

Back to Hongthong content

Evaluation of tropical forages as feeds for growing rabbits

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Table of contents

1. Introduction
2. Objectives
3. General discussion
 - 3.1 The physiological characteristics of rabbits
 - 3.2 Nutrient requirement of rabbits
 - 3.3 Feeds and feeding systems
 - 3.4 Production characteristics
 - 3.5 *Stylosanthes guianensis* CIAT 184 as an animal feed
 - 3.6 *Panicum maximum* as an animal feed
 - 3.7 Cassava hay as an animal feed
 - 3.8 Cassava, stylo or guinea grass as feed for rabbits
4. Conclusions
5. Acknowledgements
6. References

Paper I

Paper II

1. Introduction

In developing countries, the vast majority of meat rabbits are produced in small scale or backyard systems. It is in such systems that the rabbits can make a valuable contribution towards supplying meat for the poorer urban and rural people.

There are many good reasons for rabbit production: rabbit production as an alternative livestock species, rabbit production as a means of utilising small rural holdings in a profitable manner and rabbit production as a more efficient means of converting low quality feed ingredients into meat for human consumption. Rabbit production can also be a family hobby for semi-rural and urban families and at the same time give the families a supply of very nutritious meat, with all amino acids for human requirements, that is low in cholesterol and high in Omega-3 fatty acids (McCroskey, 2000).

Rabbits have a potential as meat-producing animals in the tropics, particularly on subsistence-type small farms. Such characteristics as small body size (thus low daily feed requirements), short generation interval, high reproductive potential, rapid growth rate and the ability to utilise forages and fibrous agricultural by-products are attributes in favour of rabbit production (Cheeke, 1986). Although rabbits, like many other traditional farm animals, are more suited to cooler climates, however, there are possibilities to raise rabbits also in hot climates.

Raising rabbits on a small scale in an urban environment can provide a means of converting garden and other food wastes into a high quality protein for the family, while also providing excellent manure for the garden, which can be used directly without composting. Cut grass, weeds, hay, straw, surplus or damaged vegetables and fruits, stale bread, and almost any other unspoiled food waste (except for coffee grounds) can be fed to rabbits (Surrey, 1997).

2. Objectives

The objectives of this thesis were to investigate the potential of using tropical forages as feed for rabbits and to test these forages on station as well as on farm.

3. General discussion

3.1 The physiological characteristics of rabbits

The rabbit is a monogastric animal with a relatively proportional stomach and a small intestine of similar length and diameter as the large intestine. The caecum is, however, extremely large in comparison to the rest of the intestinal tract, with a diameter about four times that of the large intestine.

The ingested feed is digested in the stomach (gastric digestion) followed by alkaline digestion in the small intestine of sugar and starch to glucose, and protein digestion to amino acids. There is also a fermentative microbial digestion in the caecum/large intestine, with production of VFA's and microbial cells similar to rumen fermentation. The importance of the caecal fermentation is indicated by the relative size of the organ in the rabbit. Rabbits are coprophages, which means that the feed is processed twice. Fibrous feeds are ground by the teeth and ingested and then digested by gastric and intestinal enzymes as they move down the alimentary canal. The caecum and large intestine is a fermentative vat where feed residues come under microbial digestion with the production of VFA and microbial cells. The residues from digestion in the caecum are formed into pellets encased in a membrane as they pass down the large intestine prior to being voided. These faecal pellets (soft faeces) are ingested and enter the stomach where they remain encased in

the membrane and fermentative activity continues. The rabbit obtains a high supply of B vitamins from the lower gut because of the coprophagia.

Coprophagia of the soft faecal pellets allows the rabbit to digest fibrous feeds efficiently. The primary monogastric type of digestion allows the animal to take advantage of proteins, sugars and starch in the feed. The rabbit feeds during the day and produces soft pellets at night. These soft pellets are consumed directly from anus and the residues are excreted as hard pellets during the day. Such a feeding strategy that includes coprophagia and two opportunities for fermentation of fibre is highly efficient (Leng et al., 2004).

3.2 Nutrient requirement of rabbits,

A correct feed and feeding method will help the rabbit to live a healthier life. Water is a very important part of the daily intake, and there should always be access to cool, clean and fresh water. Without water, a rabbit will not eat (Mindy, 2003).

The rabbit's response to the quality of the proteins in its diet has long been a controversial issue, but which has now been established beyond doubt. There are 21 common amino acids, some of which are synthesised by rabbits and others that are not. Researchers have found that growing rabbits need feed that contains certain amounts of 10 of the 21 amino acids that make up the proteins. Rabbits will always eat more of a balanced feed containing these essential amino acids (Coudert et al., 1986) and the diet should provide a significant portion of the essential amino acids. Growing rabbits require more protein because they are still building bone and tissue.

Fibre is composed of simple sugars (monosaccharides) that are linked in such a fashion that they are undigestible by the rabbit's own enzymes. Some fibre can be degraded by bacteria in the caecum. Products of this are absorbed by the rabbit and provide about 30% of the daily energy need. The undigestible parts of plants (lignin, cell walls, etc.) from hay, straw and branches from foliages contain high percentages of fibre. Fruits and vegetables contain some fibre. However, because of their high water content they are not a good source of fibre. The rabbit needs the fibre to drive digested feed through the digestive tract and divide digested food/faeces into small portions. Fibre is also the best source of energy for bacteria living in the caecum where it is converted into volatile fatty acids. Fibre also protects against GI stasis and helps prevent blockages due to hair, and to retain water in the digestive tract.

Fibre content is generally evaluated on the basis of crude fibre, though this analytical technique is far from perfect. For growing rabbits a 13% to 14% crude fibre in the diet seems satisfactory (Coudert et al., 1986).

Carbohydrates are the primary energy source in the diet of the rabbit. Therefore, the rabbit's need for carbohydrate is also dictated by their energy level. Rabbits with higher energy demands, such as nursing mothers or young growing rabbits, may require more carbohydrates in the diet. Spaying and neutering decreases the need for energy and intake should be modified accordingly. Young, growing rabbits have a high carbohydrate requirement; however, their caecal bacteria can be more sensitive to a high carbohydrate diet than that of more mature rabbits. (Atkins and Smith, 1997)

Studies on the calcium and phosphorus requirements of growing rabbits have shown they need much less of these minerals than lactating does. Any sodium, potassium or chlorine imbalance in the diet can cause nephritis and birth accidents. The risk is particularly high when plants used in the feed have been fertilised with high rates of potassium. Rabbits require water soluble (B group and C) as well as fat soluble vitamins (A, D, E, K). Microorganisms in the digestive flora synthesize sizable quantities of water soluble vitamins which are utilised by the rabbit through caecotrophy (Coudert et al., 1986).

Rabbits are generally divided into 4 classes based on their dietary needs. They are: (a) growing and fattening rabbits; (b) resting (non-pregnant and non-lactating) does and bucks; (c)

pregnant does and (d) lactating does with litters. Each of these classes should be fed a different ration.

3.3 Feeds and feeding systems

Rabbits are grazers and browsers: In natural conditions they eat small meals throughout the day. Most rabbits will graze selectively through a pile of hay, picking out the tastier bits. Rabbits can be extremely picky eaters, and often do not enjoy any attempts to expand their diet. Limiting the amount of pellets fed will encourage nibbling and tasting of hay. Rabbits are herbivores and can be successfully raised on diets that are low in grains and high in roughage (Cheeke, 1986a). It has been reported that growing rabbits can be maintained satisfactorily on diets consisting of 100-200 g green roughage and 40-60 g concentrate mixtures preferably in the form of pellets (Ranjhan, 1980) for optimum production, and about 4 months are required to produce a 2 kg market rabbit under subsistence conditions (NRC, 1991).

Mature and growing rabbits should receive fresh grass hay or straw on a free choice basis. Alfalfa and other legume hays are high in protein, calcium and energy and low in fibre and should be avoided. However, some rabbits are very picky and alfalfa hay is better than no hay at all.

Ambient temperature affects appetite in rabbits. High temperatures usually lead to lower intake, which in turn reduces growth during warm seasons (Maertens and de Groote, 1990; Prud'hon, 1976). This has been shown particularly for low quality diets such as those based on bran (Muir and Massaete, 1991). Most studies have shown that growth rates in high temperature, low intake situations can be increased by increasing the concentration of the digestible nutrients in the feed (Borgida and Duperray, 1992). Diets based on by-products with low degree of concentration, such as bran, may therefore be less useful in tropical hot seasons and more useful in the cooler seasons (Muir and Massaete, 1996).

One of the advantages of rabbit production in tropical countries is that rabbits can be fed forages and agricultural by-products that are not suitable for human consumption. The niche that rabbit production can occupy is in the utilisation of fibrous feeds. Tropical grasses have a cellular structure that resists degradation in the digestive tract. They have a high content of poorly digested constituents such as vascular tissue, parenchyma bundle sheaths and epidermis, and a low content of the more readily digested mesophyll cells. Many tropical feeds contain toxic substances. Some of the tropical legumes contain toxic amino acids or alkaloids (e.g. leucaena contains mimosine, while cassava contains cyanogens). By the use of a mixture of forages, the concentration of specific toxins can be kept to non-hazardous levels (Lukefahr and Cheeke, 1990). The amount of forage offered should be adjusted to be close to the amount voluntarily consumed. The amount of concentrate offered should be about 50 g per animal per day. Either a purchased commercial concentrate or a homemade mix, compounded supplement consisting of garden/table refuse may be used. In addition rabbits require salt in their diet. The palatability of forages is important in rabbit production, particularly in situations when the forages are expected to provide a major part of the daily nutrient intake. Raharjo and Cheeke (1985) and Raharjo (1987) evaluated a number of Indonesian forages in feed preference tests. In general, tropical legumes were preferred over grasses and agricultural by-products, with the exception of gliricidia (*Gliricidia sepium*), a legume which proved to be unpalatable. Leucaena (*Leucaena leucocephala*) is a very palatable feed to rabbits, even though it contains the toxic amino acid mimosine. Erythrina (*Erythrina lithosperma*), another legume, was well accepted. Sweet potato vines were palatable to rabbits in the study of Raharjo (1987), while banana and papaya leaves were poorly accepted. Most of the grasses (eg: Setaria, Brachiaria, elephant grass) were less palatable than the legumes.

Tree leaves can be used in many areas to provide forage in the dry season. Besides the tropical legumes previously mentioned, other trees with potential for feeding include the mulberry (*Morus spp.*) which is used in India, Brazil and Costa Rica as a forage, and black locust (*Robinia*

pseudoacacia), grown extensively in China for rabbit feed. Ramie is utilized in Brazil, where it is considered a highly palatable and nutritious green feed for rabbits (Raharjo 1987).

Table 1. Digestibility in rabbits of some tropical forages fed in the fresh (wilted) state (adapted from Raharjo et al., 1986).

Forage	DM	% Digestibility		
		GE	CP	NDF
Tree legumes				
<i>Calliandra calothyrsus</i>	49.5	51.4	49.8	25.6
<i>Leucaena leucocephala</i>	74.2	69.5	75.9	54.5
<i>Sesbania formosa</i>	69.5	65.8	64.2	46.5
Non-woody legumes:				
<i>Cassia rotundifolia</i>	41.6	40.1	57.5	26.8
<i>Stylosanthes guianensis</i>	43.4	55.1	58.9	18.5
Grasses				
<i>Brachiaria brisantha</i>	16.7	24.5	17.8	11.3
<i>Panicum maximum</i>	12.3	10.7	13.0	7.3
<i>Pennisetum purpureum</i>	46.3	45.2	64.7	42.8
By-products				
<i>Cassava tops</i>	49.9	47.0	42.0	33.0

GE= Gross Energy

Where rabbits are raised on a back-yard scale on subsistence-type farms in the tropics, feeding systems should be as simple as possible. The simplest feeding system would be the free choice feeding of good-quality tropical forages supplemented with a concentrate, roots, tubers or fruit. The adequacy of this feeding system needs to be established by feeding trials conducted in tropical environments (Cheeke, 2003).

Rabbits full-fed on tropical forage may not consume enough to satisfy their water requirements (Jin et al., 1990). Supplementation with roots (cassava, sweet potato) and fruit (banana) may allow the animals to meet their water requirements as well as increasing energy intake (Cheeke, 2003).

3.4 Production characteristics

Medium-weight breeds (4.5 to 6 kg) are able to start breeding at 6 to 7 months of age, with males maturing one month later than females. Because outward signs of heat are not always evident in mature does, a strict breeding schedule should be followed. One buck can service about 10 does, but no more than two to three times a week. The female should be placed in the buck's cage for breeding since if the buck is put in the cage of the doe she will fight to protect her territory. Mating should occur immediately, and the doe should then be returned to her cage. The average gestation period lasts 31 to 32 days. Twenty eight days after breeding a nest box should be placed in the cage of the doe. The average commercial litter consists of 8 to 10 baby rabbits. The nest box can be removed 15 to 21 days after birth. The young should be weaned in about 30 days so that the doe will produce five litters a year (Penn State, 1994).

The growth performance of rabbits in studies reported from tropical countries is generally in the range of 10-20 g per day, in contrast to 35-40 g per day commonly observed in temperate

regions (Cheeke, 2003). The rabbits in Paper I grew from 9.2 to 16.2 g/day and in Paper II from 12.2 to 16.9 g/day which can be considered to be normal for rabbits in the tropics.

3.5 *Stylosanthes guianensis* CIAT 184 as an animal feed

The genus *Stylosanthes*, a legume native to South America, is an important commercial forage legume genus in tropical areas around the world. It is widely used for forage, green manure, cover crops, erosion control, and commercial hay and meal production (Yi Kexian, 2000). *Stylosanthes guianensis* CIAT 184, Stylo 184, is a short-lived perennial legume (2 to 3 years), which grows into a small shrub with some woody stems. It is adapted to a wide range of soils and climates but is one of the few herbaceous legumes, which will grow well on infertile, acid soils. It grows well on coarser textured soils, but not so well on heavy clays and it is not very tolerant of salinity. Unlike earlier varieties of *S. guianensis* (eg. cv. Schofield, Cook and Graham) Stylo 184 has shown good resistance to the fungal disease anthracnose in Southeast Asia. It is usually grown as a cover crop, which is cut every 2-3 months (Horne and Stür, 1999). It does not tolerate being cut close to the ground since there are few buds on the lower stem for regrowth. This can be improved by making the first cut at 10 to 20 cm to encourage branching close to the ground. Subsequent cuts must be made higher (>25 cm) to ensure good regrowth (Horne and Stür, 1999). It is excellent as standover feed as its palatability is high at this stage. Sillar (1969) showed that cattle could be fattened during the three normal dry months in north Queensland on a pure diet of standing stylo. Palatability it is relatively low in the early stages of growth. Schofield (1945) found that it was not grazed by cattle, that had no experience with the legume but, after confining the stock for two days to pure legume alone, they ate it readily.

Over a three-year period, rotationally grazed oversown *Stylosanthes guianensis* pasture at Serere produced a mean of 254 kg/ha/year live-weight gain without fertiliser and a mean of 450 kg/ha/year where single superphosphate was applied. Heavy grazing is detrimental to the plant. Grof and Harding (1968) found that harvesting at 18-week frequency caused the lower stems and crown to become woody, with an almost complete loss of stand. There are very few growing points on these plants as they mature. Stylo persisted under grazing at eight-week intervals at Sigatoka, Fiji (Payne et al., 1955). Since *Stylosanthes* spp. are tolerant of drought and infertile soils, and have multiple uses and high nutritive value, the genus is being more widely used in SE Asia in recent years. Nitrogen concentrations of *Stylosanthes guianensis* range from 1.5 to 3%. Dry matter digestibility of young plant material lies between 60 and 70%, but with increasing age and lignification this may be reduced to below 40% (Mannetje and Lones, 1992). Crude protein figures range from 12.1 to 18.1 % for the whole plant (Sukkasem et al., 2002), but up to 21 % has been reported for leaves by Huy et al. (2000). Stylo should be lightly grazed in the first year after six to eight weeks, to promote tillering and prevent it from becoming woody (Risopoulos, 1966). Long grass should be prevented from shading the stylo.

Table 2. Nutritive value of *Stylosanthes guianensis*

	DM g/kg	g / kg DM					
		CP	CF	Ash	NDF	ADF	
Hay, 6 weeks after first harvest,	921	106	328	73	-	-	Nigeria
Fresh, 40-45 day-old, Lao PDR	202	190	642	55	-	-	Fresh, 40-45
day-old, Lao PDR*	219	200	-	57	602	406	Hay, First cut 3
months after 956 Planting, Thailand	171	-	94	568	391		

(Source: Bamikole and Ezenwa, 1999; Phengsanvanh, 2003; Kiyothong, 2003);*- Result from Paper I

3.6 *Panicum maximum* as an animal feed

Panicum maximum, Guinea grass, is a tufted perennial, often with a short creeping rhizome, variable height, 60-200 cm, leaf-blades up to 35 mm wide tapering to fine point; panicle 12- 40 cm long, open spikelets 3-3.5 mm long, obtuse, mostly purple red, glumes unequal, the lower one being one-third to one-fourth as long as the spikelet, lower floret usually male. The grass originates from tropical Africa, but has been introduced in many countries. It requires a rainfall usually in excess of 1 000 mm per year. With summer dominance, cv. Gaton and creeping Guinea do not tolerate very wet conditions, the range is 780-1,797 mm (Russell and Webb, 1976), and it does not tolerate severe drought. On an oxisol at Carimagua, Colombia, *Panicum maximum* dried the profile to a depth of 60 cm in the dry season, where *Andropogon gayanus* dried it to over 120 cm depth.

Guinea grass is the most productive forage grass in tropical areas and produces high yields of palatable fodder. The highest nutritive value is obtained at the cutting height of 60-90 cm, but for higher yields it can be cut up to 1.5 m height as it does not become coarse even if left to grow to that height. (Sukkasame and Krongyuti, 1999) reported that DM and CP yields of *Panicum maximum* TD 58 at 45 days cutting interval were 7182 kg/ha and 490 kg/ha, which were different and higher than at 30 and 60 days cutting interval. When nitrogen fertiliser was applied (287 kg/ha) there was a significant increase in DM and CP yield (42,281 and 3,050 kg/kg respectively) compared to the non nitrogen fertiliser application (30,587 and 2,206 kg/ha) Yuthavoravit et al., 1995).

Table 3: Nutritive value of *Panicum maximum*

	DM g/kg	g / kg DM				ME
		CP	Ash	NDF	ADF	MJ
Fresh, 40-45 day-old, Lao PDR	230	121	52	712	445	94
Fresh, 40-45 day-old, Lao PDR*	245	96	83	770	438	94
Fresh, cut at interval 1 week Malaysia	220	200	110	-	-	-
Fresh, cut at interval 6 week Malaysia	250	90	130	-	-	-

(Source: Duke, 1983; Viengsavanh, 2001);*- Result from Paper I

3.7 Cassava hay as an animal feed

Cassava cultivation for several years usually results in a decline in soil fertility. Planting cassava for hay making, aims at increasing the whole crop digestible biomass, and the tuber root is a by-product. Earlier work by Wanapat et al. (1997) showed that planting cassava at 60x40 cm between rows and intercropped with cowpea or *Leucaena* could improve the soil fertility and the biomass could be used as food and feed for humans and livestock. The fresh whole crop was directly sun-dried or chopped before sun-drying to obtain a DM of 80% to 90%. This took 2-3 days but chopping shortens the drying process. Sun-drying also eliminates hydro-cyanic acid (HCN) by more than 90% and enhances the palatability and long-term storage.

Protein yield of cassava hay has been reported to range from 1.5-1.7 t/ha for six consecutive harvests (Wanapat, 2002). Cassava leaf/hay contains high levels of nutrients, especially protein. It has been found that cassava hay harvested at a younger state of growth (3 months) contained up to 25% CP and with a good profile of amino acids. When comparing cassava leaf and cassava hay with soybean meal and alfalfa hay the amino acid profiles were relatively similar. Cassava hay contains condensed tannins or proanthocyanidins, which are common in tropical plants. Condensed tannins are polyphenolics, which are easily soluble in water and can precipitate protein.

Omole and Onwudike (1983) reported that inclusion of 5% palm oil in rabbit diets containing cassava peel meal reduced the toxic effects of cyanide and increased the urinary excretion of thiocyanate. The same authors have also reviewed the use of cassava in rabbit feeding. Both cassava meal and cassava peel meal have supported adequate performance (compared to controls in the same environment) when used at levels up to 30–40% of the diet. In an experiment in Scotland, performed with cassava meal imported from Thailand, Radwan et al. (1985) observed excellent growth rates (41 g/day) of rabbits fed diets with up to 50% cassava meal, substituted for barley. Omole and Sonaiya (1981) noted better growth of rabbits when fishmeal rather than groundnut meal was the protein supplement in diets containing cassava peel meal, reflecting the poor protein quality of cassava protein (Cheeke, 1986).

Table 4. Nutritive value of Cassava hay

	DM g/kg	g / kg DM				
		CP	CF	Ash	NDF	ADF
Cassava hay, 3 months, Thailand	923	206	-	75	550	389
Cassava hay, 3 months, Lao PDR* 787	224	-	53	540	307	
First cut 3 months after planting, Thailand	953	323	-	57	257	252
Fresh, 3 months after planting, Vietnam (Ho Chi Minh City)	180	196	-	51	382	286

(Source: Wanapat, 1999; Kiyothong, 2003; Khang, 2004);*- Result from Paper I

3.8 Cassava, Stylo 184, Guinea grass or natural vegetation as feed for rabbits

The Guinea grass diet in Paper I could not sustain the growth of the rabbits, which was also found by Bamikole and Ezenwa (1999). The weight gains obtained were lower than those reported by Harris et al. (1981). The CP and the intake of the Guinea grass diet in Paper I was not enough to get a good growth performance of the rabbits. The rabbits fed Stylo 184, *Spilanthes* and Cassava hay had a higher daily weight gain than the rabbits fed Guinea grass. There was a strong positive relationship between CP intake and daily weight gain, which could be expected. As shown in Diagram 3, however, the optimum level in this experiment was between 138 g and 139 g CP/kg DM, which is lower than the recommendations by NRC (1977). When promoting small scale rabbit production in tropical areas the problem is often to find suitable protein and energy sources in all seasons. Cassava leaves can be produced on-farm by using simple techniques like chopping and sun-drying, which reduce tannins and free cyanides in the cassava leaves. Fresh Stylo can also be used to feed to rabbits directly. These two feeds can supply a major part of the protein and fibre required. However for good growth performance the rabbits also require supplementation with some source of energy, such as rice bran, cassava root and maize. These feeds are normally available and produced by the farmers and can be used to make concentrate mixtures for feeding rabbits.

The natural vegetation used as a control consisted mainly of one herb (*Spilanthes acmella* Murr) in Paper I and of many different grasses in Paper II. The two experiments were carried out in different seasons. The herbage in Paper I was in an early vegetative state in June to August and had a good nutritional value. When the second experiment was carried through this herb was not available and the natural grasses had already started to lignify, which explains why the intake and growth were lower for the natural grasses diet in Paper II.

4. Conclusions

Rabbit production can be a family hobby for semi-rural and urban families and at the same time give the families a supply of very nutritious meat. This is largely attributable to the rabbit's high rate of reproduction; early maturity; rapid growth rate; high genetic selection potential; efficient feed and land utilization; limited competition with humans for similar foods; and high-quality nutritious meat.

On small farms in Laos rabbits are only raised in small-scale systems, in which high-cost inputs such as pig starter pellets or commercial concentrate feeds cannot be justified. The small backyard rabbitry therefore depends on local feed resources such as forages and native grasses, both of which can be collected close to the production site.

The strategy of using tropical forages as a supplement to a home made concentrate can be a potential way to improve the growth performance of rabbits. The results from Papers I and II show that when feeding growing rabbits a concentrate as a basal diet the best performance was obtained when supplementing with Stylo 184 or *Spilanthes acmella* Murr in an early development stage.

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