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# PHYSICAL TREATMENT OF RICE STRAW FOR GOATS AND SHEEP AND THE RESPONSE TO SUBSTITUTION WITH VARIABLE LEVELS OF CASSAVA *(MANIHOT ESCULENTA* CRANTZ), LEUCAENA *(LEUCAENA LEUCOCEPHALA)* AND GLIRICIDIA *(GLIRICIDIA MACULATA)* FORAGES

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*Keywords:* Rice straw, Long, Chopped, Intake, Digestibility, Cassava, Leucaena, Gliricidia forages, Metabolisable energy.

## RINGKASAN

Keputusan-keputusan dari lima kajian imbangan telah dibentangkan mengenai penggunaan jerami padi yang tidak diberi rawatan dengan perlakuan fizikal dan penggantian samada dengan daun ubi kayu *(Manihot esculenta* Crantz), daun petai belalang *(Leucaena leucocephala)*, daun petai belalang dicampur dengan batang dan lenggai atau gliricida *(Gliricidia maculata)*. Pemberian jerami padi yang baru dipungut berbanding dengan jerami padi tua yang disimpan kepada kambing dan biri-biri menunjukkan bahawa pengambilan bahan kering lebih tinggi bagi jerami padi yang tua (46.3 – 55.2 g/$W^{0.75}$kg) berbanding dengan jerami padi yang baru dipungut (40.5 – 41.0 g/$W^{0.75}$ kg). Kambing-kambing mengambil bahan kering lebih banyak dari biri-biri ($P<0.05$) dan kehazaman gentian kasar dan abu adalah dipergunakan dengan lebih berkesan bagi jerami tua ($P<0.05$). Dengan melayukan jerami pada kadar 1 kg/liter merendahkan pengambilan bahan kering (59.9 berbanding 51.6 g/$W^{0.75}$kg) dan kehazaman bahan kering ($P<0.05$). Pemberian jerami yang dipotong adalah berhubungan dengan kenaikan retensi kasar dan N berbanding dengan jerami yang tidak dipotong. Kandungan ME bagi jerami padi yang baru dipungut (dipotong), disimpan (dipotong) atau yang tidak dipotong ialah masing-masingnya 6.09 – 6.19, 5.38 – 6.04 dan 6.39 MJ/kg. Kesan penggantian jerami padi dengan 33 – 34 peratus daun-daun ubi kayu telah meninggikan pengambilan bahan kering sebanyak 34 – 37 peratus, dan meninggikan kehazaman bahan organik (OM), protein kasar (CP), gentian kasar (CF), ekstrak eter (EE) dan ekstrak bebas nitrogen (NFE) ($P<0.05$). Penggantian jerami padi di antara 10 – 60 peratus daun petai belalang didapati meninggikan pengambilan bahan kering dan kehazaman ketara protein kasar dan ekstrak bebas nitrogen ($P<0.05$). Pengambilan bahan kering dan kehazaman protein kasar adalah paling tinggi di paras penggantian 50 peratus. Penggantian jerami padi samada dengan 30 peratus daun ubi kayu, daun petai belalang, daun petai belalang dan batang serta lenggai dan daun gliricidia tidak memberikan perbezaan terhadap pengambilan bahan kering. Walaupun begitu, terdapat yang berkesan di dalam kehazaman OM, CP, EF dan NFE ($P<0.05$). Bekalan tenaga dari makanan, imbangan nitrogen dan mineral menunjukkan bahawa dalam semua keadaan, kesan penggantian dapat meninggikan ME makanan, imbangan N dan mineral (Ca, P dan Mg). Keputusan-keputusan ini juga memberi penekanan terhadap nilai pemakanan terutama sekali bagi daun ubi kayu dan petai belalang di dalam meninggikan kualiti makanan yang berasaskan gentian bagi haiwan ruminan.

## INTRODUCTION

There are two principal strategies concerning the efficient use of low quality roughages in the tropics. One strategy is to aim for feeding systems that can use the feeds *in situ* with other ingredients in relation to where it is produced, to overcome problems of cost of handling, transportation and pollution. The alternative strategy is to upgrade the nutritive quality of the material through physical (wetting, cutting, chopping or grinding), chemical (alkali or acid) or biological treatments (microbial growth) prior to utilisation, to render the feed more useful to ruminant animals. With chemical treatment for example, there is usually increased dry matter intake (DMI), improved digestibility and therefore an increased uptake of metabolisable energy.

In either case, a major constraint in ensuring effective utilisation of the low quality roughages in appropriate feeding systems is the level of dietary N. Dietary N is the main limiting factor affecting intake and performance in all ruminant animals in Malaysia. A first essential therefore in ensuring a sufficient intake of dry matter is the presence of a sufficient dietary protein level in the base material. Unless this dietary protein level is above the critical level of

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approximately 6–7 per cent (MILFORD and MINSON, 1968; DEVENDRA, 1975), the voluntary feed intake (VFI) is impaired, resulting in reduced intake and poor performance.

A good example of a feed that falls into the category of low crude protein content is untreated rice straw, with average levels of about 3–4 per cent in the dry matter. Mainly because of this, the dry matter intakes as percentage of body weight is variable and around 1.7 – 2.8 per cent, based on a review of the literature (DEVENDRA, 1982a). Although the higher intake values are suggestive of adequacy, however, much of this is due to gut fill and it is doubtful if feeding exclusively on rice straw provides anything more than the minimum energy and to a lesser extent, protein requirements for maintenance.

Thus supplementation with some protein sources is desirable either from conventional preformed protein, non-protein nitrogen (NPN) or from unconventional feed sources such as from cassava leaves (*Manihot esculenta* Crantz) or leguminous sources such as leucaena forage *(Leucaena leucocephala)*. The last two mentioned sources are realistic in that in many instances these are locally available and can be readily used. Preformed sources such as fish meal and soyabean meal on the other hand have to be imported at high cost and are in any case more suited to feeding non-ruminants (pig, poultry and ducks). The underlying fact is that the feeding system should provide at low cost, dietary proteins that can supplement rumen microbial proteins for body function, such that this can supplement rumen microbial proteins for production.

These considerations led to an examination of three forage protein sources, cassava (*M. esculenta* Crantz), leucaena *(L. leucocephala)* and gliricidia *(Gliricidia maculata)* in the diet of sheep fed untreated rice straw. The present paper reports the response, in terms of intake and digestibility, due to the effect of inclusion of these forages when fed to sheep.

## MATERIALS AND METHODS

### 1. Experiments

Five experiments, all balance trials, were completed involving adult sheep. Trial 1 also involved goats. In the first experiment, an initial study was undertaken to assess the utilisation of freshly collected versus stored older rice straw, both untreated. In trial 2, the effect of feeding chopped rice straw either dry or wet was studied. In trials 3 and 4, rice straw was substituted by variable levels of either cassava leaves (33–34 per cent) and leucaena leaves (10–60 per cent). In the fifth trial, the effect of substituting rice straw with leucaena leaves was compared to leucaena leaves plus stems plus pods, cassava and gliricidia leaves at a constant level of about 30 per cent. The five trials were as follows:

Trial 1 : Fresh versus stored older rice straw (RS)

Trial 2 : Effect of feeding dry versus wet rice straw

Trial 3 : Effect of substituting long or chopped RS with 33–34 per cent cassava leaves (CL)

Trial 4 : Effect of substituting with 10–60 per cent leucaena leaves (L)

Trial 5 : Effect of substituting with 30 per cent either cassava leaves (CL), leucaena leaves plus stems pods (LSP), or gliricidia leaves (GL).

Each balance trial lasted for 21 days, a 14-day period of adaptation being followed by seven day collection period.

### 2. Feeds Used

Five main feed ingredients were used : fresh and old rice straw, cassava leaves, leucaena leaves, leucaena leaves plus stems plus pods and gliricidia leaves. The fresh rice straw was of an unknown variety and collected for feeding within a week of harvesting, while the older rice straw was the *Bahagia* variety, stored for about two years. As might be expected, the fresh straw was of a slightly superior quality than the older, stored variety *(Table 1)*; the differences were however, not significant. The straw was chopped 2 to 3 cm lengths using a mechanical chopper. Both types were fed either dry or wet (1 kg of straw/litre of water to investigate a possible effect on palatability). The cassava leaves were derived from the bitter variety C5 during harvesting of the roots and were fed inclusive of the petioles. In view of the higher inherent hydrocyanic content in this variety (DEVENDRA, 1978), relatively low levels were used for substituting the rice straw. Concerning leucaena leaves, these were first harvested and then plucked to separate the stems and pods leaving mainly the leaves. Thus the crude protein content, as expected, was much higher than the forage with leaves, stems and pods intact *(Table 1)*.

### 3. Sheep and Goats

Except for trial one where both goats and sheep were used, all the other four trials involved sheep only. All animals were adult with goats weighing 27–33 kg and sheep weighing about 23–26 kg. In trial 1, a total of 8 sheep and 8 goats were used. In trials 2, 3 and 5, the number of sheep used were 16, 21 and 16 respectively. All animals were drenched before the trial as part of the normal flock management programme. They were weighed for two days before the start and end of the trial before the morning feed was given. They were allocated in a randomised block design, to treatment on body weight basis so that the mean live-weights were approximately similar.

In trials 2, 3 and 4, the level of substitution of the rice straw by particular forage was achieved by knowledge of the capacity for dry matter intake (DMI) by sheep fed untreated rice straw during the first week. This level was than used to substitute with forage in a manner such that residues were approximately within 10 per cent of the established DMI. The sheep had access to ample drinking water.

### 4. Chemical analyses

The sampling methods used to bulk both feeds and faeces, storage and collection of urine samples, and the techniques used for

TABLE 1: CHEMICAL COMPOSITION OF THE RICE STRAW TYPES AND THAT OF CASSAVA AND LEUCAENA FORAGE USED (% dry matter basis)
(Each value is the mean of seven samples)

| Constituent | Fresh rice straw | Old rice straw | Cassava leaves | Leucaena leaves | Leucaena leaves plus stems plus pods |
|---|---|---|---|---|---|
| Dry matter | 37.8 | 86.0 | 21.1 | 30.0 | 30.1 |
| Crude protein (N x 6.25) | 5.4 | 4.9 | 17.8 | 22.0 | 17.4 |
| Crude fiber | 31.8 | 31.7 | 14.8 | 19.6 | 30.5 |
| Ether extract | 2.3 | 1.3 | 7.9 | 6.9 | 3.8 |
| Ash | 11.3 | 14.9 | 6.3 | 4.4 | 4.6 |
| Nitrogen-free extract | 49.2 | 47.2 | 53.2 | 47.2 | 43.6 |
| GE (MJ/Kg) | 16.36 | 15.52 | 20.71 | 22.18 | 32.59 |
| Ca | 0.31 | 0.12 | 0.87 | 0.55 | 0.30 |
| Mg | 0.12 | 0.03 | 0.32 | 0.34 | 0.71 |
| P | 0.03 | 0.08 | 0.26 | 0.13 | 0.14 |

the chemical analyses of feeds and faeces were identical to those that had been previously described (DEVENDRA, 1975). These included collection of feed and faeces samples daily for each animal. A 10 per cent sample of the faeces was then sub-sampled for chemical analyses. Urine was collected in plastic bottles containing 10 per cent $18N-H_2SO_4$ to reduce N losses, and 100 ml aliquots were bulked for chemical analyses. Residues were confined to within 10 per cent of the intake during the preliminary period to ensure maximum intake as well as to reduce wastefulness of the feed. The chemical analytical techniques used were those recommended by A.O.A.C. (1970). Dry matter was determined by drying at 102°C for 24 hours, ash by firing at 600°C for six hours, protein by the microkjeldahl procedure, crude fibre was determined by successive boiling with alkali and acid and other extract by soxhlet extraction using petroleum spirit (40–60°C B.P.). Gross energy was determined using an adiabatic bomb calorimeter (Gallenkamp, London), Ca and Mg were determined by titration and P as molybdate by colourimetry.

The samples of feeds given and residues were chemically analysed and checked for differences. No statistically significant differences were found, suggesting that diet selection was not a factor in the study undertaken.

**5. Statistical analyses**

The analysis of variance of digestibility and nitrogen data, and factorial comparisons of the different sources of protein were as described by SNEDECOR, (1965). The method of least significant differences between means and also the between-treatment means using the multiple range test were used.

## RESULTS

*Table 2* summarises the response to DMI of fresh versus stored old rice straw fed. Both goats and sheep consumed more fresh rice straw than older rice straw. In terms of

TABLE 2: THE VOLUNTARY FEED INTAKE OF GOATS AND SHEEP FED FRESH OR STORED OLDER STRAW – TRIAL I
(Each value is the mean of four animals)

| | Parameter | Goats | Sheep | L.S.D.* P=0.05 |
|---|---|---|---|---|
| 1. | Fresh rice straw intake (g/day) | 1344.0 | 1308.7 | N.S. |
| | Dry matter intake (DMI/day, g) | 474.8 | 466.6 | N.S. |
| | DMI/$Kg^{0.75}$ (g/day) | 40.5 | 41.0 | N.S. |
| | Relative intake (%)$^+$ | 51.3 | 51.0 | N.S. |
| | DMI as % of mean live weight (%) | 1.8 | 1.8 | N.S. |
| 2. | Stored older rice straw, chopped intake (g/day) | 638.1 | 716.1 | 24.9 |
| | DMI (g/day) | 556.7 | 634.6 | 21.3 |
| | DMI/$kg^{0.75}$ (g/kg) | 46.3 | 55.2 | 8.9 |
| | Relative intake (%)$^+$ | 58.9 | 66.0 | 4.4 |
| | DMI as % of mean live weight (%) | 2.0 | 2.5 | 0.19 |

$$\text{Relative intake} = \frac{\text{Observed intake}}{80 \times kg^{0.75}} \times 100$$

N.S. – Not statistically significant
* – Least significant difference

DMI however, both species consumed more older stored rice straw than fresh straw and this is reflected in a higher DMI/day, DMI expressed as a percentage of body weight or DMI/$W^{0.75}$kg. Whereas the differences between species in the fresh matter intake were not significant, the differences in DMI for older rice straw were significant ($P<0.05$), with goats eating more than sheep. Goats also had a significantly higher ($P<0.05$) DMI/$W^{0.75}$kg, relative intake and DMI as percentage of mean live weight.

*Table 3* presents the mean apparent digestibility coefficients for fresh versus stored older straw. Between straw types, statistically significant differences were only found for the digestibility of crude fibre and ash ($P<0.05$) with older straw tending to be digested better than the fresh straw. No statistically significant differences were noted between-species for all dietary constituents.

Since one of the main tasks in rice utilisation is overcoming problems of palatability, a study was also conducted on the effect of adding water at the rate of 1 litre/kg of straw. The addition of water to chopped, stored older rice straw significantly reduced both the rice straw intake as fed, DMI, DMI/$W^{0.75}$kg, relative intake and DMI as percentage of mean live weight ($P<0.05$). In all cases, the values were consistently higher for the older rice straw *(Table 4)*.

Concerning digestibility, dry rice straw was better digested than wet straw, with significant differences being found in dry matter, organic matter, nitrogen-free extract and energy digestibility ($P<0.05$). *Table 5* summarises the results. Whereas with dry straw there was only a negative digestibility for P, with wet straw, the values was negative for Ca, P and Mg.

The effect of feeding cassava leaves to long or chopped stored rice straw showed *(Table 6)* that the effect of substitution was to increase intake significantly ($P<0.05$). There was no differences in the DMI of long or chopped rice straw. However, with cassava leaves, the DMI was increased about 34 to 37 per cent to between 728 to 780 g/day. This increase was also reflected in DMI/$W^{0.75}$kg, relative intake and also DMI as percentage of mean live weight.

*Table 7* summarises the corresponding apparent digestibility to the proximate components concerning the inclusion of cassava leaves. There were no differences in the apparent digestibility of dry matter but the digestibilities of organic matter, crude protein, crude fibre, ether extract and nitrogen-free extract were significantly improved ($P<0.05$). Of these digestibilities, the improvement in crude protein digestibility was particularly conspicuous.

*Table 8* presents the results of trial 4 where up to 60 per cent leucaena forage was fed to chopped rice straw as control. The effect of adding the leucaena was to increase DMI significantly ($P<0.05$) and the highest intake was recorded for RS + 50 per cent leucaena forage level. A parallel trend was also observed for DMI/$W^{0.75}$kg, relative intake and DMI as percentage of mean live weight. There was no particular trend and was in any case not significant.

Concerning digestibility, the effect of substituting with leucaena gave differences in the apparent digestibility of dry matter and organic matter *(Table 9)*. There were also significant differences between treatments in crude protein and nitrogen-free extract digestibility. The highest crude protein digestibility was recorded for the RS + 50 per cent leucaena level. A trend analysis indicated that this was linear and statistically significant ($P<0.01$). The corresponding equations were:

$$Y_1 = 28.925 + 0.568X_1 \qquad r = 0.952$$

$$\text{and } Y_2 = 73.904 + 0.165X_1 \qquad r = 0.867$$

where $Y_1$ and $Y_2$ are the digestibilities of crude protein and nitrogen-free extract respectively and $X_1$ is the level of dietary leucaena.

TABLE 3: MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF DIETARY CONSTITUENTS OF FRESH OR STORED OLDER STRAW FED TO GOATS OR SHEEP (%) – TRIAL 1

(Each value is the mean of four animals)

| Type of rice straw \ Dietary constituents | DM | | OM | | CP | | CF | | A | | EE | | NFE | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | S | G | S | G | S | G | S | G | S | G | S | G | S | G | S |
| Fresh straw+ | 43.9 | 44.9 | 47.5 | 47.8 | 18.2 | 31.1 | 51.8 | 43.9 | 14.5 | 19.6 | 38.6 | 37.6 | 50.0 | 53.0 | 45.5 | 46.2 |
| Stored old straw+ | 52.4 | 44.6 | 56.6 | 48.8 | 24.1 | 13.8 | 67.2 | 56.0 | 28.8 | 19.7 | 16.3 | 25.8 | 54.3 | 48.7 | 45.1 | 47.4 |
| L.S.D. (P = 0.05)++ | N.S. | | N.S. | | * | | * | | * | | * | | N.S. | | N.S. | |
| L.S.D. (P = 0.05)+++ | N.S. | | N.S. | | N.S. | | N.S. | | N.S. | | N.S. | | N.S. | | N.S. | |

+Chopped
++Between straw types
+++Between species

TABLE 4: THE VOLUNTARY FEED INTAKE OF SHEEP FED CHOPPED RICE STRAW (RS) EITHER DRY OR WET – TRIAL 2
(Each value is the mean of eight sheep)

| Parameter | Treatments | | L.S.D.* P = 0.05 |
|---|---|---|---|
| | RS+ (Dry) | RS (wet) | |
| Fresh rice straw intake (g/day) | 741.3 | 432.8 | 208.5 |
| Dry matter intake (DMI/day, g) | 677.7 | 479.3 | 65.2 |
| DMI/kg$^{0.75}$ (g/day) | 59.9 | 42.8 | 8.9 |
| Relative intake (%)++ | 75.0 | 51.6 | 7.6 |
| DMI as % of mean live weight (%) | 2.7 | 1.9 | 0.6 |

+Chopped rice straw

++Relative intake = $\frac{\text{Observed intake}}{80 \times kg^{0.75}} \times 100$

*Least significant difference (P<0.05)

TABLE 5: MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF DIETARY CONSTITUENTS OF CHOPPED RICE STRAW FED DRY OR WET (%) – TRIAL 2
(Each value is the mean of eight sheep)

| Constituent | Treatments | | L.S.D.* P = 0.05 |
|---|---|---|---|
| | RS (Dry) | RS (Wet) | |
| Dry matter | 42.4 | 36.0 | 3.8 |
| Organic matter | 50.6 | 39.3 | 7.8 |
| Crude protein (N x 6.25) | 19.7 | 11.5 | N.S.+ |
| Crude fibre | 58.1 | 51.8 | N.S. |
| Ash | 19.5 | 13.4 | N.S. |
| Ether extract | 24.5 | 17.5 | N.S. |
| Nitrogen-free extract | 74.1 | 69.5 | 6.8 |
| Energy | 40.4 | 33.1 | 4.8 |
| Ca | 6.82 | –ve | – |
| P | –ve | –ve | – |
| Mg | 40.89 | –ve | – |

*Least significant difference (P<0.05)
+N.S – Not statistically significant

The last trial involved the effect of substituting rice straw with 30 per cent level of either cassava leaves, leucaena leaves, leucaena stems plus pods or gliricidia leaves. It was found that there were no differences in intake between treatments *(Table 10)*.

The corresponding apparent digestibility between these four treatments showed significant differences (P < 0.05) only for organic matter, crude protein, ether extract and nitrogen-free extract digestibility *(Table 11)*. Concerning crude protein diges-

TABLE 6: THE VOLUNTARY FEED INTAKE OF LONG OR CHOPPED RICE STRAW (RS) FED WITH OR WITHOUT CASSAVA LEAVES (CL) – TRIAL 3
(Each value is the mean of three sheep)

| Parameter | Treatments | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|
| | Long RS+ | Chopped RS | Long RS + CL | Chopped RS + CL | |
| Fresh intake (g/day) | 626.4 | 633.6 | 1692.0 | 1640.9 | 412.6 |
| Dry matter intake (DMI/day, g) | 567.9 | 543.2 | 780.1 | 727.8 | 52.4 |
| DMI/$Kg^{0.75}$ (g/day) | 50.7 | 49.7 | 70.1 | 67.4 | 12.6 |
| Relative intake (%)++ | 63.9 | 62.3 | 88.6 | 84.2 | 4.4 |
| DMI as % of mean live weight (%) | 2.6 | 2.3 | 3.2 | 3.1 | 3.1 |

+Rice straw

++Relative intake = $\frac{\text{Observed intake}}{80 \times kg^{0.75}} \times 100$

*Least significant difference (P<0.05)

TABLE 7: MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF DIETARY CONSTITUENTS OF LONG OR CHOPPED RICE STRAW FED WITH OR WITHOUT CASSAVA LEAVES (%) – TRIAL 3
(Each value is the mean of eight sheep)

| Constituent | Treatments | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|
| | Long RS+ | Chopped RS | Long RS + CL | Chopped RS + CL | |
| Dry matter | 46.4 | 41.3 | 53.0 | 49.8 | N.S. |
| Organic matter | 51.1 | 47.2 | 61.4 | 54.2 | 9.1 |
| Crude protein (N x 6.25) | 18.3 | 31.4 | 64.7 | 62.4 | 8.2 |
| Crude fibre | 69.3 | 61.6 | 63.0 | 56.8 | N.S. |
| Ash | 18.4 | 11.6 | 21.9 | 14.5 | N.S. |
| Ether extract | 31.0 | 10.1 | 39.4 | 39.9 | 19.7 |
| Nitrogen-free extract | 40.2 | 37.6 | 51.5 | 50.5 | 11.4 |
| Energy | 48.4 | 42.4 | 55.5 | 51.1 | N.S. |
| Ca | 22.6 | 44.2 | 19.4 | 10.9 | 14.6 |
| P | 26.2 | –ve | 30.2 | 24.3 | – |
| Mg | 28.1 | 41.1 | 28.5 | 74.5 | 21.7 |

NS – Not statistically significant
* – Least significant difference (P<0.05)

TABLE 8: THE VOLUNTARY INTAKE OF CHOPPED RICE STRAW (RS) FED WITH VARYING LEVELS OF *LEUCAENA* LEAVES (L) – TRIAL 4

(Each value is the mean of three sheep)

| Parameter | Treatments | | | | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|---|---|---|
| | RS+ (Control) | RS + 10% L | RS + 20% L | RS + 30% L | RS + 40% L | RS + 50% L | RS + 60% L | |
| Fresh intake (g/day) | 741.3 | 890.7 | 967.7 | 1158.7 | 1446.0 | 1475.7 | 1300.7 | 413.5 |
| Dry matter intake (DMI/day, g) | 677.7 | 659.8 | 667.8 | 676.0 | 775.8 | 791.7 | 677.3 | 54.8 |
| DMI/$kg^{0.75}$ (g/day) | 59.9 | 58.9 | 53.2 | 59.9 | 68.5 | 70.7 | 59.9 | 16.8 |
| Relative intake (%)++ | 74.9 | 72.9 | 79.5 | 74.8 | 85.8 | 87.57 | 75.6 | 9.6 |
| DMI as % of mean live weight (%) | 2.7 | 2.6 | 2.6 | 2.8 | 3.1 | 3.1 | 2.7 | 0.28 |

+Chopped rice straw

++Relative intake $= \frac{\text{Observed intake}}{80 \times kg^{0.75}} \times 100$

*Least significant difference (P<0.05)

TABLE 9: MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF DIETARY CONSTITUENTS OF CHOPPED RICE STRAW AND VARYING *LEUCAENA* LEAVES (%) – TRIAL 4
(Each value is the mean of three sheep)

| Parameter | Treatments | | | | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|---|---|---|
| | $RS^+$ (Control) | RS + 10% L | RS + 20% L | RS + 30% L | RS + 40% L | RS + 50% L | RS + 60% L | |
| Dry matter | 42.8 | 48.5 | 46.7 | 49.5 | 50.5 | 53.2 | 49.6 | 4.6 |
| Organic matter | 50.9 | 51.3 | 49.5 | 52.5 | 53.3 | 55.5 | 52.4 | 1.8 |
| Crude protein (N x 6.25) | 19.7 | 40.5 | 47.2 | 49.6 | 52.0 | 66.2 | 50.5 | 4.6 |
| Crube fibre | 58.1 | 57.9 | 52.8 | 53.0 | 47.1 | 40.3 | 44.2 | N.S. |
| Ash | 19.5 | 27.7 | 23.2 | 23.0 | 25.7 | 27.9 | 24.6 | N.S. |
| Ether extract | 24.5 | 31.7 | 32.2 | 27.7 | 21.3 | 36.0 | 23.5 | N.S. |
| Nitrogen-free extract | 74.1 | 75.8 | 78.0 | 76.5 | 81.5 | 84.4 | 81.6 | 4.8 |
| Energy | 40.4 | 46.6 | 46.3 | 52.1 | 51.5 | 54.7 | 46.2 | 3.2 |
| Ca | 6.8 | 11.7 | 0.1 | 4.5 | 12.4 | 12.3 | 23.8 | 4.4 |
| P | 33.7 | 41.4 | 40.8 | 62.7 | 49.9 | 60.0 | 62.5 | 18.6 |
| Mg | 40.9 | 30.1 | 31.4 | 33.6 | 46.8 | 38.8 | 35.2 | 6.8 |

*Least significant difference ($P<0.05$)

TABLE 10: VOLUNTARY FEED INTAKE OF CHOPPED RICE STRAW (RS) AND CASSAVA LEAVES (CL), LEUCAENA LEAVES (L), LEUCAENA LEAVES PLUS STEMS PLUS PODS (LSP) OR GLIRICIDIA LEAVES (GL) – TRIAL 5
(Each value is the mean of four sheep)

| Parameter | Treatments | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|
| | RS + CL | RS + L | RS + LSP | RS + CL | |
| Fresh intake (g/day) | 1556.8 | 1408.6 | 1414.5 | 1414.3 | N.S.++ |
| Dry matter intake (DMI, g/day) | 713.4 | 755.6 | 674.6 | 693.3 | N.S. |
| DMI/Kg$^{0.75}$ (g/day) | 65.9 | 69.7 | 64.7 | 64.1 | N.S. |
| Relative intake (%)+ | 82.6 | 86.7 | 80.3 | 77.7 | N.S. |
| DMI as % of mean live weight (%) | 3.0 | 3.2 | 3.0 | 2.7 | N.S. |

+ Relative intake = $\frac{\text{Observed intake}}{80 \times kg^{0.75}} \times 100$

*Least significant difference (P<0.05)

++Not statistically significant

TABLE 11: MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF DIETARY CONSTITUENTS OF CHOPPED RICE STRAW WITH EITHER CASSAVA LEAVES, LEUCAENA LEAVES, LEUCAENA LEAVES PLUS STEMS PLUS PODS OR GLIRICIDIA LEAVES (%) – TRIAL 5
(Each value is the mean of four sheep)

| Constituent | Treatments | | | | L.S.D.* P = 0.05 |
|---|---|---|---|---|---|
| | RS + CL | RS + L | RS + LSP | RS + GL | |
| Dry matter | 53.5 | 49.2 | 48.0 | 47.6 | N.S. |
| Organic matter | 60.5 | 56.9 | 55.4 | 55.4 | 4.9 |
| Crude protein (N x 6.25) | 49.7 | 50.4 | 44.3 | 31.6 | 11.2 |
| Crude fibre | 53.6 | 49.2 | 56.0 | 55.6 | N.S. |
| Ash | 19.8 | 21.1 | 20.2 | 24.2 | N.S. |
| Ether extract | 31.5 | 11.5 | 6.0 | 22.8 | 9.9 |
| Nitrogen-free extract | 67.7 | 64.8 | 61.4 | 61.2 | 5.7 |
| Energy | 54.7 | 52.6 | 45.7 | 48.9 | N.S. |
| Ca | 34.4 | 25.6 | 14.0 | 23.3 | 12.3 |
| P | 65.7 | 36.9 | 41.6 | 40.4 | 24.3 |
| Mg | 46.8 | 45.7 | 48.1 | 48.3 | N.S. |

NS – Not statistically significant

* – Least significant difference (P<0.05)

tibility, the highest digestibility was recorded for RS + L leaves treatment.

## DISCUSSION

A comparison of fresh versus old stored rice straw indicated that both goats and sheep consistently recorded a higher DMI from older rice straw and the differences in intake between straw types for both species was statistically significant ($P<0.05$). The implication of this finding is that although more fresh straw is eaten, probably because this is more palatable, fresh and also relatively greener compared to older rice straw, the fact is that in terms of higher DMI, older rice straw is preferable. The magnitude of this finding is considerable, accounting for a 15.1 per cent and 32.3 per cent increase for g DMI/$W^{0.75}$kg and 0.2 and 0.7 per cent as percentage of mean live weight for goats and sheep, respectively *(Table 2)*. The implication of this finding is that between-straw types in quality, older straw is clearly more preferable where the objective is to ensure maximum DMI. Older rice straw may be inferior in palatability, however, high intakes can be established with a suitable level of molasses. Coupled with this conclusion is also the finding that between-straw types, although there were no differences in the apparent digestibility of most of the principal constituents, there were differences in favour of higher apparent digestibility data for crude fibre and ash for the older rice straw *(Table 3)*.

Since one of the main limitations in old, dry rice straw is palatability and also energy uptake imposed by its bulk, it is important that as a first step to its effective utilisation, palatability of the material be secured. One of the earliest attempts, initiated by Indian scientists, was to wet the straw at the rate of 1 kg of straw per litre of water. In this study however, wetting was shown to provide no advantages and did in fact produce reduced performance in terms of intake. Compared to the DMI intake of dry straw, the intake of wet straw was reduced by 28.5 per cent in terms of g/$W^{0.75}$kg or 0.8 per cent as percentage of mean live weight *(Table 4)*. This is probably due to a reduced dry matter availability in the feed consequent to wetting. The consistent finding was a preference for the older stored rice straw. Support for soaking not having any effect on the intake of straw in the present study has also been reported for carabaos in the Philippines (CASTILLO *et. al.*, 1982).

Parallel to the intake preferences for stored older rice straw *(Table 4)*, the apparent digestibility data also indicated that, dry matter, organic matter, nitrogen-free extract and energy were much better digested in the older material *(Table 5)*. This latter point is also consistent with the results of the earlier study *(Table 3)* which indicated that crude fibre and ash was better digested in the older stored rice straw.

The effect of substituting rice straw with cassava leaves was to increase VFI and also the DMI significantly. The increase DMI per kg $W^{0.75}$ with cassava leaves was of the order of 35.1 to 38.7 per cent and between 0.6 to 0.8 per cent as percentage of body weight, indicating the importance of the added dietary protein *(Table 6)*. This intake was associated with improved apparent digestibility of the proximate constituents, notably organic matter, crude protein, ether extract, nitrogen-free extract, Ca and Mg *(Table 7)*. The improvement in crude protein digestibility was particularly evident with apparent digestibilities of 62.4 to 64.7 per cent with the presence of cassava leaves.

When 10–60 per cent levels of leucaena leaves was substituted for rice straw, the intake increased significantly and the highest DMI was achieved with a 50 per cent level *(Table 8)*, this represented an 18 per cent increase in terms of per kg $W^{0.75}$ over the rice straw diet. The corresponding digestibility data also indicated that the highest statistically significant effects were noted for crude protein and nitrogen-free extract at this same level. It is relevant to point out that the highest DMI also corresponds to the highest N retention data for the 40, 50 and 60 per cent levels of leucaena.

*Figure 1* illustrates the trend and optimum level of leucaena inclusion. Using the quadratic equation of $Y = -15.859 + 2.530X - 0.031X^2$, it was determined that the optimum level of leucaena inclusion was about 40 per cent.

The comparative value of cassava leaves, leucaena, leucaena stems plus pods and gliricidia leaves, showed no significant effects in VFI, DMI, DMI/$W^{0.75}$kg, relative intake and DMI as percentge of mean live weight. Rice straw plus cassava leaves however gave the highest VFI and DMI, whereas the intakes for the other three treatments are comparable *(Table 10)*.

Concerning digestibility, the highest digestibility of organic matter, crude protein, nitrogen-free extract and Ca was found for substitution with cassava or leucaena leaves. In each instance the differences between these leaves were not significant, suggesting that both these leaves are better utilised and also comparable in feeding value *(Table 11)*.

It is of interest to compare the DMI data in the present trials with those of other published values. *Table 12* summarises the position. Several conclusions can be made. Firstly, the value for rice straw alone are higher than the data from Bangladesh (HAQUE *et al.*, 1981) and comparable to an

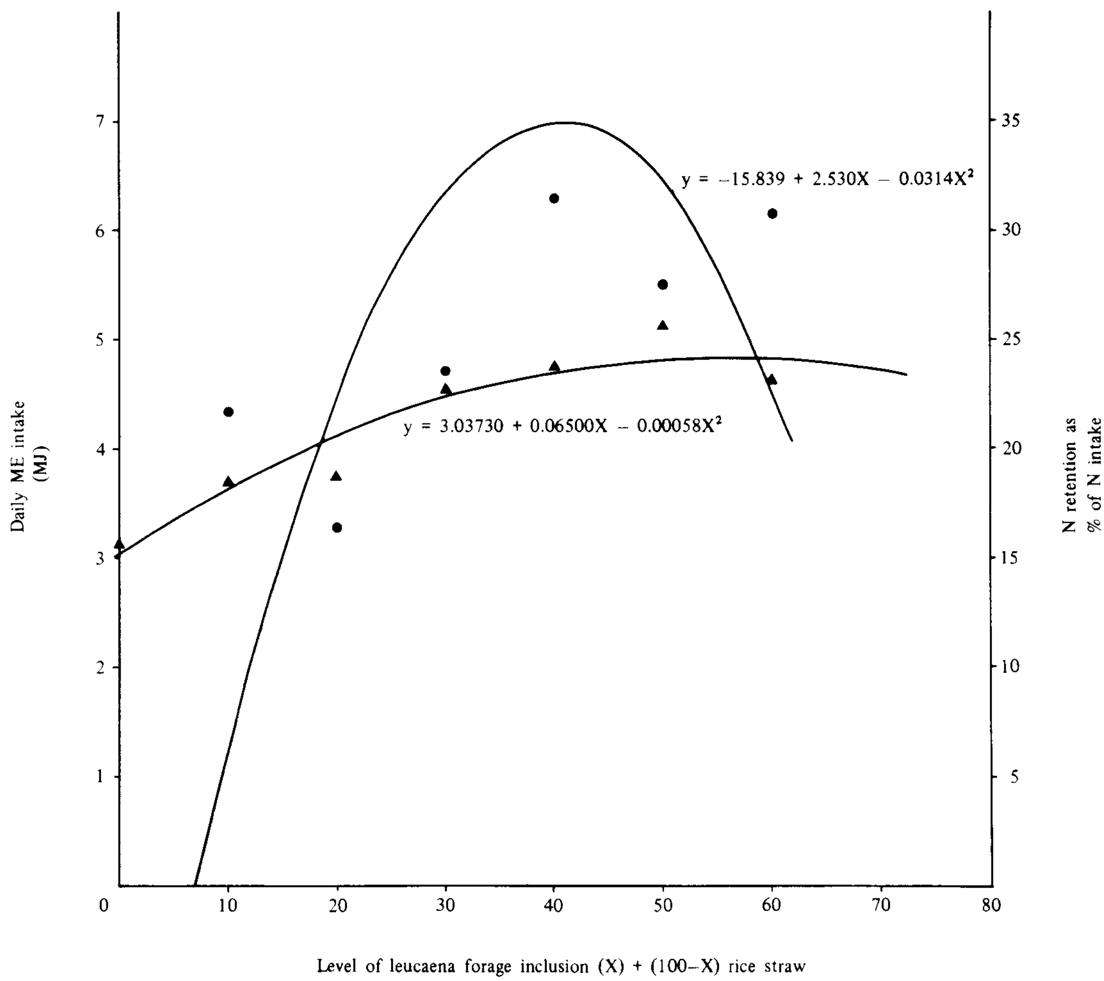


*Figure 1: Trends in the intake of ME and N retention in sheep with increasing level of dietary leucaena forage.*

earlier result in Malaysia (DEVENDRA, 1978). Secondly, the addition of forage such as cassava or leucaena leaves considerably increased DMI and both high intakes and apparent digestibility of dry matter were found, in particular improved crude protein digestibility. Thirdly, *Table 12* suggests that there exists very little data on the feeding of ground or pelleted rice straw to ruminants.

Since the main value of substituting rice straw with forages was to not only promote higher VFI but also utilisation of the available proteins, the assessment of nitrogen balance data consequent to the substitution is of considerable significance. *Table 13* sets out the pattern of nitrogen balance in trials 3, 4 and 5 where the effect of the substitution was studied. With cassava leaves alone (trial 3), substitution with 33 to 34 per cent improved N retention which was twice as much as chopped rice straw alone. The increased N from cassava leaves was about 11.9 g which was evidently well utilised.

*Table 13* also demonstrates the importance of physical form in rice straw feeding. The effect of chopping was to

TABLE 12: SUMMARY OF INTAKE AND DIGESTIBILITY OF UNTREATED RICE STRAW BY ADULT RUMINANTS

| Species | Physical form | | Location | Dry matter intake as % body weight | $DMI/W^{0.75}kg$ (g) | Dry matter digestibility (%) | Reference |
|---|---|---|---|---|---|---|---|
| Cattle (Bullocks) | Unknown[3] | | Bangladesh | 2.5 | 90 | 37 | Dolberg *et. al.*, (1981) |
| Unkown | Ground[1] | | Bangladesh | – | – | 30 – 35 | Haque *et. al.*, (1981) |
| Cattle (Beef) | Chopped[4] | | Bangladesh | – | – | 49 | Hossain and Rahman (1981) |
| Cattle (Dairy) | Unknown[2] | | Bangladesh | 1.7 – 1.9 | 78 – 87 | – | Khan and Davis (1981) |
| Cattle (Dairy) | Unknown[5] | | Sri Lanka | 2.3 | 83 | – | Perdok *et. al.*, (1982) |
| Cattle (Dairy) | | | | 2.5 | 100 | – | |
| Buffaloes (Dairy) | | | | 2.8 | 119 | – | |
| Sheep | Chopped[1] | | Malaysia | 2.0 | 42.6 | 37.1 | Devendra (1978) |
| Buffaloes | Chopped rice straw | | Philippines | 1.54 | 67.0 | – | Castillo *et. al.*, (1982) |
| | Long rice straw | | | 2.3 – 2.9 | 96 – 116 | – | |
| | Long rice straw | | | 11.46 | 63.0 | – | |
| | Long rice straw + concentrate | | | 1.5 – 1.8 | 66 – 73 | – | |
| Goats | Fresh rice straw | Trial 1 | Malaysia | 1.8 | 40.5 | 43.9 | Present trials |
| | Older rice straw | | | 2.0 | 41.0 | 44.9 | |
| Sheep | Fresh rice straw | | | 1.8 | 46.2 | 52.4 | |
| | Older rice straw | | | 2.5 | 55.2 | 44.6 | |
| Sheep | Fresh rice straw | Trial 2 | Malaysia | 2.7 | 60.0 | 42.4 | |
| | Older rice straw | | | 1.9 | 42.7 | 36.0 | |
| Buffaloes | Rice straw + other hay | | Indonesia | 2.21 – 2.70 | 89.1 – 108.5 | – | Parakkasi (1975) |
| Buffaloes | Rice straw | | Indonesia | 1.81 | 73.4 | – | Moran (1983) |
| Buffaloes | Rice straw (unknown) | | Thailand | 1.91 | 78.8 | 50.2 | Wanapat, Sriwattanasombat and Chanthai (1983) |
| Sheep | Long | Trial 3 | | 2.6 | 50.7 | 46.4 | Present trials |
| | Chopped | | | 2.3 | 49.7 | 41.3 | |
| | Long + cassava leaves | | | 3.2 | 70.1 | 53.0 | |
| | Chopped + cassava leaves | | | 3.1 | 67.4 | 49.8 | |
| Sheep | Chopped + 10–60% leucaena forage | Trial 4 | | 2.6 – 3.1 | 53.2 – 70.7 | 42.4 – 53.2 | |
| Sheep | Chopped + cassava leaves | Trial 5 | | 3.0 | 65.7 | 53.5 | |
| | Chopped + leucaena leaves | | | 3.2 | 69.7 | 49.2 | |
| | Chopped + leucaena leaves + stems + pods | | | 3.0 | 64.7 | 48.0 | |
| | Chopped + gliricidia leaves | | | 2.7 | 64.1 | 47.6 | |

1 Complete rice straw diet
2 Rice straw + Napier grass + concentrates
3 Rice straw + green grass + grasing + concentrates
4 Rice straw + concentrates
5 Rice straw + grass silage + concentrates

TABLE 13: NITROGEN BALANCE DATA

| Parameter | Treatments | | | |
|---|---|---|---|---|
| Trial 3 | Long RS | Chopped RS | Long RS + CL | Chopped RS + CL |
| Nitrogen intake (g/day) | 4.60a* | 4.73a | 16.23b | 16.63b |
| Nitrogen in faeces (g/day) | 4.17a | 3.27a | 6.10b | 5.80b |
| Nitrogen in urine (g/day) | –2.42a | 0.38b | 0.65b | 3.58c |
| Balance (g/day) | –1.99a | 1.08a | 9.48b | 7.25b |
| Apparent digestibility of N (%) | 9.35 | 69.1b | 62.4b | 65.1b |
| N retention as % intake | –43.3a | 22.8b | 58.4c | 43.6c |

| Trial 4 | RS + (Control) | RS + 10% L | RS + 20% L | RS + 30% L | RS + 40% L | RS + 50% L | RS + 60% L |
|---|---|---|---|---|---|---|---|
| Nitrogen intake (g/day) | 7.17a | 8.70a | 9.86b | 11.19b | 14.83c | 13.45c | 15.50c |
| Nitrogen in faeces (g/day) | 5.75a | 5.17a | 5.13a | 6.02b | 7.19c | 58.3a | 5.29a |
| Nitrogen in urine (g/day) | 1.40a | 1.77a | 3.11b | 3.08b | 2.97b | 3.92c | 54.4d |
| Balance (g/day) | 0.02a | 1.76b | 1.62b | 2.81c | 4.67b | 3.70b | 4.77d |
| Apparent digestibility of N (%) | 19.8a | 40.6b | 47.9b | 51.5b | 49.5b | 51.5b | 65.9d |
| N retention as % intake | –0.1a | 20.2b | 16.4b | 23.6b | 31.5c | 27.5c | 30.8c |

| Trial 5 | RS + CL** | RS + L** | RS + LSP** | RS + GL** |
|---|---|---|---|---|
| Nitrogen intake (g/day) | 10.93a | 14.04b | 11.37c | 10.09a |
| Nitrogen in faeces (g/day) | 5.46a | 6.99b | 6.32b | 6.38b |
| Nitrogen in urine (g/day) | 3.70a | 2.16b | 4.61c | 2.88b |
| Balance (g/day) | 1.77a | 4.89b | 0.44c | 0.93c |
| Apparent digestibility of N (%) | 50.0a | 50.2a | 44.4b | 37.8c |
| N retention as % intake | 16.2a | 34.8b | 3.9c | 9.2cd |

*Means on the same line with different superscripts differ significantly ($P<0.05$)
**CL – Cassava leaves, L – Leucaena leaves, LSP – Leucaena leaves + stems + pods.
GL – Gliricidia leaves.

increase the intake of the fresh material *(Table 6)*, which was associated with improved crude protein digestigility *(Table 7)* and also N retention *(Table 13)*. The differences in N retention between long and chopped rice straw was significant ($P<0.05$), implying that chopping is clearly advantageous. However, the finding that there were no differences in the digestibility is somewhat surprising. Chopping and pelleting has little effect on the digestibility of roughages, but fine grinding results in a decrease, in association with a more rapid passage of particles from the rumen (MOORE, 1964).

Similarly, the effect of substituting with either leucaena leaves *(Table 9)* or cassava leaves, leucaena leaves, leucaena leaves plus stems plus pods and gliricidia leaves *(Table 10)* also confirm the value of added dietary protein in these forages. With leucaena leaves, the highest retention was observed with 40% substitution leucaena. This value was different to the 10, 20 and 30 per cent levels, and in view of the known effects of 3–hydroxy–4–1 (H)–pyridone (DHD), the breakdown product of mimosine, on fibre growth, lower levels of usage (up to 30 per cent) may be more advisable. When a 30 per cent level of leucaena leaves substitution was compared to the three other forage types in terms of N retention leucaena leaves was superior, followed by cassava leaves, gliricidia and finally leucaena leaves plus stems plus pods *(Table 13)*. The practical significance of these findings is supported by the results of PEREZ (1976) who showed that whereas a ration of 50 per cent rice straw and 50 per cent concentrates gave a daily live weight gain of 0.54 kg in bulls, a diet of 35 per cent rice straw + 35 per cent leucaena leaves + 30 per cent concentrate gave a daily gain of 0.71 kg.

These findings have three important practical implications. Firstly, it is patently clear that in situations such as with feeding rice straw, bagasse or palm press fibre feeding exclusively, where the crude protein content is below the critical level of 6–7 per cent, the addition of leucaena forage or cassava leaves has considerable potential, whereby the combined diet of these leaves and the base roughage material alleviates the total value of the diet to one which supplies both energy and also proteins for production. This added value is significant in that in the rural areas much of the energy available in large quantities of cellulosic material is made available to ruminants for productive purposes. Secondly, high N retentions and increased availability of N to the animal, brought about by reduced degradability of the N possibly because of the presence of tannins implies that increase use can be made of either leucaena or cassava leaves as important sources of N. Thirdly, increased use of leucaena or cassava leaves as sources of dietary N can bring about a decreased dependence on expensive pre-formed proteins with the likelihood that the cost of feeding can be reduced (DEVENDRA, 1977).

In trial 2 and 3 where rice straw was fed alone, data on the mineral balance indicated that P was negative *(Table 2* and *7)* whereas Ca and Mg was positive. With wet rice straw on the other hand, all three minerals were in negative balance *(Table 5)* indicating that the effect of wetting was to make these minerals unavailable. With Ca for example, this could possibly have been due to its removal as calcium oxalates, which implicates a greater need for calcium supplementation (TALAPATRA, RAY and SEN, 1948). More particularly, it is clear from the data in trial 3*(Table 7)*, trial 4 *(Table 8)* and trial 5 *(Table 11)*, that one other advantage of providing proteinaceous forages like leucaena and cassava leaves was to ensure that there was indeed a positive mineral balance implying that the requirements for body function are met. In trial 3 for example, feeding cassava leaves to either long or chopped straw was to alleviate Ca from negative balance to provide 0.45–0.96g, also from negative balance to 0.17–0.28g and Mg from 0.14–0.21g to 0.37–0.77g. Support for this finding is seen in studies on Ongole and swamp buffalo bulls which when offered NaOH-rice straw and 30 per cent leucaena in the dry matter gave improved N, Ca and P balance (MORAN, SATOTO and DAWSON, 1983).

In view of the limited information on the metabolisable energy (ME) content of rice straw, the opportunity was taken to calculate this value based on the *in vivo* studies in trial 1, 2, 3 and 4. Rice straw differs from other cereal straws with its low organic matter (75 per cent) and high silica contents (12–16 per cent), (JACKSON, 1977). The ME values for fresh (chopped), stored (chopped) or long rice straw were 6.09–6.19, 5.38–6.04 and 6.39 MJ/kg respectively. These values are slightly higher compared to the value of 5.38–5.43 MJ/kg reported for Ongole bulls and swamp buffaloes in Indonesia (MORAN, SATOTO and DAWSON, 1983).

The present trials concerning the utilisation of leucaena forage confirm work reported previously on sheep and goats (DEVENDRA, 1982b), that the forage is of potentially useful value in the diet of ruminants. Similarly in Indonesia, leucaena forage has been reported to be useful in the diet of Ongole cattle (WAHYNII *et al.*, 1982). Not only is there a supply of much needed dietary protein in situation where because of low levels (below 6 per cent) in coarse roughages, the pattern of voluntary feed intake is alleviated to one of increased DMI, there is also the distinct likelihood of enhanced supply of minerals as well. In situation where nutrition is a limiting factor therefore, added dietary leucaena must surely shift animal performance from one of maintenance or below maintenance to one of production. It has also been reported that added leucaena produces a response not only to nitrogen, calcium and phosphorus but also possibly to sulphur since the forage also supplied 0.3–0.5 per cent of this mineral to the basal rice straw (0.1 per cent sulphur) diet (MORAN, SATOTO and DAWSON, 1983).

The results together demonstrate that forages such as cassava, leucaena and gliricidia which have a relatively high crude protein content (17.4 to 22.0 per cent in the dry matter), are clearly advantages when included in feeding systems for ruminants. This is especially so in small farm situations where the base roughage feed is low in crude protein content (3 to 5 per cent), such that adding the forages can stimulate increased DMI, energy and mineral supply to levels which make the difference between maintenance and furnishing the requirements for ploughing or meat production in adult ruminants. In trial 5 for example, the addition of cassava leaves, leucaena leaves, leucaena leaves plus stems and pods or gliricidia leaves increased dietary ME supply by 62.7, 67.4, 31.3 and 62.0 per cent respectively. More emphasis should therefore be given to increasing the supply of these potentially useful forages, and also intensifying their utilisation in feeding systems for ruminants in Malaysia.

## CONCLUSION

Stored, older rice straw is a valuable roughage material and in terms of DMI, more of this was eaten than freshly collected, more palatable rice straw. Wetting to improve palatability at the rate of 1 kg per litre of water produced no advantage. In terms of physical form, chopping rice straw was more advantageous to the animal than feeding long straw. The effect of substituting variable levels of rice straw with cassava leaves, leucaena leaves, leucaena leaves plus stems plus pods or gliricidia leaves was to substantially increase DMI, apparent digestibility of nutrients, increase N retention and also establish positive Ca, P and Mg balance. The results together demonstrate the limitations of untreated rice straw on the one hand and the advantageous of providing forages such as leucaena to increase N availability as well as enhance Ca, P and Mg balance. More particularly, the data suggest that the effect of the increased uptake of ME is likely to have an important stimulating influence on animal response (meat or milk).

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## SUMMARY

The results of five balance studies are presented concerning the utilisation of untreated rice straw with physical treatment and substitution with either cassava leaves *(Manihot esculenta* Crantz*)*, leucaena leaves *(Leucaena leucocephala)*, leucaena leaves plus stems plus pods *(L. leucocephala)* or gliricidia *(Gliricidia maculata)*. Feeding freshly collected versus stored older rice straw to goats and sheep increased DMI with older straw (46.3 – 55.2 g/$W^{0.75}$kg) compared to the fresh feed (40.5 – 41.0 g/$W^{0.75}$kg). Goats significantly consumed more DMI than sheep ($P<0.05$), and the digestibility of crude fibre and ash were significantly better utilised in the older straw ($P<0.05$). Wetting the straw at 1 kg/litre of water reduced DMI (59.9 vs 51.6 g/$W^{0.75}$kg) and dry matter digestibility significantly ($P<0.05$). Feeding chopped straw was associated with increased crude protein digestibility and N retention compared to long straw. The ME content of fresh (chopped), stored (chopped) or long rice straw were 6.09 – 6.19, 5.38 – 6.04 and 6.39 MJ/kg respectively. The effect of substituting rice straw with 33 – 34 per cent cassava leaves was to significantly ($P<0.05$) increase DMI by 34 to 37 per cent and also improve the digestibility of organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE) and nitrogen-free extract (NFE), (P<0.05). Substituting rice straw with 10 to 60 per cent leucaena leaves was to increase DMI, and the apparent digestibility of crude protein and nitrogen-free extract significantly (P<0.05); this improvement was linear and statistically significant (P<0.01). The highest DMI and crude protein digestibility was recorded for the 50 per cent level of substitution. Substituting rice straw with 30 per cent of either cassava or leucaena leaves, leucaena leaves plus stems plus pods or gliricidia leaves gave no differences in DMI, however, there were significant differences in OM, CP, EE and NFE digestibility (P<0.05). Dietary energy supply, nitrogen and mineral balance indicated that in all instances, the effect of the substitution was to increase dietary ME, N and also mineral supply (Ca, P and Mg). The results emphasise the feeding value of especially cassava and leucaena leaves for improving the dietary quality of basal roughage diets for ruminants.

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