Erythrina Foliage as an Alternative Feed for Growing Goats in Lao PDR

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Cover: Erythrina foliage, an alternative feed that goats are looking for!!!
(photo: Daovy Kongmanila)

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Abstract

Foliages from some tropical plants and from different species of the legume Erythrina were examined in five studies assessing the characteristics of these foliages as feed for goats.

Digestibility and feed preference studies showed that *ad libitum* feeding of foliage from Erythrina (*Erythrina variegata*), jackfruit (*Artocarpus heterophyllus*) and kapok (*Ceiba pentandra*) resulted in a longer time spent eating and more changes in diet selection, feed intake, crude protein (CP) digestibility and nitrogen (N) retention than foliage from jujube (*Ziziphus jujube* Mill), fig (*Ficus racemosa*) and mango (*Mangifera indica*). Supplementation of low quality foliage with water spinach (*Ipomoea aquatica*) increased intake and apparent digestibility.

In a survey study, three different Erythrina spp., *E. indica*, *E. subumbrans* and *E. variegata*, were found in the north, centre and south of Lao PDR. These species were in limited use as an animal feed on smallholder farms. *Erythrina variegata* appeared to be a better option in terms of degradability than *E. indica* and *E. subumbrans* according to *in vitro* gas production and *in sacco* degradation studies.

A cropping study showed that cow manure or mineral fertiliser significantly decreased shoot mortality and increased shoot height and fresh and CP yield of *E. variegata* foliage compared with no fertiliser. The nutritive value of the foliage did not differ significantly between the fertilised and unfertilised treatments.

Studies on different degrees of processing (fresh or sun-dried) of *E. variegata* foliage showed similar CP, neutral detergent fibre and acid detergent fibre contents, and no difference in total voluntary intake, when either fresh or dry foliage was fed *ad libitum* to growing goats.

Four levels of replacement (0, 20, 40 and 60%) of dietary CP with CP from *E. variegata* foliage resulted in similar dry matter intake, apparent CP digestibility, N retention and carcass characteristics, but total CP intake was significantly higher in goats fed the diet with 60% replacement compared with 20%. Thus CP from *E. variegata* foliage can replace up to 60% of CP in a mixed diet with soybean meal without any negative effects on animal growth performance.

Keywords: Intake, digestibility, N retention, growth performance, carcass characteristics, tropical foliage, *Erythrina indica*, *Erythrina subumbrans, Erythrina variegata,* degradability

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Dedication

To my family with my respectful gratitude,
To my husband Khamphouvieng,
and my son Symoungkhoun.

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Kongmanila, D. and Ledin, I. (2009). Chemical composition of some tropical foliage species and their intake and digestibility by goats. *Asian-Australasian Journal of Animal Sciences* 22 (6), 803-811.

II Daovy, K., Preston, T.R. and Ledin, I. (2008). Selective behaviour of goats offered different tropical foliages. *Livestock Research for Rural Development* 20 (5), 1-7.

III Kongmanila, D., Bertilsson, J., Ledin, I. and Wredle, E. (2012). Effect of feeding different levels of foliage from *Erythrina variegata* on the performance of growing goats. *Tropical Animal Health and Production* 44 (7), 1659-1665.

IV Kongmanila, D., Bertilsson, J., Ledin, I. and Wredle, E. (2012). Utilisation of some Erythrina species and biomass production of *Erythrina variegata. Livestock Research for Rural Development* 24 (8), 1-8.

V Kongmanila, D., Bertilsson, J., Ledin, I., Yuangklang, C. and Wredle, E. Assessment of degradability and intake of Erythrina species by goats (submitted).

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Abbreviations

ADF	Acid detergent fibre
ADG	Average daily gain
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
BW	Body weight
CP	Crude protein
DM	Dry matter
DMI	Dry matter intake
IVOMD	*In vitro* organic matter digestibility
Lao PDR	Lao People's Democratic Republic
LSB	Lao Statistics Bureau
NDF	Neutral detergent fibre
NPK	Fertiliser containing nitrogen, phosphorus and potassium
OM	Organic matter

1 Introduction

Lao PDR is located in Southeast Asia, and has an estimated population of 6.3 million (2010 data). Approximately 73% of the population lives in rural areas, obtaining their income from a combination of rice-based agriculture, collection of forest products and livestock production. In 2010, 28.4% of GDP came from the agriculture sector, 79% of which was from crops and livestock production, 10% from forest products and 11% from aquaculture products (LSB, 2010).

Livestock production plays an important role for the livelihood of farmers in rural areas, providing the majority of their cash income, dietary protein and organic fertiliser for crop production. However, even though ruminants provide a major proportion of the annual cash income and capital assets of households, small farmers only keep a small number of animals, using traditional management methods such as free range grazing systems and selling at opportunistic times. In general, the main limitations to ruminant production are diseases and lack of feed, particularly in the dry season. Supplementation with conventional concentrates is generally too costly and the levels of concentrate feeding are therefore limited or even non-existent (Daovy *et al.*, 2008; Xaypha, 2005). High morbidity and mortality rates are common and poor nutrition causes low reproductive rates and weight gain (FAO, 2005; Stür *et al.*, 2002).

Goats have the advantage of having lower requirements for space and capital investment than cattle or buffalo. Goats are important and suitable for poor farmers, who cannot afford to invest in large ruminant production (Boyazoglu *et al.*, 2005). Goats can be found everywhere in Lao PDR at present, with 366,000 head in total in 2010, but this is a small number compared with the population of other animals: 1.18 million buffaloes, 1.47 million cattle, 2.75 million pigs and 24.08 million poultry (LSB, 2010). However, the population of goats has increased slightly annually, 8.7-14.2% during the last 20 years (LSB, 2010; FAOSTAT, 2003). There appears to be a growing interest in goat production at present, due to the increase in local and export demands from neighbouring countries such as Thailand and Vietnam,

offering a price incentive to producers. The current market price of goats is between 2.3 and 2.8 USD per kg live weight, which is higher than that for cattle and pigs (1.9-2.1 and 2.0-2.3 USD per kg live weight, respectively).

Almost 100% of goat production is performed under smallholder conditions and is based on feeds derived from available native pastures, such as grass, browse and fodder trees. The animals are allowed to graze freely all year round in forest and fallow cropland or natural grassland, without any supplementary feeds. However, grazing land is limited in intensive cropping areas in the rainy season, so the goats are only allowed to graze for 3-4 hours per day in some areas. Hence the animals do not consume sufficient nutrients, which results in weight loss or low annual weight gain and poor reproductive performance.

Therefore, there is a need to look at ways to improve goat production in smallholder systems in Lao PDR. New low-cost alternatives to commercial or home-made concentrates are needed. The locally available feedstuffs, such as fruit tree leaves, fodder trees and legumes, in different seasons need to be investigated and improved by feed processing and conservation, and used as strategic supplementation. Improvement of the quality and quantity of feeds will play a key role in increasing the productivity of smallholder goat production in the future.

2 Objectives

The overall aim of this thesis was to find new potential local feed resources for goats that can be recommended to smallholder farmers in Lao PDR. Specific objectives were to:

+ Study the nutritive value of foliage from six different tropical species and compare their intake, preference and digestibility in goats.

+ Investigate the effect of feeding fresh or sun-dried *E. variegata* foliage as a sole feed and as a supplement at different levels of this foliage on the performance of growing goats.

+ Identify species of the legume Erythrina available in Lao PDR and determine their utilisation, foliage yield and characteristics as animal feed.

2.1 Hypotheses

+ Some of the six tropical foliages studied will be preferred by goats and these foliages will positively influence intake and digestibility in growing goats (Papers I and II).

+ Protein from *E. variegata* foliage can replace the more expensive protein from soybean meal in a mixed diet, without any negative effects on the performance of growing goats (Paper III).

+ More than one Erythrina species is grown in different areas in Lao PDR and their foliage has different potential as animal feed (Papers IV and V).

+ Using cow manure as a fertiliser when cultivating *E. variegata* gives a higher foliage yield than mineral fertiliser (Paper IV).

+ The voluntary intake by goats is similar for dry *E. variegata* foliage and fresh foliage (Paper V).

3 Background

3.1 Smallholder goat production in Lao PDR

In Lao PDR goats are mainly kept for meat production, but the number of animals per household is small (less than 10 head), growth rates are low and productivity is generally poor. Goats are more important for cash income than other animal species in many areas (Daovy *et al.*, 2008; Xaypha, 2005). Due to the small size of goats, they are reasonably easy to manage and women or children are generally responsible for their care (Millar & Photakoun, 2008). Normally, the goats sold as live animals for local consumption and to restaurants come directly from villagers. The animals are purchased per head by size of the animal and individual appearance. The goats on smallholder farms play an important role for food security and also have special social and cultural values in celebrations (*e.g*. Lao New Year, anniversary occasions, *etc*.).

The breed used is a native or local breed, which is closely related to the Vietnamese grass goat and similar to the "Ma T'ou" or "Katjang" goats that are common throughout Southeast Asia. The mature weight of the goats can reach 40 kg, but the average live weight is around 32 kg for the male and 28 kg for the female. The first kidding of this local goat is at an average age of 12 months, with only one kid in the first kidding, and then commonly twins in later kiddings. The goats can produce 1.4 to 1.9 litters per year and 1.7 to 1.9 kids per litter (Daovy *et al.*, 2008; Xaypha, 2005; Phengsavanh, 2003b; Phimphachanhvongsod, 2001; Phengvichith, 1997).

Phimphachanhvongsod (2001) found four different systems for goat production in northern areas of Lao PDR according to land area, community regulations and management practices. These are: (1) Free range, in which the goats are allowed to graze freely on natural forages without supervision; (2) semi-rotational grazing, in which the goats are confined and grazed on the crop

fallow land during the planting season and allowed to graze freely after crop harvesting; (3) semi-free range, in which the goats are allowed to graze freely during the off-season for crops, while during the cropping season they are tethered or confined and cut-and-carry feeding is practised; and (4) permanent grazing, in which the animals are grazed permanently in a specified area by some groups of farmers, and salt and water are provided regularly.

3.1.1 Potential for goat production

Over 90% of the goat population in the world can be found in developing countries, and goats are becoming increasingly important in these countries as subsistence food producers (Glimp, 1995). Goats are small livestock and can produce in extensive production systems with lower capital, and fewer other inputs, compared with large ruminants such as cattle or buffaloes. They generally have a high reproductive rate, which makes them very attractive and accessible to poor smallholder farmers (Phengsavanh, 2003b). Goats also play an important role in replacing pigs in Muslim areas of many countries, *e.g*. in Indonesia, Malaysia, the Philippines and Thailand.

The aim of the Lao government is to obtain an average meat supply of 60 kg/capita/year and to increase meat exports to a value of USD 50 million by 2020 (FAO, 2005). Meat demand and consumption are increasing in Thailand, Vietnam and China (Quirke *et al.*, 2003). These countries border Lao PDR, which is creating an opportunity to capitalise on the growing livestock sector (Stür *et al.*, 2002). Approximately 25% of all ruminants produced are exported annually to Thailand or Vietnam (FAO, 2005). The price of goats is higher in those countries than in local markets in Lao PDR. Therefore, exports of goat meat have increased in recent years and are likely to continue to do so in the future. The availability of approximately 7-8 million hectares in Lao PDR that are suitable for ruminant grazing is an another advantage for goat production (Bouahom, 1994). The goats are usually managed as part of multi-species grazing systems, and including goats with herds of cows generally reduces shrub competition (Glimp, 1995).

3.1.2 Constraints and limitations to goat production

Nampanya *et al.* (2010) found that the main constraints for livestock production in smallholder systems in Lao PDR are low reproduction rates and poor nutrition. The animals are highly affected by parasitic disorders and infectious diseases. There are also seasonal feed shortages due to the fact that native grasses have a low yield and are plentiful only during the rainy season. Lack of land and labour to look after the animals in poorer households is an additional limitation (Stür *et al.*, 2002). The traditional feeding systems are

also not suitable, especially in the lowland and valley areas of the uplands (Xaypha, 2005), due to limited grazing land as crop production and constructions areas have expanded.

During the cropping season, goats are tethered or confined in small areas, where feed is limited, to avoid crop damage. In the dry season, the amount and quality of feed is low (Phengsavanh, 2003b). Although goats are allowed to graze freely in this season, they probably need to walk long distances in search of feed, resulting in inadequate nutrient consumption. Thus farmers' knowledge of livestock management needs to be improved to enhance the potential for ruminant productivity gains (Nampanya *et al.*, 2010). Knowledge about the potential of foliage from different indigenous trees and shrubs and how to use these feed resources as a dietary supplement for livestock is limited in lowland areas (Daovy *et al.*, 2008).

Diseases such as internal parasitic infestation, orf (contagious ecthyma) and bloat generally occur in goats in many areas (Wilson, 2007; Phengsavanh *et al.*, 2004). Heavy worm infestations and bloat are the main cause of high post-weaning mortality of kids, which can be as high as 50% in some years (LSB, 2010). While goats infected with orf can be treated relatively easily if farmers take care at the time of an outbreak, in general goats are severely affected and lose weight.

3.2 Available feeds and feeding of ruminants in smallholder production systems

Feeding systems for ruminants differ in various countries in Southeast Asia. Tethered or free-grazing animals utilise the native grasses, often communally, in rangelands, forests, fallows, wasteland, roadsides and cultivated areas after crop harvest. Animal confinement with cut-and-carry systems and zero-grazing on intensively-cropped small mixed farms are also commonly practised (Devendra *et al.*, 2000).

Four main categories of feed resources are potentially available for use in smallholder crop-animal systems in Asia, according to Devendra and Sevilla (2002): pastures (native and improved grasses, legumes and multipurpose trees), crop residues, agro-industrial by-products and non-conventional feed resources. Native grasses (*e.g.* in permanent pastures, unclassified land and forest areas) and crop residues (*e.g.* straw and stubble) are the main feed resource for ruminants and are available in large quantities, but are of poor quality. Most energy-rich and protein-rich concentrate feed ingredients available are used by the feed manufacturing industry to produce feeds for

monogastric animals. There is a lack of data on the amount of material available as feed supplements for smallholder ruminants.

In many regions, native grasslands are in decline due to changes in land use. Crops, including forages and legumes, are grown specifically for ruminants represent a relatively small component of the available feed resources on mixed farms. Some multi-purpose trees, leguminous trees and shrubs, such as Sesbania (*Sesbania sesban*), Gliricidia (*Gliricidia sepium*), Flemingia (*Flemingia macrophylla*), Leucaena (*Leucaena leucocephala*), Calliandra (*Calliandra calothyrsus*) and cassava (*Manihot esculenta,* Crantz) have been introduced in some regions (Devendra & Sevilla, 2002; Stür *et al.*, 2002; Sukanten *et al.*, 1997; Yuhaemi & Ivory, 1994). Many advantages and uses of these trees have been described, *e.g*. by Devendra (1993). Leucaena is the species used most extensively on small farms in Asia, although Gliricidia gained some popularity as a substitute for Leucaena in the 1980s. The role of multi-purpose trees and shrubs in the nutrition of farm animals is especially significant in the harsher, drier environments of the arid/semi-arid zones, as well as in the hills and uplands of the humid parts of Asia during summer (Devendra & Sevilla, 2002). The main potential role of introduced forage grasses and tree legumes in Lao PDR is as a supplement to ruminants that spend most of their time grazing on the native grassland (Phimphachanhvongsod, 2003; Stür *et al.*, 2002).

The overall extent of utilisation of trees and shrubs as fodder in global smallholder mixed farming systems is still limited. The conservation of fodder by silage and hay making for dry season feeding has also not made any impact on smallholder farmers. For example, in Nepal, despite the fact that some 60 species of trees and shrubs are utilised for animal feed on small farms, only 2 kg of fresh leaves from these sources constitute the given ration during the peak of feed scarcity. In coconut-growing areas of Sri Lanka, the feed rations for cattle and buffaloes contain only 8-12% Gliricidia (Ibrahim & Jayatileka, 2000). Moreover, there are 42 different forages available to goats in Indonesia (Dahlanuddin, 2001) and 20 browse species are important for goats in Burkina Faso (Sanon *et al.*, 2007), while 15 species have been mentioned for lowland areas of Lao PDR (Daovy *et al.*, 2008). Foliages are not used to any great extent by small farmers, which is probably due to low indigenous knowledge about foliages and how important they can be as animal feeds.

3.3 Foliage as a feed for ruminants - advantages and limitations

Use of fodder trees, shrubs and legumes has been demonstrated as a technical solution for areas facing serious nutrient shortages (Ben Salem & Smith, 2008).

Many types of foliage are available around such farms and in forests, and these foliages have been proven to be good feed resources for small ruminants, especially in the dry season (Binh & Lin, 2005; Chen *et al.*, 1991). Simbaya (2002) reported that the foliage from fodder trees, legumes and shrubs has a high protein content, ranging from 14 to 25%. The advantage of using these trees as a source of feed for ruminants is that supplementation with their foliages to up to about 35% of the diet does not seem to have any effect on the intake of fibrous feed materials. The dry matter (DM) intake is often increased by feeding green fodder or fodder legumes as a supplement, *e.g*. kapok (*Ceiba pentandra*) or cassava foliage can increase feed intake and weight gain when used as a supplement to natural grasses of low or medium quality, and tamarind (*Pithecellobium dulce*) foliage can increase the milk yield of female goats after kidding (Kouch *et al.*, 2005; Phengvichith & Ledin, 2005).

In the various farming systems of Asia and the Pacific region, some foliages are offered as sole feeds and feeding most of these foliages results in a high feed intake and digestibility and a positive nitrogen (N) balance in small ruminants. This applies to foliage from acacia (*Acacia mangium*), cassava, Erythrina, Flemingia, Gliricidia, jackfruit (*Artocarpus heterophyllus*), Leucaena and water spinach (*Ipomoea aquatica*) (Van *et al.*, 2005; Lin *et al.*, 2003; Mui *et al.*, 2002; Phimphachanhvongsod, 2001; Baidya *et al.*, 1995). Some foliages are also used as protein sources to supplement other feeds, *e.g*. cassava (Phengvichith & Ledin, 2005; Khang, 2004); Erythrina (*Erythrina variegata*), Gliricidia and Leucaena (Ajayi *et al.*, 2005; Aregheore & Perera, 2004a; Kusmartono, 2002; Dana *et al.*, 2000); jackfruit (Kusmartono, 2002; Duyen *et al.*, 1996), kapok (Kouch *et al.*, 2005); mango (*Mangifera indica*) and fig (*Ficus racemosa*) (Ajayi *et al.*, 2005). In general, the foliages can improve the feed quality when feeding roughages of low nutritive value and can also increase DM and N intake.

In addition to the high levels of proteins, minerals and vitamins in their foliage, the potential of fodder trees and shrubs is also enhanced by the presence of many complex chemical constituents which have anthelminthic, antimicrobial, antiprotozoal and antiseptic properties (Devendra & Sevilla, 2002). According to Leng (1997), the main limitation to effective utilisation of these foliages as a feed for ruminants is a high content of tannins and other anti-nutrients such as saponins, cyanogens, mimosine and coumarins. Several studies have demonstrated that dietary condensed tannins affect animal nutrition, growth performance and milk yield (Ben Salem & Smith, 2008; Hove *et al.*, 2001; Ramirez, 1999; Singh & Joshi, 1990). Condensed tannins are able to bind and precipitate with proteins and then depress the activity of

digestive tract enzymes (Silanikove *et al.*, 2001) and inhibit ruminal bacteria growth and metabolism (Min *et al.*, 2005).

However, tannins can also have a beneficial effect on small ruminants, in helping to increase the amount of rumen undegradable protein and supplying essential amino acids to the gut, which may occur especially when the level of tannin is low (2-4%) (Barahona *et al.*, 1997; Fassler & Lascano, 1995). Forage legumes containing condensed tannins can also reduce parasite infections in small ruminants (Nguyen *et al.*, 2005). There are some simple methods to reduce the negative effects of tannins, *e.g.* post-harvest processing techniques such as sun-drying, wilting or ensiling of forages, which can reduce the tannin content by 55-77% of the initial value (Bunyeth, 2005; Ben Salem *et al.*, 1999; Jackson *et al.*, 1996; Makkar & Singh, 1993).

3.4 Feed selection and dietary preferences of small ruminants

It is well known that animals choose different plant species to meet their nutritional requirements. Species preference differs according to various factors, such as animal species, forage availability and accessibility and the nutritional and physiological state of the animals. Ruminants select nutritious diets from a diverse array of plant species. They possess a degree of nutritional wisdom in the sense that they generally select feeds that meet nutritional needs and avoid feeds that cause toxicosis, particularly goats and sheep (Provenza, 1995; Provenza *et al.*, 1994a; Provenza *et al.*, 1994b).

When small ruminants graze and browse under extensive conditions, goats have a habit of selecting their feed carefully when eating and are considered to be browsers, while cattle and sheep are grazers (Sanon *et al.*, 2007; Ngwa *et al.*, 2000; Dumont *et al.*, 1995). Goats can utilise a wide range of native range plants, including foliage from trees and shrubs (browse), forbs and grasses throughout the year. They are able to select a relatively high quality diet from a variety of available feeds (Ramirez, 1999). According to Steele (1996), the anatomical characteristics of goats, with small mouths and split upper lips, enable them to select even very small parts of a plant. However, goats are also considered to be very fastidious and even when they have a very large selection to choose from, they only consume the most nutritious feed available (Fajemisin *et al.*, 1996), and the more selective feeding behaviour of goats results in lower feed intake compared with sheep (Abijaoudé *et al.*, 2000).

In general, shrubs are preferred and selected over other types of vegetation by small ruminants in extensive production systems (Ramirez, 1999). The shoots and leaves are generally preferred to stems when goats are allowed to select (Steele, 1996), and goats spend 383 minutes of every 24 hours on eating

activity (Keskin *et al.*, 2005). Method of presentation of feed is also an important factor for animal-selected diets. Van *et al.* (2005) and Samkol (2003) suggested that hanging up the foliage was the best way to improve feed intake and eating rate of local goats fed jackfruit, Flemingia, acacia and Muntingia (*Muntingia calabura*) foliage.

An optimal intake of nutrients by grazing animals could be more easily achieved and controlled if their dietary habits and preferences were better understood. In the traditional system, factors such as quality and quantity of forage ingested, time spent during grazing and the skill of the herdsman play a great role in the productivity of the flock (Ngwa *et al.*, 2000). Therefore, knowledge of the feeding behaviour and an understanding of diet selection in ruminants is of fundamental importance for grazing management and the determination of opportune feeding strategies (Claps *et al.*, 1997). This information could allow optimal forage allocation to different types of herbivores, the selection of appropriate plant species for reseeding deteriorated rangeland, prediction of the outcome of overgrazing by different animals and identification of new forage species on which to base animal production systems.

4 Summary of materials and methods

4.1 Overall layout of the study

The study involved five experiments: fresh foliage from six tropical plant species, Erythrina (*Erythrina variegata*), fig (*Ficus racemosa*), jackfruit (*Artocarpus heterophyllus*), jujube (*Ziziphus jujube* Mill), kapok (*Ceiba pentandra*) and mango (*Mangifera indica*), was compared concerning intake and digestibility (Paper I) and dietary preferences in growing goats (Paper II). The results showed that the Erythrina foliage had potential based on crude protein (CP) content, intake and digestibility. This foliage would also be suitable as an animal feed on small-scale farms due to its biomass production and alternative uses.

In Paper III, different levels of *E. variegata* foliage were added to the diet of goats to replace more expensive feedstuffs. The biomass production of this foliage was investigated when two types of fertilisers were used (Paper IV) and voluntary intake of sun-dried foliage was tested (Paper V). The occurrence of *E. variegata* and other Erythrina spp. in Lao PDR was also mapped and utilisation of Erythrina species and the nutritive value of their leaves were examined (Paper V).

4.2 Location of the study areas

All experiments on animal performance (Papers I, II, III and V) and the biomass study (Paper IV) were carried out at the Faculty of Agriculture, National University of Laos (14˚20'N, 100˚108'W), which is located about 35 km south of Vientiane, Lao PDR, at an altitude of 200 m above sea level. The climate in this area is tropical monsoon, with a rainy season between May and October and a dry season from November to April. Annual rainfall averages

about 2000 mm and peak rainfall occurs in the period June to August. The temperature range is 22-35˚C and relative humidity is 70-80%.

The survey study (Paper IV) was conducted in five areas of Lao PDR: Vientiane capital and province in the centre of the country, Luanprabang province in the north and Champasack and Salavanh provinces in the south (Figure 1). The degradability study (Paper V) was carried out at the Faculty of Natural Resources, Rajamangala University of Technology-Isan, Sakon Nakhon Campus, Thailand.

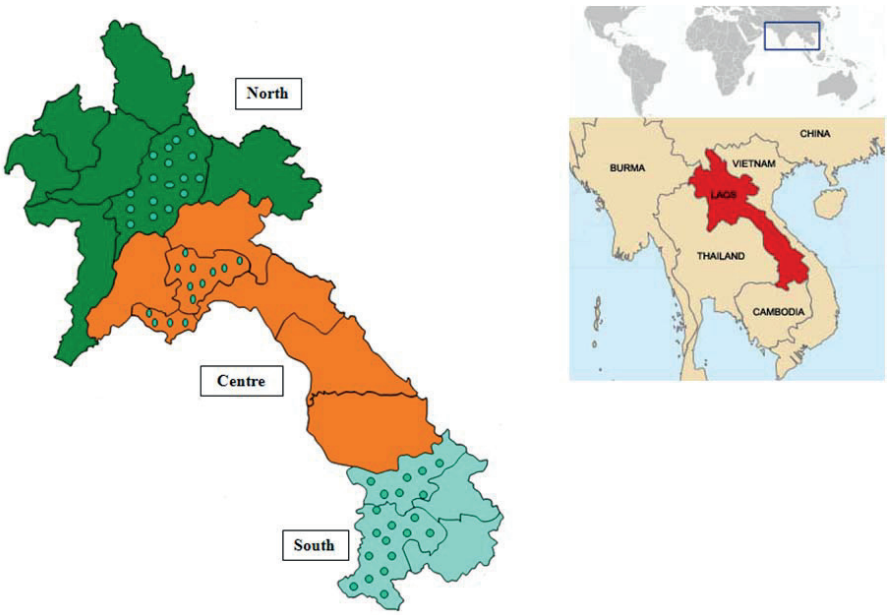

Figure 1. Map of Lao PDR, with dotted areas indicating the different sites used in the survey on utilisation of Erythrina spp. Number of dots represent number of farmers interviewed.

4.3 Experimental animals, feeds, designs and management

The goats used for the feeding experiments (Papers I, II, III and V) were the local breed of goats in Lao PDR. Only male goats were used in Papers I and II, but in Papers III and V the goat numbers were balanced in terms of sex. All goats in the feeding trials were kept in individual. Water and mineral lick blocks were available in the feeding pens. One week before starting the experiments, the goats were treated for parasites.

Fresh foliage (leaves, petioles and 30 cm of the stem) used in the animal performance experiments and Ruzi grass (*Brachiaria ruziziensis*) were harvested twice a day (Papers I, II and III). In Paper V, the fresh Erythrina foliage was collected once a day and half the amount harvested daily was dried under sunlight for 4 days to obtain dry foliage. In Paper III, soybean meal was bought in an animal feed store and cassava chips were made by chopping and drying fresh cassava root in the sun.

A summary of animals, feeds, designs and management (Papers I, II, III and V) is presented in Table 1.

Table 1. *Summary of animals, feeds, designs and management in Papers I, II, III and V*

	Intake & digestibility (Paper I)	Feed preference (Paper II)	Growth performance (Paper III)	Intake study (Paper V)
Experimental animals	-1st trial: 12 male goats, 3.5 months, average BW 14.6 kg - 2nd trial: 4 male goats, 6 months, average BW 13.4 kg	8 male goats, 7 months, BW 15.7 kg	24 goats (12 males and 12 females), 3.5 months, BW 11.2 kg	20 goats (10 males and 10 females), 6.5 months, BW 15.7 kg
Experimental diets	-1st: Erythrina, fig, jackfruit, jujube, kapok and mango foliage *ad libitum* - 2nd: Water spinach *ad libitum* and fig, jujube and mango foliage *ad libitum* + 0.5% of BW as DM of water spinach	1.5% of BW as DM of each foliage from Erythrina, fig, jackfruit, jujube, kapok and mango	- E-0: 100% CP from Ruzi grass, soybean meal and cassava chips - E-20: 20% CP replacement of the diet CP with CP from Erythrina foliage - E-40: 40% CP replacement of the diet CP with CP from Erythrina foliage - E-60: 60% CP replacement of the diet CP with CP from Erythrina foliage	- Fresh and dry Erythrina foliage
Experimental design	-1st: a change-over design with 3 periods -2nd: a 4x4 Latin square	- Offered six foliages separately at the same time - Direct observation	Randomised with 6 replicates	Randomised with 10 replicates
Measurements	- Feed intake - Nutrient intake - Digestibility - N-retention	- Time spent eating - Number of selective changes - Intake	- Feed intake - Nutrient intake - Live weight gain -Feed conversion ratio -Digestibility -N-retention - Carcass characteristics	-Feed intake -Nutrient intake

4.4 Assessments of feed preferences

The six types of tropical foliage (Table 1) were hung in separate bunches in a large pen (2.5 m x 2.5 m). Total amount of the foliage was divided equally into three parts, and offered at 08.00 h, 11.00 h and 14.00 h. One goat was let into the pen every morning and the feeding behaviour was recorded as time spent consuming the foliages from 08.00 h to 17.00 h (9 hours). The foliages were weighed before and after feeding to estimate feed intake of the different species. Fresh bunches of feed and a new goat, were provided every day and the procedure was repeated for 8 days.

4.5 Survey study

Utilisation of Erythrina species in Lao PDR was investigated using two techniques: informal interviews and a formal questionnaire. The informal interviews were carried out by advisory officers in districts and provinces to identify the specific location and general reasons for Erythrina cultivation. The formal questionnaire was used in interviews with 50 households in three regions where Erythrina species are used in smallholder farming. The questions concerned Erythrina species cultivated, general uses, seasonal foliage available and specific information on animal feeding in relation to this foliage.

4.6 Biomass study: design, planting, management and data collection

The study of *E. variegata* foliage yield was carried out in 2,400 m^2 field (1,152 m^2 for planting and the remainder as border areas). The soil in this area is a clay loam soil, with pH 4.7 and 41.2 g organic matter (OM) per kg DM soil. A randomised complete block design (RCBD) was used in the study. Three treatments, control (no fertilisation), cow manure and mineral fertiliser were randomised in 36 plots (12 plots per block and 4 plots per treatment and block).

Stem cuttings of *E. variegata*, 3-4 cm in diameter and 35-40 cm long, were planted in an upright position at 15 cm depth, with 1 m between plants and 2 m between rows and with 25 stems per plot. In the fertilised plots, 2430 kg DM/ha of cow manure or 150 kg/ha of mineral fertiliser (30 kg NPK 15:15:15, 70 kg NPK 16:20:00 and 50 kg urea) were divided equally and applied in two doses, at 2 weeks after planting and 3 months later.

Six months after establishment, number and height of shoots and foliage yield were measured. Leaves, petioles and stems were sampled separately for chemical analyses.

4.7 Degradability study

In Paper V, 20 samples of the three Erythrina species (*E. indica, E. subumbrans* and *E. variegata*) from different areas and last cutting time were tested in degradability studies. The samples were milled through a 1-mm screen and incubated *in vitro* with rumen fluid in calibrated glass syringes as proposed by Menke and Steingass (1988). Gas production was recorded before incubation (0) and hourly during 1-12 hours, each 3 hrs until 24 hrs, each 6 hrs until 72 hrs and at 96 h of incubation. *In vitro* OM digestibility was predicted by the gas values at 24 and 48 hours and chemical composition using the equation: 15.38 + 0.8453*GP + 0.0595*CP + 0.0675*Ash, where GP is gas volume produced at the incubation time.

In sacco degradation of DM was determined by incubating samples ground to pass a 2-mm screen in nylon bags, according to Ørskov (1982). The samples were incubated for 2, 4, 8, 16, 24, 48 and 96 h. Effective DM degradability was then calculated as: a + b*c/(c + k), where k = rumen passage rate. In addition, CP and neutral detergent fibre (NDF) degradation were determined.

4.8 Sampling and chemical analyses

Samples of feed offered and refusals were taken to determine DM content daily during the data collection periods of the intake or digestibility studies, whereas in the feeding trial the corresponding samples were taken once a week. The proportions of leaves, petioles or leaves plus petioles and stems of the foliage were estimated and these samples were analysed separately.

In the biomass study, the Erythrina samples were taken by cutting 50% of each shoot on the 9 plants inside each plot. The samples were then pooled based on treatment and blocks, giving 12 bulk samples. The samples of different Erythrina spp. (Paper V) were randomly collected from 60 different trees in three different areas of Lao PDR. These samples were cut at 50-60 cm from the tip of the second youngest branch at the top of each tree. The 60 samples were sub-grouped based on area, species and last cutting time, giving 20 samples for analyses.

In the digestibility study, the faeces and urine excreted were recorded twice daily, and 10% of the total amount was sampled for further analyses.

Feed samples were analysed for DM, ash, N, NDF, acid detergent fibre (ADF), condensed tannins (only in Papers I and IV) and minerals such Ca, P, Mg, K, Na and S (only in Paper IV). Faeces samples were analysed for DM, ash, N, NDF and ADF. Urine samples were analysed only for N. The CP content was calculated as 6.25*N.

The DM content was determined according to the method of Undersander *et al.* (1993) for Papers I and II, and method 934.01 of AOAC (1990) for Papers III, IV and V. The content of ash (ID 942.05) and N (method 984.13) were determined according to AOAC (1990). NDF (without heat-stable amylase) and ADF were expressed inclusive of residual ash using the procedure of Van Soest *et al.* (1991). Condensed tannins were analysed using the butanol-HCl procedure (Makkar, 1995) for Paper I and the vanillin-HCl method (Burns, 1971) for Paper IV. Mineral concentrations were determined by plasma emission spectroscopy (Spectro Analytical Instruments GmbH & Co., Kleve, Germany) after extraction of samples with HNO_3 according to Bahlsberg-Pålsson (1990).

4.9 Statistical analysis

Data in Papers I and III, biomass production data (Paper IV) and degradability data (Paper V) were analysed statistically by ANOVA using the general linear model (GLM) procedure of Minitab software version 13.31 (Minitab, 2000) for Paper I, version 15.1 (Minitab, 2007) for Paper III and version 16.1.1 (Minitab, 2010) for Papers IV and V. Treatment least square means that showed significant differences at the probability level $P<0.05$ were compared using Tukey's pair-wise comparison procedure. The data on feed selection behaviour (Paper II) were presented in the form of frequencies and means using the Excel programme. In Paper IV, interview data were presented by descriptive statistics.

5 Summary of results

5.1 Erythrina species available and their utilisation in Lao PDR

Three Erythrina species, *E. indica, E. variegata and E. subumbrans,* were found in different areas of Lao PDR. In the centre of the country, *E. indica* and *E. variegata* were available and were used for fencing around houses or crop fields, while *E. variegata* leaves were also used as a food or as traditional medicine (a sedative and an analgesic) for humans. *Erythrina variegata* was also found in the north and its utilisation was similar to that in central Lao PDR. *Erythrina subumbrans* was cultivated and used mainly as a shade tree and as a fertiliser for Arabica coffee plants in the north and south of the country.

In all three areas, Erythrina foliage was found to be used as a feed supplement for cattle and goats in some cases. In the south, Erythrina foliage was available for a longer period and other animals such as buffaloes and horses were also fed the foliage. In the centre and north, the foliage was available during a shorter time and its use as an animal feed seemed to be less common (Paper IV).

5.2 *Erythrina variegata* foliage yield

The mortality of the Erythrina shoots was more than 10% in the plots without fertiliser (Paper IV). Cow manure or mineral fertiliser decreased the mortality and increased the height of shoots, total fresh yield and CP yield significantly compared with the control treatment.

5.3 Chemical composition of the feeds

The foliage (leaves, petioles and stems) had a CP content that varied from 64 to 172 g/kg DM in the Erythrina foliage and mango foliage (Paper I). The CP content of the other foliages (fig, jackfruit, kapok and jujube) was intermediate between that of Erythrina and mango foliage. The content of condensed tannins in leaves plus petioles ranged from 51 g/kg DM in the Erythrina foliage to 130 g/kg DM in the jackfruit foliage.

The chemical composition of Erythrina foliage from different species and different parts of the plant (Papers I, III, IV and V) is presented in Table 2. Different Erythrina species and processed forms showed a large variation in CP, NDF and ADF content, which was 156-244 g/kg, 492-649 g/kg and 304-436 g/kg on a DM basis, respectively, in the leaves or leaves plus petioles. In Paper IV, the concentration of minerals in the leaves plus petioles ranged from 0.2 g/kg DM for Na to 11.3 g/kg DM for K. The Ca, P, Mg and S contents in this foliage were intermediate between those of Na and K.

Ruzi grass at 6 months of age had 48 g CP/kg DM. The CP content of soybean meal was 424 g/kg DM, while the home-made cassava chips contained 19 g CP/kg DM (Paper III).

5.4 Degradability

The *in vitro* gas production, IVOMD and *in sacco* DM degradability as a mean for different last cutting times in the three Erythrina species studied (*E. indica, E. variegata* and *E. subumbrans*) generally did not differ significantly (Paper V). Over 90% of total CP and 70% of NDF were degraded in the rumen after 96 h of incubation in all Erythrina species.

However, in the north*, E. variegata* leaves showed higher CP and NDF degradation than *E. subumbrans* leaves ($P<0.05$), while those from central Lao PDR had a faster rate of gas production than *E. indica* leaves. The CP and fibre degradability of *E. variegata* were higher for samples from the north than samples from the centre of Lao PDR.

The last cutting time was statistically significant for gas volume during the fermentation period, *e.g*. the leaves of *E. variegata* from central Lao PDR cut at 24 months gave lower gas volume than leaves from shorter cutting intervals.

Table 2. *Chemical composition of Erythrina foliage of different species and processed forms*

Species	Proportion of foliage	DM	Ash	CP	NDF	ADF	Remark
			g/kg DM				
Fresh *E. indica*	Leaves + petioles	-	75	156	556	423	Paper V
Fresh *E. subumbrans*	Leaves + petioles	-	78-94	200-244	511-588	377-424	
Fresh *E. variegata*	Leaves + petioles	197	97-116	193-223	463-582	424-426	Papers I and V
	Leaves	252-330	68-97	164-201	492-593	304-423	Papers III, IV and V
	Petioles	191-257	60-79	60-92	609-699	454-566	
	Stem	198-328	54-94	59-89	525-756	488-597	Papers I, III, IV and V
Dry *E. variegata*	Leaves	796	113	199	649	436	Paper V
	Petioles	592	120	69	731	593	
	Stem	352	73	89	634	544	

5.5 Feed preference and voluntary intake

On average, the goats spent 48% of day time (9 hours) eating. There was a large variation in the number of times individual goats changed between foliages and time spent eating the different foliages (Paper II). More time was generally spent on Erythrina, jackfruit and kapok than on fig, jujube and mango. The DM intake of goats ranged from 487 to 809 g/day and was 4.0% of BW on average. The time spent eating was significantly related to the total DM intake and the number of changes between foliages.

The total DM intake (DMI) in Paper I ranged from 380 to 613 g/day. The DMI of jujube and mango foliage was significantly lower than of jackfruit, Erythrina and kapok foliage, but similar to the intake of fig foliage. In Paper II, there was a significantly higher intake of Erythrina, jackfruit and kapok foliage compared with fig, jujube and mango foliage.

Increasing replacement level of diet CP with CP from Erythrina foliage had no effect on DMI (Paper III). Feeding dry Erythrina foliage also had no significant effect on DMI and nutrient intake (Paper V). The DMI ranged from 530 to 613 g/day (3.2-4.0% of BW) when Erythrina foliage was fed as the sole feed (Papers I and V).

5.6 Digestibility

Feeding Erythrina, jackfruit and kapok foliage resulted in higher apparent CP digestibility and N retention compared with fig, jujube and mango foliage (Paper I). The 60% level of replacement of diet CP with CP from Erythrina foliage resulted in a higher apparent digestibility of DM, OM, NDF and ADF, while replacement at 20 and 40% also gave higher fibre digestibility in the goats than the control diet with no Erythrina foliage (Paper III).

5.7 Growth performance and carcass characteristics

The average daily gain (ADG) was 51-63 g and feed conversion ratio was 7.2-8.4 kg DM/kg live weight gain in the goats fed diets including 20-60% CP from *E. variegata* foliage in the diet. A strong relationship between CP intake and ADG ($r^2 = 0.9276$) was also found (Paper III).

Replacing CP in the diet with different levels of CP from *E. variegata* foliage had no significant effect on carcass characteristics such as whole warm carcass weight, dressing percentage, proportion of muscle and bone, digestive systems and internal organs (Paper III).

6 General discussion

6.1 Characterisation of some tropical foliage as feedstuffs

Numerous tropical foliages (fodder trees, shrubs and legumes) are possible options for improving animal nutrition. The first critical step in the general use of a feed in animal diets is reliable knowledge of the chemical composition, digestibility and nutritional value. Regarding the nutrient content, CP content is an important characteristic of foliage. In Paper I, the CP content of the foliages tested ranged from 69 to 193 g/kg DM. The protein fraction in those foliages consists of soluble and insoluble components, which are used both as an important source of nitrogen to increase rumen microbial activity and as by-pass protein for supplying amino acids to the lower gut of the host animal (Leng, 1997; Bonsi *et al.*, 1996). However, anti-nutritional substances, in particular condensed tannins, in fodder trees and shrubs can limit animal performance, especially when these foliages are fed in large quantities (Simbaya, 2002; Hove *et al.*, 2001). In this thesis, *E. variegata* foliage had a low content of condensed tannins (Papers I and IV), below the level of 60-100 g total condensed tannins/kg DM which is considered harmful and likely to reduce feed intake, digestibility and growth. No negative effect on voluntary intake or performance of goats fed the Erythrina foliage was observed (Papers I, III and V).

Foliage yield is an additional critical factor determining the suitability of fodder trees or shrubs as animal feeds. In the biomass production study (Paper IV), it was found that six-month-old *E. variegata* trees yielded only 300 kg DM of foliage/ha. Higher yields of *E. poeppigiana* can be obtained by starting pruning at 9-12 months, as recommended by Nygren (1996). Muschler (1993) reported that *E. fusca* trees yielded 3.4 tons of DM of leaves/ha/year when they were 2-3 years old and pruned 4-6 times per year. However, intervals longer than 6 months could not be quantified in Paper IV, since many Erythrina trees,

particularly in the control plots, were damaged by termites during the dry season. Erythrina trees generally grow well in fertile soils, but in Paper IV they proved difficult to maintain during the first year of cultivation, as also reported by farmers interviewed in the survey. Erythrina foliage is generally abundant during the rainy season, but sheds its leaves during the dry season.

In Paper V, feeding sun-dried *E. variegata* foliage to growing goats resulted in similar voluntary feed intake as feeding fresh foliage. Wilted or dried *E. burana, E. abyssinica* and *E. bentipoeme* leaves also have a high palatability index in goats (Kaitho *et al.*, 1997). Such information is particularly vital in the Lao PDR context, where farmers are trying to achieve more sustainable production throughout the year. However, some foliage, *e.g*. from fig, jujube and mango, is available throughout the year. Although those foliages have low nutritive values, they can be used as sole feeds for goats (Papers I and II). Most of the foliages tested in Papers I and II were preferred by goats and are already being used by smallholder farmers (Daovy *et al.*, 2008), especially the jujube foliage from the *Ziziphus* family.

Jackfruit leaves have higher content of condensed tannins than other foliages (Paper I; Van *et al.*, 2005; Mui *et al.*, 2001). However, the high tannin content in jackfruit did not seem to be a deciding factor for feed intake in Papers I and II. The condensed tannins probably have a beneficial effect on the nutritional metabolism through enhancing rumen escape, increasing the efficiency of nitrogen recycling to the rumen and improving microbial growth efficiency (Waghorn, 1990). Jackfruit foliage also has high potential as a protein source and supplement to grasses, sugarcane, acacia or Flemingia foliage. Feeding jackfruit results in high intake, digestibility and a positive N balance in growing goats (Mui *et al.*, 2002). This foliage could also replace concentrate by up to 50% with no effect on DM and CP intake (Van *et al.*, 2005; Mui *et al.*, 2002; Mui *et al.*, 2001; Duyen *et al.*, 1996). Feeding kapok foliage as a sole feed to growing goats resulted in a DM intake of 4.6% of BW and 76% DM digestibility in one study (Nhan, 2000). Kouch *et al.* (2005) concluded that supplementation with kapok foliage appears to be a viable option to improve the nutritional status of goats during periods of the year when grazing is restricted.

6.2 Effect of feed preferences on voluntary intake

The effect of feed preference and eating behaviour on feed intake is related to anatomical and physiological characteristics, different feeds, feed properties, feed quality and management methods. As reported in Paper II, there are large individual differences in the feeding behaviour of goats. The total time spent

eating during 9 hours of observation in that study ranged from 178 to 390 minutes when the animals were fed six foliage species independently at the same time in a large pen. In general, goats seem to be selective (Dumont *et al.*, 1995) and they eat more slowly and spend more time on selection and eating than other small ruminants (Van, 2006). According to the results in Paper I, a growing goat can consume up to 613 g/day of Erythrina foliage. However, the same breed of goats did not reach this level of intake in Paper III. When a mixed diet was fed the preferences differed, *e.g*. some goats preferred a basal diet (Ruzi grass) over the supplement feed, *i.e*. Erythrina foliage, soybean meal or cassava chips. Individual differences in diet selection behaviour (Paper II), or familiarity from birth with a free-grazing system could possibly result in these different diet preferences. On the other hand, feeding in groups during the adaptation period resulted in a higher level of intake (Papers III and V), probably due to competition. In another study, total DM feed intake increased linearly as the number of animals in the pen increased from one to five (Van, 2006).

The goats spent most of their eating time on Erythrina, jackfruit and kapok foliage, indicating that these had the best intake characteristics of the six foliages compared (Paper II). These three foliages also have a high CP content, the structure of the leaves is soft and they have an attractive smell or a distinctive taste, resulting in higher intake compared with fig, jujube and mango foliage (Paper I). This confirms previous findings that goats choose and consume the most nutritious feed available, *e.g*. showing an increased preference for plants or plant parts with higher than average nutrient content in pasture (Fajemisin *et al.*, 1996; Provenza, 1996; Papachristou & Nastis, 1993). Similarly, Papachristou *et al.* (2005) found that goats on pasture selected diets significantly higher in CP and IVOMD and lower in NDF and ADF content than samples collected by hand-plucking mimicking the foraging of goats. However, some goats also spent quite a high proportion of eating time on lower quality foliages. Even though intake of jujube was not very high in Paper II, foliages from the *Ziziphus* family are reported to be preferred by goats (Sanon *et al.*, 2007; Ngwa *et al.*, 2000). Morand-Fehr (2005) and Abdel-Moneim and Abd-Alla (1999) indicated that plant characteristics such as taste, texture, nutrients, toxins and morphological structure could affect forage preferences by goats. Palatability of feedstuffs is also influenced by feed composition and shape, the physiological status of the animals and experience (Quaranta *et al.*, 2006). The soft, smooth structure of the Erythrina and kapok foliage (Papers I and II) probably had a positive effect on eating time and intake by goats, while lower intake was found for mango foliage, which has a high DM content, low CP content and hard leaves. Van *et al.* (2005) reported

that the total eating time was longer for kids fed jackfruit foliage than for kids fed Flemingia or acacia foliage (385, 297 and 202 minutes, respectively), which was probably due to the better intake characteristics of jackfruit foliage.

6.3 Rumen degradation and fermentation characteristics of Erythrina foliage

The studies of rumen degradation and fermentation characteristics presented in this thesis show that leaves of Erythrina species have potential as a substantial nutrient source for goats (Paper V). Although legumes are characterised by high degradation in the rumen (Camero *et al.*, 2001), there are differences in potential gas production that might depend on their chemical composition (Getachew *et al.*, 2004) and concentration of anti-nutrient factors in the foliages (Silanikove *et al.*, 2001; Getachew *et al.*, 1998). Species from the same legume family, such as Leucaena and Gliricidia, have lower values of IVOMD at 48 h of incubation time (Edwards *et al.*, 2012) and lower DM effective degradability (Osuga *et al.*, 2006; Larbi *et al.*, 1997) than the leaves of Erythrina species (Paper V). Higher contents of NDF and ADF, and probably also higher lignin content, could be the reason for the lower IVOMD. Tropical forages generally have a high proportion of lignified cell walls, resulting in low digestibility rates (Ibrahim *et al.*, 1995).

Higher sources of energy and nitrogen can also lead to higher nutrient availability, resulting in increased microbial growth at the beginning of incubation, and thus in more fermentation and increased gas production (Calabrò *et al.*, 2005). Gas production parameters also indicate differences in nutritional values generally closely related to chemical composition (Cerrillo & Juárez, 2004), such as carbohydrate fraction (Chumpawadee *et al.*, 2007), and especially aspects of the fibre content such as the extent of lignification of NDF (Rubanza *et al.*, 2003; Fonseca *et al.*, 1998). In Paper V, gas production as a mean for different last cutting times did not differ significantly, indicating that the content of degradable carbohydrates was quite similar in the different Erythrina species. However, the lower rate of gas production from *E. indica* leaves from central Lao PDR (c_{gas}, 0.04%/h) was probably due to the higher NDF content compared with *E. variegata* leaves from the same area (c_{gas} = 0.06 %/h). A faster rate of gas production is possibly due to soluble carbohydrate fractions being readily available to the microbial population because of high fermentation of plant cell walls. Deaville and Givens (2001) also reported that NDF degradability possibly had an effect on gas volume produced. This supports the results in Paper V, where cutting at longer time

intervals (24 months) and foliage with high NDF and ADF content resulted in lower gas production.

The DM degradation characteristics of *E. variegata* found in Paper V were similar to results reported by Ibrahim *et al.* (1998). However, this species had higher DM degradability (>70% after 72 h of incubation) compared with other species such as *E. poeppigiana* (65%) (Camero *et al.*, 2001). Degradation of DM, CP and NDF during 96 h of rumen incubation and degradation kinetics, were high in the leaves of *E. variegata* from the north of Lao PDR, but low in the leaves of *E. subumbrans*, while gas production was similar for these Erythrina species. This indicates that the differences in chemical composition and cell wall structure between Erythrina species influenced the results obtained with *in vitro* gas production and *in sacco* methods. Therefore, it seems that no single method works well in all situations (López *et al.*, 1998). To improve the accuracy of the results, the reasons of these discrepancies must be established and the suitability of each procedure must be determined for each particular case. However, the high gas volume produced and degradation of Erythrina foliage coincided with high digestibility and improved growth rate of animals in the feeding trials (Papers I and III).

6.4 Effect of feeding Erythrina foliage on performance in goats

6.4.1 Voluntary feed intake, digestibility and N utilisation

Feeding fresh *E. variegata* foliage resulted in an intake that covered the CP requirement in goats, as suggested by Mandal *et al.* (2005). The characteristics of this foliage, with soft leaves and a lower content of condensed tannins, had a positive effect on animal performance. However, feeding Erythrina foliage at 100% of CP in the diet for a prolonged period of time did not seem to be possible in the present study. Some goats showed a high variation in daily consumption of the fresh foliage and did not reach the expected level of intake (Paper III). Therefore, supplementing with Erythrina foliage at 35-50% of DM offered or supplying 40-60% of CP in mixed diets using this foliage could be an appropriate level with regard to lowering the cost of feeding and achieving acceptable ingestion levels.

Sun-drying *E. variegata* foliage had no effect on CP or fibre content and feed intake in goats (Paper V). Wilting the foliage or drying it for 2-3 days in the shade can therefore be another option, particularly during the rainy season when farmers need to feed this foliage as a supplement. Kaitho *et al.* (1997) showed that wilting the foliage from Erythrina spp. had no negative effect on feed intake in goats. In Paper V, feeding dry foliage resulted in stable daily

intake during the experiment. This information is particularly important for smallholder farmers trying to conserve foliage by drying.

According to McDonald *et al.* (2002), leguminous leaves are more rapidly digested than other roughages and therefore promote higher intake. Using foliage from Erythrina spp. as a sole feed for goats is reported to result in high intake, CP digestibility and N balance (Baidya *et al.*, 1995; Kibria *et al.*, 1994). Furthermore, in Paper III apparent digestibility of NDF and ADF was higher when CP in the diet was replaced with CP from *E. variegata* foliage. This is similar to previous findings that supplementation of low quality roughage with *E. variegata* leaves to ruminants at 50% of the total diet resulted in increased feed intake, DM and CP digestibility (Aregheore & Perera, 2004a; Aregheore & Perera, 2004b; Larbi *et al.*, 1993). Legumes can alleviate N deficiency in the diet, thereby improving the rate of degradation of the basal diet and the fractional outflow of liquid matter from the rumen, and hence feed intake (Goodchild & McMeniman, 1994).

6.4.2 Growth performance and carcass characteristics

In Paper III, all diets were formulated to be isonitrogenous and isocaloric in order to provide sufficient CP and energy for growing goats. Replacing up to 60% of diet CP with CP from *E. variegata* foliage had no negative effect on growth in goats, which ranged from 51 to 63 g/day. A number of factors such as genetic potential of the animal, hormones, nutrition, environment and their interactions affect growth performance or productivity (McDonald *et al.*, 2002). The daily intake of CP (approximately 60-65 g) was sufficient to support the growth rate found in Paper III, as it exceeds the recommended level for goats weighing 15 kg and growing by 50 g/day (NRC, 2007; Peacock, 1996). In a nutritional perspective, growth in young animals is always associated with a high rate of protein deposition, which is in relation to the intake of energy and other essential nutrients in the diets. While the actual rate of protein deposition is influenced by the availability of dietary proteins and energy, the limit depends on the genetic potential of the animal (McDonald *et al.*, 2002). However, the same local goat breed as in Paper III fed only Gamba grass showed lower ADG, only 27-29 g/day (Phengvichith & Ledin, 2007b; Phengsavanh, 2003a). Grass as the sole feed could not meet the nutrient requirements of growing goats to achieve acceptable levels of growth. Ruminants in tropical regions are generally fed natural grasses and crop residues, without feed supplements. They often tend to lose weight due to low or inadequate nutrient supply for maintenance. Supplementation with Erythrina foliage to ruminants consuming low quality forage can often improve intake and productivity. For example, supplementation of foliage from *E. abyssinica*

can double the daily weight gain of sheep and goats (Larbi *et al.*, 1993), while feeding *E. variegata* foliage as the sole feed was reported to give a live weight change of 77 g/day during a digestibility study (Kongmanila, 2007).

The slaughter weight, empty BW, carcass weight, dressing percentage, muscle weight, muscle percentage and muscle/bone ratio found in Paper III indicate that the animals had a high quality diet. According to Phengvichith and Ledin (2007a) and Valderrábano *et al.* (2002), animals fed diets high in energy and protein have high carcass characteristics similar to those found in Paper III. However, when more fibrous material from *E. variegata* foliage was fed in Paper III, rumen fill increased and consequently the dressing percentage was lower. Feeding a higher level of forage in the diet generally results in a lower dressing percentage (Haddad, 2005; Moore *et al.*, 2002). Similarly, increasing the level of a protein supplement containing maize bran, cottonseed, sunflower and sugarcane molasses (102, 150 and 177 g CP/kg DM) in the diet has been shown to decrease the dressing percentage in growing goats (Mtenga & Kitaly, 1990). Other factors such as breed, age and BW of animals can also influence the dressing percentage. For example, the dressing percentage of local goat breeds in Lao PDR ranged from 43-50% (Paper III), while it was 51-58% in seven different goat breeds in an earlier study (Dhanda *et al.*, 2003; Mahgoub & Lu, 1998). Furthermore, Marichal *et al.* (2003) found that goats with a live weight at slaughter of 6 and 10 kg had a lower dressing percentage than goats with 25 kg live weight at slaughter, due to an incompletely developed digestive tract in the lower live weight goats.

7 Conclusions and implications

7.1 Conclusions

- Feeding Erythrina, jackfruit and kapok foliage as the sole feed for growing goats resulted in a longer time spent eating and selecting feed and higher intake, CP digestibility and N retention compared with fig, jujube and mango foliage.
- *Erythrina indica, E. subumbrans* and *E. variegata* were found in different areas in the north, centre and south of Lao PDR. These legume species were generally used for fencing, shade and green manure, but were in limited use as an animal feed.
- Fermentation kinetics in the rumen and degradation characteristics of the three Erythrina species leaves, were similar, but the cutting intervals of foliage should be more frequent for high fermentation rate and degradability.
- *Erythrina variegata* can be established using branch cuttings and fertiliser should be supplied for more effective results. Foliage yield of *E. variegata* was about 300 kg DM/ha at 6 months after establishment but this is too early to prune. The trees should probably not be pruned until at least one year after establishment.
- *Erythrina variegata* foliage could be an alternative protein source for growing goats in smallholder farms. Replacing soybean meal CP in mixed diets with CP from *E. variegata* foliage resulted in a good level of feed intake and growth performance.
- Feeding dried foliage had no negative effect on voluntary feed intake in goats. Including *E. variegata* foliage in the diet can therefore supply sufficient nutrients and improve animal productivity.

7.2 Implications

The results of this study can be used to promote the use of locally available foliages as feed in goat rearing systems in Lao PDR. The foliage from fruit trees and legumes such as Erythrina is a possible option for improving animal nutrition. Erythrina can be an alternative fodder tree and should be planted on smallholder farms together with other crops in order to fix nitrogen and to provide an animal protein feed source at a low cost. Foliage from Erythrina spp. is a high quality feed in terms of nutritive value, particularly protein content and digestibility. Including Erythrina foliage as a protein source at 35-50% of DM offered in a mixed diet can be recommended where a conventional protein source such as soybean meal is too costly.

However, owing to the characteristics of Erythrina, the leaves are shed during the dry season. Therefore, conservation of foliage by sun-drying could be a suitable option to achieve more sustainable production throughout the year. Supplementing dry Erythrina foliage to lower quality forages that are available during dry season, *e.g.* jujube or mango foliage could also be a viable option to improve animal nutrition. Since goats are selective, offering many types of available foliage together could be another alternative feeding system. In conclusion, information on utilisation of local foliages and simple processing methods such as wilting or drying needs to be provided to smallholder farmers to help them increase the use of available feed resources and improve animal productivity.

Soil quality, fertilisers, precipitation and cutting interval are important for foliage yield of Erythrina. Establishment using branch cuttings every 2-3 years and a supply of organic or mineral fertiliser are needed for effective Erythrina cultivation. Cattle or goats can provide organic fertiliser for poor soils where farmers lack the cash to buy mineral fertiliser, thus creating sustainable integration of the crop-livestock system. For high foliage yields, the first pruning of Erythrina should be delayed until at least one year after establishment. More frequent cutting times should be practised thereafter for good nutritive value and better degradation or digestibility.

8 Future research

- In the present study, three Erythrina species were found in different areas of Lao PDR, but only *E. variegata* was studied concerning foliage production and the effect of the foliage on animal performance. Therefore, *E. indica* and *E. subumbrans* should also be investigated in future studies.
- Dry Erythrina spp. foliage should be considered in future studies on animal performance, since some form of conservation will be needed for the dry season.
- *Erythrina variegata* foliage was only studied as a sole or supplemented feed for growing goats in this thesis. The effects of this foliage on reproductive performance and lactation in adult goats should be investigated. Long-term feeding of Erythrina foliage to ruminants may result in positive effects on animal health, since some farmers use the foliage as traditional medicine. Thus, further studies should examine these aspects.
- Studies should be carried out to examine other alternative locally available forages and emphasise the possibility to combine these with Erythrina foliage to improve nutrition and ruminant productivity.

ສະຫຼຸບຫຍໍ້

ບົດວິທະຍານິພົນເຫຼັ້ມນີ້ ປະກອບມີ 5 ຫົວຂໍ້ການຄົ້ນຄວ້າທີ່ພົວພັນກັນ ໂດຍມີຈຸດປະສົງລວມ ເພື່ອຊອກຫາແຫຼ່ງອາຫານທີ່ສຳຄັນ ແລະ ເປັນປະໂຫຍດ ທີ່ມີຢູ່ໃນທ້ອງຖິ່ນ ເຊິ່ງການສຶກສາຄັ້ງນີ້ ໄດ້ເນັ້ນໃສ່ແຫຼ່ງອາຫານທີ່ເໝາະສົມສຳລັບສັດຄ້ຽວເອື້ອງ (ແບ້), ເພື່ອເປັນການປັບປຸງຄຸນນະພາບອາຫານ, ເພື່ອຍົກລະດັບຜົນຜະລິດ ແລະ ເພື່ອເປັນຂໍ້ມູນໃຫ້ແກ່ປະຊາຊົນຜູ້ລ້ຽງແບ້ທົ່ວໄປ ໃນ ສປປ ລາວ.

ໃນປະຈຸບັນ, ການລ້ຽງແບ້ ແມ່ນມີຄວາມສຳຄັນຕໍ່ຊີວິດການເປັນຢູ່ຂອງປະຊາຊົນໃນຫຼາຍຂົງເຂດ, ພ້ອມກັນນັ້ນ ຄວາມຕ້ອງການໃນການບໍລິໂພກຊີ້ນແບ້ ທັງພາຍໃນ ແລະ ຕ່າງປະເທດ ກໍ່ນັບມື້ນັບເພີ່ມຂຶ້ນ. ແຕ່ໃນຄວາມເປັນຈິງ, ການລ້ຽງແບ້ ພັດມີຫຼາຍປັດໃຈທີ່ເປັນຂໍ້ຈຳກັດ ໃນການຂະຫຍາຍຝູງສັດ ຫຼື ຜົນຜະລິດ. ໜຶ່ງໃນບັນດາປັດໃຈຕ່າງໆກໍ່ຄື: ບັນຫາເລື່ອງການຂາດທາດອາຫານ ຫຼື ອາຫານບໍ່ພຽງພໍກັບຄວາມຕ້ອງການຂອງສັດ ໂດຍສະເພາະໃນລະດູແລ້ງ. ເນື່ອງຈາກວ່າ ການລ້ຽງແບ້ໃນປະເທດເຮົາ ແມ່ນຍັງລ້ຽງແບບປ່ອຍຕາມທຳມະຊາດເປັນສ່ວນໃຫຍ່, ແຫຼ່ງອາຫານທີ່ມີໃນທົ່ງຫຍ້າທຳມະຊາດເຫຼົ່ານັ້ນ ມີຂໍ້ຈຳກັດທັງປະລິມານ ແລະ ຄຸນນະພາບ, ການໃຫ້ອາຫານເສີມແກ່ສັດ ແມ່ນມີພຽງເລັກນ້ອຍເທົ່ານັ້ນ ຫຼື ບໍ່ເຄີຍໄດ້ປະຕິບັດເລີຍ. ນອກຈາກນັ້ນ, ພື້ນທີ່ໃນການລ້ຽງສັດກໍ່ຖືກຈຳກັດລົງໃນບາງທ້ອງຖິ່ນ ໂດຍສະເພາະໃນໄລຍະທີ່ທຳການຜະລິດ, ສັດຈະມີໂອກາດໄປຊອກກິນພຽງແຕ່ 3-4 ຊົ່ວໂມງ/ວັນເທົ່ານັ້ນ. ດ້ວຍເຫດນັ້ນ, ຈຶ່ງສົ່ງຜົນໃຫ້ ແບ້ມີການຈະເລີນເຕີບໂຕຊ້າ ແລະ ໃຫ້ຜົນຜະລິດຕ່ຳ.

ຕໍ່ກັບບັນຫາດັ່ງກ່າວ, ວຽກງານສົ່ງເສີມການປູກພືດອາຫານສັດ, ການເກັບຮັກສາອາຫານ, ແລະ ການຄົ້ນຄວ້າແຫຼ່ງວັດຖຸດິບອາຫານສັດທີ່ມີໃນທ້ອງຖິ່ນ ໄດ້ເລີ່ມມີຈັດຕັ້ງປະຕິບັດ. ໃນນັ້ນ, ການປັບປຸງອາຫານສັດໂດຍການນຳໃຊ້ໃບໄມ້ຊະນິດຕ່າງໆເຊັ່ນ: ຈຳພວກໄມ້ຢືນຕົ້ນ, ໄມ້ໃຫ້ໝາກ ແລະ ພືດຕະກຸນຖົ່ວ ກໍ່ເປັນອີກທາງເລືອກໜຶ່ງທີ່ໜ້າສົນໃຈ ເພາະວ່າ ໃບໄມ້ຫຼາຍຊະນິດແມ່ນມີຄວາມອຸດົມສົມບູນຕະຫຼອດປີ, ການສຶກສາຄົ້ນຄວ້າກ່ຽວກັບຄຸນລັກສະນະຂອງໃບໄມ້ຊະນິດຕ່າງໆຍັງມີໜ້ອຍ, ຄວາມຮູ້, ຄວາມເຂົ້າໃຈ ແລະ ການນຳໃຊ້ປະໂຫຍດຂອງໃບໄມ້ເຫຼົ່ານີ້ ຂອງປະຊາຊົນຜູ້ລ້ຽງສັດກໍ່ຍັງຈຳກັດ.

ດ້ວຍເຫດນັ້ນ, ການສຶກສາຄັ້ງນີ້ ຈຶ່ງໄດ້ເລີ່ມຈາກການນຳເອົາໃບໄມ້ 6 ຊະນິດ ເຊັ່ນ: ໃບທອງ, ໃບມີ້, ໃບງົ້ວ, ໃບເດື່ອ, ໃບກະທັນ ແລະ ໃບມ່ອງ ມາກວດສອບ ຄຸນຄ່າທາງດ້ານອາຫານສັດ ແລະ ທົດສອບ ຕໍ່ພຶດຕິກຳການກິນໃບໄມ້ເຫຼົ່ານີ້ຂອງແບ້, ປະລິມານການກິນໄດ້ ແລະ ການຍ່ອຍໄດ້ຂອງແບ້ທີ່ກຳລັງຈະເລີນເຕີບໂຕ. ຜົນໄດ້ ຮັບພົບວ່າ: ໃບໄມ້ທັງ 6 ຊະນິດມີຄຸນຄ່າທາງອາຫານແຕກຕ່າງກັນ ແຕ່ພວກມັນທັງ ໝົດສາມາດນຳມາເປັນອາຫານແບ້ໄດ້. ຢ່າງໃດກໍ່ຕາມ, ໃບໄມ້ຈຳພວກ ໃບທອງ, ໃບ ມີ້ ແລະ ໃບງົ້ວ ມີຄຸນລັກສະນະທີ່ດີກວ່າ ໃບໄມ້ຊະນິດອື່ນໆ. ໃນນັ້ນ, ໃບທອງ ເປັນ ພືດຕະກຸນຖົ່ວ ທີ່ມີທາດຊີ້ນສູງກວ່າໝູ່ ແລະ ອາດຈະສາມາດໃຊ້ເປັນແຫຼ່ງອາຫານເສີ່ມ ໄດ້. ດັ່ງນັ້ນ, ຈຶ່ງໄດ້ມີການສຶບຕໍ່ລົງເລິກກ່ຽວກັບ ການປູກຕົ້ນທອງເພື່ອຜົນຜະລິດຂອງ ໃບ, ການນຳໃຊ້ໃບທອງເປັນແຫຼ່ງໂປຼຕີນ ເພື່ອທົດແທນແຫຼ່ງໂປຼຕີນຈາກການາກຖົ່ວເຫຼືອງ ໃນສູດອາຫານ, ທົດສອບ ການກິນຂອງແບ້ ເມື່ອໃຫ້ໃບທອງແຫ້ງເປັນອາຫານ. ພ້ອມ ກັນນັ້ນ, ຍັງມີການສຳຫຼວດຊະນິດ, ການນຳໃຊ້ປະໂຫຍດຂອງຕົ້ນທອງ ແລະ ຄຸນຄ່າ ທາງອາຫານຂອງໃບທອງແຕ່ລະຊະນິດ ໃນ ສປປ ລາວ: ພາກໃຕ້ (ແຂວງຈຳປາສັກ ແລະ ສາລະວັນ), ພາກກາງ (ວຽງຈັນ ແລະ ນະຄອນຫຼວງວຽງຈັນ) ແລະ ພາກເໜືອ (ຫຼວງພະບາງ).

ຈາກຜົນຂອງການຄົ້ນຄວ້າ ສາມາດສະຫຼຸບ ແລະ ມີບາງຂໍ້ແນະນຳ ດັ່ງລຸ່ມນີ້:

- ເມື່ອໃຊ້ໃບໄມ້ 6 ຊະນິດ ເປັນອາຫານຫຼັກສຳລັບແບ້ພົບວ່າ: ແບ້ໃຊ້ເວລາສ່ວນ ຫຼາຍໃນການເລືອກກິນໃບໄມ້ປະເພດ ໃບທອງ, ໃບມີ້ ແລະ ໃບງົ້ວ ແລະ ປະລິມານ ການກິນ ແລະ ການຍ່ອຍໄດ້ຂອງແບ້ ທີ່ກິນໃບໄມ້ທັງ 3 ປະເພດນີ້ ແມ່ນສູງກວ່າ ແບ້ທີ່ກິນໃບເດື່ອ, ໃບກະທັນ ແລະ ໃບມ່ອງ.

- ການສຳຫຼວດພົບວ່າ: ມີຕົ້ນທອງ 3 ຊະນິດ ທີ່ປະຊາຊົນປູກ ແລະ ເກີດຂຶ້ນເອງ ຕາມທຳມະຊາດ, ເຊິ່ງການນຳໃຊ້ຂອງແຕ່ລະຊະນິດ ແມ່ນມີຄວາມແຕກຕ່າງກັນ, ແຕ່ ສ່ວນຫຼາຍແມ່ນນິຍົມໃຊ້ເປັນຫຼັກຮົ້ວ ແລະ ເປັນຮົ່ມ. ໂດຍສະເພາະເຂດພາກໃຕ້ ແມ່ນ ນິຍົມປູກຕົ້ນທອງ ເພື່ອເປັນຮົ່ມສຳລັບຕົ້ນກາເຟ. ໃນນັ້ນ, ແຕ່ມີພຽງຂໍ້ມູນຈຳນວນເລັກ ນ້ອຍເທົ່ານັ້ນ ທີ່ປະຊາຊົນໃຊ້ໃບທອງເປັນອາຫານສັດ.

- ໃບທອງທັງ 3 ຊະນິດ ບັນຈຸທາດຊີ້ນປະມານ 15-24% ໂດຍຂຶ້ນກັບຊະນິດ ແລະ ອາຍຸຂອງໃບພືດ, ໃບທອງເຫຼົ່ານີ້ ມີຄວາມສາມາດໃນການຍ່ອຍໄດ້ໃນລະດັບທີ່ດີ (70-80 %) ເຊິ່ງສາມາດນຳໃຊ້ເປັນອາຫານແບ້ໄດ້.

- ຈາກການສຶກສາຜົນຜະລິດໃບທອງ (ຊະນິດທີ່ມີຫຼາຍໃນພາກກາງ) ພົບວ່າ: ພືດຊະນິດນີ້ສາມາດປູກໄດ້ໂດຍງ່າທີ່ມີອາຍຸປະມານ 2-3 ປີ, ການໃສ່ຝຸ່ນຄອກ ຫຼື ປຸ໋ຍເຄມີ ແມ່ນມີຄວາມຈຳເປັນສຳລັບການປູກພືດຊະນິດນີ້. ການຕັດໃບທອງເພື່ອໃຫ້ຜົນຜະລິດທີ່ດີ ຄວນເລີ່ມຕັດຫຼັງຈາກຕົ້ນທອງອາຍຸຫຼາຍກວ່າ 1 ປີ ຂຶ້ນໄປ.

- ໃບທອງ ສາມາດໃຊ້ເປັນແຫຼ່ງໂປຼຕີນໃນອາຫານແບ້ໄດ້ ແລະ ສາມາດທົດແທນແຫຼ່ງໂປຼຕີນທີ່ມີໃນສູດອາຫານທີ່ປະກອບດ້ວຍກາກຖົ່ວເຫຼືອງໄດ້ເຖິງ 60%, ມີຜົນໄດ້ຮັບໃນການກິນໄດ້ ແລະ ການຈະເລີນເຕີບໂຕຂອງແບ້ ໃນລະດັບທີ່ດີສົມຄວນ (51-63 g/ວັນ). ພ້ອມກັນນັ້ນ, ໃບທອງແຫ້ງກໍ່ສາມາດເປັນອາຫານແບ້ໄດ້ ເຊິ່ງແບ້ທີ່ກິນໃບທອງແຫ້ງ ມີປະລິມານການກິນໄດ້ທີ່ໃກ້ຄຽງກັບແບ້ທີ່ກິນໃບທອງສົດ.

ຈາກຜົນການຄົ້ນຄວ້າຂ້າງເທິງເຫັນວ່າ: ການນຳໃຊ້ໃບໄມ້ທີ່ມີໃນທ້ອງຖິ່ນ ເຂົ້າໃນອາຫານສັດ ຄວນມີການສົ່ງເສີມ ແລະ ຈັດຕັ້ງປະຕິບັດ ໃນລະບົບການລ້ຽງແບ້ ໃນ ສປປ ລາວ. ໃບໄມ້ທີ່ໄດ້ຈາກຕົ້ນໄມ້ໃຫ້ໝາກຫຼາຍຊະນິດ ແລະ ພືດຕະກຸນຖົ່ວ (ໃບທອງ) ເປັນອີກທາງເລືອກໜຶ່ງທີ່ສາມາດນຳມາເປັນອາຫານສັດ ເພື່ອເປັນການປັບປຸງຄຸນນະພາບອາຫານ ແລະ ເພີ່ມຜົນຜະລິດຂອງສັດໃຫ້ສູງຂຶ້ນເລື້ອຍໆ. ຕົ້ນທອງ ເປັນພືດຊະນິດໜຶ່ງທີ່ຄວນປູກປະສົມປະສານກັບພືດຊະນິດອື່ນໆ ເພື່ອເປັນການປັບປຸງດິນ ແລະ ໃບທອງ ຍັງເປັນແຫຼ່ງໂປຼຕີນທີ່ມີຄຸນນະພາບດີ, ລາຄາຖືກ ແລະ ສາມາດໃຊ້ເສີມໃນສູດອາຫານໄດ້ເຖິງ 50%. ເຖິງຢ່າງໃດກໍ່ຕາມ, ຂໍ້ເສຍຂອງພືດຊະນິດນີ້ ກໍ່ຄື: ໃບຂອງມັນຈະຫຼົ່ນໃນໄລຍະລະດູແລ້ງ. ດັ່ງນັ້ນ, ຂະບວນການແປຮູບ ຈຶ່ງມີຄວາມສຳຄັນຫຼາຍ ເປັນຕົ້ນແມ່ນ ‘‘ການເຮັດແຫ້ງ’’ ກໍ່ເປັນອີກວິທີໜຶ່ງທີ່ເໝາະສົມ ແລະ ຄວນປະຕິບັດ, ເພື່ອເປັນການເກັບຮັກສາອາຫານສຳລັບສັດ ໃນລະດູແລ້ງ ຫຼື ໃຊ້ເປັນອາຫານເສີມ. ນອກຈາກນັ້ນ, ການນຳໃຊ້ໃບໄມ້ທີ່ມີຫຼາຍໃນລະດູແລ້ງເຊັ່ນ: ໃບກະທັນ, ໃບມ່ວງ ແລະ ຊະນິດອື່ນໆ ທີ່ມີໃນທ້ອງຖິ່ນ ມາເປັນອາຫານສັດກໍ່ເປັນອີກວິທີໜຶ່ງ ໃນການເພີ່ມຄຸນຄ່າທາດອາຫານໃຫ້ແກ່ສັດໄດ້.

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