^{b}	64.4^{b}	68.0
1.5	23.6^{a}	29.5	36.4^{a}	46.7^{a}	58.1^{a}	63.1^{a}	66.8^{a}	68.3
Mean	22.7^{A}	28.8^{A}	34.1^{A}	42.4^{A}	52.9^{A}	58.3^{A}	65.2^{A}	67.8
R8 (40% CFM : 60% RS)								
0	18.4	24.8^{b}	29.3^{b}	32.5^{b}	40.7^{c}	46.6^{b}	59.8^{c}	65.4^{b}
1	19.3	26.0^{ab}	29.5^{b}	33.6^{a}	41.7^{b}	48.7^{b}	61.2^{b}	67.2^{a}
1.5	20.1	27.1^{a}	30.7^{a}	34.6^{a}	44.9^{a}	51.5^{a}	63.2^{a}	68.3^{a}
Mean	19.4^{B}	26.0^{B}	29.8^{B}	33.7^{B}	42.4^{B}	48.9^{B}	61.4^{B}	67.0
Overall mean	21.0^{G}	27.4^{G}	32.0^{G}	38.1^{G}	47.6^{G}	53.6^{G}	63.3^{H}	67.4^{H}
R9 (60% CFM : 40% WS)								
0	22.4	26.5^{b}	30.8^{b}	38.0^{b}	48.2^{b}	54.6^{b}	62.8^{c}	64.9^{b}
1	22.4	27.1^{b}	31.3^{b}	38.4^{b}	48.9^{b}	55.8^{b}	65.6^{b}	68.7^{a}
1.5	23.6	29.0^{a}	34.0^{a}	41.8^{a}	53.1^{a}	60.1^{a}	68.9^{a}	71.0^{a}
Mean	22.8^{A}	27.5^{A}	32.0^{A}	39.4^{A}	50.0^{A}	56.8^{A}	65.8^{A}	68.2^{A}
R10 (40% CFM : 60% WS)								
0	19.7^{b}	23.8	26.9^{b}	32.5^{b}	41.0^{b}	47.3^{c}	57.5^{c}	63.5^{c}
1	20.1^{ab}	24.1	28.1^{a}	34.6^{b}	44.8^{a}	51.4^{b}	60.4^{b}	64.7^{b}
1.5	20.5^{a}	24.4	28.3^{a}	34.8^{a}	45.3^{a}	52.9^{a}	64.9^{a}	67.9^{a}
Mean	20.1^{B}	24.1^{B}	27.7^{B}	34.0^{B}	43.7^{B}	50.5^{B}	61.0^{B}	65.3^{B}
Overall mean	21.5^{G}	25.8^{H}	29.9^{H}	36.1^{G}	46.9^{G}	53.7^{G}	63.4^{H}	66.7^{H}

a, b, c: Values in the same column for each item with different superscripts differ significantly ($P<0.05$).
A, B: Means in the same column for each roughage with different superscripts differ significantly ($P<0.05$).
E, F, G, H: Overall means in the same column with different superscripts differ significantly ($P<0.05$).

Table 3: Ruminal degradation and effective degradability (%) of DM for different rations.

Enzyme level	Degradation fractions				Effective degradability		
	a	b	c	u	K=0.02	K=0.05	K=0.08
R1 (60% CFM : 40% BH)							
0	30.2	56.2	0.04	13.6	62.6^{b}	49.6^{c}	43.3^{c}
1	30.3	56.7	0.04	13.0	66.2^{a}	53.5^{b}	47.7^{b}
1.5	30.9	57.2	0.04	11.9	67.2^{a}	54.7^{a}	49.8^{a}
Mean	30.5^{A}	56.7	0.04	12.8^{B}	65.3	52.6	46.9
R2 (40% CFM : 60% BH)							
0	24.9	55.5	0.03b	19.6	58.9^{b}	46.5^{c}	40.7^{c}
1	26.1	55.5	0.05a	18.4	65.3^{a}	53.3^{b}	47.0^{b}
1.5	26.5	56.2	0.05a	17.3	66.9^{a}	54.9^{a}	48.5^{a}
Mean	25.8^{B}	55.7	0.04	18.5^{A}	63.7	51.6	45.4
Overall mean	28.2^{F}	56.2^{E}	0.04^{FG}	15.6^{G}	64.5^{F}	52.1^{F}	46.2^{F}
R3 (60% CFM : 40% DSBT)							
0	37.0	52.1^{c}	0.04^{b}	10.9^{a}	68.8^{c}	57.6^{c}	52.4^{c}

1	38.3	58.7^{a}	0.07^{a}	3.0^{c}	72.7^{a}	62.2^{a}	56.4^{a}
1.5	37.0	55.1^{b}	0.06^{a}	7.9^{b}	70.5^{b}	59.7^{b}	54.5^{b}
Mean	37.4^{A}	55.3	0.05	7.3	70.7	59.8	54.4
R4 (40% CFM : 60% DSBT)							
0	34.1^{b}	49.2	0.02^{c}	16.7^{a}	65.4^{c}	55.9^{c}	50.4^{c}
1	37.1^{a}	53.3	0.06^{a}	9.6^{c}	73.4^{a}	63.2^{a}	57.5^{a}
1.5	35.9^{a}	51.8	0.05^{b}	12.3^{b}	70.3^{b}	58.3^{b}	53.1^{b}
Mean	35.7^{B}	51.4	0.04	12.9	69.7	59.3	53.7
Overall mean	36.6^{E}	53.4^{F}	0.05^{EF}	10.0^{H}	70.2^{E}	59.6^{E}	54.1^{E}
R5 (60% CFM : 40% CS)							
0	22.9	49.5^{b}	0.06	27.6^{a}	60.0^{c}	50.2^{b}	44.4^{b}
1	23.6	52.3^{ab}	0.06	24.1^{b}	61.9^{b}	51.4^{ab}	45.4^{ab}
1.5	24.1	53.3^{a}	0.06	22.6^{c}	63.6^{a}	53.7^{a}	46.5^{a}
Mean	23.5^{A}	51.7	0.06	24.8	61.8^{A}	51.8	45.4
R6 (40% CFM : 60% CS)							
0	19.1^{c}	48.0^{b}	0.05^{b}	32.9^{a}	59.6^{b}	49.3	42.7
1	21.4^{b}	51.7^{a}	0.07^{a}	26.9^{b}	60.6^{a}	50.6	44.2
1.5	23.7^{a}	53.2^{a}	0.07^{a}	23.1^{c}	61.0^{a}	53.9	47.0
Mean	21.4^{B}	51.0	0.06	27.6	60.4^{B}	51.3	44.6
Overall mean	22.5^{G}	51.4^{G}	0.06^{E}	26.1^{F}	61.1^{G}	51.6^{F}	45.0^{F}
R7 (60% CFM : 40% RS)							
0	21.0^{b}	47.5^{b}	0.01^{c}	31.5^{a}	56.0^{b}	45.9^{c}	40.7^{c}
1	21.7^{b}	51.3^{a}	0.04^{b}	27.0^{ab}	56.1^{b}	47.7^{b}	42.5^{b}
1.5	24.3^{a}	51.7^{a}	0.07^{a}	24.0^{b}	59.6^{a}	51.9^{a}	47.3^{a}
Mean	22.3	50.2^{B}	0.04^{A}	27.5^{B}	57.2^{A}	48.5^{A}	43.5^{A}
R8 (40% CFM : 60% RS)							
0	21.2^{b}	43.9^{b}	0.02b	34.9^{a}	52.5^{c}	40.7^{c}	35.6^{c}
1	21.8^{ab}	45.9^{a}	0.02b	32.3^{b}	53.8^{b}	42.0^{b}	37.2^{b}
1.5	22.3^{a}	46.2^{a}	0.03a	31.5^{b}	54.9^{a}	44.2^{a}	39.1^{a}
Mean	21.8	45.3^{A}	0.02^{B}	32.9^{A}	53.8^{B}	42.3^{B}	37.0^{B}
Overall mean	22.1^{G}	47.8^{H}	0.03^{G}	30.1^{E}	55.5^{H}	45.4^{H}	40.3^{H}
R9 (60% CFM : 40% WS)							
0	21.8^{b}	43.9^{b}	0.05	34.3^{a}	54.3^{c}	45.2^{b}	40.1^{b}
1	22.4^{b}	47.8^{a}	0.06	29.8^{b}	56.5^{b}	46.3^{b}	41.0^{b}
1.5	23.6^{a}	48.0^{a}	0.06	28.4^{b}	59.2^{a}	49.7^{a}	44.1^{a}
Mean	22.6^{A}	46.6^{A}	0.06^{A}	30.8^{B}	56.7^{A}	47.1^{A}	41.7^{A}
R10 (40% CFM : 60% WS)							
0	20.1	42.5^{c}	0.04	37.4^{a}	49.4^{c}	39.8^{c}	34.9^{b}
1	20.1	43.6^{b}	0.04	36.3^{a}	52.0^{b}	42.5^{b}	37.3^{a}
1.5	20.5	50.9^{a}	0.05	28.6^{b}	55.1^{a}	43.6^{a}	37.8^{a}
Mean	20.2^{B}	45.7^{B}	0.04^{B}	34.1^{A}	52.2^{B}	42.0^{B}	36.7^{B}
Overall mean	21.4^{G}	46.2^{H}	0.05^{EF}	32.4^{F}	54.5^{H}	44.6^{H}	39.2^{H}

a, b, c: Values in the same column for each item with different superscripts differ significantly ($P<0.05$).
A, B: Means in the same column with different superscripts differ significantly ($P<0.05$).
E, F, G, H: Overall means in the same column with different superscripts differ significantly ($P<0.05$).

Table 4: *In situ* ruminal CP disappearance (%) of different rations.

Enzyme level	Incubation times (hours)							
	0	2	4	8	16	24	48	72
R1 (60% CFM : 40% BH)								
0	24.8^{a}	29.8^{b}	34.3^{b}	42.3^{b}	54.8^{b}	63.9^{b}	78.6^{b}	84.1^{ab}
1	25.2^{a}	30.3^{a}	35.0^{a}	43.3^{a}	56.1^{a}	65.2^{a}	79.7^{a}	84.9^{a}
1.5	23.3^{b}	28.7^{c}	33.6^{c}	42.2^{b}	55.3^{ab}	64.6^{ab}	78.7^{b}	83.4^{b}
Mean	24.4^{A}	29.6^{A}	34.3^{A}	42.6^{A}	55.4	64.6	78.8^{A}	84.2^{A}

R2 (40% CFM : 60% BH)								
0	21.2^{a}	26.9^{a}	32.1^{b}	41.2^{b}	54.7^{b}	64.0^{b}	77.4^{b}	81.8^{b}
1	21.4^{a}	27.5^{a}	33.1^{a}	42.6^{a}	56.8^{a}	66.3^{a}	79.6^{a}	83.6^{a}
1.5	19.7^{b}	25.1^{b}	30.0^{c}	38.7^{c}	52.0^{c}	61.4^{c}	75.9^{c}	81.0^{b}
Mean	20.8^{B}	26.5^{B}	31.8^{B}	40.8^{B}	54.5	63.9	77.7^{B}	82.1^{B}
Overall mean	22.6^{F}	28.1^{F}	33.0^{F}	41.7^{F}	55.0^{F}	64.2^{F}	78.3^{F}	83.1^{F}
R3 (60% CFM : 40% DSBT)								
0	34.4	39.5	44.2	52.3	64.4^{b}	72.6^{b}	84.4	88.2^{b}
1	33.7	39.8	45.3	54.2	66.0^{a}	74.6^{a}	86.8	93.1^{a}
1.5	33.6	39.2	44.3	53.0	66.0^{a}	73.5^{ab}	83.4	90.4^{ab}
Mean	33.9^{A}	39.5^{A}	44.6^{A}	52.5	65.5	73.6	84.9	90.6^{A}
R4 (40% CFM : 60% DSBT)								
0	31.6	37.3^{b}	42.4^{c}	51.3^{c}	64.4^{c}	73.1^{c}	85.4	89.0^{a}
1	31.3	37.9^{a}	43.6^{a}	53.3^{a}	66.7^{a}	75.0^{a}	88.5	88.0^{ab}
1.5	31.3	37.5^{ab}	43.0^{b}	52.3^{b}	65.6^{b}	74.1^{b}	85.2	87.6^{b}
Mean	31.4^{B}	37.5^{B}	43.0^{B}	52.3	65.8	74.1	86.4	88.2^{B}
Overall mean	32.7^{E}	38.5^{E}	43.8^{E}	52.4^{E}	65.5^{E}	73.8^{E}	86.2^{E}	89.0^{E}
R5 (60% CFM : 40% CS)								
0	19.9^{b}	25.2^{c}	30.1^{c}	38.6^{c}	51.4^{c}	61.3^{c}	76.0^{c}	81.3^{c}
1	20.3^{ab}	25.9^{b}	30.9^{b}	39.8^{b}	53.3^{b}	62.9^{b}	77.4^{b}	82.1^{b}
1.5	20.9^{a}	26.4^{a}	31.5^{a}	40.4^{a}	54.4^{a}	63.8^{a}	78.6^{a}	83.7^{a}
Mean	20.4^{A}	25.8^{A}	30.8	39.6	53.1	62.6	77.3^{A}	82.4^{A}
R6 (40% CFM : 60% CS)								
0	19.0^{b}	24.5^{c}	29.5^{c}	36.6^{b}	51.7^{b}	60.9^{b}	74.7^{b}	79.3
1	19.1^{b}	25.2^{b}	30.6^{b}	40.1^{ab}	54.0^{a}	63.2^{a}	76.2^{a}	79.9
1.5	19.9^{a}	25.9^{a}	31.4^{a}	40.8^{a}	54.6^{a}	63.8^{a}	76.5^{a}	80.2
Mean	19.3^{B}	25.2^{B}	30.5	39.2	53.4	62.6	75.8^{B}	79.8^{B}
Overall mean	19.9^{G}	25.5^{G}	30.7^{G}	39.4^{G}	53.3^{G}	62.6^{G}	76.1^{G}	81.2^{G}
R7 (60% CFM : 40% RS)								
0	14.5^{c}	20.7^{b}	25.9^{b}	35.2^{b}	49.0^{b}	58.2^{b}	71.0^{b}	74.7^{b}
1	15.4^{b}	21.7^{a}	27.4^{a}	37.0^{a}	51.1^{a}	60.4^{a}	73.1^{a}	76.6^{a}
1.5	15.6^{a}	22.0^{a}	27.5^{a}	37.1^{a}	51.2^{a}	60.5^{a}	73.1^{a}	76.7^{a}
Mean	15.2^{A}	21.4^{A}	26.9^{A}	36.5^{A}	50.5^{A}	59.7^{A}	72.4^{A}	76.0^{A}
R8 (40% CFM : 60% RS)								
0	13.1^{b}	18.5^{b}	23.1^{b}	31.9^{b}	44.8^{b}	53.7^{b}	66.7^{b}	71.8^{b}
1	14.7^{a}	19.4^{ab}	24.4^{a}	33.1^{a}	46.3^{a}	55.2^{a}	68.3^{a}	72.4^{a}
1.5	13.9^{ab}	20.1^{a}	25.1^{a}	33.7^{a}	46.6^{a}	55.4^{a}	68.3^{a}	72.5^{a}
Mean	13.9^{B}	19.3^{B}	24.2^{B}	32.9^{B}	45.9^{B}	54.8^{B}	67.8^{B}	71.9^{B}
Overall mean	14.5^{I}	20.4^{H}	25.6^{H}	34.7^{H}	48.5^{H}	57.2^{H}	70.1^{H}	74.0^{H}
R9 (60% CFM : 40% WS)								
0	16.0	21.4	26.4	35.0	48.2	57.4	71.2	75.9
1	16.2	22.0	27.2	35.9	48.9	57.9	71.4	76.0
1.5	17.1	24.5	27.4	36.2	49.7	58.8	72.0	76.2
Mean	16.4^{A}	22.6^{A}	27.0^{A}	35.7^{A}	48.9^{A}	58.0^{A}	71.6^{A}	76.0^{A}
R10 (40% CFM : 60% WS)								
0	14.6	19.0	23.1^{b}	30.3^{b}	41.7^{b}	50.1^{b}	64.0	69.4
1	14.7	19.2	23.4^{ab}	30.8^{ab}	42.6^{ab}	51.3^{ab}	64.9	69.5
1.5	14.4	19.2	23.7^{a}	31.4^{a}	43.4^{a}	51.9^{a}	65.8	71.6
Mean	14.6^{B}	19.2^{B}	23.4^{B}	30.8^{B}	42.6^{B}	51.1^{B}	64.9^{B}	70.2^{B}
Overall mean	15.5^{H}	20.9^{H}	25.2^{H}	33.3^{I}	45.7^{I}	54.5^{I}	68.2^{I}	73.1^{H}

a, b, c: Values in the same column for each item with different superscripts differ significantly ($P<0.05$).
A, B: Means in the same column for each roughage with different superscripts differ significantly ($P<0.05$).
E, F, G, H, I: Overall means in the same column with different superscripts differ significantly ($P<0.05$).

Table 5: Ruminal degradation and effective degradability (%) of CP for different rations.

Enzyme level	Degradation fractions				Effective degradability		
	a	b	c	u	K=0.02	K=0.05	K=0.08
R1 (60% CFM : 40% BH)							
0	24.3	62.6	0.04	13.1	66.6^{b}	52.9	45.8^{b}
1	25.1	62.7	0.04	12.2	67.8^{a}	56.2	46.9^{a}
1.5	24.9	62.7	0.04	12.4	66.8^{b}	54.0	46.0^{b}
Mean	24.8^{A}	62.7^{B}	0.04^{B}	12.5^{B}	67.1^{A}	54.4^{A}	46.2
R2 (40% CFM : 60% BH)							
0	19.7^{b}	62.6	0.05	17.7^{a}	63.6^{c}	49.6^{c}	42.5^{b}
1	21.4^{a}	63.9	0.05	14.7^{b}	67.1^{a}	53.5^{a}	46.2^{a}
1.5	21.3^{a}	63.9	0.04	14.8^{b}	65.4^{b}	51.8^{b}	46.1^{a}
Mean	20.8^{B}	63.5^{A}	0.05^{A}	15.7^{A}	65.4^{B}	51.7^{B}	44.9
Overall mean	22.8^{F}	63.1^{E}	0.04^{G}	14.1^{G}	66.3^{F}	53.1^{F}	45.6^{F}
R3 (60% CFM : 40% DSBT)							
0	33.6	54.1	0.05	12.3^{a}	73.4	61.7	55.2
1	35.3	58.3	0.05	6.4^{c}	75.4	63.4	56.2
1.5	34.4	55.3	0.06	10.3^{b}	73.6	62.9	55.4
Mean	34.4^{A}	55.9	0.05	9.7	74.2	62.7	55.6
R4 (40% CFM : 60% DSBT)							
0	31.3	56.8^{b}	0.05	11.9^{a}	73.9	61.3^{c}	54.5^{c}
1	31.6	58.9^{a}	0.06	9.5^{b}	74.2	62.6^{a}	55.9^{a}
1.5	31.4	57.7^{b}	0.06	10.9^{ab}	73.9	61.9^{b}	55.2^{b}
Mean	31.4^{B}	57.8	0.06	10.8	74.0	61.9	55.2
Overall mean	32.9^{E}	56.9^{G}	0.06^{E}	10.2^{H}	74.1^{E}	62.3^{E}	55.4^{E}
R5 (60% CFM : 40% CS)							
0	19.9^{b}	64.3^{b}	0.04	15.8^{a}	63.8^{c}	49.7^{c}	42.4^{c}
1	20.3^{ab}	64.6^{b}	0.04	15.1^{a}	65.0^{b}	50.8^{b}	43.5^{b}
1.5	20.7^{a}	65.4^{a}	0.04	13.9^{b}	66.0^{a}	51.6^{a}	44.2^{a}
Mean	20.3^{A}	64.8^{A}	0.04^{B}	14.9^{B}	64.9^{A}	50.7	43.4
R6 (40% CFM : 60% CS)							
0	19.0^{b}	61.9	0.05	19.1	62.7^{b}	49.0^{b}	41.7^{c}
1	19.0^{b}	62.4	0.05	18.6	64.0^{a}	50.7^{a}	43.4^{b}
1.5	19.9^{a}	62.6	0.05	17.5	64.4^{a}	51.3^{a}	44.2^{a}
Mean	19.3^{B}	62.3^{B}	0.05^{A}	18.4^{A}	63.7^{B}	50.3	43.1
Overall mean	19.8^{G}	63.6^{E}	0.05^{F}	16.6^{F}	64.3^{G}	50.5^{G}	43.3^{G}
R7 (60% CFM : 40% RS)							
0	14.5^{b}	61.8	0.05	23.7^{a}	58.9^{b}	45.7^{b}	38.6^{b}
1	15.4^{a}	62.5	0.05	22.1^{b}	60.8^{a}	47.6^{a}	40.3^{a}
1.5	15.6^{a}	62.6	0.05	21.8^{b}	60.9^{a}	47.7^{a}	40.4^{a}
Mean	15.2^{A}	62.3^{A}	0.05	22.5^{B}	60.2^{A}	47.0^{A}	39.8^{A}
R8 (40% CFM : 60% RS)							
0	13.1^{b}	59.6	0.05	27.3^{a}	55.1^{b}	42.1^{b}	35.3^{b}
1	13.9^{ab}	59.7	0.05	26.4^{a}	56.6^{a}	43.5^{a}	36.5^{a}
1.5	14.7^{a}	60.5	0.05	24.8^{b}	56.7^{a}	43.8^{a}	36.9^{a}
Mean	13.9^{B}	59.9^{B}	0.05	26.2^{A}	56.1^{B}	43.2^{B}	36.3^{B}
Overall mean	14.6^{I}	61.1^{F}	0.05^{F}	24.3^{E}	58.2^{H}	45.1^{H}	38.1^{H}
R9 (60% CFM : 40% WS)							
0	16.0	61.3	0.05	22.7	59.2	45.7	38.6
1	16.2	61.9	0.05	21.9	59.7	46.3	39.4
1.5	17.1	62.3	0.05	20.6	59.8	46.7	39.6
Mean	16.4^{A}	61.8^{A}	0.05^{A}	21.8^{B}	59.6^{A}	46.2^{A}	39.2^{A}
R10 (40% CFM : 60% WS)							

0	14.4	57.5	0.04	28.1^{a}	53.2	40.2^{b}	33.8^{b}
1	14.7	58.4	0.04	26.9^{a}	53.9	41.1^{ab}	34.5^{a}
1.5	14.7	60.7	0.04	24.6^{b}	54.6	41.3^{a}	34.8^{a}
Mean	14.6^{B}	58.9^{B}	0.04^{B}	26.5^{A}	53.9^{B}	40.9^{B}	34.4^{B}
Overall mean	15.5^{H}	60.4	0.04^{G}	24.1	56.8^{I}	43.6^{I}	36.8^{I}

a, b, c: Values in the same column for each item with different superscripts differ significantly (P<0.05).
A, B, C, D, E: Means in the same column with different superscripts differ significantly (P<0.05).
E, F, G, H, I: Overall means in the same column with different superscripts differ significantly (P<0.05).

Table 6: *In situ* ruminal CF disappearance (%) of different rations.

Enzyme level	Incubation times (hours)							
	0	2	4	8	16	24	48	72
R1 (60% CFM : 40% BH)								
0	22.7	28.1^{b}	32.8^{b}	40.9^{c}	52.9^{c}	61.6^{c}	74.0^{c}	78.0^{c}
1	23.1^{b}	28.2^{b}	33.0^{b}	41.6^{b}	54.7^{b}	63.7^{b}	77.2^{b}	81.6^{b}
1.5	24.4	30.5^{a}	35.5^{a}	44.2^{a}	57.6^{a}	66.7^{a}	80.8^{a}	85.3^{a}
Mean	23.4	28.9^{A}	33.8^{A}	42.3^{A}	55.1^{A}	64.0^{A}	77.3^{A}	81.7^{A}
R2 (40% CFM : 60% BH)								
0	20.2	25.4^{b}	30.2^{c}	38.5^{c}	51.9^{b}	59.5^{b}	71.2^{b}	74.3^{b}
1	20.4	25.9^{b}	30.9^{b}	39.4^{b}	53.3^{ab}	60.0^{b}	72.0^{b}	76.0^{b}
1.5	21.1	26.8^{a}	32.1^{a}	41.1^{a}	54.3^{a}	63.0^{a}	75.3^{a}	78.9^{a}
Mean	20.6^{B}	26.1^{B}	31.1^{B}	39.6^{B}	53.1^{B}	60.8^{B}	72.8^{B}	76.4^{B}
Overall mean	22.0^{F}	27.5^{G}	32.4^{F}	41.0^{F}	54.1^{F}	62.4^{F}	75.1^{E}	79.0^{E}
R3 (60% CFM : 40% DSBT)								
0	32.9	38.4^{b}	43.0^{b}	49.6^{c}	59.7^{c}	67.0^{c}	75.9^{c}	77.7^{c}
1	34.2	40.3^{a}	44.5^{a}	51.7^{a}	62.7^{a}	70.3^{a}	81.6^{a}	85.3^{a}
1.5	33.7	39.4^{ab}	43.1^{b}	50.7^{b}	61.4^{b}	67.9^{b}	78.7^{b}	83.1^{b}
Mean	33.6	39.4^{A}	43.5^{A}	50.7^{A}	61.3^{A}	68.4^{A}	78.7^{A}	82.0^{A}
R4 (40% CFM : 60% DSBT)								
0	30.6	35.6^{b}	39.6^{c}	46.5^{c}	57.2^{c}	64.6^{c}	74.3^{b}	76.2^{b}
1	31.3	37.0^{a}	42.0^{a}	50.2^{a}	61.4^{a}	68.0^{a}	75.7^{a}	79.4^{a}
1.5	31.2	36.0^{ab}	40.7^{b}	48.6^{b}	59.6^{b}	66.1^{b}	75.5^{a}	77.0^{b}
Mean	31.0	36.2^{B}	40.8^{B}	48.5^{B}	59.4^{B}	66.9^{B}	75.2^{B}	77.5^{B}
Overall mean	32.3^{E}	37.8^{E}	42.2^{E}	49.6^{E}	60.3^{E}	67.3^{E}	76.9^{E}	79.8^{E}
R5 (60% CFM : 40% CS)								
0	20.5	32.0^{b}	36.3^{c}	43.4^{b}	53.2^{b}	59.2^{b}	66.4^{b}	72.2
1	21.1	33.0^{ab}	37.3^{b}	44.2^{b}	54.6^{b}	59.6^{b}	67.3^{ab}	72.8
1.5	21.5	34.0^{a}	38.8^{a}	46.6^{a}	56.9^{a}	62.7^{a}	68.8^{a}	74.4
Mean	21.0	33.0^{A}	37.5^{A}	44.7^{A}	54.9^{A}	60.5^{A}	67.5^{A}	73.1
R6 (40% CFM : 60% CS)								
0	21.3	25.1^{b}	27.3^{b}	32.2^{c}	41.0^{b}	48.4^{c}	62.8^{c}	71.4
1	21.6	25.2^{b}	29.8^{a}	34.1^{b}	44.9^{a}	51.3^{b}	64.7^{b}	73.7
1.5	22.3	27.9^{a}	31.0^{a}	36.5^{a}	45.8^{a}	52.9^{a}	66.2^{a}	73.7
Mean	21.7	26.1^{B}	29.4^{B}	34.3^{B}	43.9^{B}	50.9^{B}	64.6^{B}	72.7
Overall mean	21.8^{F}	29.5^{F}	33.4^{F}	39.5^{F}	49.4^{G}	55.7^{G}	66.1^{F}	72.9^{F}
R7 (60% CFM : 40% RS)								
0	21.4^{b}	25.4^{c}	29.1^{c}	35.8^{c}	46.4^{c}	54.5^{b}	65.9^{c}	69.2^{b}
1	22.7^{a}	27.0^{b}	30.8^{b}	37.4^{b}	47.5^{b}	54.8^{b}	67.6^{b}	72.2^{a}
1.5	22.9^{a}	28.1^{a}	32.8^{a}	40.9^{a}	52.5^{a}	60.0^{a}	70.0^{a}	72.9^{a}
Mean	22.3^{A}	26.8^{A}	30.9^{A}	38.0^{A}	48.8^{A}	56.3^{A}	67.7^{A}	71.4
R8 (40% CFM : 60% RS)								
0	19.4^{c}	22.2^{b}	25.0^{b}	30.1^{b}	37.9^{c}	46.0^{b}	61.2^{c}	69.8
1	20.6^{b}	25.4^{ab}	28.0^{ab}	33.2^{a}	42.2^{b}	49.5^{a}	63.2^{b}	70.2
1.5	21.4^{a}	26.3^{a}	29.7^{a}	34.3^{a}	45.9^{a}	50.6^{a}	65.6^{a}	70.7

Mean	20.5^{B}	24.6^{B}	27.6^{B}	33.5^{B}	42.1^{B}	48.6^{B}	63.3^{B}	70.2
Overall mean	21.4^{F}	25.7^{GH}	29.2^{G}	35.3^{G}	45.6^{H}	52.5^{H}	65.5^{F}	70.8^{G}
R9 (60% CFM : 40% WS)								
0	22.7	28.1^{b}	31.5^{c}	37.5^{c}	46.8^{c}	53.2^{c}	63.8^{b}	66.9^{b}
1	22.8	28.7^{b}	32.7^{b}	38.8^{b}	48.3^{b}	54.7^{b}	63.9^{b}	67.6^{b}
1.5	23.0	29.6^{a}	34.3^{a}	42.3^{a}	53.4^{a}	60.1^{a}	68.7^{a}	70.7^{a}
Mean	22.9^{A}	28.8^{A}	32.8^{A}	39.5^{A}	49.5^{A}	56.1^{A}	65.5^{A}	68.4^{A}
R10 (40% CFM : 60% WS)								
0	18.4^{b}	19.3^{b}	24.1^{b}	29.0^{b}	37.3^{b}	43.7^{b}	55.4^{b}	61.0^{b}
1	18.8^{b}	21.8^{a}	24.4^{b}	29.4^{b}	37.6^{b}	44.0^{b}	55.9^{b}	61.6^{b}
1.5	19.6^{a}	22.8^{a}	25.7^{a}	31.1^{a}	40.3^{a}	47.4^{a}	61.2^{a}	67.9^{a}
Mean	18.9^{B}	21.3^{B}	24.7^{B}	29.8^{B}	38.4^{B}	45.0^{B}	57.5^{B}	63.5^{B}
Overall mean	20.9^{F}	25.0^{H}	28.8^{G}	34.7^{G}	43.9^{H}	50.6^{H}	61.5^{G}	66.0^{H}

a, b, c: Values in the same column for each item with different superscripts differ significantly ($P<0.05$).
A, B: Means in the same column for each roughage with different superscripts differ significantly ($P<0.05$).
E, F, G, H: Overall means in the same column with different superscripts differ significantly ($P<0.05$).

Table 7: Ruminal degradation and effective degradability (%) of CF for different rations.

Enzyme level	Degradation fractions				Effective degradability		
	a	b	C	u	K=0.02	K=0.05	K=0.08
R1 (60% CFM : 40% BH)							
0	22.7^{b}	56.9^{b}	0.05	20.4^{a}	62.8^{c}	50.7^{c}	44.2^{c}
1	23.1^{b}	62.6^{a}	0.05	14.3^{b}	65.4^{b}	52.1^{b}	45.1^{b}
1.5	25.0^{a}	63.7^{a}	0.05	11.3^{b}	68.6^{a}	55.0^{a}	47.8^{a}
Mean	23.6^{A}	61.1^{A}	0.05	15.3^{B}	65.7^{A}	52.6^{A}	45.7^{A}
R2 (40% CFM : 60% BH)							
0	20.2	55.1^{b}	0.05	24.7^{a}	60.4^{b}	48.3^{b}	41.7
1	20.4	57.8^{a}	0.05	21.8^{b}	60.8^{b}	48.7^{b}	41.2
1.5	21.1	59.3^{a}	0.05	19.6^{c}	63.7^{a}	51.1^{a}	42.3
Mean	20.6^{B}	57.4^{B}	0.05	20.1^{A}	61.7^{B}	49.4^{B}	41.8^{B}
Overall mean	22.1^{G}	59.3^{E}	0.05^{E}	18.6^{G}	63.7^{F}	51.0^{F}	43.8^{F}
R3 (60% CFM : 40% DSBT)							
0	33.2	45.0^{b}	0.04^{c}	21.8^{a}	67.2^{c}	58.0^{b}	52.5^{b}
1	36.8	51.4^{a}	0.05^{b}	11.8^{b}	71.6^{a}	60.5^{a}	54.6^{a}
1.5	35.7	50.3^{a}	0.06^{a}	14.0^{b}	69.3^{b}	58.1^{b}	52.7^{b}
Mean	35.2^{A}	48.9	0.05^{B}	15.9^{B}	69.4^{A}	58.9^{A}	53.3^{A}
R4 (40% CFM : 60% DSBT)							
0	30.6	46.1^{b}	0.05^{b}	23.3^{a}	65.5^{b}	55.1^{c}	49.4^{c}
1	31.3	50.0^{a}	0.07^{a}	18.7^{b}	66.7^{a}	57.5^{a}	52.2^{a}
1.5	31.2	46.2^{b}	0.06^{ab}	22.6^{a}	66.1^{ab}	56.1^{b}	50.7^{b}
Mean	31.0^{B}	47.4	0.06^{A}	21.6^{A}	66.1^{B}	56.3^{B}	50.8^{B}
Overall mean	33.1^{E}	48.2^{G}	0.06^{E}	18.7^{G}	67.8^{E}	57.6^{E}	52.1^{E}
R5 (60% CFM : 40% CS)							
0	24.0^{b}	41.5^{b}	0.06	34.5^{a}	56.1^{b}	44.3^{b}	39.3^{b}
1	27.2^{a}	42.0^{b}	0.07	30.8^{b}	58.4^{ab}	50.0^{ab}	45.2^{ab}
1.5	28.4^{a}	53.4^{a}	0.04	18.2^{c}	60.9^{a}	53.0^{a}	48.1^{a}
Mean	26.5^{A}	45.6^{B}	0.06^{A}	27.9^{A}	58.5^{A}	49.1^{A}	44.2^{A}
R6 (40% CFM : 60% CS)							
0	21.3^{b}	53.2^{b}	0.02^{b}	25.5^{a}	54.3^{b}	41.3^{c}	36.0^{c}
1	21.9^{b}	54.3^{b}	0.03^{a}	23.8^{a}	54.4^{b}	43.1^{b}	37.4^{b}
1.5	24.7^{a}	59.5^{a}	0.03^{a}	15.8^{b}	57.3^{a}	45.1^{a}	39.7^{a}
Mean	22.6^{B}	55.7^{A}	0.03^{B}	21.7^{B}	55.3^{B}	43.2^{B}	37.7^{B}
Overall mean	24.6^{F}	50.7^{G}	0.05^{F}	24.7^{F}	56.9^{G}	46.2^{G}	41.0^{G}

R7 (60% CFM : 40% RS)							
0	21.4^{b}	49.0^{b}	0.04^{b}	29.6^{a}	56.6^{c}	45.1^{b}	39.1^{c}
1	22.6^{a}	50.4^{b}	0.06^{a}	27.0^{a}	57.4^{b}	45.8^{b}	40.1^{b}
1.5	22.9^{a}	55.3^{a}	0.04^{b}	21.8^{b}	59.8^{a}	49.4^{a}	43.5^{a}
Mean	22.3^{A}	51.6^{B}	0.05^{A}	26.1^{A}	58.0^{A}	46.8^{A}	40.9^{A}
R8 (40% CFM : 60% RS)							
0	19.4^{b}	51.6^{b}	0.02^{b}	29.0^{a}	52.7^{c}	39.2^{c}	33.5^{c}
1	20.4^{ab}	55.5^{b}	0.04^{a}	24.1^{b}	54.5^{b}	42.0^{b}	36.4^{b}
1.5	22.5^{a}	61.3^{a}	0.03^{ab}	16.2^{c}	56.2^{a}	44.7^{a}	39.0^{a}
Mean	20.8^{B}	56.1^{A}	0.03^{B}	23.1^{B}	54.5^{B}	42.0^{B}	36.3^{B}
Overall mean	21.6^{G}	53.9^{F}	0.04^{F}	24.5^{F}	56.3^{G}	44.0^{GH}	38.6^{GH}
R9 (60% CFM : 40% WS)							
0	24.2	44.9	0.04^{c}	30.9^{a}	55.3^{b}	45.2^{c}	40.1^{c}
1	24.5	45.5	0.06^{a}	30.0^{a}	55.6^{b}	46.2^{b}	41.2^{b}
1.5	26.0	47.2	0.05^{b}	26.8^{b}	59.5^{a}	49.9^{a}	44.4^{a}
Mean	24.9^{A}	45.9^{B}	0.05^{A}	29.2	56.8^{A}	47.1^{A}	41.8^{A}
R10 (40% CFM : 60% WS)							
0	18.4	47.4^{b}	0.03	34.2^{a}	47.5^{b}	36.8^{b}	31.9^{b}
1	18.8	47.8^{b}	0.03	33.4^{a}	47.9^{b}	37.1^{b}	32.2^{b}
1.5	19.6	55.1^{a}	0.03	25.3^{b}	52.3^{a}	40.0^{a}	34.4^{a}
Mean	18.9^{B}	50.1^{A}	0.03^{B}	31.0	49.2^{B}	38.0^{B}	32.8^{B}
Overall mean	21.9^{G}	48.0^{G}	0.04^{F}	30.1^{E}	53.0^{H}	42.6^{H}	37.3^{H}

a, b, c: Values in the same column for each item with different superscripts differ significantly ($P<0.05$).
A, B, C, D, E: Means in the same column with different superscripts differ significantly ($P<0.05$).
E, F, G, H: Overall means in the same column with different superscripts differ significantly ($P<0.05$).

COCLUSION

Form these results it could be concluded that the *in situ* ruminal DM, CP and CF disappearance and degradation decreased with increasing the proportion of roughage in the rations and added fibrolytic enzyme at the level of 1g/kg DM showed the highest DM and CF disappearance and degradation for DSBT rations and CP disappearance and degradation for BH and DSBT rations. While, the level of 1.5 g/kg showed the highest DM and CF disappearance and degradation for BH, CS, RS and WS rations and CP disappearance and degradation for CS, RS and WS rations.

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