Ruminal and Intestinal Digestibility of Some Tropical Legume Forages

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ABSTRACT : Two experiments were conducted to examine the degradation rates of 4 tropical legume forages in rumen and intestine of Kedah-Kelantan (KK) cattle. Three KK cattle, averaging 173±17.15 kg each fitted with a permanent ruminal and a T-shaped duodenal cannulae were used. The cattle were fed a maintenance diet (1% DM of their body weight) composing of 60% oil palm frond (OPF) pellet and 40% of a legume mixture of *Arachis pintoi* (AP) and *Leucaena* throughout the study. The overall DM and CP degradabilities in the rumen for *Gliricidia sepium* (GS) and AP were significantly higher than those for *Leucaena leucocephala*-Bahru (LB) and *Leucaena leucocephala*-Rendang (LR). This implies that LB and LR would have higher dietary protein flows into the intestine for the more efficient enzymatic digestion. However, the results of the present study suggested only limited proportions of the ruminal undegraded protein in the *Leucaenas* were digested in the intestine. (*Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 3 : 321-325*)

Key Words : Tropical Legumes, Ruminal Digestibility, Intestinal Digestibility, Total Tract Digestibility

INTRODUCTION

The use of oil palm fronds (OPF) as ruminant feed is limited because of their low nitrogen (N) content. Protein supplementation has been used to increase animal productivity in OPF based diet, but high importing cost of supplementation often limits its widespread use. Forage legumes such as *Leucaena leucocephala*, *Arachis pintoi* (AP), and *Gliricidia sepium* (GS), which are adapted to local environment can be a good source of cheap protein supplements.

Gliricidia sepium as a protein supplement to increase animal productivity has been reported (Robertson, 1988; Richard et al., 1994). Similarly, AP has been adapted to a wide range of climate and soil condition, even under heavy grazing (Stür and Ndikumana, 1993) and a shade tolerant ground cover in humid areas (Cook et al., 1993). *Arachis pintoi* also showed high potential as cover crop in oil palm plantation (Wong, unpublished data). *Leucaena leucocephala* is the most widely used species as valuable fodder shrub for increased animal production in the tropics. Crude protein (CP) of edible material (leaves and small stems) of *L. leucocephala* ranged from 14 to 30% (Jones, 1979; Akbar and Gupta, 1985). It is generally accepted that *L. leucocephala* can constitute up to 30% of the diet of unadapted ruminants without any signs of toxicity. However, Bray (1994) reported that the arrival of psyllid insect, is one of its significantly disadvantages. Recently two new *Leucaena* hybride namely *Leucaena leucocephala*-Bahru (LB) and *Leucaena leucocephal*-Rendang (LR) species have been shown well adapted to acid soil and psyllid resistance (Wong et al., 1998).

Hence, an experimental study was undertaken to determine the nutritive value of the above Leucaenas along with AP and GS.

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MATERIALS AND METHODS

Sample preparation

Four legume forages namely AP, GS, LR and LB were harvested at about 6 weeks old from the Malaysian Agricultural Research and Development Institute (MARDI) research farm at Serdang for the study. Short samples of about 10-30 cm from the growing points of the plant were cut and oven dried at 60℃ for 48 h, ground through 2 mm screen sieve and stored for chemical analysis, *in sacco* and mobile bag studies.

Animals and feeding

Three Malaysia indigenous Kedah Kelantan (KK) cattle of about 2½ years of age and averaged body weight (BW) 173±17.15 kg each fitted with a ruminal and a duodenal cannulae were used. The cattle were in good conditions during the trial and were kept in individual pen. They were offered a maintenance diet at 1% DM of BW comprising of 60% OPF and 40% of mixed legume (AP and LB). The daily feed was offered to the cattle in two equal portions, one at 0900 h. and the other at 1630 h. Clean drinking water was available at all times to the animals.

Ruminal digestibility

Dry matter (DM) and crude protein (CP) degradation rates of the forages in the rumen were determined in the three canulated KK cattle using nylon bag technique. The experiment consisted of 7

days adaptation to the diet, followed by 2 days of sample collection. Nylon bags of 6 cm×10 cm with average pore sizes of 40 micron were each filled with about 5 g of ground sample. All samples prepared in duplicates, totaling 48 bags (4 variaties×6 incubation times×duplicate) in the rumen of each animal for 2, 6, 12, 24, 36, and 48 h. After the specified incubation periods, the nylon bags removed from the rumen were immediately washed in washing machine for 10 min and then oven dried at 60℃ for 48 h. Samples in bags without incubation (0 h) were washed and dried in similar manner as the above samples as a control. The ruminal digestibility of the legume forages were calculated following method of Ørskov and McDonald (1979).

Intestinal digestibility

Separate samples of the same legumes (in duplicates) were prepared, incubated for 24 h in the rumen of the same cattle, washed and dried in similar manner as described above. The dried ruminal residue samples were used for measurement of intestinal digestibility using the mobile bag method described by Van Straalen et al. (1993). The ruminal residues from each of the four legumes in an amount of 0.3 g were placed in mobile bag (3 cm×4 cm) in duplicates and sealed by heat sealing machine. The bags were then inserted into duodenal cannulae of the same animal at intervals of three-hour. A total of six bags were inserted into per cattle per day. The mobile bags recovered from the faeces were washed and dried and their DM and N contents were later determined.

Intestinal DM or CP digestibility of a forage was calculated as the percent DM or CP (N×6.25) loss in the mobile bag before and after insertion into the intestine.

Chemical analysis

Dry matter (DM), Organic matter (OM), and Kjeldahl-N of forage samples, ruminal and intestinal residues were determined by the AOAC (1984) procedures. Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin (ADL) were analysed as described by Goering and Van Soest (1970).

Data and statistical analysis

The DM and CP degradation of samples were fitted to an exponential equation developed by Ørskov and McDonald, (1979) and McDonald, (1981) to calculate rate and extent of rumen digestion. The equation was $P=A+B(1-e^{-ct})$, where, P is actual degradation at time t, A is washing loss, B is the insoluble but potentially degradable material in time t and defined as B=(A+B)-A, A+B is the potential degradability, c is the rate of degradation of B with constant in the equation (Ørskov and Ryle, 1990; Kibon and Ørskov, 1993). The effective degradability (%) where fraction outflow rates of 0.02, 0.05 and 0.08 h^{-1} were also estimated by the equation of Ørskov and McDonald (1979).

The parameter measured in the degradability studies was calculated using the NEWAY computer program. Analysis of variance to determine DM and CP in the ruminal, intestinal and total tract digestibilities were analysed by the Statistical Analysis System Institute (SAS, 1998). The differences between treatment means were tested using the least significant difference method (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Chemical composition of OPF and legume forages

The concentration of CP of OPF, GS, AP, LB, and LR were 6.12, 24.59, 23.13, 21.99 and 18.11%, respectively (table 1). NDF contents of the four legumes were quite similar (40.2% to 42.5%), while their ADF contents differed 10% units from 19.9% for GS to 29% for LR. Lignin contents ranged from 13.70% for GS to 20.16% for AP. Tannin contents of LR (8.29%) and LB (7.53%), were 2 to 3 folds of those for AP (3.69%) and GS (1.96%).

Ruminal digestibility

The washing loss (A) and degradability of water insoluble fraction (B) of GS, and AP were higher than those of LB, and LR, resulted in higher potential degradable fractions (A+B) for GS, (84.3%) and AP, (77.9%), than LB, (56.4%) and LR, (53.2%). The effective degradability of GS at the various out flow rates was the highest followed by AP, LB, and LR. The above data together with the degradation curves as shown in figure 1a, clearly indicate that the four legumes can be grouped into 2 categories according to their degradation rates in the rumen; the highly degradable (GS and AP) and slowly degradable (LR and LB).

Table 1. Chemical composition of oil palm fronds (OPF), *Gliricidia sepium* (GS), *Arachis pintoi* (AP), *Leucaena leucocephala*-Bahru (LB) and *Leucaena leucocephala*-Rendang (LR) (% based on DM basis)

Components	OPF	GS	AP	L	LR
Organic matter	95.71	92.81	93..94	96.62	96.17
Crude protein	6.12	24.59	18.11	23.13	21.99
NDF	75.00	42.02	40.79	42.51	40.19
ADF	45.05	19.94	26.44	23.30	28.97
Lignin	36.99	13.70	20.61	14.79	16.03
Tannin	5.03	1.96	3.69	7.53	8.29
Ash	4.29	7.19	6.06	3.38	3.83
Energy (kcal/g)	3,980	4,321	4,105	4,675	4,917

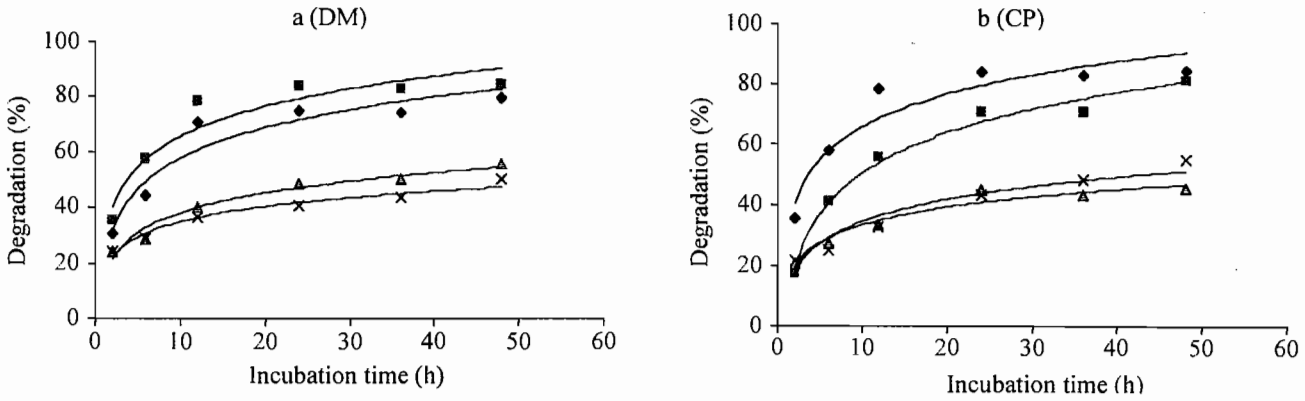

Figure 1. Dry matter (DM) and crude protein (CP) degradation curves of *Gliricidia sepium* (x), *Arachis pintoi* (◆), *Leucaena*-Rendang (▲) and *Leucaena*-Bahru (■) incubated in the rumen of KK cattle

Results of the present study indicated that *Leucaena* forages have lower DM degradation than GS and AP. The present results, however, differed from those of Richard et al. (1994) who reported that *in vitro* DM digestibility of *Leucaena* was higher than that of *Gliricidia*.

Like DM degradation, CP degradability of GS was higher than LB and LR in all incubation periods above 6 h, while differences between GS and AP were smaller and less consistent (table 2). The results of the present study are consistent with those of Richard et al. (1994) and Van Eys et al. (1986) who also reported higher CP degradation rates for GS than Leucaena.

Negi et al. (1989) have reported a much higher rumen degradable CP content in *Leucaena* (69%) than the present study. The lower CP degradation rates of LB and LR in the present study as compared to the value for *Leucaena* used in the study of Negi et al. (1989) could be due to varietal differences. Tamminga, et al. (1991) also reported that the undegradable CP fraction of forages in the rumen was related to DM, CP and NDF content and to harvest date. The two Leucaena varieties used in the present study were new cultivars with little documented animal test on them.

Table 2. Percent DM and CP degradability of *Gliricidia sepium* (GS), *Arachis pintoi* (AP), *Leucaena leucocephala*-Bahru (LB) and *Leucaena leucocephala*-Rendang (LR) incubated in rumen of Kadah-Kelantan cattle fed 60% OPF and 40% mixed legumes diet

Item	GS	AP	LB	LR	SEM
DM degradability parameter (%)					
A	19.1[a]	14.9[b]	7.1[a]	8.6[c]	0.03
B	65.2[a]	63.0[b]	49.3[c]	44.6[d]	0.17
(A+B)	84.3[a]	77.9[b]	56.4[c]	53.2[c]	0.28
C	0.18	0.08	0.06	0.04	0.01
Effective degradability (%)					
Outflow rate					
0.02	77.5	60.4	47.3	42.9	
0.05	69.2	45.1	39.7	36.0	
0.08	62.8	36.0	35.3	32.6	
CP degradability parameter (%)					
A	11.4[a]	10.0[a]	5.6[b]	0.0[c]	0.12
B	78.2[a]	66.9[b]	42.2[c]	67.0[b]	0.19
(A+B)	89.7[a]	76.9[b]	47.9[d]	67.0[c]	0.22
C	0.10[a]	0.10[a]	0.08[a]	0.03[b]	0.00
Effective degradability (%)					
Outflow rate					
0.02	77.9	65.4	42.6	46.9	
0.05	66.1	53.7	36.5	36.0	
0.08	58.1	45.8	33.0	31.1	

[a,b,c,d] Means in the same row with different superscripts are significantly different ($p<0.05$).

A: washing loss (%), B: insoluble but fermentable matter, (A+B): potential degradability, C: degradation rate of B (fraction h-1).

SEM: standard eror of the means.

Table 3. Ruminal (24 h. incubation) and intestinal DM and CP degradations (%) of *Gliricidia sepium* (GS), *Arachis pintoi* (AP), *Leucaena leucocephala*-Bahru (LB) and *Leucaena leucocephala*-Rendang (LR)

Item	GS	AP	LB	LR	SEM
Ruminal					
DM	81.52[a]	73.61[b]	51.18[c]	47.40[c]	0.38
CP	76.55[a]	64.32[b]	40.36[c]	33.75[c]	0.39
Intestinal					
DM	21.68[a]	18.01[b]	6.54[c]	4.88[c]	0.13
CP	54.15[a]	51.81[a]	18.20[c]	25.19[b]	0.17

[a,b,c,d] Means in the same row with different subscripts differ significantly ($p<0.01$).

SEM: standard error of the means

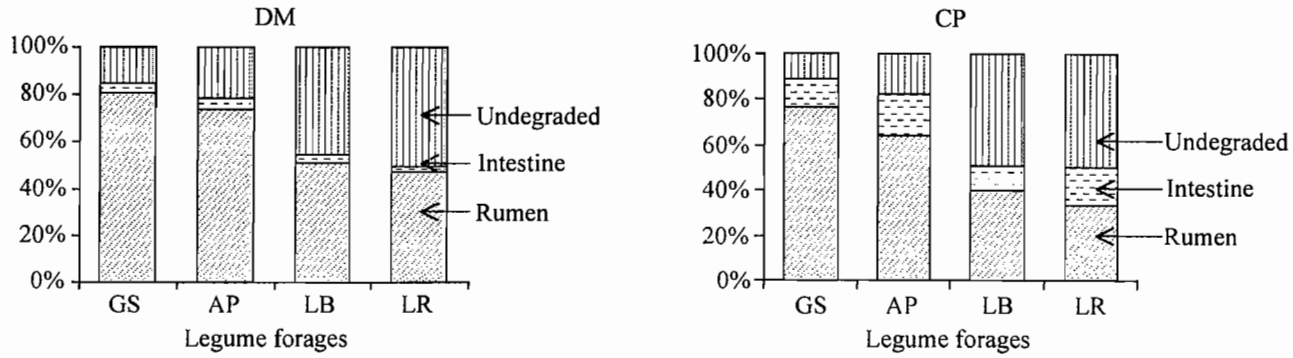

Figure 2. Dry matter (DM) and crude protein (CP) degradation in the rumen and intestine of *Gliricidia sepium* (GS), and *Arachis pintoi* (AP), *Leucaena*-Bahru (LB) and *Leucaena* Rendang (LR)

The low rumen degradability observed in LB and LR as compared to the Leucaena of Negi et al. (1989) as well as GS and AP in the present study could be due to low solubility of their protein (Makkar and Becker, 1996) or the present of other plant complexes such as tannin and lignin. In ruminant, condensed tannin (2-3%) have been shown to reduce protein degradation in the rumen (Barry, 1987). This characteristic was regard as providing undegraded ruminal protein, thus making it more available in small intestine (Van Soest, 1982). The relatively low CP degradation in LB and LR, apparently suggests more dietary protein leaving the rumen and possibly, resulting in higher dietary protein potentially digestible in the intestine (PID).

Intestinal digestibility

The DM and CP degradations of the four legume forages incubated in the rumen for 24 h, which were subsequently used for intestinal digestibility studies are shown in table 3. The DM and CP degradations at 24 h recorded here were consistent with those of table 2, where values for GS were the highest, followed by AP and the 2 *Leucaenas*.

Intestinal digestibility of ruminally undegraded materials are shown in table 3. Once again the 2 parameters (DM and CP) measured were similar to the ruminal degradation, where values for GS and AP were significantly higher than those for LB and LR. The present study suggested that intestinal DM digestibility for GS and AP was 3 to 5 folds higher than that of LB and LR, while CP degradability between the 2 groups was about 2 folds. The low DM and CP intestinal degradability for LB and LR was rather surprising, and implying that only limited proportion of the ruminal undegraded portions of LB and LR were available for utilization by the animal.

Total tract disappearances (ruminal plus intestinal digestibility) of the four legumes are shown in figure 2. Once again, The total tract DM disappearance for GS (85.6%), was highest, followed by AP (78.4%), LB (54.4%) and LR (50.0%). Similar trend was recorded for total tract CP disappearance, being 89.3%, 82.8%, 51.2% and 50.5%, respectively for GS, AP, LB and LR.

Generally speaking, materials with low ruminal degradable protein fraction would leave a higher dietary protein flow into the intestine for a more efficient enzymatic digestion. *Leucaena* has often been quoted as a good protein forages for ruminants because of its low ruminal digestibility, implying it is a valuable "by-passed" protein source (Bamualim, 1984; McNeill et al., 1998). The results of the present study, however, suggested that only limited proportions of the rumen undegradable materials including protein of LR and LB are digested in the intestine, resulting in lower total tract digestibility than those for GS and AP (figure 2).

CONCLUSION

The GS and AP are good protein sources and can serve as substitutes for the more expensive imported gains for ruminants in the tropics. However, more animal studies involving these leguminous forages are needed to confirm their actual value.

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