STUDIES ON PROTEIN DEGRADABILITIES OF FEEDSTUFFS IN BANGLADESH

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Summary

This experiment was conducted to determine RDP values of locally available feedstuffs that are commonly used in ruminant rations in Bangladesh. Four cattle were fistulated in the rumen for the *in situ* nylon bag studies. Seventeen different feedstuff samples (9 roughages and 8 concentrates) were evaluated in 4×14 cm nylon bags and incubated in the rumen for different periods of time (2, 6, 12, 24, 48 and 72 h). The variation in crude protein (CP) contents reflected on the average CP disappearance value throughout the rumen incubation. Soluble fraction (a), insoluble but degradable fraction (b) along with the rate of degradation also varied widely among the various feedstuffs. Under 2% of rumen outflow rate, the percentages of the calculated protein degradabilities of roughages were rice straw, 16.7; maize grass, 70.6; oat grass, 70.8; dhal grass, 71.1; sunhemp, 78.4; napier grass, 62.4; matikalai grass, 72.1; khesarikalai grass, 76.9 and daincha browse, 78.4, respectively. The results in the protein degradabilities (%) in 8% ruminal outflow rate of concentrates were wheat bran, 61.6; rice polish (red), 61.3; rice polish (auto), 30.9; mustard oil cake, 71.8; sesame oil cake, 74.2; coconut oil cake, 57.9; soybean meal, 49.2 and fish meal, 37.9, respectively.
(**Key Words** : *In situ*, Protein Degradation, Nylon Bag, Roughages, Concentrates)

Introduction

The protein requirements of ruminants and protein value of feedstuffs have been expressed as digestible crude protein (DCP) for a long time. The DCP system has been used as a standard for evaluating the protein requirements of ruminants for many years. With the increasing knowledge of true digestible process of protein in ruminants, it is known that this system is unable to cope with the protein requirement of high yielding cattle during their peak performance period. In order to overcome the limitations of DCP system, Agricultural and Food Research Council (AFRC, 1992) proposed that the dietary crude protein needs of the ruminants must be supplied in terms of rumen degradable protein(RDP) to meet the nitrogen requirement of rumen microorganisms and undegradable protein (UDP) which should be made available to the animals whenever microbial protein synthesis in the rumen is insufficient to meet the nitrogen requirement of host animal tissues. This system can also provide an appropriate quantity of protein that can bypass the rumen without being degraded. This kind of protein system can not only supply nitrogen for maximum ruminal fermentation, but can also provide better metabolizable protein for high performance cattle.

The protein degradation in the rumen varies considerably between feeds and within feeds and different chemical or physical treatments of the feed can influence the degradability (Zinn et al., 1981 and Madsen et al., 1984). It is therefore, necessary to determine RDP values of locally available feedstuffs in Bangladesh.

The nylon bag technique (Orskov et al., 1980) for assessing the ruminal degradation of dry matter and nitrogen in ruminants feeds has been widely used for evaluating mixed diets (Stern and Satter, 1984), forages (Negi et al., 1988 and Chiou et al., 1995), grains and grain mixtures (Krishnamoorty et al., 1983) and various protein rich sources (Freer and Dove, 1984 and Ha and Kennelly, 1984). The nylon bag *in situ* technique is the most promising approach that can provide rapid and reasonable estimates for a wide varieties of feedstuffs, though the technique is subject to variance that can influence the results.

However, information is scanty on the contribution on the rumen degradable protein by feeds largely used as energy and protein sources for animals in Bangladesh. In the present study, an attempt has been made to determine protein degradabilities of the conventional ruminant

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feedstuffs in Bangladesh in terms of effective degradability of crude protein (EDCP) in cattle using *in situ* nylon bag technique.

Materials and Methods

Experimental animals and management

Four fistulated indigenous cattle averaging 130 kg of body weight (3-4 years) fitted with permanent rumen cannulae were used in this experiment. Cattle were placed in a pen of 5 × 8 m cement floor pen with a holding in a pen of 5 × 8 m cement floor with a holding stanchion inside. For 15 days before and during the study period, cattle were offered a diet (2.5% body weight) composed of roughage (70%) and concentrate (30%) having 8.0% CP to meet their maintenance requirements (Kearl, 1982). Cattle were fed equally divided twice a day at 08:00 and 16:00. Fresh water was freely available. Ration formulation is presented in table 1.

Feedstuff samples

Nine conventional roughage sources, namely, rice straw, maize grass, oat grass, dhal grass, sunhemp, napier grass, matikali grass, khesarikalai grass and daincha browse and eight concentrate feed sources, namely, wheat bran, rice polish (red), rice polish (auto), mustard oil cake, sesame oil cake, coconut oil cake, soybean meal and fish meal were procured for the present study. The samples were dried and ground in a laboratory wiley mill using 2 mm mesh screen and placed into the plastic bottle for *in situ* incubation. Name, botanical name and protein content of feedstuffs are presented in table 2.

TABLE 1. DIET FORMULATION IN THE TRIAL CONSUMED BY RUMINALLY CANNULATED CATTLE FOR *IN SITU* TRIAL

Ingredients	%
Rice straw	70.0
Wheat bran	5.4
Mustard oil cake	9.2
Rice polish	5.3
Molasses	8.8
Common salt	0.4
Mineral mixture*	0.8

* The mineral mixture contained (g/100 g): $CaCO_3$ - 44, $MgSO_4$ - 7, K_2PO_4 - 45, Trace mineral mixture ** - 4.
** Composition of trace mineral mixture (g/100 g): $FeSO_4$ $7H_2O$ - 48, $CuSO_4$ $7H_2O$ - 9, $MnSO_4$ H_2O - 41, KI - 0.4, $ZnSO_4$ $7H_2O$ - 0.5, $CoCl_2$ $6H_2O$ - 1 and Na_2 SeO_4 - 0.1.

TABLE 2. SOURCES OF FEEDSTUFFS AND SPECIFICATION

Name	Botanical name	Abbreviation	CP (%)	Remarks
Roughages				
Rice straw	*Oryza sativa*	RS	3.8	Local
Maize grass	*Zea mays*	MGR	11.5	65 days of age
Oat grass	*Avena sativa*	OTG	8.8	65 days of age
Dhal grass	*Hymenachne pesudointerrupta*	DGR	13.9	65 days of age
Sunhemp	*Crotalaria juncea*	SHM	9.4	65 days of age
Napier grass	*Pennesetum purpureum*	NPG	10.9	Local
Matikali grass	*Phaseolus mungo*	MKL	18.3	flowering stage
Khesarikalai grass	*Lathyrus sativus*	KKL	22.2	flowering stage
Daincha browse	*Sesbania aculata*	DNB	24.3	flowering stage
Concentrates				
Wheat bran	*Tritioum aestisum*	WBR	19.2	Local
Rice polish (red)	*Oryza sativa*	RPR	12.3	Local
Rice polish (auto)	*Oryza sativa*	RPA	8.6	Local
Mustard oil cake	*Brassica spp.*	MOC	35.5	Local
Sesame oil cake	*Seeamum indicum*	SOC	32.1	Local
Coconut oil cake	*Cocos nucifera*	COC	23.9	Local
Soybean meal	*Clycine max G. Soy*	SBM	44.2	Local
Fish meal (Grade-A)	–	FM	55.8	Local

Procedure for *in situ* incubation

The procedure of ruminal incubation in this trial followed the method of Orskov et al. (1980). Four replicate samples of 17 feeds (3 g roughage and 5 g concentrate) were placed in the nylon bags (pore size 24-28 μm, bag size 4 × 14 cm) and then anchored from the top of the cannulae using 35 cm nylon tubing. All feed samples were incubated simultaneously in all four cattle using one bag per sample. The bags were incubated in the rumen for 2, 6, 12, 24, 48 and 72 h in each cattle. Upon removal from the rumen, the nylon bags were washed in running tap water till the fluid was cleared and gave gentle squeeze and dried to a constant weight at 70℃ for 48 h. The CP contents of pre- and post-incubated feed samples were determined by kjeldhal method (AOAC, 1984).

Blank correction for nitrogen contamination of nylon bag residues was done by measuring the extent of nitrogen content per a nitrogen free filter paper fermented in nylon bags under the same condition of feeding and management.

In situ degradability calculation

From the % of CP disappearance data, the degradation of protein values (P) was calculated by the exponential equation of McDonald (1981) as $P = a + b(1 - e^{-ct})$ where

P = percentage disappearance at time t,
a = rapidly soluble fraction,
b = slowly degradable fraction,
c = rate constant of disappearance for b fraction and
t = time.

Effective degradability of crude protein (EDCP) was calculated from the rumen outflow rate (K) and the constants a, b and c from the above model. K is usually calculated on 0.02/h, 0.05/h or 0.08/h. The EDCP formula is as follows:

$EDCP = a + bc/(c + K)$

where K is the estimated rate of outflow from the rumen.

Statistical analysis

Data from the *in situ* bag study were analysed using linear regression to establish rates of degradation (K) of fraction 'b'. Data were analysed statistically following

TABLE 3. THE PERCENTAGE OF CRUDE PROTEIN DISAPPEARANCE (%)* OF FEEDS FROM NYLON BAG AT DIFFERENT HOURS OF RUMEN FERMENTATION

Feedstuffs	Incubation time (hours)					
	2	6	12	24	48	72
Roughages						
Rice straw	2.4 ± 0.3	5.9 ± 0.6	8.2 ± 0.2	11.8 ± 0.8	18.2 ± 1.6	24.7 ± 0.9
Maize grass	32.5 ± 4.2	37.9 ± 1.8	65.2 ± 6.3	73.5 ± 2.7	76.6 ± 3.3	86.2 ± 1.8
Oat grass	40.8 ± 2.1	58.6 ± 4.7	65.2 ± 2.9	69.6 ± 1.2	75.8 ± 4.1	82.3 ± 7.2
Dhal grass	35.4 ± 1.8	44.4 ± 4.2	55.2 ± 5.1	74.0 ± 4.1	79.1 ± 7.3	87.0 ± 6.5
Sunhemp	44.8 ± 4.1	62.9 ± 2.7	67.5 ± 1.8	76.5 ± 5.2	87.1 ± 3.0	90.2 ± 3.9
Napier grass	37.2 ± 2.4	49.8 ± 4.1	53.4 ± 1.7	59.6 ± 6.2	68.4 ± 2.8	73.5 ± 4.8
Matikali grass	27.7 ± 5.2	48.7 ± 2.7	67.5 ± 5.1	72.8 ± 7.3	78.4 ± 4.7	88.0 ± 6.2
Khesarikalai grass	43.8 ± 3.1	68.5 ± 7.2	71.3 ± 2.7	76.8 ± 4.1	81.7 ± 5.5	88.6 ± 4.9
Daincha browse	33.0 ± 4.4	46.4 ± 1.5	59.3 ± 4.6	79.4 ± 1.1	92.6 ± 6.6	95.8 ± 4.8
Concentrates						
Wheat bran	45.4 ± 6.3	57.2 ± 2.7	66.7 ± 5.7	77.7 ± 7.8	81.7 ± 5.7	–
Rice polish (red)	47.1 ± 3.6	54.4 ± 2.9	68.8 ± 4.1	75.3 ± 5.1	76.9 ± 4.4	–
Rice polish (auto)	23.7 ± 1.9	29.9 ± 4.2	32.1 ± 2.1	37.0 ± 3.0	41.8 ± 5.3	–
Mustard oil cake	57.2 ± 3.3	68.5 ± 1.8	77.9 ± 7.1	84.8 ± 3.5	86.8 ± 6.3	–
Sesame oil cake	49.9 ± 2.8	75.4 ± 4.5	87.0 ± 3.7	90.1 ± 5.1	90.7 ± 2.5	–
Coconut oil cake	39.9 ± 6.1	51.3 ± 5.0	63.4 ± 6.1	76.6 ± 2.6	84.9 ± 2.0	–
Soygean meal	27.0 ± 4.3	39.9 ± 7.3	54.6 ± 2.2	72.9 ± 2.8	87.6 ± 6.3	–
Fish meal (Grade-A)	24.4 ± 6.4	29.0 ± 6.2	42.9 ± 1.8	55.2 ± 4.1	60.6 ± 3.6	–

* Each value is an average of four measurements.

Snedecor and Cochran (1967).

Results and Discussion

Among the feed resources evaluated in the present study, CP content (%) of roughages varied from 3.8 in RS to 24.3 in DNB and that of concentrates varied from 8.6 in RPA to 55.8 in FM (table 2). These values differed widely as reported by others (Gangadhar et al., 1993 and Chiou et al., 1995). The average CP disappearance of feedstuffs from nylon bags at different hours is presented in table 3. Wide differences in CP disappearance value of both roughages and concentrates were observed among the different feeds at all incubation intervals. The extent of increase in CP disappearance ranged from 98% for NPG to 929% for RS in roughages and 52% for MOC to 224% for SBM in concentrates by extending the incubation time from 2 to 48 h, respectively. Wide variation of protein degradability with different time from different sources was noted by Gangadhar et al. (1992). It is reported that protein fractions present in each feedstuffs are important factors influencing crude protein degradability (Blethen et al., 1990).

The EDCP values along with the values for the constants 'a', 'b' and 'c' are presented in table 4. The soluble fractions (a) were 2.7 and 17.0 for RS (roughage) and FM (concentrate), respectively. Mustard oil cake was containing more soluble proteins as evident from the highest 'a' value of 49.2, followed by SHM (41.8), RPR (39.4), WBR (38.3), NPG (36.8), OTG (35.5), COC (32.9), KKL (30.9), DGR (28.8), DNB (25.4), SOC (24.0), RPA (23.4), MGR (20.7), SBM (19.5) and MKL (18.9). The insoluble but degradable 'b' fraction ranged from 23.1 (RPA) to 73.6 (SBM). Rice straw had 33.2 while DNB 72.0. Among the concentrates, SBM had the highest 'b' value (73.6). The results constant of soybean meal for example, were quite agreeing with Chiou et al. (1995) who found value of 20.3 and 77.3 for 'a' and 'b' value, respectively, whereas our values for those were 19.5 and 73.6, respectively. Most of the CP disappearance rates of the feedstuffs from ruminal incubation nylon bag were fitted into the model of Orskov and McDonald (1979) or their modified model of McDonald (1981).

Wide variation in 'c' fraction ranging from 0.01/h to 0.25/h was observed among the 9 roughages and 8 concentrate feeds selected for the present study. Degradation rate for CP of fraction 'b' was greatest for SOC (.25/h) followed by KKL (.17/h), MOC (.12/h), MKL (.11/h), OTG (.10/h), WBR and RPR (.09/h), MGR (.08/h), COC, SHM and FM (.07/h), DGR and DNB (.06/h), SBM and NPG (.05/h), RPA (.04/h) and RS (.01/h). A large 'b' fraction as found with DNB and SBM, would indicate that a roughage and concentrate is degraded in the rumen slowly. In contrast, CP in MOC with a large 'a' fraction would be degraded in the rumen very rapidly.

TABLE 4. DEGRADATION CHARACTERISTICS IN NYLON BAGS INCUBATION FOR 2-72 HOURS IN THE RUMEN, $P = a + b(1-e^{-ct})$

Feedstuffs	Degradation characteristics (%)*			
	a	b	c	Residual SD
Roughages				
Rice straw	2.7	33.2	.01	1.07
Maize grass	20.7	62.1	.08	6.48
Oat grass	35.5	42.5	.10	4.62
Dhal grass	28.8	57.7	.06	2.88
Sunhemp	41.8	47.4	.07	3.86
Napier grass	36.8	36.1	.05	3.22
Matikali grass	18.9	67.4	.11	5.26
Khesarikalai grass	30.9	51.5	.17	5.93
Daincha browse	25.4	72.0	.06	0.95
Concentrates				
Wheat bran	38.3	44.0	.09	0.56
Rice polish (red)	39.4	40.4	.09	2.68
Rice polish (auto)	23.4	23.1	.04	1.48
Mustard oil cake	49.2	37.8	.12	0.01
Sesame oil cake	24.0	66.4	.25	0.23
Coconut oil cake	32.9	54.0	.07	0.00
Soybean meal	19.5	73.6	.05	0.00
Fish meal	17.0	46.5	.07	2.80

* a (soluble), b (insoluble but degradable) and c (rate of constant/h) are constants.

The EDCP values were higher at rumen outflow rate at .02 than at .08, indicating higher protein degradability. In the present study, in one (RS) out of 9 roughages and two (RPA and FM) out of 8 concentrate feeds, the EDCP values at 2 and 8% outflow rate were found to be less than 50% indicating their low potential degradability in the rumen.

In the present study, the EDCP at rumen outflow rate of 2% in RS was 16.7%. It followed that the RS contained a nonsignificant proportion of RDP to contribute to the nutrition of rumen microorganisms. The RDP of RS in the present study is much lower than that observed by Krishnamoorthy et al. (1982). The EDCPs of

NPG, WBR, SBM and FM at 2, 5 and 8% rumen outflow rate (table 5) were different from the results obtained by Chiou et al. (1995). It showed higher values of NPG (62.4%), RPR (61.3%) and lower values of WBR (61.6 %), SBM (49.2%) and FM (37.9%) than the values reported in the literature (NRC, 1988 and Chiou et al., 1995) for these ingredients i.e. 53.8%, 52.5%, 76.8%, 65.0-68.0% and 37.5-40.0% respectively. The difference in the estimates can be attributed to variations in the type of animals used and quality/processing of the feedstuffs.

TABLE 5. EFFECTIVE DEGRADABILITY OF CRUDE PROTEIN OF FEEDS AT DIFFERENT OUTFLOW RATES, EDCP = a + bc /(c+K)

Feedstuffs	Degradability of CP at outflow rate (K) %		
	0.02	0.05	0.08
Roughages			
Rice straw	16.7	9.8	7.5
Maize grass	70.6	59.2	52.1
Oat grass	70.8	63.7	59.0
Dhal grass	71.1	59.0	52.2
Sunhemp	78.4	69.1	63.6
Napier grass	62.4	54.6	52.4
Matikali grass	72.1	61.6	54.3
Khesarikalai grass	76.9	70.5	65.7
Daincha browse	78.4	63.4	55.0
Concentrates			
Wheat bran	74.3	66.6	61.6
Rice polish (red)	72.7	65.7	61.3
Rice polish (auto)	38.6	33.4	30.9
Mustard oil cake	81.5	75.8	71.8
Sesame oil cake	85.5	79.3	74.2
Coconut oil cake	74.8	64.2	57.9
Soybean meal	73.2	57.7	49.2
Fish meal (Grade-A)	52.5	43.3	37.9

Conclusion

Large differences among the roughages and concentrates were found in CP content measured *in situ*. *In situ* protein degradabilities from this study allow direct comparisons between several roughages and concentrates that are commonly used in Bangladesh. An important point is that results were obtained from local cattle. As attempts are made to formulate rations for rumen degradable and undegradable protein, results can be used to approximate degradabilities of roughages and concentrates for which there is limited information.

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