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 The original data on which the graphs are based should always be presented in tabular form. Always supply the original spreadsheets and data which were used to produce graphics in the papers, since this allows us to produce a uniform look and maintain the quality of the finished proceedings.

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Authors are encouraged to use photos (no more than 2 or 3) to illustrate elements in the “Materials and Methods” section. They should be saved in the “jpg” format and should not exceed 100 kb in size. They should be sent as separate files and identified as follows: “author1.jpg, author 2.jpg where “author” is an abbreviation of the author’s name (eg: thu1.jpg).

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**References:**

They should be set up with minimum punctuation but maximum detail of the actual citation. Abbreviations of journal titles should not be used. In the list of references, citations to electronic journals or proceedings such as "Livestock Research for Rural Development" and those in the “mekarn.org” web page, should include the appropriate "URL" for the article. For example, for papers published in LRRD prior to 2004, the citations are of the following format.

**Guèye E F, Ndiaye A and Branckaert R D S 1998** Prediction of body weight on the basis of body measurements in mature indigenous chickens in Senegal; Livestock Research for Rural Development. (10) 3: <http://www.lrrd.org/lrrd10/3/sene103.htm>

Beginning in 2004, the format was changed to:

**Cerón-Muñoz M F, Tonhati H, Costa C N, Rojas-Sarmiento D and Solarte Portilla C 2004:** Variance heterogeneity for milk yield in Brazilian and Colombian Holstein herds. Livestock Research for Rural Development. Vol. 16, Art. #20 Retrieved June 1, 2004, from <http://www.lrrd.org/lrrd16/4/cero16020.htm>

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Title is Heading 1

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Main sections (eg: Abstract, Introduction …) are in Heading 4

Key words are in Heading 6

Sub-sections (eg: Experimental design…) are in Heading 5

Sub-sub-sections are in Heading 6

# The template follows from here (next page)Effect of levels of sun-dried cassava foliage on growth performance of cattle fed rice straw

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#### Abstract

An on-farm trial experiment was carried out in Treang district, Takeo province from June to September 2006. Twenty female cattle were allocated to five levels of sun-dried cassava foliage (0, 0.25, 0.5, 0.75 and 1 % of body weight in DM basis) to evaluate the growth response when fed a basal diet of untreated rice straw plus a rumen supplement. The heifers were tethered alongside the feed trough in each household, where they had free access to the experimental diet and water. The heifers were provided rumen supplement (mainly urea, sulphur and other minerals) at 0.25% body weight and *ad libitum* rice straw. The design was a completely randomized design (CRD) with four replications of each treatment.

The intake of the leaf component of the cassava was 90% of the offer but only 45% of the offer level of petiole was consumed. The total intake of DM and crude protein intake increased according to the intake of cassava foliage. Daily weight gain increased from 201 to 402 g/day and feed conversion was better with increasing levels of protein from sun-dried cassava foliage in the diet. The responses were linear over the range of cassava crude protein intakes from 0 to 1.6 g/kg live weight.

It is concluded that supplementation with sun dried cassava foliage stimulated the growth performance of cattle and that the response was linear over the range from 0 to 1.6g cassava crude protein/kg live weight.

***Key words:*** *On-farm trial, Sun-dried cassava foliage, rumen supplement, rice straw, growth response cattle, intake*

#### Introduction

Similar with other developing countries in the region, large ruminants in Cambodia depend on natural pasture and crop residues, mainly rice straw. These are of low digestibility and usually imbalanced in essential nutrients which contribute to low feed intake (Schiere and Ibrahim, 1989). Supplements are required to improve rumen microbial fermentation and therefore the performance of the host animals (Dixon and Egan, 1987). Inadequate nutrition in cattle has often caused economic loss to the farmers because their animals loose weight and body condition, resulting in reduced reproductive capacity and increased susceptibility to diseases and parasites (Leng, 1997).

Early work with fresh cassava leaves showed that it could be the sole source of supplementary protein and roughage in diets for fattening cattle based on liquid molasses-urea (Ffoulkes and Preston, 1978). When used as a supplement to untreated rice straw the growth rates in ‘local “yellow” cattle were increased threefold by supplementing them with fresh cassava foliage (Seng Mom et al., 2001). Ho Quang Do et al. (2002) reported a curvilinear increase in N retention in goats when fresh cassava leaves replaced grass as the supplement to ammoniated rice straw.

In Cambodia, cassava (*Manihot esculenta*) is usually planted by the farmers with the main purpose of root harvesting and the leaves are left in the field. It has been shown that this residue can be a valuable source of protein for feeding to many kinds of animals (Preston, 2001). When farmers harvest cassava root, the leaves are still a good quality protein feed for cattle particularly in the dry season. This situation can give an opportunity for farmers to get more benefit by collecting the cassava leaves for cattle feeding. Therefore, it is important to promote ways of maximizing the use of this valuable crop. Wanapat et al. (1997) have drawn attention to the potential of cassava foliage made into hay, which combined leaves, stems and petiole, as a feed for ruminants. Added to this, cassava foliage contains condensed tannins (Wanapat et al., 1997), which when fed to buffaloes in form of sun dried hay (Netpana et al., 2001; Granum et al., 2002) and goats (Seng sokerya and Preston, 2003) in fresh form has been reported to reduce nematode egg counts.

In view of the potential of cassava foliage as a supplement for ruminant animals, there is a need to promote research with this feed for cattle in the Cambodia situation.

#### Objectives

* To study effect of levels of sun dried cassava foliage on growth performance of cattle fed rice straw
* To study effect of sun dried cassava foliage on faecal nematode egg counts
* To introduce to farmers the idea of using cassava foliage for their animals

#### Materials and Methods

##### Location and duration

The experiment was carried out in villages in Treang district, Takeo province which is about 80 km south of Phnom Penh city. The experiment was conducted for 3 months from June to September, 2006 excluding adaptation and organizing period.

##### Farmer selection

In Treang district, Takeo provice, CelAgrid has been implementing a cattle project financed by Heifer International Cambodia. The aims of the implementation are to improve cattle management and feeding. Twenty farmers (including women householders) were selected for the study to evaluate the response to sun-dried cassava foliage. Beside these farmers, seven other farmers joined in the study to serve as controls using the traditional system of un-supplemented free grazing treatment. The selection of the farmers was based on:

* Having Heifers of 1.5 to 2 years of age
* Availability of land for growing cassava foliage
* Willingness to participate in the research and strong commitment to the idea
* Willingness to share technologies with neighbors

##### Experimental design

The experimental design was a “production function” to evaluate the growth response of cattle to increasing levels of sun-dried cassava foliage when fed untreated rice straw plus a “rumen supplement”. One female animal per household (n=20) was allocated to one of 5 levels of sun dried cassava foliage (0, 0.25, 0.5, 0.75 and 1 % of body weight in DM basis). The design was a completely randomized design (CRD) with 4 replications of each treatment.

The individual treatments were

- **RC0:** Rice straw + rumen supplement at 0.25% body weight

**- RC0.25:** Rice straw + rumen supplement 0.25% body weight + sun dried cassava foliage 0.25% body weight (in DM)

**- RC0.50:** Rice straw + rumen supplement 0.25% body weight + sun dried cassava foliage 0.50% body weight (in DM)

- **RC0.75:** Rice straw + rumen supplement 0.25% body weight + sun dried cassava foliage 0.75% body weight (in DM)

**- RC1:** Rice straw + rumen supplement 0.25% body weight + sun dried cassava foliage 1% body weight (in DM)

##### Animals and management

The heifers were vaccinated against Foot and Mouth Disease before starting the experiment. They were from 1.5 to 2 years of age with an average live weight of 174 kg live weight. Twenty heifers were tethered alongside the feed trough (Photo 1) in each household, where they had free access to the experimental diet. The sun-died cassava foliage was fed first at about 7.00 am. The rumen supplement and rice straw were fed 2 times per day in the morning (8:00h) and afternoon (16:00h). Water was available the whole day. The seven “control” heifers were kept under traditional farmer management of free grazing and no supplementation.

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| IMG_1277 |
| **Photo 1:** Individual animals tethered to the feed trough in each household |

##### Experimental Feeding

The cassava foliage was bought from farm households situated along the riverside in Kandal province, at the time of harvesting the roots. It was taken to CelAgrid for drying. The cassava leaves plus petioles were separated from the hard stem and sun dried by spreading on a plastic sheet placed on the ground. The duration of sun drying was 3 to 5 days until the leaves become crisp (>85%DM). After sun drying, the foliages were stored in bags and transported to the study site in Takeo province.

The ingredients for the rumen supplement (Table 1) were bought at the local market and mixed by the farmers participating in the study (Photo 2). After mixing, it was kept by each farm household and fed to the cattle at the rate of 0.25% of body weight per day. Rice straw was bought from farmers in the study area. It was from rice grown under rain-fed conditions.

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| **Table 1:** Composition of the rumen supplement |
| **Ingredient** | **% (fresh basis)** |
| Sugar palm syrup | 27 |
| Water | 13 |
| Rice bran | 33.5 |
| Urea | 13 |
| Diammonium phosphate | 3 |
| Salt | 5 |
| Lime | 5 |
| Sulfur | 0.5 |

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| **Photo 2:** Farmers preparing the rumen supplement  |

##### Data collection

Feeds offered and refused were recorded daily and weighed to measure daily feed intake. Representative samples of feeds offered and refused were collected for chemical analysis. The live weight was taken at the beginning of the study and then every 2 weeks until the end of the trial (Photo 3). Faecal samples were collected directly from the rectum of each animal once at the beginning of the experiment and after every 2 week interval to check the nematode egg count.

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| **Photo 3:** the method of weighing the cattle |

##### Chemical analyses

The feeds offered and refused were analyzed for DM using microwave radiation (Undersander et al., 1993) and N following the Kjeldahl procedure as outlined by AOAC (1990). For faecal egg counts, 4 g of representative samples of faeces were ground and mixed with 56 ml of floatation fluid (a saturated salt solution in water). A sub sample was transferred to both compartments of a McMaster counting chamber and allowed to stand for 5 minutes. All helminth eggs were counted under a microscope at 10x10 magnification and multiplied by 50 to yield the eggs per gram of faeces (Hansen and Perry, 1994).

##### Statistical analysis

Data for feed intake, growth and feed conversion were analyzed by analysis of variance (ANOVA) using the General Linear Model procedure of MINITAB software (Version 13.31 2000). Sources of variation were levels of sun dried cassava foliage and error. Regression analysis was used to relate the independent variable (levels sun dried cassava foliage) with the dependent variables (live weight gain, feed intake and feed conversion).

#### Results and discussion

##### Animal health

There were no signs or symptoms of disease or toxicity in the animals during the experiment. Animals were in good healthy and it was observed that the skin became brighter in colour towards the end of the experiment, especially in the treatments with highest offer levels of cassava foliage. The changing appearance of the skin observed in this study may have been due to the effect of the protein supplementation enhancing the expression of immunity against internal and external parasite (Leng R A. personal communication).

##### Chemical composition of diet

The chemical composition of the components of the sun-dried cassava foliage, and of the rumen supplement, are shown in tables 2 and 3. The crude protein level in the cassava leaves was almost three times higher in the leaves than in the petioles. It was lower than in the studies of Wanapat (2003) and Vongsamphanh and Wanapat (2004) where the values reported were 23.6% and 27.3% in DM. These higher values could be because these authors harvested the foliage 3 months after planting, whereas the sun-dried cassava foliage in this study was collected at root harvesting. The nutritive value of cassava foliage has been shown to be affected by variety, location, soil type and other environmental conditions as well as the method of chemical analysis (Seerley, 1972).

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| **Table 2:** Mean values for chemical composition of feed ingredients  |
|  | **% DM** | **N\*6.25, % in DM** |
| Whole sun dried cassava foliage  | 87 | 18.8 |
| Sun dried cassava leaves | 88.7 | 23.4 |
| Sun dried cassava petiole  | 86.3 | 9.7 |
| Rumen supplement | 70.6 | 39.6 |

The DM and crude protein of the rice straw varied slightly among the different households (Table 3). The mean overall values were 87.1% DM and 5.41% crude protein.

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| **Table 3:** Mean values for chemical composition of rice straw in the different house-holds |
| **Family name** | **% DM** | **N\*6.25, % (in DM)** |
| Mr. Banh Keo | 85.6 | 5.8 |
| Mr. Chham Kosal | 85.5 | 4.9 |
| Mrs. Eth Sarom | 87.5 | 5.1 |
| Mr. Im Ean | 88.0 | 5.1 |
| Mr. Khat Youn | 88.3 | 4.9 |
| Mr. Kim Cho | 86.3 | 5.7 |
| Mr. Kong Thol | 87.5 | 4.9 |
| Mr. Moa Khon | 88.4 | 5.7 |
| Mrs. Moa Yat | 85.7 | 5.8 |
| Mr. Ngan Thy | 85.8 | 5.7 |
| Mrs. Nhem That | 86.3 | 5.7 |
| Mrs. Nhem Theoun | 87.3 | 5.7 |
| Mr. Ni Chivo | 87.5 | 4.9 |
| Mrs. Oam Rani | 86.6 | 4.9 |
| Mrs. Om Yen | 88.0 | 5.1 |
| Mrs. Sok Chanthy | 88.0 | 5.8 |
| Mrs. Sok Mali | 88.3 | 5.1 |
| Mrs. Sok Min | 85.9 | 5.8 |
| Mrs. Thou Ka | 86.8 | 5.8 |
| Mrs. Yong Thuch | 87.8 | 5.7 |
| **Mean±SD** | **87.1±1.01** | **5.41±0.39** |

##### Feed intake

The actual intake of the supplements was lower than the planned offer levels (Table 4; Figure 1). The heifers selected the cassava leaves in preference to the petioles, such that intakes of the former were 90% of the offer levels while for the latter it was less than 45% of offer levels. The low acceptability of the sun-dried petioles may be due to the effect of drying (rather hard in texture) or the lower protein content. In this study, leaves and petioles were sun-dried without chopping. In contrast, when feeding fresh cassava foliage managed by repeated harvesting there was no selection (personal observation) against the petioles. The cattle consumed petioles, leaves and soft stems but refused the hard stems.

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| **Table 4:** Actual intake of sun dried cassava foliage compared with planned levels  |
| Planned, % of body weight (DM) | 0 | 0.25 | 0.5 | 0.75 | 1 |
| Actual intake,% body weight (DM) | 0 | 0.18 | 0.34 | 0.55 | 0.73 |
| Intake as % amount offered |  |  |
|  Cassava leaf | 0 | 96.7 | 95.7 | 94.9 | 96.0 |
|  Cassava petiole | 0 | 40.1 | 30.3 | 44.2 | 39.4 |
| Crude protein, g/g total CP in diet | 0 | 0.16 | 0.26 | 0.38 | 0.43 |

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| **Figure 1:** Mean values for intake of diet ingredients as % of amount offered according to the offer level of sun-dried cassava foliage |

There were no significant effects of cassava foliage intake on DM and crude protein intake of rice straw and rumen supplement (Table 5). However, total intake of DM and crude protein intake increased according to the intake of cassava foliage (Figures 2 and 3). The total DM increased by 30% and the crude protein by 65% at the highest level of cassava foliage. The proportion of dietary crude protein from sun dried cassava foliage was 40% of the total crude protein intake at the highest level of supplementation (Figure 4). The effect of the sun-dried cassava foliage in increasing the total DM intake in this study is in agreement with reports by Vongsamphanh and Wanapat (2004), who supplemented rice straw with cassava hay in a study with cattle, and by by Ho Quang Do et al. (2002) who supplemented fresh cassava foliage to goats fed ammoniated rice straw. The positive linear trend in total DM intake in response to the supplementary cassava foliage protein (Figure 5) is in accordance with the thesis outlined by Leng and Preston (1976) and by IAEA (2002) that the selected protein supplement should not reduce intake and utilization of the basal diet but instead have potential to enhance them.

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| **Table 5:** Mean values for feed intake and crude protein intake of heifers fed rice straw with levels of sun dried cassava foliage  |
|  | **Planned levels of cassava, % of live weight (DM basis)** |
|  | **0** | **0.25** | **0.5** | **0.75** | **1** | **SEM** | **P** |
| **DM intake, g/day** |  |  |  |  |  |  |
| Rice straw | 4295 | 4156 | 4538 | 3967 | 4336 | 224 | 0.49 |
| Rumen supplement | 315 | 293 | 303 | 258 | 309 | 18.5 | 0.26 |
| Cassava | 0 | 323 | 621 | 994 | 1305 |  |  |
| Total | 4609c | 4772c | 5462bc | 5219bc | 5950ab | 234 | 0.001 |
| DMI, g/kg LW | 25.6 | 27.0 | 30.1 | 29.2 | 32.8 | 1.97 | 0.14 |
| **CP intake, g/day** |  |  |  |  |  |
| Rice straw | 245 | 223 | 243 | 213 | 224 | 16.7 | 0.62 |
| Rumen supplement | 125 | 116 | 120 | 102 | 122 | 7.32 | 0.26 |
| Cassava | 0 | 64.7 | 127 | 196 | 261 |  |  |
| Total | 369d | 404cd | 490bc | 511b | 608a | 20.8 | 0.001 |

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| **Figure 2:** Mean values for intake of diet ingredients according to intake of crude protein from sun-dried cassava foliage  |

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| **Figure 3:** Mean values for intake of crude protein from the different dietary ingredients according to intake of intake of crude protein from sun-dried cassava foliage |

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| **Figure 4:** Mean values for percentage of dietary crude intake from the different ingredients according to intake of crude protein from sun-dried cassava foliage  |

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| **Figure 5:** Relationship between sun-dried cassava foliage intake and DM intake |

##### Growth rate

There were major differences in live weight gain between the heifers fed rice straw and rumen supplement (without cassava foliage) and those on un-supplemented free grazing (Figure 6). The rumen supplement provided nutrients for rumen microbes (ammonia, sulphur, phosphorus and other minerals) that can correct deficiencies of these nutrients in poor quality feeds such as rice straw. It cannot be concluded that the difference was due only to the rumen supplement as the grazing areas were extremely limited due to the land being used for the rice crop. The daily weight gain of the cattle fed only rumen supplement and straw in this experiment was higher than in the study of Seng Mom et al. (2001); however, there were differences in the breeds which were larger and of Zebu type in our study compared with the smaller “Yellow” breed of cattle used by Seng Mom et al. (2001).

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| **Figure 6:** Comparison of rice straw + rumen supplement (without cassava) and free grazing on live weight gain |

Daily weight gain increased and feed conversion was better with increasing levels of protein from sun-dried cassava foliage in the diet (Table 6). The responses (Figures 7 and 8) were linear over the range of cassava crude protein intakes recorded in the experiment (from 0 to 1.6 g crude protein/kg live weight). The improved growth rates and feed conversion in this study are in agreement with the reports of Seng Mom et al. (2001) and Ho Quang Do et al. (2001), who used fresh cassava foliage as a supplement for cattle fed rice straw and Moore, (1976) who gave cassava foliage to steers fed *Pennisetum purpureum* with varying levels of cassava foliage. Le Huu Khoung and Duong Nguyen Khang (2005) reported a linear increase in live weight gain in “Sindhi\* Yellow” cattle fed fresh cassava foliage as a supplement to urea-treated rice straw. The maximum response of 60% was less than the 200% response in our study probably because the rate of cassava foliage supplementation was higher (1.6 g/kg live weight compared with 1.0 g/kg live weight in the study of Le Huu Khoung and Duong Nguyen Khang (2005). The response in the experiment of Seng Mom et al. (2001) was 400% for cassava foliage protein at 1.3 g/kg live weight compared with the control.

The results of this study, together with the numerous reports in the literature, indicate strongly that the beneficial effect in ruminants of the protein in cassava foliage is due to its “ bypass” or “ escape’’ properties presumably because of the binding effect on the protein of the tannins present in this forage (Wanapat et al., 1997). In an *in vitro* study, Promkot and Wanapat (2003) estimated that the rumen undegradable protein (assumed to be bypass protein) as percent of total protein in cassava hay was 52.7 compared with 50.4 for cottonseed meal (considered to be one of the best sources of bypass protein according to Preston and Leng, 1987) and 35 for leucaena leaf meal.

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| **Table 6:** Mean values for live weight and conversion of heifers fed rice straw with levels of sun dried cassava foliage  |
|  | **Planned levels of cassava, % of live weight (DM basis)** |
|  | **0** | **0.25** | **0.5** | **0.75** | **1** | **SEM** | **P** |
| **Live weight, kg** |  |  |  |  |  |  |
| Initial | 175 | 166 | 170 | 168 | 166 | 8.88 | 0.93 |
| Final | 191 | 189 | 196 | 192 | 199 | 9.24 | 0.93 |
| Final# | 185 | 192 | 195 | 193 | 202 | 3.50 | 0.058 |
| Daily gain, g/day | 201b | 266ab | 282ab | 278ab | 402a | 33.0 | 0.01 |
| **Feed DM conversion** | 25.1 | 18.4 | 20. | 18.8 | 15.0 | 2.39 | 0.09 |
| *# Adjusted for differences in initial weight* |

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| **Figure 7:** Relationship between protein from sun-dried cassava foliage intake (as g/kg live weight) and live weight gain |

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| **Figure 8:** Relationship between protein from sun-dried cassava foliage (as proportion of total crude protein intake) and live weight gain |

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| **Figure 9:** Relationship between intake of crude protein from sun-dried cassava foliage and DM feed conversion |

##### Parasite egg count

The numbers of nematode eggs in the faeces were extremely low both in the supplemented cattle and those on free grazing with no obvious tendencies due to date of sampling or supplementation (Table 7).

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| **Table 7:** Nematode egg counts/g of faeces in the heifers fed rice straw and sun-dried cassava foliage or on free grazing  |
| Sample date | **Crude protein from cassava foliage, g/kg live weight** | **Free grazing**  |
| **0** | **0.37** | **0.69** | **1.09** | **1.43** |
| 6/27/2006 | 275 | 188 | 238 | 200 | 425 | 243 |
| 7/11/2006 | 138 | 150 | 225 | 150 | 188 | 143 |
| 7/25/2006 | 238 | 250 | 275 | 375 | 175 | 193 |
| 8/8/2006 | 150 | 125 | 466 | 213 | 225 | 171 |
| 8/22/2006 | 213 | 100 | 325 | 163 | 288 | 171 |
| 9/5/2006 | 163 | 88 | 225 | 88 | 150 | 179 |
| 9/19/2006 | 200 | 75 | 138 | 100 | 163 | 229 |

#### Conclusions

Based on the results of this research it is concluded that:

* Increasing levels of sun dried cassava foliage led to significant increases in total dry matter intake and daily weight gain of cattle fed untreated rice straw and a rumen supplement
* The response to cassava foliage protein in cattle fed untreated rice straw and rumen supplement is linear over the range of 0 to 1.6 g crude protein/kg live weight.
* Sun dried cassava foliage is a good source of bypass protein source for cattle

#### Acknowledgements

The authors are grateful to the MEKARN project, financed by the Sida-SAREC agency and my assistants Mr. Pek Samnang and Chea Chheangly for their technical help. Thanks are also due to 27 farmers in Treang District, Takeo province, who shared their experiences and participated actively in this study.

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