Tropical Agricultural Research Vol. 5 1993

Evaluation of Degradation Characteristics of Fodders and Agro-Industrial by Products Using the Nylon Bag Technique.

V.M.K. Yaparatne, A.N.F. Perera[1], and J. van Bruchem[2]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya.

ABSTRACT. *In order to evaluate the rumen degradation characteristics, seven fodder species and five agro-industrial by-products commonly used in ruminant diets were selected. Dry matter (DM) and Nitrogen (N) degradations were studied using the nylon bag technique for a period up to 48 h, in the rumen of ruminally cannulated buffaloes fed on Guinea grass (Panicum maximum- Eco type A), supplemented with 15 g coconut meal per kg* $W^{0.75}$. *Results were analyzed by non linear regression.*

The average initial DM solubility of fodder (32.8%) was lower than that of agro-industrial by-products (42.5%). All agro-industrial by-products had a very high total degradable DM in the rumen, above 75% disappearance within 24 hours, except for Rubber seed meal (44.5%). The average N disappearance in fodders and agro-industrial by-products showed a similar trend as the DM disappearance. Gliricidia, Leucaena and Erythrina had high potentially fermentable fractions. In contrast to other fodders, Albizzia had a very low total degradable N, in the rumen leaving about 74% as undegradable. In agro-industrial by-products Rubber seed meal had a high readily fermentable N content. However, subsequent potential N disappearance was minimal. More than 80% of the N of Agro-industrial by-products disappeared within 24 hours, leaving small quantities for lower gut enzymatic digestion. These results suggest that Gliricidia, Tithonia, Erythrina, and Leucaena to be the most promising fodders for

---

[1] Department of Animal Science, Faculty of Agriculture, University of Peradeniya

[2] Division of Tropical Animal Production,
Department of Human and Animal Physiology, Agricultural University,
Wageningen, Netherlands.

supplementation in ruminant diets to replace high cost agro-industrial by-products.

INTRODUCTION

One of the major constraints in the ruminant livestock production in Sri Lanka is the unavailability of quality green feed year round. Therefore, tree and shrub fodder and agro-industrial by products play an important role in the nutrition of ruminants. A majority of dry matter and proteins consumed by the animal is degraded in the rumen by the rumen microbes, making most of the nutrients available to the host animal as volatile fatty acids or by synthesising high biological value microbial proteins, available at the lower gut. The N that is degraded to Ammonia in the rumen, if not properly utilized by the rumen microbes in their microbial protein synthesis, escape the rumen to the liver and is lost as urea in urine. In converting ammonia in to microbial protein, degradation of dry matter in the rumen plays an important role by providing the required energy and the carbon skeleton for the microbial protein synthesis (Tamminga, 1979). Therefore, the rate of degradation of dry matter and protein in the rumen has become salient in evaluating feedstuffs for ruminants. Many attempts (Crooker *et al.*, 1978; Nocek *et al.*, 1983; Mehrez and Orskov, 1977) have been made to evaluate the concentrates, forages and silages. Solubility of proteins in various buffers have been suggested by many workers (Crooker *et al.*, 1978; Waldo and Goering, 1979). Others have suggested enzymatic techniques (Nocek *et al.*, 1983; Pion *et al.*, 1983).

The Nylon bag technique was another procedure adopted to measure the in situ degradation of dry matter and N with great accuracy (Mehrez and Orskov, 1977). This technique became widely accepted due to its easiness in use and accuracy. The objective of this study was to evaluate different feedstuffs used for ruminant feeding by its rate of degradation in the rumen, using the nylon bag technique.

MATERIALS AND METHODS

This study was conducted at the Department of Animal Science, University of Peradeniya, Sri Lanka. Five agro- industrial by-products [Rice polish (*Oryza sativa*), Rubber seed meal (*Hevea breziliensis*), Sesame meal (*Sesamum indica*), Soybean meal (*Glycine max*) and Coconut oil meal (*Cocos*

nucifera)] and seven tree fodders [Peuro (*Peuraria phasioloids*), Gliricidia (*Gliricidia sepium*), Albizzia (*Albizzia fulcatria*), Tithonia (*Tithonia diversifolia*), Erythrina (*Erythrina verigata*), Rain tree (*Samane saman*) and Leucaena (*Leucaena leucocephala*)] were used in this study. Agro-industrial by-products from the wholesale feed dealers and fodder samples from the mid country region at an altitude of approximately 750 m above sea level were collected.

In tree fodders, only the edible parts, mainly leaves and twigs were used. The sun dried fodder samples and agro-industrial by-products were round to pass a 2 mm screen using a laboratory mill. Three ruminally cannulated Surti x Local crossed, male swamp buffaloes were used in rumen incubation studies. During the incubation period, the animals were fed on medium quality Guinea A grass (*Panicum maximum*-Ecotype A) ad libitum, supplemented with 15 g coconut meal per Kg $W^{0.75}$.

Three grams of dry ground material of each test samples were incubated in a 7*13 cm^2 nylon bag with a pore size of approximately 61 μm. The bags were incubated in the rumen for 4, 8, 24 and 48 hours. Collection of respective bags were done at the same time and were washed in a rotating drum type washing machine, and dried at 60 c until a uniform weight was attained. The nitrogen content of the samples prior to and after incubation was analyzed using the standard techniques (AOAC, 1980).

The rate of degradation was analyzed by non-linear regression (SAS, 1985) according to the following model:

$$P = a+b(1-e^{-ct})$$

where,

P = Degradability at time t, (%)
a = Readily fermentable fraction, (%)
b = Potentially fermentable fraction, (%) and
c = Rate constant

RESULTS AND DISCUSSION

In Sri Lanka, agro-industrial by-products are the best source of protein supplements ruminant diets. However, their use in ruminant feeds becomes limited due to the high prices and high demand by

the non ruminant feed industries. The tree and shrub fodders tested are comparable to some agro-industrial by-products in crude protein content; and the rate of their utilization mainly depends on the rate of degradability in the rumen and amount the escaped to the lower gut (Perera *et al.*, 1991).

The average initial loss of DM disappearance of tree fodders incubated in the rumen was 32.8%(a). However, it ranged from 42.8 to 24.4% indicating the highest readily fermentable fraction in Gliricidia and lowest in Albizzia (Table 1).

Table 1. Degradation characteristics of dry matter of fodders incubated in the rumen for different time intervals and constants of exponential equation $p=a+b(1-e^{-ct})$

Fodders	4	8	24	48	a	b	c	rsd
		(h)						
Rain tree	36.0	37.6	43.1	49.4	33.4	20.8	0.0253	1.37
Peuro	34.1	38.6	52.5	54.2	29.2	34.2	0.0355	2.73
Gliricidia	47.7	53.2	65.7	72.3	42.8	33.6	0.0415	1.65
Albizzia	27.2	28.4	37.0	41.4	24.4	22.6	0.0280	1.29
Tithonia	45.0	52.5	86.9	94.4	32.1	64.7	0.0644	4.21
Erythrina	43.8	56.5	73.3	77.9	33.6	45.7	0.0799	2.35
Leucaena	38.7	41.2	54.7	63.3	34.1	34.8	0.0354	1.16
MEAN	38.9	44.0	59.0	64.7	32.8	36.6	0.0443	2.11
SE±	2.7	3.9	6.6	6.9	2.1	5.6	0.0077	0.41

rsd= Residual standard deviation Lag phase = 0

The average of potential degradable (b) dry matter for tree fodder was 36.6%. This also ranged from as high as 64.7% in Tithonia and as low as 20.8% in Rain tree. Albizzia had a potential rumen degradable dry matter of 22.6%. This low potential degradable dry matter in both Rain tree and Albizzia may be due to the presence of high content of tannin (Lohan *et al.*, 1983) and lignin (Baertsche *et al.*, 1986). In Tithonia 86.9% was degraded within the first 24 hours exhibiting the highest potential dry matter disappearance (Table 1). This indicates the high organic matter fermentation of this tree fodder in the rumen. In addition to Tithonia, Gliricidia and Erythrina also showed a substantial degradation of potential dry matter in the rumen within the first 24 hours. These results suggest that Tithonia, Gliricidia, Erythrina and Leucaena as potential green fodders to be included in the rumen diets.

The average readily fermentable DM fraction of agro industrial products was higher than that of tree fodders (32.8 and 42.5%) (Tables 1 and 2).

Table 2. Degradation characteristics of dry matter of agro-industrial by-products incubated in the rumen for different time intervals and constants of exponential equation $p=a+b(1-e^{-ct})$.

Agro-industrial by-products	4	8	24	48	a	b	c	rsd
	(h)							
Rice polish	48.6	61.4	75.4	77.4	34.6	43.1	0.1150	1.18
Soybean meal	49.9	59.6	87.1	94.1	36.0	62.5	0.0628	1.61
Coconut meal	58.2	60.5	84.0	92.6	48.1	46.3	0.0537	2.69
Rubber seed meal	41.2	42.8	44.2	46.5	40.0	7.0	0.0426	0.60
Sesame meal	63.9	77.7	86.0	86.8	53.9	32.6	0.1261	2.43
Mean	52.4	60.4	75.3	79.4	42.5	38.3	0.0800	1.70
SE±	4.0	5.5	8.1	8.8	3.7	9.2	0.0169	0.35

rsd= Residual standard deviation Lag Phase = 0

However, the readily fermentable fraction of individual by-products varied from 53.9 to 34.6%. The highest readily fermentable fraction was observed in Sesame meal (53.9%) the rest averaged to 36.9%. More than 80% of the DM in coconut meal, soybean meal and sesame meal disappeared within 24 hours, indicating a very high rate of fermentation. They also had a high potentially degradable fraction. In contrast, rubber seed meal had a readily fermentable fraction of 40% and the potential degradable fraction after 24 hours was 44.2%. This indicates a slow improvement in the degradation of dry matter only by 1.1%. Totally undegradable dry matter fraction (100-(a+b)) of rubber seed meal was 53.%. This high value in Rubber seed meal could be due to the presence of the seed coat, which mainly consists of lignin, and resistant to microbial degradation (Baertsche *et al.*, 1986). Therefore, the use of rubber seed meal as a protein supplement is limited, if it is used without decorticating.

In sun dried fodders, the average initial N disappearance was 36.2% (Table 3). However, the values ranged from 53.4% (Peuro) to 14.7% (Albizzia). As observed with dry matter losses, Albizzia contributed to the lowest initial losses as compared with other fodders (14.7%). This may be associated with the low initial dry matter loss of Albizzia.

Table 3. Degradation characteristics of nitrogen of fodders incubated in the rumen for different time intervals and constants of exponential equation $p=a+b(1-e^{-ct})$

Fodders	4	8	24	48	a	b	c	rsd
	(h)							
Rain tree	41.6	43.9	51.5	61.7	37.6	42.9	0.0162	1.69
Peuro	58.9	65.0	77.9	85.4	53.4	36.0	0.0420	1.97
Gliricidia	56.5	61.9	77.1	84.7	51.2	38.3	0.0394	2.40
Albizzia	16.3	14.1	17.5	20.2	14.7	11.1	0.0102	1.96
Tithonia	40.0	50.7	90.7	97.6	30.7	67.8	0.0424	4.21
Erythrina	50.8	64.8	87.0	91.6	38.3	55.6	0.0722	2.35
Leucaena	32.5	35.5	51.4	64.1	27.7	54.4	0.0230	0.85
Mean	42.3	48.0	64.7	72.2	36.2	43.7	0.0351	2.20
SE±	5.6	7.1	9.9	10.0	5.1	6.9	0.0037	0.51

rsd= Residual standard deviation Lag phase = 0

However, the potential degradability of N of Albizzia was also low (11.1%). Totally undegradable fraction of Albizzia was 74.2%. This may be due to the presence of a high tannin content, which is unfavourable for protein digestion by both microbes and enzymes (Lohan *et al.*, 1983). Therefore, Albizzia cannot be considered as a good source of protein supplement when considering the availability of protein. Perera *et al.*, (1991) suggested the rumen and intestinal degradable protein of Albizzia to be 3.9 and 1.6% respectively. Potentially degradable N fraction was very high in Gliricidia, Erythrina and Leucaena (Table 3). Therefore, these fodders can be considered as very valuable sources of supplements in ruminant feeding.

The agro-industrial by products, on average showed a high readily fermentable N fraction (43%) compared with tree fodders (36.2%) (Table 3 and 4). Of all tested agro-industrial by products, Rubber seed meal showed the highest initial N disappearance (77.8%) and the lowest value was observed in Coconut meal (19.5%). In contrast to the low readily

fermentable N, Coconut and Soybean meal had the highest potential degradable fraction of N (80.1 and 76.9% respectively). In general, more than 90% of the total N in agro-industrial by-products become degraded in the rumen within 24 to 48 hours.

Table 4. Degradation characteristics of nitrogen of agro-industrial by-products incubated in the rumen for different time intervals and constants of exponential equation $p=a+b(1-e^{-ct})$

Agro-industrial by-products	4	8	24	48	a	b	c	rsd
	(h)							
Rice polish	53.2	66.9	83.5	45.2	36.1	50.6	0.1099	1.31
Soybean meal	36.9	48.1	82.0	91.3	22.1	76.9	0.0554	2.33
Coconut meal	44.4	47.9	77.7	95.3	19.5	80.1	0.0520	3.13
Rubber seed meal	84.4	87.8	90.4	92.0	77.8	13.6	0.1484	0.91
Sesame meal	79.8	96.6	98.2	99.4	59.4	39.6	0.2558	2.09
Mean	59.8	69.5	86.4	84.6	43.0	52.2	0.1253	1.95
SE ±	9.5	10.0	3.6	2.2	11.2	12.3	0.0375	0.39

rsd = Residual standard deviation Lag phase = 0

Though the rubber seed meal had a very high initial N solubility, the subsequent degradation was negligible as compared with other agro-industrial by-products. The rate of N disappearance between the initial loss and until 24 hour was only 12.6%, whereas the values for coconut meal and Soybean meal were, 58.2 and 59.9% respectively (Table 4). This suggests that N in rubber seed meal is highly soluble and is made available to rumen microbes for microbial protein synthesis.

Among the factors which influence efficient N utilization, both available N and also the rate of incorporation into microbial proteins are of significance. During this is process the valuable proteins and other N sources degraded to ammonia, could be lost as urea in the urine. Therefore, it is of prime importance to regulate the generation of ammonia in the rumen, at a rate not exceeding that of utilization by microbes. This could be done by reducing the rumen degradable fraction and allowing N to escape the rumen unchanged and become available at the lower gut for enzymatic digestion.

According to Tamminga (1979), efficient microbial protein synthesis depends on the amount of organic matter fermented in the rumen for microbial ATP production and to provide carbon skeleton to the microbial protein synthesis. Therefore, not only N, but also the rate of DM disappearance becomes important in the utilization of any feed stuff efficiently.

CONCLUSIONS

This study suggests that the nylon bag technique could be used in determinating the degradation characteristics of feedstuffs such as fodder and agro-industrial by-products. Based on the results, this study also suggests that Gliricidia, Tithonia, Erythrina and Leucaena could be satisfactorily used as protein supplements in ruminant feeding to replace costly agro- industrial by-products.

ACKNOWLEDGMENTS

The authors wish to tender their sincere thanks to CEC for funding (contract TS-0091-NL) and Prof. Y.D.A. Senanayake and PGIA staff for administering the funds for a smooth operation of this project and to the Department of Animal Science for providing facilities to carry out this study. Thanks are also extended to Drs. (Ms) S. Premaratne for granting permission to use cannulated animals and H. Peris of VRI of Peradeniya, for post cannulation activities.

REFERENCES

Association of Official Agricultural Chemists (AOAC). Official methods of analysis. Washington. D.C. 13th edition. Personal communication - 1980.

Baertsche S.R., Yokoyama M.T. and Hanover J.W. (1986). Short duration, hardwood tree biomass as potential ruminant feed-chemical composition, nylon bag ruminal degradation and ensilement of selected species. J.Anim. Sci.63: 2028-2043.

Crooker, B.A., Sniffen, C.J., Hoover, W.H. and Johnson, L.L.(1978). Solvents in soluble nitrogen measurement in feed stuffs. J. Dairy Sci.61: 437-447.

Lohan, O.P., Lall, D., Vaid, J. and Negi, S.S. (1983). Utilization of Oak tree (*Quercus incana*) fodder in cattle rations and fate of Oak leaf tanin in the ruminant system. Indian J. Anim. Sci. 53: 1057-1063.

Mehrez, A.Z. and Orskov. E.R. (1977). Study of the artificial fibre technique for determining the digestibility of feeds in the rumen. J.Agric. Sci.88:645-651.

Nocek, J.E., Herbein, J.H. and Polan, C.E. (1983). Total amino acid release rates of soluble and insoluble protein fractions of concentrate feedstuffs by Streptomyces griseus. J. Dairy Sci. 66: 1663-1667.

Perera, A.N.F., Yaparatne, V.M.K. and Bruchem. J. van (1991). Characterization of protein in some Sri Lankans tree fodders and agro-industrial by products nylon bag degradation. Proc. Int. Seminar on Livestock and feed development in the tropics. Eds. I.M.N. Ibrhim., J. van Bruchem. and R. De Jong. pp: 171-177. Malang. Indonesia. October 1991.

Pion, R., Genset, C., Bayle, G. and Thivend, P. (1983). Assessment of protein degradability in concentrates using an enzymatic method. *In:* 4th Int. symp. protein metabolism and nutrition, Clermont-Ferrand (France), Sept. 5-9, 1983. Inst. Natl. Rech. Agron. Publ. 1983. II (Les Colloques de I' Inst. Natl. Rech. Agron., No 16). pp 207-210.

SAS, (1985). SAS user's Guide 5th edition. Cray, NC:SAS institute Inc.

Tamminga, S.(1979). Protein degradation in the forestomachs of ruminants. J. Anim. Sci. 49:1615-1627.

Waldo, D.R. and Goering, H.K. (1979). Insolubility of proteins in ruminant feed by four methods. J. Anim. Sci. 49:1560-1568.