PRODUCTION AND UTILIZATION OF CASSAVA IN INTEGRATED FARMING SYSTEMS FOR SMALLHOLDER FARMERS IN VIETNAM AND CAMBODIA

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ABSTRACT

A considerable amount of new research information about the use of cassava foliage as animal feed is becoming available from ongoing research in Vietnam, Thailand and Cambodia. Previously, cassava has been characterized as an "exploitive" crop, destructive of soil fertility. However, when cassava is grown as a component of a whole farming system, in which livestock and crops are closely integrated, its capacity to "exploit" the nutrients in livestock manure becomes a valuable asset.

Managed as a perennial forage, annual foliage yields equivalent to four tonnes of protein per hectare have been obtained, using heavy dressings of biodigestor effluent as fertilizer and with repeated harvesting of the foliage at eight week intervals. For cattle, fresh cassava foliage has been successfully fed as the only protein supplement in diets based on rice straw or molasses. Goats fed cassava foliage as a supplement have been shown to have negligible nematode worm infestations. For pig feeding the ensiled cassava leaves have a higher digestibility when the crop is managed as a semi-perennial forage and harvested at eight week intervals compared with ensiled leaves from cassava plants destined for root production and harvested at 8-12 months.

Key words: Cassava, foliage, livestock, nutritional value, integrated farming system.

INTRODUCTION

The role of cassava in integrated farming systems is closely linked with three major issues that must be addressed in the course of this century. The first issue is the need to develop new feed resources in order to respond to the predicted doubling of the demand for animal products in developing countries by 2020 (Delgado *et al*., 1999). The second issue is the need to develop renewable sources of energy to compensate for the inevitable decline in fossil fuel supplies (ASPO, 2002). The third issue is to improve the environment and to reduce pollution. The question then is: how can the cultivation and utilization of cassava become a part of the above strategy?

The first point to be appreciated is that there is more than enough energy coming from the sun to cover our present and future needs for food and fuel (**Table 1**). At the same time, this only holds true if optimum use is made of our natural resources, the most important of which is solar energy.

Cassava as a Dual Purpose Crop

Cassava has one important characteristic, namely that it can be managed to produce carbohydrate (by harvesting the roots), or protein (by harvesting the leaves). For root production the growth cycle is from 6 to 12 months, at the end of which the entire plant is harvested. When maximum protein production is the aim, the foliage is harvested at 2 to 3

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month intervals by cutting the stems at 50 to 70 cm above the ground, thereby encouraging the plant to re-grow. In this case the roots act as a nutrient reserve to facilitate the re-growth of the aerial part. This process can continue for 2 to 3 years if the nutrients exported in the leaves are recycled as fertilizer (Preston *et al*., 2000). Dual-purpose production systems are also possible whereby one or two harvests of the leaves are taken before the plant is allowed to continue the normal development of the roots.

Table 1. Relative use of solar energy for production of biomass and food/feed.

	Joules	Relative to sun=100
Sun	$52x10^{23}$	100
Biomass	$4x10^{21}$	0.077
Fuel energy	$3.9x10^{20}$	0.0077
Food/feed	$16x10^{18}$	0.003

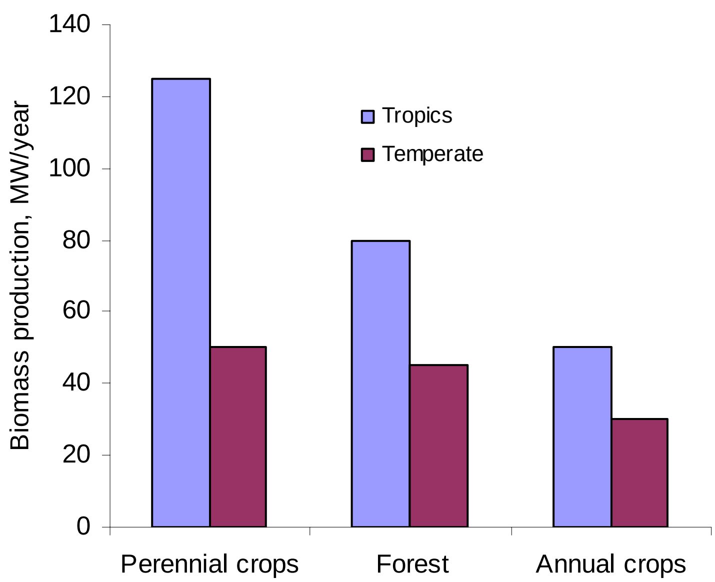

Figure 1. Biomass yield from different ecosystems.
Source: *Kormondy, 1969.*

Cassava as a Perennial Forage

In tropical ecosystems, the cultivation of perennial crops is the most efficient way to capture solar energy in the form of biomass (**Figure 1**). Thus the management of cassava as a perennial forage is one way of responding to the need to use solar energy more efficiently. Growing and using cassava as a perennial forage was first proposed by Moore (1976) based on observations at CIAT in Colombia. High yields of foliage were obtained when cassava was managed as a semi-perennial crop with repeated harvesting of the foliage at 2 to 3 month intervals. This idea was taken up in the Dominican Republic by Ffoulkes and Preston (1978) who showed that the fresh foliage could be used as the sole source of protein and fiber for supplementing a liquid diet of molasses-urea for fattening cattle. Growth rates were over 800 g/day and were not improved when 400 g/day of additional soybean meal was given (**Figure 2**). However, although successful at the level of the animal, the system could not be sustained agronomically. Yields of foliage fell rapidly with successive harvests and were negligible by the fourth harvest, due to a lack of appreciation of the need to return to the soil the considerable amounts of nitrogen and other nutrients removed by repeated harvesting (T.R. Preston, personal observations).

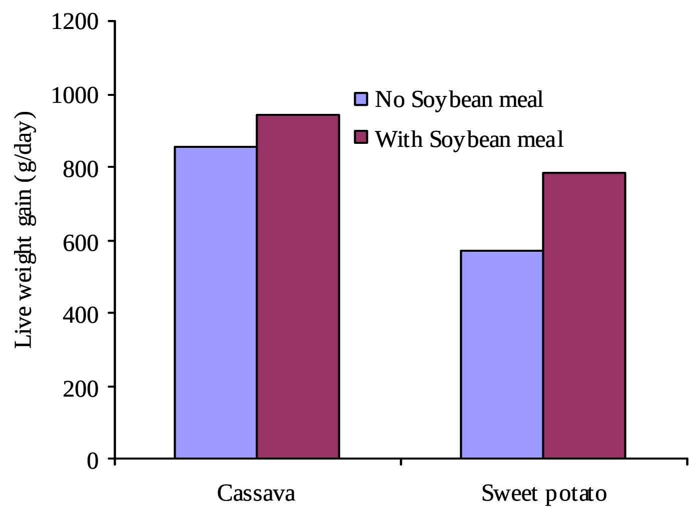

Figure 2. Cassava foliage can provide all the protein and fiber in a cattle fattening diet based on ad libitum molasses-urea, and is superior in this respect to sweet potato vines
Source: *Ffoulkes and Preston, 1978.*

More recent research, first in Vietnam (Preston *et al*., 2000), then in Cambodia (Preston, 2001), has demonstrated that the cassava plant can be maintained as a semi-perennial forage crop for at least two years provided there is heavy fertilization either with goat manure (**Figure 3**) or with the effluent from biodigesters charged with pig manure (**Figure 4**).

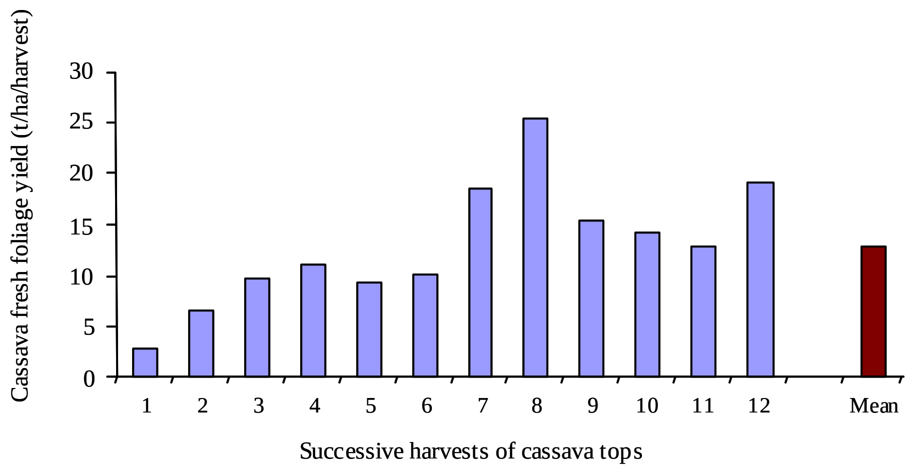

Figure 3. Fresh foliage yields of cassava managed as a semi-perennial forage crop in Vietnam, with repeated harvests at 50 to 70 day intervals and fertilized with fresh goat manure (20 t/ha/harvest)
Source: *Preston et al., 2000.*

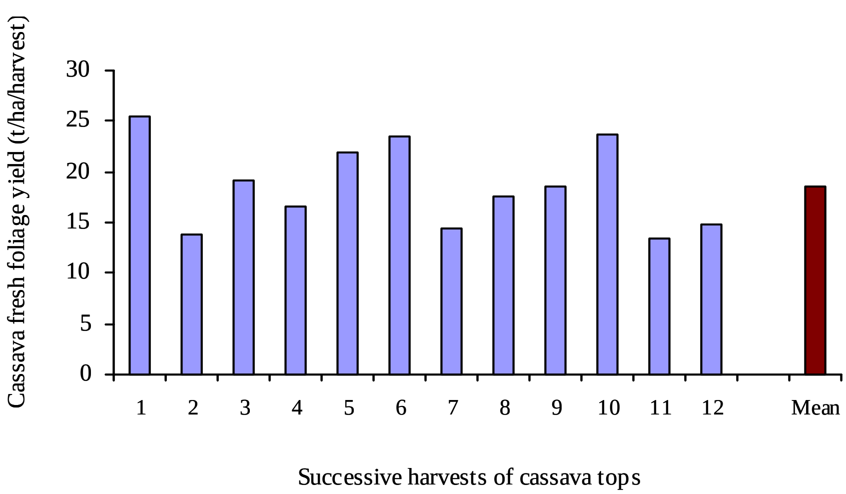

Figure 4. Fresh foliage yields of cassava managed as a semi-perennial forage crop in Cambodia with repeated harvests at 50 to 70 day intervals and fertilized with biodigester effluent (100 kg N/harvest).
Source: *Preston, 2001.*

Cassava and Manure Recycling

In countries with industrialized agriculture the disposal of manure from large-scale livestock units situated close to urban areas has become a major problem (Narrod, 2001). This situation is exacerbated by the restricted growing season in temperate latitudes where industrialized livestock production is concentrated. For example, in Germany the maximum amount of nitrogen that can be applied as manure is only 170 kg N/ha/year. Tropical countries with year-round growth potential do not have this problem. Livestock manure is a major asset and crops such as cassava are capable of taking up as much as 1000 kg N/ha/year in the form of fresh livestock manure or effluent from biodigesters (Preston, 2001).

The processing of livestock manure in biodigesters results in the conversion of much of the organic nitrogen to ammonia (Pedrosa *et al*., 2002; San Thy *et al*., 2003). This makes the biodigester effluent a potentially better source of plant nutrients than the manure from which it is derived. Data in support of this hypothesis were reported by Le Ha Chau (1998) who showed that the effluent supported higher yields of cassava foliage with a higher protein content than the raw manure (either from cattle or pigs) used to charge the biodigesters (**Figure 5**).

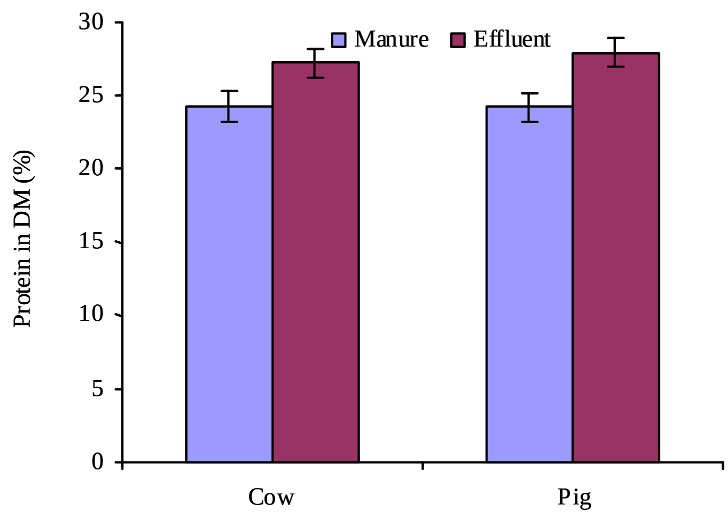

Figure 5. Protein content in cassava leaves is higher when fertilization is with biodigester effluent rather than the original manure used to charge the biodigester.
Source**:** *San Thy et al., 2003.*

Cassava as a Source of Biomass Energy

Irrespective of whether cassava is grown for root or forage production, a considerable part of the biomass is present in the stem. Some stem material is needed as cuttings for re-establishing the crop; however, when it is grown as a perennial forage this requirement is much reduced as the plant will continue to produce from the same root stock for at least 2 to 3 years, provided there is an adequate supply of nutrients.

The cassava stem is a potential source of energy and has been used successfully as a fuel source in a downdraft gasifier (Dinh Van Binh and Preston, unpublished observations). Cassava as a source of fuel (the stems) and protein (the leaves) is a logical complement to energy-rich sugarcane in a co-generation system to provide energy and animal feed (**Table 2**) from high biomass crops.

Table 2. Potential for production of electrical energy (by gasification of residual fiber from sugarcane and cassava) and feed energy and protein (high-test sugarcane molasses and dehydrated cassava leaves) in a co-generation system.

	Sugarcane (ha/yr)	Cassava (ha/yr)
Biomass, tonnes	190	120
Electricity, kwh	61,920	37,840
High test molasses, tonnes	16	
Leaf meal, tonnes		8
Protein, tonnes		2.24

***Source**: T.R. Preston unpublished data.*

Cassava Foliage as Animal Feed

Recent work in Cambodia has aimed to evaluate cassava as a protein supplement for cattle and goats (the fresh foliage) and pigs (the ensiled leaves). Ensiling the leaves after chopping and wilting for 24 hours reduced HCN concentrations to levels that presented no deterrent to feed intake or N retention in growing pigs (Ly and Rodríguez, 2001). In several trials, the cassava silage has been fed successfully to pigs at up to 50% of the diet dry matter (Chhay Ty *et al*., 2003a). In this connection, an important recent finding is that the digestibility of the organic matter and of the protein by pigs was significantly higher when the leaves were derived from fresh re-growths (from repeated harvesting at 2-month intervals) than from mature leaves harvested at 5 months from cassava grown for root production (Chhay Ty *et al*., 2003b).

For ruminant animals, the approach in Cambodia and Vietnam has been on the use of the fresh foliage from cassava grown as a semi-perennial crop on a year-round basis. This is in contrast with the cassava research program in Thailand, which is mainly based on production and utilization of cassava dry hay for dry season feeding (Wanapat *et al*., 1997; Wanapat, 2001).

Results from feeding fresh cassava foliage as a supplement to Brewer's grains for goats are summarized in **Figures 5** and **6**. There were positive effects of the cassava foliage in reducing nematode worm burdens (**Figure 5**) and in supporting growth rates (**Figure 6**). Similar findings have been recorded in Vietnam with goats fed rice bran supplemented with fresh cassava foliage or grass (Nguyen Kim Lin *et al*., 2003). In a trial reported by Ho Quang Do *et al.* (2001), N retention in goats increased linearly when cassava foliage replaced elephant grass in the diet.

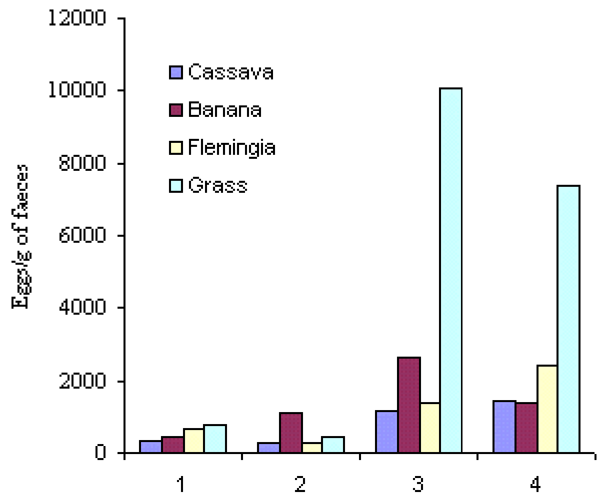

Figure 5: Effect of feeding goats with three types of tree foliages or grass on counts of faecal nematode eggs.
Source: *Seng Sokerya and Rodríguez, 2001.*

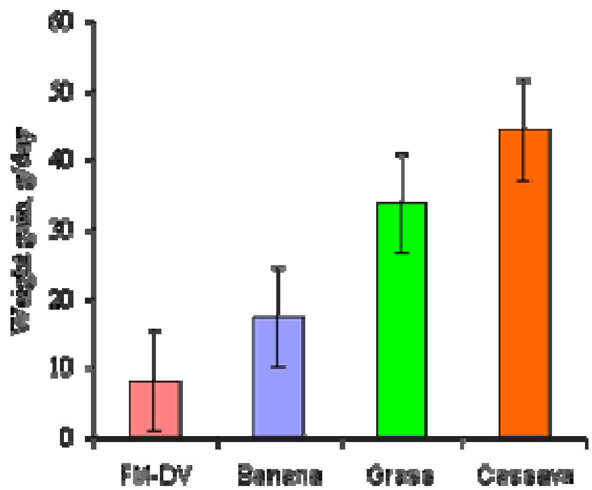

Figure 6: Effect of tree foliages on the growth rate of goats.
Source: *Seng Sokerya and Rodríguez, 2001.*

For cattle the emphasis has been on the use of the cassava foliage to supplement untreated rice straw as a fattening system for local yellow cattle. The results are encouraging, especially when the cassava foliage was combined with a single drench of vegetable oil at the beginning of the fattening period (**Figure 7**).

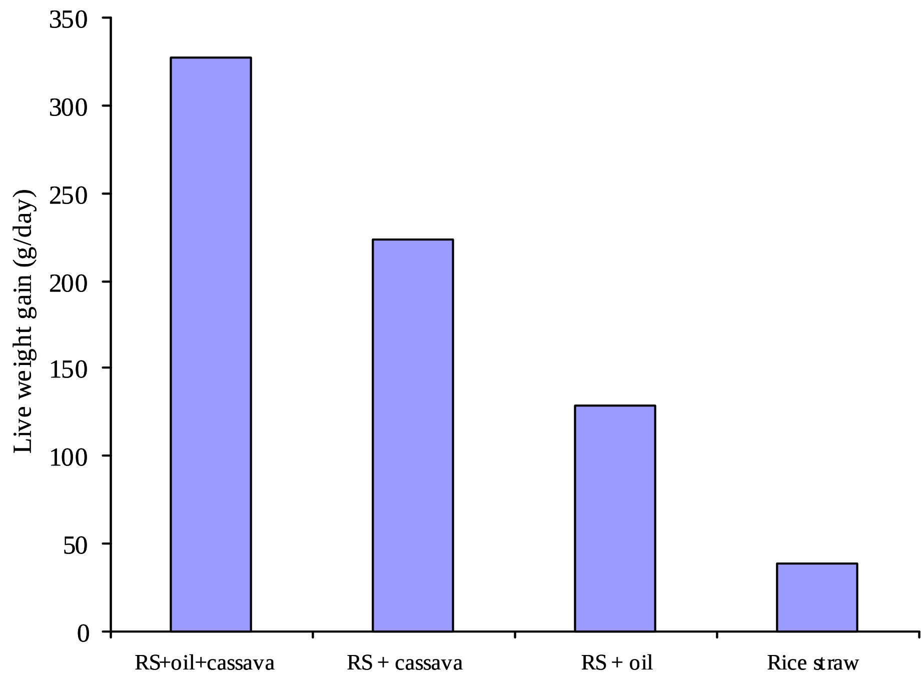

Figure 7. Effect of supplementing rice straw with cassava foliage and a single oil drench for local cattle in Cambodia (all had urea and minerals).
Source: *Seng Mom et al., 2001.*

CONCLUSIONS

Cassava can produce very high yields, especially of protein (up to 4 tonnes/ha/year), which makes it an ideal element for taking advantage of recycled livestock wastes. This high yield potential is complemented by the high nutritive value of the leaves for cattle, goats and pigs. The presence of cyanogenic glucosides does not appear to be a problem in ruminants and can be neutralized by ensiling or drying the leaves before feeding them to pigs. Recent findings that the leaves have anthelmintic properties in goats and cattle confer further advantages on this crop as a component of integrated farming systems.

REFERENCES

ASPO. 2002. Statistical review of world oil and gas. Association for the study of peak oil. 1st Edition, K. Aleklett and C. Campbell (Eds.). Proc. 1st Intern. Workshop on Oil Depletion, held in Uppsala, Sweden. www.isv.uu.se/iwood2002/ASPO-stat-Rev.hlml

Chhay Ty, T.R. Preston and J. Ly. 2003a. The use of ensiled cassava leaves in diets for growing pigs. 1. The effect of graded levels of palm oil on N digestibility and N balance. Livestock Research for Rural Development (15) 7: http://www.cipav.org.co/lrrd/lrrd15/7/chha157.htm

Chhay Ty, T.R. Preston and J. Ly. 2003b. The use of ensiled cassava leaves in diets for growing pigs. 2. The influence of type of palm oil and cassava leaf maturity on digestibility and N balance for growing pigs. Livestock Research for Rural Development (15) 8: http://www.cipav.org.co/lrrd/lrrd15/8/chha158.htm

Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui and C. Courbois. 1999. Livestock to 2020: The Next Food Revolution. Food, Agriculture, and the Environment. Discussion Paper 28. International Food Policy Research Institute. Washington DC.

Ffoulkes, D and T.R. Preston. 1978. Cassava or sweet potato forage as combined sources of protein and roughage in molasses based diets: effect of supplementation with soybean meal. Tropical Animal Production (3):186-192.

Ho Quang Do, Vo Van Son, Bui Phan Thu Hang, Vuong Chan Tri and T. R. Preston. 2001. Effect of supplementation of ammoniated rice straw with cassava leaves or grass on intake, digestibility and N retention by goats. Livestock Research for Rural Development. (14) 3: http://cipav.org.co/lrrd/lrrd14/3/do143.htm

Kormondy, E. J. 1969. Concepts of Ecology. Prentice-Hall, Engelwood Cliffs, NJ, USA.

Le Ha Chau. 1998. Biodigester effluent versus manure from pigs or cattle as fertilizer for production of cassava foliage (*Manihot esculenta*). Livestock Research for Rural Development (10) 3: http://www.cipav.org.co/lrrd/lrrd10/3/chau1.htm

Ly J and L. Rodríguez. 2001. Studies on the nutritive value of ensiled cassava leaves for pigs in Cambodia. *In*: T.R. Preston, R.B. Ogle and M. Wanapat (Eds.). Intern. Workshop on Current Research and Development on Use of Cassava as Animal Feed. MEKARN (SAREC) and Khon Kaen University. ..\My Webs\mekarn\procKK\ly.htm

Moore, C. P. 1976. El uso de forraje de yuca en la alimentación de rumiantes. Seminario Internacional de Ganaderia Tropical, held in Acapulco, Mexico

Narrod, C. 2001. Comments from LEAD. *In*: Electronic conference on area wide integration of crop and livestock production. FAO, Rome Clare.Narrod@fao.org

Nguyen Kim Lin, T.R. Preston, Dinh Van Binh and Nguyen Duy Ly. 2003. Effects of tree foliages compared with grasses on growth and intestinal nematode infestation in confined goats. Livestock Research for Rural Development (15) 6: http://www.cipav.org.co/lrrd/lrrd15/6/lin156.htm

Pedrosa G. J. Chará, N. Conde, S. Giraldo and L. Giraldo. 2002. Evaluación de los biodigestores en geomembrana (pvc) y plástico de invernadero en clima medio para el tratamiento de aguas residuales de origen porcino. Livestock Research for Rural Development (14) 1: http://www.cipav.org.co/lrrd/lrrd14/1/Pedr141.htm

Preston, T. R., L. Rodriguez and Khieu Borin. 2000. Associations of cassava and legume trees as perennial forage crops for livestock. *In*: T.R. Preston and R.B. Ogle (Eds.). Workshop-seminar "Making Better Use of Local Feed Resources" Jan. 2000. SAREC-UAF, UAF, Ho Chi Minh City, Vietnam. http://www.mekarn.org/sarpro/trplrkb.htm

Preston, T. R. 2001. Potential of cassava in integrated farming systems. *In*: T.R. Preston, R.B. Ogle and M. Wanapat (Eds.). Intern. Workshop on Current Research and Development on Use of Cassava as Animal Feed. MEKARN (SAREC) and Khon Kaen University. http://www.mekarn.org/procKK/pres.htm

San Thy, T.R. Preston and J. Ly. 2003. Effect of retention time on gas production and fertilizer value of biodigester effluent. Livestock Research for Rural Development (15) 7: http://www.cipav.org.co/lrrd/lrrd15/7/sant157.htm

Seng Sokerya and L. Rodríguez. 2001. Foliage from cassava, *Flemingia macrophylla* and bananas compared with grasses as forage sources for goats: effects on growth rate and intestinal nematodes. Livestock Research for Rural Development (13) 2: http://www.cipav.org.co/lrrd/lrrd13/2/sok2132.htm

Seng Mom, T.R. Preston, R.A. Leng and U. ter. Meulen. 2001. Response of young cattle fed rice straw to supplementation with cassava foliage and a single drench of cooking oil. Livestock Research for Rural Development (13) 4: http://www.cipav.org.co/lrrd/lrrd13/4/seng134.htm

Wanapat, M, O. Pimpa, A. Petlum and U. Boontao. 1997. Cassava hay: A new strategic feed for ruminants during the dry season. Livestock Research for Rural Development (9) 2: http://www.cipav.org.co/lrrd/lrrd9/2/metha92.htm

Wanapat, M. 2001. Role of cassava hay as animal feed in the tropics. *In*: T.R. Preston, R.B Ogle and M. Wanapat (Eds.). Intern. Workshop on Current Research and Development on Use of Cassava as Animal Feed. MEKARN (SAREC) and Khon Kaen University. http://www.mekarn.org/procKK/wana3.htm