UTILISATION OF MADRAS THORN, LEUCAENA AND GLIRICIDIA AS PROTEIN SUPPLEMENTS BY GROWING GOATS IN THE COASTAL LOWLANDS OF KENYA

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A thesis submitted to the graduate school in partial fulfilment for the requirement of Master of Science degree in Animal Production (Nutrition option) of Egerton University.

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and that to my best of my knowledge it has not been submitted for an award of a degree in any university degree in any university.

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ABSTRACT

Small scale goat farmers in coastal Kenya lowland tether their animals on small strips of pastureland with minimal supplementation. The quality and quantity of pasture varies throughout the year. Supplements such as oilseed cakes and animal by product meals are rarely used because they are expensive. Tree fodders contain high crude protein (19-30 %) content hence are used as supplements to low quality diets and significantly improve intakes and performance of ruminants in the tropics. The main objective of this study was to assess the performance of goats offered roughage based diet and supplemented with dry Madras thorn, leucaena or gliricidia leaves. In the first experiment fifteen small East African goats six months old on average were randomly allocated to five treatments: Napier grass offered alone (control) or supplemented with 7.5, 15, 22.5 and 30 g DM/kg $W^{0.75}$ of Madras thorn. Supplementing with Madras thorn up to 22.5 g DM/kg $W^{0.75}$ had no significant ($P > 0.05$) effect on the intake of the basal diet, however there was a 29 % depression in the intake of the basal diet at 30 g DM/kg $W^{0.75}$ level of supplementation. There was a significant ($P< 0.05$) increase in the total dry matter intake (TDMI) from 242.1 for the control to 357.0 and 428.5 g DM/day for 22.5 and 30 g DM/kg $W^{0.75}$ respectively. Supplementation also resulted in increase ($P< 0.05$) in dry matter and digestibility. Feed nitrogen (N), N retained and N loss increased with increase in supplementation. Positive N balance was recorded for all treatments. Goats offered the control diet lost a mean of 8 g/day while those supplemented with 7.5, 15, 22.5 and 30 g DM/kg $W^{0.75}$ gained 8, 23, 43 and 44 g/day respectively.

In the second experiment twelve Small East African goats average 8 months old and 9.65 kg (±1.52) weight were randomly assigned to four treatments namely panicum hay fed *ad libitum* plus 100 g of maize bran (control), control supplemented with 18.6, 22.5 and 19.9 g DM/kg$W^{0.75}$ isonitrogenous levels of leucaena, gliricidia or Madras thorn respectively. Crude protein concentrations were 3.5, 21, 23 and 25 % for hay, gliricidia, madras and leucaena respectively. Total dry matter intake was 229, 365, 387 and 398 g/day for the control, Madras thorn, gliricidia and leucaena respectively. Animals supplemented with the legumes retained significantly ($P<0.05$) more N than the control (leucaena 3.5, gliricidia 3.6, Madras thorn 3.7, vs. 0.6 g/day control). Legume supplementation increased ($P<0.05$) daily gains from 2 g/day in the control treatment to 19, 22 and 25 g/day for gliricidia, madras thorn and leucaena respectively. Supplementing panicum hay with madras thorn gave similar growth performance to gliricidia and leucaena. It is recommended that Madras thorn should be offered at between 40-50 % of the diet for optimal production.

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ABBREVIATIONS

ADF	Acid detergent fibre
ADG	Average daily gains
CP	Crude protein
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
ENU	Efficiency of nitrogen utilisation
FCR	Feed conversion ratio
ME	Metabolisable energy
N	Nitrogen
NDF	Neutral detergent fibre
NDS	Neutral detergent solubles
OM	Organic matter
OMD	Organic matter Digestibility
SEM	Standard error of mean
TDMI	Total dry matter intake
$W^{0.75}$	Metabolic body weight

CHAPTER ONE

1. GENERAL INTRODUCTION

Small-scale goat farmers in coastal lowland Kenya tether their animals on small strips of pastureland with minimal supplementation (MoALDM, 2000). Pasture quality and availability varies markedly throughout the year in the tropics. Crude protein (CP) content of dry, mature tropical grasses often falls below the minimum 7 % required for optimum microbial function in the rumen (Minson and Milford, 1967). The potential dry matter yield of Napier grass surpasses that of tropical grasses thus its popularity among small holder dairy farmers in Kenya (Anindo and Potter, 1994). However the CP levels are between 5-9 % thus not adequate for livestock production and require protein supplementation to maximize utilisation in the rumen. Protein supplements include oilseed cakes, concentrates and leguminous tree fodders. The concentrates and oilseed cakes are often too expensive for resource constrained small scale farmers and their availability is varied.

Leguminous trees have not only been used as fodder but also for soil nitrogen fixation, fuel, hedges and as ornamental plants. Tree fodders have a higher protein and mineral contents compared to grasses, whose quality decline rapidly with progression to maturity (Norton, 1994). Most tree fodders have medium to high CP content (15 -31 %). They play a significant role in feeding ruminants in the tropics due to their ability to supplement protein deficiency in low quality basal diet and their availability throughout the year (Kaitho *et al.*, 1996). With increasing population pressure there is increased demand for food hence increase of agricultural by products like maize stover, rice and wheat straw. These agricultural by products require protein supplementation when fed to ruminants, therefore high quality fodder from tree legumes could have a more significant role in ruminant feeding systems throughout the developing world (Baumer, 1992).

After leucaena *(Leuceana leucocephala,)* gliricidia *(Gliricidia sepium)* is one of the most widely cultivated multipurpose tree in the world (Simons and Stewart, 1994). These tree legumes (leucaena and gliricidia) have been used as protein supplements to low quality forages and resulted in improved ruminant productivity (Norton, 1994). Leucaena and gliricidia have been used to supplement Napier grass with significant increases in weight gains (Abdulrazak *et al.*, 1996). Richards *et al.* (1994) replaced upto 50 % of concentrate nitrogen (N) with gliricidia and leucaena and observed no reduction in milk production by lactating does. Gliricidia foliage has some bypass protein hence there is a marked stimulation of growth when fed as a supplement to a basal diet of low digestibility (Preston, 1992). One of the reasons for its popularity is its complete resistance to the defoliating psyllid *(Heteropsylla cubana)*, which has devastated leuceana in many parts of the tropics (Simons and Stewart, 1994). However gliricidia could be unpalatable due to the odour of the leaves, which is reduced by wilting. Thus there is need for screening more tree fodders as alternative source of feed for ruminants. Madras thorn *(Pithecellobium dulce)* provides edible fruits, posts, shade, hedges and fodder. The leaves have a CP of about 24% and *in vitro* dry matter digestibility of about 59 % (Quiroz, 1997). However, most of the work done is on its chemical composition, which is not a good indicator of its nutritive value. Supplementation using Madras thorn could improve utilisation of low quality tropical grasses, hence an increase in animal performance.

1.1 The statement of the problem

Small-scale farmers in coastal Kenya are faced with the problem of low growth rates of their small East African goats, which take a long time, more than 24 months to reach market weight (MoALDM, 2000). This is mainly attributed to the low quality grass diets which are deficient in major nutrients especially protein. The CP is often below 7 %, which is inadequate for optimum microbial activities. Hence there is need for supplementation of the low quality grass diet.

1.2 General objective

To study the performance of goats offered a roughage based diet and supplemented with dry Madras thorn, leucaena or gliricidia leaves.

1.2.1 Specific objectives

1. To determine the effect of supplementing roughage based diet with increasing levels of Madras thorn on intake, digestibility and live weight changes of growing goats.

2. To determine the effects of supplementing roughage based diet with isonitrogenous levels of Madras thorn, leucaena and gliricidia on intake, digestibility and live weight changes of growing goats.

1.3 Hypotheses

To meet the objectives of the study, the following two hypotheses were postulated:

1. Ho: $\mu_O = \mu_1$- Madras thorn leaves supplementation at increasing levels will have no effect on feed intake, digestibility and live weight changes of growing goats.

H1: $\mu_O \neq \mu_1$ –Madras thorn leaves supplementation at increasing levels will cause an increase feed intake, digestibility and live weight changes of growing goats.

2. Ho: $\mu_O = \mu_1$ - Supplementation using madras thorn, leucaena or gliricidia leaves will cause the same effect on feed intake, digestibility and live weight changes of growing goats.

H1: $\mu_O \neq \mu_1$ - Supplementation using leucaena or gliricidia leaves will not have a similar effect on feed intake, digestibility and live weight changes of growing goats as compared to madras thorn leaves.

1.4 Justification

Protein being one of the limiting nutrients in grass based diets, there is need for more information on locally available and affordable alternative sources of protein supplement. Madras thorn, which is naturally grazed by goats, is expected to complement the low nitrogen grass diets and provide cheaper protein supplement to be used by both resource limited rural and small-scale peri-urban farmers. Despite the fact that pruning of Madras thorn's hedges is routinely practiced, the tree has seldom been exploited for its nutritional potential for ruminants. Due to the CP content contained in Madras thorn's leaves (24 %) its utilization is expected to compare with that of leucaena and gliricidia. The study was conducted in the coastal lowland of Kenya where Madras thorn, leucaena and gliricidia were readily available

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CHAPTER TWO

2. LITERATURE REVIEW

2.1 Meat goat industry in Kenya

The small ruminants industry plays a very important role in the economic and social life of many Kenyans, contributing largely as source of red meat, milk, wool, skins and to some extent mohair (MoALDM, 2000). Goats are kept under different production systems, depending on the environment, production objectives and market opportunities (Okeyo, 1997). Semi-intensive system of rearing is practised in medium and high rainfall areas. Small scale farmer stall feed the animals on fodder and crop residues or the animals are tethered on small strips of pastureland.

Goat meat contributes about 30 % of the total domestic red meat consumed, which is lower compared to beef (MoALDM, 2000). This is because little progress has been made in the humid or sub-humid Africa by research and development projects for increasing goat meat production on small scale farms. Government development through research and extension has lagged behind due to: inadequate nutrition and health, lack of affirmative and comprehensive policies on goat development and marketing. Research into forage production has only produced adaptable technologies for increased milk production (Reynolds, 1994).

The current population of sheep and goats in Kenya is approximately 18.6 million, with 7.6 million and 11.0 million sheep and goats, respectively. In Coast province there are 766,802 meat goats, which provide 19 % of the country's goat meat (MoALDM, 2000). Although goats play a minor role (compared to cattle) in Kenya's meat industry, they hold a promise for increasing meat production and small holder farmers' incomes. This is because goats require fewer resources, have faster production cycles and greater environmental adaptation (Reynolds, 1994).

Given a choice goats will often obtain more than 50 % of their daily ration from browse (Landau *et al.*, 2000). However, goats will perform well given that grazing management practices match their grazing behavior. Stall-feeding studies have shown that tree legumes such as *Gliricidia sepium* and *Leucaena leucocephala* can be used to replace some of the concentrate used in Napier-based diets for growing male kids and lactating does (Luginbuhl *et al.,* 1996).

2.2 Tree legumes as protein supplements

In developing countries feed shortage is a common phenomenon especially in the dry season. To overcome the feed shortages, surplus may be conserved as hay, silage or standing hay. Supplements such as oilseed cakes and animal by product meals are rarely used because they are expensive and unavailable to the farmers. Fodder plants such as leucaena and gliricidia which are used in alley cropping or in hedgerows can provide a year supply of feed. The high protein and mineral content of tree leaves are valuable supplements or feed during times when either quantity or quality is scarce (Norton *et al.*, 2000). The tree leaves correct dietary deficiencies thus increase the microbial degradation of food in the rumen, which increase voluntary feed intake of digestible organic matter and animal production.

The level of supplement offered will provide a different effect depending on the quality of the basal diet, the quality of the supplements and the level of animal production expected. Thus at a lower level of supplementation several constraints are alleviated, while at higher levels the supplements could be a source of energy and also contain some bypass nutrients especially protein. Norton (1994) suggested that any evaluation on forage trees as supplements should therefore investigate the effects of increasing levels of supplements on animal performance, so that minimum quantity maximum quality effect responses can be determined.

2.2.1 Influence of nutritive value of tree legumes on voluntary feed intake and digestibility

The nutritive value of forages depends on voluntary intake of feed consumed, and the extent to which dry matter eaten by the animal supplies dietary energy, proteins minerals and vitamins (Norton, 1994). Factors affecting voluntary feed intake in ruminant include chemostatic, thermostatic and lipostatic regulation, sensory appraisal, size of reticulo-rumen, digestibility and rate of passage of feed from the gut and physiological state of the animal (Mc Donald *et al*, 1991). The palatability of forages has been related to both physical characteristics (hairiness, bulk density) and presence of compounds (volatile oils, soluble carbohydrates, antinutritional factors) that may affect its taste. Palatability however, is not an important factor in determining the intake of good quality forages, but may limit the intake of poor quality feeds like cereal straws (Kaitho, 1997).

The rate of disappearance of digesta from the reticulo-rumen depends on the rate of digestion which is dependent on the chemical and physical characteristic of the feed. Fibrous feed of low digestibility are broken down slowly, taking a long time in the rumen, reducing further intake of the feed. The extent and rate of degradation determines the contribution, which the dietary protein makes to, the rumen microbial need and the amount of protein which passes the rumen undegraded (bypass protein). Preston and Leng (1987) reported that supplementing the diet with bypass protein often increases the intake of feeds that are deficient in protein.

Digestibility of a feed is the percentage of the whole or any single nutrient which is not excreted by the animal, therefore assumed to be available for absorption from the gastro intestinal tract. Digestibility is affected by the feed composition, preparation of feeds and level of feeding. Analyses can separate plant dry matter into neutral detergent solubles (NDS) or the cell content and neutral detergent fibre (NDF) or the cell wall content. Acid detergent fibre (ADF) is the fraction that contains mainly cellulose and lignin. The amount of NDF in tree fodders varies from 228-619 g/kg dry matter (Topps, 1992). Variation in NDF levels leads to difference in feed digestibility. Thus forages of low NDF content 200-350 g/kg DM are usually of high digestibility (Norton, 1994). High fibre reflects low amount of soluble carbohydrate which show low content of digestible energy hence low digestibility of the diet. In most tree fodder ADF is a large portion of NDF indicating low content of hemicellulose and high content of cellulose and lignin.

The CP content of tropical grasses decreases with maturity. The digestible CP varies considerably and is associated especially with level of CP and animal species. Low CP digestibility has been associated with low feed digestibility.

Studies by Abdulrazak *et al.* (1997) showed that supplementation of maize stover with gliricidia and leucaena fed to steers improved their total dry matter intake. Similar results were obtained by Adeloye (2000) who noted that goats consumed increasing amounts of dry matter and crude protein with increasing dietary *Albizia lebbeck* inclusion to a sorghum glume based diet. A higher level of N supplementation may be necessary for improved ruminal performance thus a reduction in retention time leading to higher intake. Camero *et al.* (2001) comparing the use of urea and legume tree forages as protein supplements to a basal diet of hay, rice bran and molasses noted that milk production was about 10 % higher with legume diet. Kaitho (1997) showed that 15 % of supplementation by four legumes; *Leucaena leucocephala, Leucaena* *pallida, Sesbania sesban and Chamaecytisus palmensis* was sufficient to convert 24 g weight loss to gain in Ethiopian highland sheep offered *Eragrotis tef* basal diet. Thus the supplements corrected deficient nutrients in the basal diet thereby improving diet digestibility and animal performance. Kaitho also observed that increasing level of supplementation further improved both diet digestibility and live weight gains.

2.2.2 Antinutritional factors in tree legumes

The utilisation of forage legumes as a complete feed or a supplement is limited by the presence of anti-nutritional factors. Anti-nutritional factors are substances generated in natural feed stuffs by the normal metabolism of species and by different mechanism like inactivation of some nutrients, which exerts an effect contrary to optimum nutrition. Some plants produce chemicals which are not directly involved in the process of plant growth (secondary compounds), but act as deterrents to insects and fungal attacks (Norton, 1994). Secondary plant compounds like cyanide, nitrate and fluoroacetate, mycotoxins, high tannins may produce toxic effects in ruminant animals, may depress intake and/or utilisation of feed components, however some like low tannins, anti-protozoal activity may enhance feed nutritive value. The common antinutritional factor is the tannins (Kumar, 1992).

Tannins are distinguishable from other polyphenols by their ability to precipitate proteins (although they also complex with starch and cellulose) (Reed, 1995). They can only be distinguished from non tannin phenolics by a protein precipitation method (Lowry *et al.*, 1996). Tannins comprise two major classes: i) Hydrolysable tannins (HT), which after hydrolysis yield carbohydrates and phenolic acids, and ii) Condensed tannins (CT), which are non-hydrolysable and are resistant to hydrolysis and are oligomers of flavan-3-ols and flavan-3, 4-diols. Tannins influence plant matter digestibitliy by: 1) Interfering with digestive enzymes through formation of tannin – enzyme complexes. 2) Interfering with digestive enzymes through formation of substrate protein – tannin complexes. 3) Combining with protein in the gut wall and preventing nutrient uptake. 4) Inhibiting the growth and enzyme activity of the rumen fungi, protozoa and bacteria.

Tannins may reduce intake of forage legumes by decreasing palatability or by negatively affecting digestion. Palatability has been thought to be associated with CT concentration due to astringency. Astringency is the sensation caused by the formation of complexes between tannins and salivary glycoproteins (Butter *et al.*, 1999). This may increase salivation and decrease palatability (Reed, 1995).

The CT may enable dietary protein to escape (undegraded) from the rumen for digestion in the lower digestive tract where the low pH allows for the dissociation of the tannin – substrate protein complexes. Readily degradable feeds can result in ammonia being released in the rumen at a rate that exceeds the capability of the microbes to utilise it in the synthesis of microbial protein. Bloat is caused by a very high solubility of forage proteins leading to the formation of a stable foam in which fermentation gases are entrapped. CT-containing legumes are known to eliminate bloat because of their protein-precipitating properties (Jones *et al.*, 1973).

Some of the compounds use to inactivate tannins are polyethylene glycol (PEG) or polvinylpyrrolidone (PVP) and drying. Tannins have a higher affinity to PEG and PVP than proteins however economic factors inhibit PEG and PVP use since its very expensive. Oven drying at 50°C caused a reduction in tannin of *A. aneura*, *A. angustissima*, *A. chinensis* and *Calliandra calothyrsus* (high CT) thus improving N utilisation in the rumen (Ahn *et al.*, 1989).

2.2.3 Leucaena leucocephala

Leucaena is indigenous to Central America as a forage crop. They have diverse sizes, tree forms, growth rates site adaptabilities, wood and leaf qualities. Leucaena is found at elevations as high as 1, 500 m (Hughes, 1998). This legume shrub is now well known and widely used, so systems of cultivation, management and harvesting are better developed than other species. Leucaena is used as fodder, provide poles and for soil fertility improvement. Dry leucaena contains an average 25 % CP which is four times as much protein as that of Napier grass. It is therefore exploited as a protein supplement to low quality basal diets.

Kaitho (1997) feeding Ethiopian highland sheep observed an increase in teff straw digestibility with increasing levels of leucaena supplementation. Muinga *et al.* (1992) reported an increase in total dry matter intake and 15 % more milk produced by Jersey cows fed leucaena supplement compared to unsupplemented cows. However the main hindrance to the use of leucaena is the presence of a non protein amino acid, mimosine. The most active metabolite of mimosine is 3hydroxy-4(IH)-pyridoxine (3,4-DHP) which is goitrogenic. Its particularly high in the actively growing shoots, young leaves of leucaena. When animals are fed dried leucaena material the enzymatic conversion of mimosine to DHP when the material is chewed since the enzyme of the plant is rendered inactive by heating. Adverse effect salivation, goitre, depressed serum tyroxine level, loss of hair, poor weight gains and even death (Jones, 1979). Thus a suggested restriction of 30 % and 50 % for cattle and goats respectively (Kumar, 1992).

2.2.4 Gliricidia sepium

It is a medium sized leguminous tree, which occurs in abundance throughout its native range in Meso-America. It has also been used extensively outside the native range in places, which include the Caribbean, the Philistine, India, Sri Lanka and West Africa. It is used to supply tree products such as fuel wood, construction poles, crop supports, green manure, fodder and bee forage (Simons and Stewart, 1994).

Gliricidia is among the best known and most widely researched tree legumes. Interest in gliricidia as a fodder has been further heightened in recent years in search for alternatives to Leucaena. Leucaena was the mostly widely used tropical tree fodder until its decimation by defoliating Psyllid *(Heteropsylla cubana)*, which spread throughout the tropics in mid 1980s to mid 1990s (Simons and Stewart 1994; Stewart 1996). Gliricidia has a wide variation in CP content (16-28 % DM), the main reason probably being the stage of growth at which harvesting occurred and the nature of the material harvested that is leaves and shoots rather than woody twigs (Topps, 1992). Due to its high CP content it can be used as a supplement to low quality diets and significantly improve intakes and performance of ruminants in the tropics (Abdulrazak *et al.*, 1997).

In West African Dwarf sheep, supplementing a basal diet of *Panicum maximum* with fresh and wilted leaves of gliricidia resulted in an increase in dry matter intake of basal diet (additive effect) while in goats there was substitution of the basal diet due to increased intake of gliricidia (Smith *et al.*, 1995). Normal feeding levels has been from 1-3 % of body weight although there are reports of goats being fed solely on gliricidia (Him Aun, 2002). Cases of unpalatability are associated with the odour of the leaves, which is reduced by wilting. There are differences in palatability of the provenances of gliricidia as shown by Norton *et al.* (2000) that the local provenance was less accepted even at low supplement intakes (0.4 % LW), while the lowest level of Retalhuleu provenance supplementation (0.55% LW) increased total digestible intake by 13 %.

2.2.5 Pithecellobium dulce

Plate 2.1. Madras thorn's hedge

Its common names include Madras thorn and Maramata in Swahili. Originally from South America, it is now cultivated in the tropics and naturalised in Kenya at lower altitude to 150 m above sea level. It tolerates arid and semi-arid conditions.

It is a thin shapeless shrub or tree 4 –15 m, with short spines 1.5-2.0 mm at the base of leaf pair. Leaves are deciduous but foliage is persistent, as the new leaves appear while the old ones are being shed; so that the tree looks evergreen, the leaves are thin stalks which bear 2 pairs of leaflets, which grow to 5 cm. The flowers are small; cream yellow on a short stalk with bunches of green white stamen 1 cm long. The fruits are heavy pods about 12 cm long spirally twisted, constricted between seeds, red when mature, splitting to release glossy black seeds.

It is used for live fence, fuel wood, poles, construction wood, fruits, fodder (leaves, pods and seeds), bee-forage, shade, wind breaks soil conservation, dune fixation, tannin and oil from the seeds (ICRAF, 1992). Goats in Kenya's coastal lowland naturally feed on it. The tree/shrub has a crude protein of between 19-27 % and i*n-vitro* dry matter digestibility of about 59.1 % (Quiroz *et al.*, 1997; Toures, 1998). Therefore it could be utilized as a source of protein especially for ruminants. However the tree/shrub has high levels of condensed tannins content (6.5 %) that more than the upper limit of 6 % (Barry and Duncan, 1984). This could probably interfere with protein digestion in the rumen.

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CHAPTER THREE

3. EFFECT OF SUPPLEMENTING NAPIER GRASS WITH INCREASING LEVELS OF MADRAS THORN ON INTAKE, DIGESTIBILITY AND LIVE WEIGHT GAINS OF GROWING GOATS

3.1 Introduction

Pasture quality and availability varies markedly throughout the year in the tropics. Crude protein content of dry mature tropical grasses often fall below the minimum 7 % required for optimum microbial function in the rumen (Minson and Milford, 1967) Where as the energy content of dry mature tropical grasses and cereal crops residues is below the animal requirement most of the year (Kaitho, 1997). To alleviate the problem one can supplement using commercial concentrates or leguminous tree fodders. Tree fodders like leucaena and gliricidia provide rumen degradable and bypass protein, digestible energy and minerals. They contain high crude protein (19-30 %) thus are used as supplements to low quality diets and significantly improve feed intake and performance of ruminants in the tropics (Kaitho, 1997). Tree fodders have nutritional diversity in terms of chemical composition, palatability and digestibility. Therefore a lot of research is needed to assess the nutritive value of more tree legumes so as to create feed diversity for ruminants.

Madras thorn *(Pithecellobium dulce)* is one of the tree legume documented as a useful fodder (Topps, 1992). It has been used in Kenya's coastal lowland for live fence, fuel wood, fruits, poles and fodder. However most of the work done on this tree legume is concentrated on its chemical composition hence there is limited information on its nutritive value as a dietary supplement although it is common knowledge that goats consumes it. The objective of this study was to determine the effect of supplementing a Napier grass (*Pennisetum purpureum*) based diet with increasing level of Madras thorn on feed intake, digestibility and live weight changes of growing goats.

3.2 Materials and methods

3.2.1 Study site

The study was carried out at Kilifi Institute of Agriculture Coast province of Kenya (3° 50'S, 39°44'E) and 3m above sea level. The institute is in coastal lowland agroecological zone 3, the site has well drained sandy soils, which are prone to leaching and have low levels of organic matter and nitrogen (Jaetzold and Schmidt, 1983). The monthly rainfall for December and January was 2 and 36mm respectively while the mean monthly minimum and maximum temperatures are 22°C and 36°C respectively over the experimental period.

3.2.2 Animals

Fifteen small East African goats of 5 to 7 months old and body weight 9 kg (± 2.28) on average were used in the experiment to measure voluntary feed intake, digestibility and live weight changes. Before the start of the experiment the goats were treated against helminths and their mean live weights were recorded. To control ticks an acaricde, (cypermethrin) was applied after every 3 weeks. The goats were confined to individual pens measuring 1 m x 0.75 m.

3.2.3 Feeds

Napier grass was harvested from the Institute's farm after it was cut back and 8 weeks regrowth allowed. There was no fertilizer use on the Napier grass plots, however the plots were irrigated daily in the month of January. Napier grass was harvested daily and chopped to pieces of about 30-40 mm. Madras thorn's leaves were harvested from the institute live fence after cutting and allowed to regrow for 6 weeks. The leaves were sun dried for two days before the start of experiment. Water and mineral lick blocks which contained 32 g P, 168 g Ca, 105 g Na, 195 g Cl, 2.5 g S, 0.31 g I, 2.3 g Zn, 1.5 g Mn, 2.0 g Cu and 0.15 g Co per kg were offered *ad libitum*. The treatment diets were as follows: Napier grass (control); Control + 7.5g DM /kg$W^{0.75}$ Madras thorn (M7.5); Control + 15g DM /kg$W^{0.75}$ Madras thorn (M15); Control + 22.5g DM /kg$W^{0.75}$ Madras thorn (M22.5); Control + 30g DM /kg$W^{0.75}$ Madras thorn (M30).

3.2.4 Experimental procedure and design

A completely randomized design (CRD) was used with each treatment being replicated three times. The basal diet was offered in the morning and added in the afternoon to ensure availability at all times. Feed refusals were weighed each morning before fresh feed was offered. The basal diet was adjusted daily so that 10 % in addition to previous day's was offered daily. The supplement was offered at 0800hrs before the basal diet and would be cleared within 30 minutes. Animals were weighed weekly and weights recorded. The amount of legume supplement was adjusted weekly to conform to live weight changes.

3.2.5 Data collection

The goats were allowed to adapt for 10 days confinement where they were fed Napier grass only. Data was collected for 7 weeks. Live weight changes were assessed weekly while feed intake and refusals were recorded daily. In the last seven days nitrogen balance trial was carried out. The total faecal and urine output of the 15 goats were collected, weighed and recorded per animal. A ten percent sample of the 24-hr faeces collected for every goat was dried at 65°C and stored for later chemical analysis. Urine was collected in plastic containers containing 50 ml of 10% hydrochloric acid, frozen and at the end of the 7 day collection period pooled per animal then sub-sampled per animal for nitrogen analysis. Napier grass and Madras thorn were sampled weekly the samples used for DM, and chemical analyses.

3.2.6 Chemical analyses

Chemical analysis was conducted to determine the nutrient composition of feed, faeces and urine. The dried feed and faecal samples were ground to pass through a 3.5 mm screen before analyzing for DM, ash, NDF, ADF, lignin and total nitrogen (Kjeldhal-N) using official methods (AOAC, 1990). Crude protein calculated by multiplying N with 6.25. Phenolics were determined according to the procedure described by Abdulrazak and Fujihara (1999).

3.2.7 *In-vitro* digestibility

The feed samples were incubated *in-vitro* in rumen fluid-buffer mixture, in calibrated glass syringes following the procedure of Menke and Steingass (1988). Rumen liquor was obtained from two steers fed on hay *ad libitum* and 2 kg of concentrates. Readings were recorded during 0, 3, 6, 12, 24, 48, 72, and 96 h of incubation. Organic matter digestibility and metabolizable energy values of feeds were calculated using 48 h gas production values as described by Abdulrazak and Fujihara (1999).

3.2.8 Data analysis

Data from the experiments was subjected to analysis of variance linear model (GLM) of SAS (1996). The treatment means were separated using least significance difference (LSD).

3.3 Results

The chemical composition of the feeds is given in Table 3. 1. Madras thorn had CP content of 23 %, which was four times the level in Napier grass. Neutral detergent fibre content was more in Napier grass than Madras thorn, while the legume had more lignin than Napier grass. The ash content of both the Madras thorn and Napier grass was similar. Differences in gas production were recorded between Napier grass and Madras thorn where Napier grass had higher gas production after 48 and 96 hrs (Table 3.2). However there were no differences at 96 hr degradation potential.

Table 3.1: Chemical composition of Napier grass and Madras thorn (%)

	DM	CP	ASH	EE	NDF	ADF	Lignin	TANNINS
NAPIER	25.00	5.94	9.9	1.15	71.31	44.02	4.50	0.86
	±1.95	±0.65	±0.80	±0.65	±2.89	±2.45	±0.45	±0.15
MADRAS	25.00	23.00	10.8	12.45	40.18	22.98	8.14	1.94
	±2.64	±1.20	±0.68	±0.50	±1.52	±1.49	±0.95	±0.21

Table 3.2: *In vitro* gas production (ml/200 mg DM) of Madras thorn and Napier grass.

Samples	Gas production at		Gas production potential 96 (h)		
	48 (h)	96 (h)	a + b	c (%h)	OMD 48 (h)
Madras thorn	29.0	34.5	45.4	0.05	46.57
Napier grass	33.0	40.0	45.6	0.05	49.34

a, b, c are constants in the equation p = a + b(1-e-ct) (Ørskov and Mc Donald, 1979).

Where p = volume of gas produced with time t; a = intercept of gas production curve;

b = asymptote of exponential b(1-e-ct); a + b = potential extent of gas production

c = rate of gas production

OMD = organic matter digestibility calculated from the equation: OMD (%) = 18.53 + 0.9239 gas production (at 48 h) + 0.054 CP (Menke and Steingass, 1988).

Table 3.3: Intake, CP (g DM/day), metabolizable energy (MJ/Kg DM) and digestibility (g/kg) of treatment diets.

	Treatment					
DMI	Control	M7.5	M15	M22.5	M30	SEM
Napier	242.13^{a}	219.88^{ab}	203.82^{ab}	201.84^{ab}	171.20^{b}	29.324
Madras	-	41.14^{c}	98.66^{bc}	155.20^{b}	257.30^{a}	31.577
Total	242.13^{c}	258.45^{bc}	302.48^{bc}	357.04^{ab}	428.50^{a}	45.939
CP	14.38	21.13	34.80	47.69	69.35	nd
ME	2.01	2.22	3.11	3.91	5.12	nd
Digestibility						
DMD	574.5^{b}	619.7^{a}	622.9^{a}	608.5^{a}	611.6^{a}	6.39

Nd = not determined

Means in the same row with the same letter superscript are not significantly different (P<0.05)

ME (MJ/kg DM) = 14.78 – 0.00147ADF

Results on dry matter intake (DMI) and digestibility are given in Table 3.3. There was a depression in the basal diet intake at 30 g DM/kg $W^{0.75}$ level of supplementation. However increase in the level of supplementation resulted in increase ($P < 0.05$) in the total dry matter intake (TDMI) for M22.5 and M30 treatments. Supplementation also resulted in significant increase ($P < 0.05$) in dry matter digestibility DMD, however there were no significant differences in DMD between the different levels of supplementation.

Table 3.4: Mean N balance (g/day) and average daily gains (g/day) of goats fed Napier grass and supplemented with Madras thorn.

	Control	M7.5	M15	M22.5	M30	SEM
Feed N	0.95^{d}	3.38^{cd}	5.57^{bc}	7.63^{b}	11.1^{a}	1.173
Faecal N	0.51^{c}	1.34^{bc}	2.15^{bc}	2.95^{b}	4.66^{a}	0.332
Urine N	0.25^{c}	0.60^{bc}	0.88^{bc}	1.43^{b}	2.87^{a}	0.847
N loss	0.76^{c}	1.94^{bc}	3.03^{b}	4.38^{b}	7.54^{a}	1.064
N retained	0.19^{c}	1.44^{bc}	2.54^{ba}	3.25^{a}	3.557^{a}	0.542
ADG	-8^{b}	8.33^{b}	22.61^{ab}	43.25^{a}	43.65^{a}	14.716

Means in the same row with the same letter superscript are not significantly different ($P<0.05$)

Positive nitrogen balance was recorded for all goats (Table 3.4). Feed nitrogen, nitrogen retained, loss and average daily gains (ADG) increased with increase in supplementation. Maximum nitrogen balance being recorded with goats fed 22.5 g DM /kg $W^{0.75}$ of Madras thorn. There were however no significant differences between the treatments receiving 22.5 and 30 g DM/kg $W^{0.75}$. Sixty seven percent of the nitrogen loss was through faeces in all the treatments.

3.4 Discussion

Chemical composition of Napier grass is within the levels reported by Kariuki (1998). However the CP level was below the 7 % minimum requirement for optimal microbial function in the rumen (Minson and Milford, 1967) hence the weight loss of 8 g/day. Tannins content in Madras thorn was below the 6 % critical level (Barry and Duncan,1984), thus the 2 % level could be beneficial in providing bypass protein or decreasing ammonia loss in the rumen. Species which contain some tannins provide degradable and undegradable rumen N and are more effective sources of supplementary N for ruminants (Norton, 1994a).

The *in-vitro* gas production technique has the potential to reflect the in vivo digestibility of feeds for ruminants; the highest predictive value for the in vivo digestibility of straw was obtained after 45 to 52 h of *in-vitro* fermentation (Prasad *et al.*, 1994). The 48 hr gas production value for Madras thorn is similar to those reported by Nyangaga *et al.* (2001) for acacia species, where gas production values ranged between 29 –37 ml. The 96 hr potential gas production and production and OMD values between Napier grass and Madras thorn were comparable. The higher gas production from Napier grass as compared to Madras thorn is similar to reported for Napier grass and gliricidia (Richards *et al.*, 1994) as a result of differences in cell wall composition between tropical grasses and legumes. Grasses contain higher hemicellulose and lower lignin content as compared to legumes.

DMD level of Napier grass was similar to the one reported by Van Eys *et al.* (1986). However diet DMD was significantly improved with supplementation, DMD was similar across the legume supplemented treatment. Dry matter digestibility of Napier grass supplemented with Madras thorn is similar to DMD of sheep on a *Cenchus ciliaris* hay basal diet fed with *Sesbania sesban* leaves (Bitende, 1994).

The increase in supplementation enhanced total DM intake. It however resulted in depression of the basal diet intake at the highest level of supplementation. Smith *et al.* (1995) noted a substitution effect in goats with increased intake of gliricidia. Abdulrazak *et al.* (1996) also reported decreasing intake of Napier grass when crossbred steers were supplemented with increasing levels of gliricidia leading to substitution of the basal diet, this was attributed to the bulk effect of the supplement.

The nitrogen retention between 22.5 and 30 g DM /kg $W^{0.75}$ treatments was similar, however higher nitrogen loss was recorded with the 30g DM /kg $W^{0.75}$ treatment. Similar results were shown by Nyanganga (2001) supplementing whether fed straw increasing levels of *Acacia brevispica* where N balance dropped beyond 20 % DMI of legume inclusion.

Goats fed the control diet lost 8 g/day as a result of low CP content (5.94 %) in the diet, however supplementation even at the lowest level 7.5 g DM/kg $W^{0.75}$ converted the weight loss to gain. This was due to increase in nutrients especially nitrogen, thus overcoming the depressing effect of low N content in the diet. Weight gain increased with increase in legume supplementation, however, at 30 g DM/kg $W^{0.75}$ level of supplementation, mean group weight gain was similar to 22.5 g DM/kg $W^{0.75}$ group which gained 43 g/day. Norton (1994b) observed a linear increase in weight gain for goats fed on barley straw and supplemented with increasing levels of *Sesbania sesban* up to 33 % DM supplementation, while at 65 % DM supplementation there was a reduction in weight gain. Norton (1994b) also noted that maximum gains are achieved when supplements are provided at 40-60 % of the total DM intake. Kaitho (1997) working with sheep observed an optimum dietary level of 30 – 45 % of the total DM intake. Phimphanhvongsod and Ledin (2002) carried out a study where local goats were supplemented with gliricidia at 0, 20, 30, 40, 50 % of the diet, the highest growth rate of 43 g/day was from the treatment with 30 % gliricidia. The study further showed that gliricidia inclusion to more than 30 % resulted in depression in weight gain.

Similarity in weight gain at 22.5 and 30 g DM /kg $W^{0.75}$ supplementation could be as a result of energy being a limiting factor to proper utilization of feed nitrogen. The energy content at 30 g DM/kg $W^{0.75}$ was below the level recommended by Peacock (1996) for higher growth rate. Ondiek (1999) recorded the highest live weight gain from supplementing with the gliricidia-maize bran mixture than gliricidia alone. Better performance in gliricidia-bran supplemented group may be explained by the phenomenon of synchronisation of energy and protein. Synchronisation of metabolizable energy and nitrogen in the gliricidia-bran mixture could have resulted in a better supply of energy and protein to microbes and hence a more efficient microbial protein synthesis (Sinclair *et al.*, 1995, cited by Ondiek, 1999).

3.5 Conclusion

It is recommended that in goats Madras thorn should be offered between 40-50 % of the diet (22.5 g DM /kg $W^{0.75}$) for optimal production. Madras thorn forage could be used to supplement roughage based diet, for goats where available.

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CHAPTER FOUR

4. EFFECTS OF SUPPLEMENTING ROUGHAGE BASED DIET WITH ISONITROGENOUS LEVELS OF MADRAS THORN, LEUCAENA AND GLIRICIDIA ON INTAKE, DIGESTIBILITY AND LIVE WEIGHT CHANGES OF GROWING GOATS.

4.1 Introduction

Tree legumes, particularly leucaena *(Leuceana leucocephala)* and gliricidia *(Gliricidia sepium)* have been used as protein supplements for low quality forages and resulted in improved ruminant productivity (Norton, 1994). This is because of their high CP content and availability throughout the year. Leucaena contains on average 25 % CP while gliricidia 22 %, (Topps, 1992). Leucaena and gliricidia have been used to supplement maize stover with significant increases in weight gain (Abdulrazak *et al*., 1997). One of the reasons why gliricidia is popular is its resistance to the defoliating psyllid *(Heteropsylla cubana)*, which has devastated leucaena in many parts of the tropics (Simons and Stewart, 1994). However gliricidia has cases of unpalatability that are associated with the odour of the leaves, which can be removed by wilting (Norton, 1994).

The most commonly used tree legumes are leucaena and gliricidia (Brewbaker, 1986). Although there is considerable diversity, past research and developmental activities have worked on a narrow range of available germplasm (Kaitho, 1997). This is unfortunate, as the narrower focus has overlooked many other valuable trees such as Madras thorn. A comparison of Madras thorn to leucaena and gliricidia reflects on the potential of the tree for utilisation as a protein supplement. This will broaden the tree legumes feed resource for ruminants.The objective of this study was to determine the effect of supplementing panicum *(Panicum maximum)* hay with gliricidia, leucaena and Madras thorn on feed intake, live weight changes, digestibility and nitrogen balance of growing goats.

4.2 Materials and methods

4.2.1 Site

This study was carried out at Kilifi Institute of Agriculture. It lies at 3° 50'S, 39°44'E, and its 3 m above sea level (Jaetzold and Schmidt, 1983). The monthly rainfall was 29 and 195 mm for March and April respectively while the mean monthly minimum and maximum temperature were 22°C and 33°C respectively during the experimental period.

4.2.2 Animals

Twelve Small East African male and female goats aged 8 to 9 months and body weight average 9.65 kg (± 1.52) were used to determine voluntary feed intake, digestibility and live weight changes. Before the start of the experiment the goats were dewormed with an antihelmintic and their mean live weights recorded. The goats were housed individually in slated floor pens (1 m x 0.75 m).

4.2.3 Feeds and treatment diets

Panicum hay used as the basal diet in the experiment was purchased from a farm in Kilifi. Madras thorn's leaves were harvested from the institute live fence after cutting and allowed to regrow for 6 weeks. Leucaena and gliricidia were established in 1989 at KARI Mtwapa station, they have since been cut back and allowed to regrow for about two months. The harvested Madras thorn, leucaena and gliricidia leaves were sun dried for two days before the start of experiment. The control diet consisted of the panicum hay fed *ad libitum* plus 100 g of maize bran and a mineral lick. The other three treatments consisted of the control supplemented with isonitrogenous levels of Madras thorn (19.5 g DM /$kgW^{0.75}$), Leucaena (18.6 g DM /$kgW^{0.75}$) and Gliricidia (22.5g DM /$kgW^{0.75}$).

4.2.4 Experimental procedure and design

A completely randomized design (CRD) was used, with each treatment being replicated three times. The basal diet was offered in the morning and added in the afternoon to ensure availability at all times. The supplements were offered at 0800hrs before the basal diet. Feed refusals were removed and weighed every morning before fresh feed was offered to determine intake. Animals were weighed weekly before feeding. The amount of legume supplement was adjusted weekly to conform to live weight changes. Data was collected for seven weeks after a seven-day adaptation.

4.2.5 Digestibility trial

In the last seven days of the trial, total fecal and urine output per animal of the 12 goats were collected, weighed and recorded. The goats were housed in metabolic cages (1 m x 0.75 m), where urine and feces were collected separately. A 10 % sample of the 24-hr feces collected for every goat was dried at 65^{O}C for 24 hrs and stored. At the end of the collection period, the fecal samples were bulked per animal, mixed and a sample taken to determine dry matter (DM), organic mater (OM), and nitrogen (N). Urine was collected over 25 ml of 10 % hydrochloric acid per 100 ml urine. Urine collected daily was frozen and at the end of the seven day collection period, urine was pooled and sub-sampled per animal for nitrogen analysis.

4.2.6 Sampling and analyses

The hay and legume forages were sampled weekly. The samples were dried at 65^{O}C and ground to pass through a 3.5-mm screen. The ash, DM, ether extracts (EE) and N (Kjeldhal-N) was determined using, the association of analytical chemist methods (AOAC, 1990), CP calculated by multiplying N with 6.25.

4.2.7 *In-vitro* digestibility

Feed samples were incubated *in-vitro* in rumen fluid-buffer mixture, in calibrated glass syringes following the procedure of Menke and Steingass (1988). Rumen liquor was obtained from two steers fed on hay *ad libitum* and 2 kg of concentrates. Readings were recorded during 0, 3, 6, 12, 24, 48, 72, and 96 h of incubation. Organic matter digestibility and metabolizable energy values of feeds were calculated using 48 h gas production values as described by Abdulrazak and Fujihara (1999).

4.2.8 Data analysis

Data from the experiment was subjected to analysis of variance using the general linear model (GLM) of SAS (1996). The treatment means were separated using least significance difference (LSD).

4.3 Results

The chemical composition of the feeds used in the experiment is given in Table 4.1. The DM content for all the legumes was 25 % while that of maize bran and panicum hay was 90 and 85 % respectively. The CP content of the legumes ranged between 21 – 25 %, leucaena having the highest CP content of 25 %. Maize bran and hay had similar ash contents, which were lower than the legumes.

Table 4.1: Chemical composition of sun-dried legumes, hay and maize bran (%).

	DM	CP	Ash	EE	NDF	ADF	Tannins
Gliricidia	25.00	21.00	8.98	12.91	27.51	20.34	3.24
	±2.05	±2.65	±0.85	±0.85	±1.67	±1.13	±0.45
Leucaena	25.00	25.00	6.87	13.25	44.17	15.72	4.39
	±1.39	±2.10	±0.79	±0.82	±1.79	±0.95	±0.32
Madras	25.00	23.00	9.92	12.45	40.08	22.96	1.94
	±2.64	±1.20	±0.68	±0.50	±1.52	±1.49	±0.21
Hay	85.00	3.50	3.20	2.15	72.20	45.45	nd
	±2.85	±0.65	±0.45	±0.25	±2.06	±2.048	
Maize bran	90.00	15.00	3.00	9.69	31.12	9.58	nd
	±1.25	±0.75	±0.50	±0.68	±1.26	±0.88	

Nd = not determined

Table 4.2: *In vitro* gas production (ml/200 mg DM) of Madras thorn, gliricidia, leucaena and panicum grass.

Samples	12	24	48	72	96	a	b	c (% h)	a + b	OMD 48 (h)
Madras thorn	16.0	23.0	29.0	34.5	34.5	3.5	33	0.05	38.5	46.57
Panicum grass	10.0	16.0	22.0	31.0	36.0	1.0	37.5	0.05	38.5	39.05
Leucaena	11.0	21.0	27.0	30.0	31.0	3.0	30	0.05	33	44.83
Gliricidia	19.0	25.5	32.0	31.0	36.0	4.5	36.5	0.05	40	49.23

a, b, c are constants in the equation p = a + b(1-e-ct) (Ørskov aand Mc Donald, 1979).

Where p = volume of gas produced with time t; a = intercept of gas production curve;

b = asymptote of exponential b(1-e-ct); a + b = potential extent of gas production

c = rate of gas production

OMD = organic matter digestibility calculated from the equation: OMD (%) = 18.53 + 0.9239 gas production (at 48 h) + 0.054 CP (Menke and Steingass, 1988).

Table 4.3: Intake (g/day) and digestibility (g/kg) of hay, legumes and maize bran.

	Treatment				
	Control	Madras	Gliricidia	Leucaena	SEM
DMI					
Hay	138.9^{a}	112.6^{a}.	128.2^{a}	158.0^{a}	22.34
Legume	-	162.3^{a}	170.2^{a}	146.0^{a}	19.10
Maize bran	90	90	90	90	-
Total	228.9^{b}	364.9^{a}	387.4^{a}	397.6^{a}	35.11
DMD	599.0^{b}	629.0^{ab}	635.0^{a}	620.0^{ab}	13.8

Means in the same row with the same letter superscript are not statistically different (P<0.05)

The intake of the basal diet was similar in all the treatments (P>0.05), however leucaena though not significantly different stimulated 14 % increase in intake of panicim hay. The total dry mater intake (TDMI) was 229, 365, 387 and 398 g/day for control, Madras thorn, gliricidia and leucaena group respectively.

Table 4.4: Mean N balance and average daily gains (g/day) of goats used in the experiment.

	Control	Madras	Gliricidia	Leucaena	SEM
Feed N	1.0^{b}	6.8^{a}	7.2^{a}	6.6^{a}	0.77
Urine N	0.2^{a}	1.0^{a}	1.2^{a}	0.4^{a}	0.59
Faecal N	0.2^{c}	2.0^{b}	2.4^{ab}	2.7^{a}	0.25
N loss	0.4^{b}	3.1^{a}	3.6^{a}	3.1^{a}	0.52
N retained	0.6^{b}	3.7^{a}	3.6^{a}	3.5^{a}	0.71
ADG	1.59^{b}	21.6^{a}	18.7^{a}	25.4^{a}	3.00

Means in the same row with the same letter superscript are not statistically different ($P<0.05$)

All the goats maintained a positive nitrogen balance (Table 4.4). However the nitrogen retained was more in the legume supplemented goats 3.7, 3.6 and 3.5 g/day for madras thorn, gliricidia and leucaena respectively as compared to the control (0.6 g/day). The supplemented goats had higher N intake and loss than those fed on the basal diet only. The N loss was similar between the legumes, (range 3.1- 3.6 g/kg DM). The goats feeding on the control diet maintained body weight, while the supplemented treatments gained 22, 19 and 25 g/day for madras thorn, gliricidia and leucaena respectively.

4.4 Discussion

Crude protein content of the legumes was within the expected range of 12-30 % reported by Kaitho (1997). The 3 % CP content of hay was similar to the value reported by Njarui *et al.* (2003) for natural pasture hay. However this level is below the 7 % minimum requirement for body maintenance (Minson and Milford, 1967) hence the addition of maize bran. The presence of 4.4 % tannins in leucaena could possibly explain its depression in gas production. However, the low tannin content (2 %) in madras thorn and low gas production indicate that the effect of tannins in gas production depends on other factors such as molecular structure and reactivity than the contents (Hagerman *et al.*, 1992).

The forage with the greatest potential, a + b and the highest volume of gas was gliricidia. The differences can be attributed to their fibre, nature of polyphenolic concentration and other antinutritional factors. Leucaena had the highest concentration of tannins and the lowest volume of gas produced. Kaitho (1997) showed that tannin induced a depression in gas production in a number of browse species. However, although gliricidia had higher tannin content, gas produced was compared to Madras thorn. Therefore the nature of tannin had a greater role to play.

Intake of the basal diet was similar (P>0.05) in all treatments. Supplementation caused an increase in the TDMI by 59, 69 and 74 % for Madras thorn, gliricidia and leucaena treatment respectively. Similar observations were reported by Abdulrazak *et al.* (1997) who found an increase in TDMI when maize stover was supplemented with leucaena or gliricidia in crossbred steers. Camero *et al.* (2001) noted that supplementation increased microbial degradation in the rumen and improved animal metabolic capacity to use energy, which in turn increased voluntary feed intake and animal production. Dry matter digestibility (DMD) of control was similar to the legume supplemented treatments, however significantly different from gliricidia treatment. The result compare with those of Abdulrazak (1996) where supplementing Napier grass (7.6 % CP) with either leucaena or gliricidia did not have any effect on DMD. In this study protein level of the control diet was 7.1 % thus microbial requirement for nitrogen were met.

The supplemented goats had higher N intake and loss than those fed on the basal diet only. The N loss was similar between the legumes, (range 3.1- 3.6 g/kg DM). More nitrogen was lost through the faeces (average 2.4 g) than through the urine (average 0.9 g). Legume supplementation increased (P<0.05) nitrogen retention. These values are in agreement with those reported by Adeloye (2000) who observed 3.1 g/day N balance in goats fed 50/50 mixture of Albizia (*Albizia lebbeck)* as supplements to sorghum glume basal diet. The increase in the nitrogen balance attributed to improved daily gains observed in goats.

Legume supplementation increased (P<0.05) the average daily gains (ADG). Goats supplemented with Madras thorn gained 22 g/day, which was comparable to the 25 g/day from the leucaena treatment. There were no significant differences (P>0.05) in the growth rate between the different legume supplements. The results are similar to those reported by Van Eys *et al.* (1986), where goats fed on a basal diet of Napier grass supplemented with leucaena gained 22 g/day.

4.5 Conclusion

- Supplementation with any of the three legumes resulted in a significant increase in total dry matter, nitrogen intake, nitrogen retained and average daily gains of growing goats.
- Supplementing panicum hay with Madras thorn gave similar growth performance to supplementing with gliricidia or leucaena.

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CHAPTER FIVE

5. GENERAL DISCUSSION

In the Coast province of Kenya 1,022,007 goats are kept as a means of obtaining quick cash and for cultural functions. The breed mainly kept is the small East African goat, and the main product is meat (MoALDM, 2000). Hence they contribute to income generation and food security for the coastal communities. The goats especially in the planting season, are tethered on small stripes of land to prevent crop damage.

There is a marked seasonality on the quality and quantity of forage consumed. In the dry season tropical grasses are low in digestibility and particularly low in total nitrogen resulting in low feed intake (Leng, 1986). Hence animal production from ruminants in developing countries is generally low and often only 10 % of the genetic potential of the animal (Leng, 1992). Poor quality forages may be improved by physical, chemical or biological treatment. Chemical and biological treatment as well as convectional protein supplements may not be practical or economical in most tropical countries, since they are expensive and out of reach of many farmers (Kaitho, 1997).

Indigenous and introduced tree and shrub species are one of many feed resources used by farmers to feed their ruminants. They are rich in protein and mineral contents and they serve two essential functions (i) To promote efficient microbial growth in the rumen (ii) Increase protein supply for digestion in the small intestine.

5.1 Effects of supplementation on animal performance

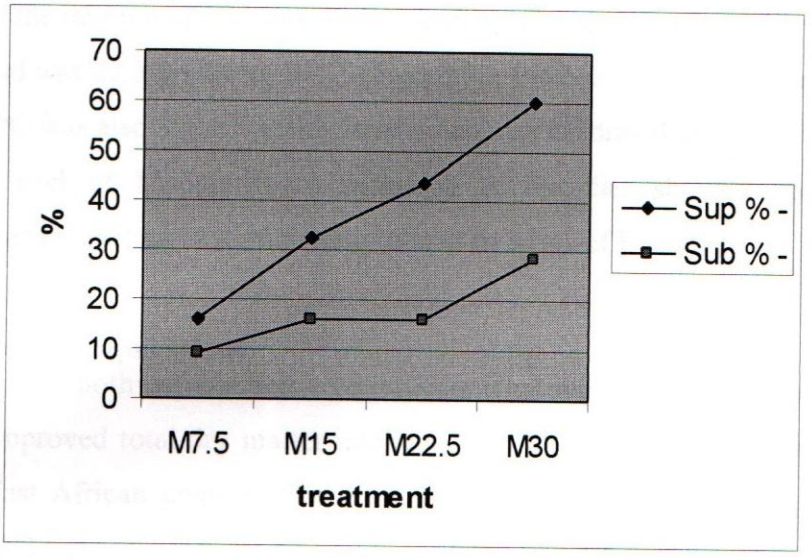
The positive animal performance reported in the two experiments were attributed to the abilities of the legumes to overcome protein deficiency in the roughage based diets and by providing more ruminally available protein and/or bypass protein.

Voluntary feed intake increased with supplementation as shown by both experiments. The observed increase in total feed intake with increasing level of supplementation in experiment one, was mainly due to substitution of Napier grass with Madras thorn (Figure 5.1). Higher levels of the legume in the diet could have displaced some ruminal volume thus reducing the intake of Napier grass. Panicum hay used in experiment two was low in CP and high in fibre, thus lower intake as compared to Napier grass used in experiment one. Supplementing with leucaena, though not significantly different stimulated a higher intake of the basal diet, unlike madras thorn and gliricidia that resulted in 18.9 and 7.7 % substitution respectively. Leucaena leaves are smaller in size as compared to Madras thorn and gliricidia. McDonald *et al.* (1991) reported that feed of smaller particle size, leads to increased feed intake through higher enzyme – substrate contact hence a higher outflow rate. However, the digestibility is usually depressed since there is faster rate of passage thus less time for digestion. The response in gas production shows that gliricidia was rapidly digested as compared to Madras thorn and leucaena, indicating that leucaena and Madras thorn could have more bypass protein. Similar findings on leucaena and gliricidia were reported by Abdulrazak (1995). Supplementing the diet with bypass protein often increases the intake of feeds that are deficient in protein (Preston and Leng, 1987).

Increasing the level of Madras thorn in the diet increased the DM digestibility. The lower digestibility of both basal diets could be attributed to their low CP, below the 6 - 8% requirement for microbial activity in the rumen thus supplementation improved digestibility of the basal diets (Minson and Milford, 1967). At low supplementation level the response in DM digestibility to addition of Madras thorn was greater than higher levels. The highest improvement in digestibility was noted at 15 g DM /kg $W^{0.75}$, higher level of inclusion beyond this point did not seem to affect the DM digestibility.

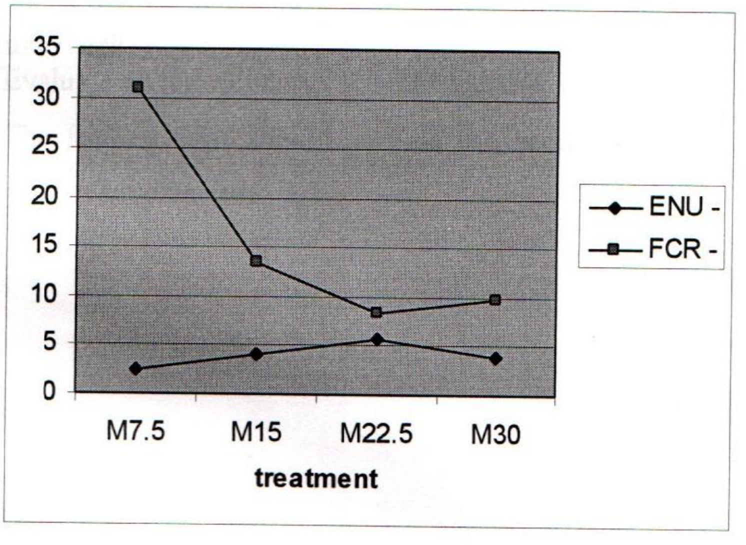
In experiment one goats fed on the control diet lost weight. The lowest level of supplementation converted weight loss to gain. Supplementing the basal diet with increasing levels of madras thorn resulted in increasing live weight gain. In experiment two the goats on control diet maintained body weight due to the fact that the hay was supplemented with maize bran thus provided the nutrients necessary for body maintenance. However higher growth rates were observed when Napier grass was the basal diet than panicum hay. Madras thorn at 32 % of the total diet was enough to cause 23 g/day live weight gain in Napier grass based diet, where as panicum hay based diet Madras thorn at 44.5 % of the total diet was required to cause the same effect in live weight gain. The animal responses in term of TDMI and weight gain depends on the quality of the basal diet as shown by Kariuki (1998) where heifers on good quality Napier grass gave better performance than poor quality Napier grass though it was supplemented.

Figure 5.1: Supplementation and substitution % of treatment diets



Sup % = supplementation % ([Madras thorn/TDMI]*100)
Sub % = substitution % ([TDMI of a treatment – control]/TDMI) *100

Figure 5.2: Efficiency of nitrogen utilisation and feed conversion ratio



ENU = efficiency of feed nitrogen utilisation (ADG/ nitrogen intake)
FCR = feed conversion ratio (TDMI/ADG)

The optimum level of legume dietary inclusion recommended by Devendra (1995) is 30 – 50 % of the ration on DM basis. From experiment one the optimum level of inclusion using FCR, ENU and was 22.5 g DM/kg $W^{0.75}$ (Figure 5.2.), where FCR was lowest while ENU was highest. The ADG was also highest at this level when was Madras thorn was at 43 % of the total diet. The higher level of Madras thorn inclusion in the diet showed no improvement on animal performance, leading to diminishing returns in terms of ENU.

5.2 Practical implications

From both experiments tree legumes improve the nutritive value of roughage based diet hence improved total dry matter intake as well as animal performance. The age at weaning for small East African goats is five months where they are about 8 kg. To achieve mature body weight (25 kg) with ADG of 40 g/day it will take 13.3 months form weaning time. Age at puberty that is 20 kg body weight, will be attained in 10 months after weaning. Hence goats will be taking 18 instead of 24 months to reach market weight. Thus supplementation will provide the nutrients necessary for proper development, faster growth and early sexual maturity.

5.3 Future work

- Evaluate on use of energy sources together with the tree legumes.
- The feeding trial should include the economic implication of using tree legumes as protein supplements.

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6. APPENDICES

Appendix I

Experiment 1: Daily mean Napier grass, legume and total dry matter intake (g/day)

	REPS	NAPIER	LEGUME	TOTAL
Control	1	236.95	0.00	236.95
Control	2	281.65	0.00	281.65
Control	3	207.77	0.00	207.77
M7.5	1	229.93	37.13	267.06
M7.5	2	226.35	40.63	266.98
M7.5	3	203.35	45.67	249.02
M15	1	168.13	70.08	238.20
M15	2	169.78	90.27	260.05
M15	3	273.55	135.62	409.18
M22.5	1	178.30	129.28	307.58
M22.5	2	220.93	130.65	351.58
M22.5	3	206.28	205.67	411.95
M30	1	176.95	181.70	358.65
M30	2	161.28	225.57	386.85
M30	3	175.36	364.64	540.00

Appendix II

Experiment 1: Daily mean CP intake (g/day) and diet digestibility (g/day)

TRT	REPS	CPNAPIER	CPLEGUME	TOTALCP	DMD	OMD
Control	1	14.07	0	14.07	567.09	581.39
Control	2	16.73	0	16.73	590.74	604.25
Control	3	12.34	0	12.34	565.59	579.93
M7.5	1	13.66	8.54	22.20	615.44	625.56
M7.5	2	13.45	9.35	22.79	621.72	630.65
M7.5	3	12.08	10.50	22.58	621.83	630.34
M15	1	9.97	16.12	26.10	627.71	646.33
M15	2	10.09	20.76	30.85	621.28	638.02
M15	3	16.25	31.19	47.44	619.82	637.27
M22.5	1	10.59	29.73	40.32	607.73	600.34
M22.5	2	13.12	30.05	43.17	614.19	609.12
M22.5	3	12.25	47.30	59.56	603.73	592.50
M30	1	10.51	41.79	52.30	607.27	601.10
M30	2	9.58	51.88	61.46	611.86	602.18
M30	3	10.42	83.87	94.27	615.62	601.68

Appendix III

Experiment 1: Weekly (1-7) live weight of growing goats (kg)

TRT	REP	1	2	3	4	5	6	7
Control	1	8.20	8.25	8.30	8.35	8.40	8.50	8.60
Control	2	10.85	10.80	10.70	10.55	10.30	10.20	10.10
Control	3	11.00	10.90	10.75	10.60	10.55	10.45	10.30
M7.5	1	6.35	6.40	6.50	6.60	6.70	6.80	6.85
M7.5	2	7.50	7.55	7.60	7.70	7.80	7.90	7.95
M7.5	3	8.25	8.25	8.30	8.35	8.35	8.40	8.40
M15	1	7.25	7.35	7.45	7.50	7.60	7.65	7.70
M15	2	7.60	7.75	7.90	8.05	8.15	8.25	8.35
M15	3	11.45	11.75	12.10	12.40	12.70	12.90	13.10
M22.5	1	7.35	7.50	7.90	8.15	8.30	8.55	8.85
M22.5	2	7.95	8.35	8.60	8.80	9.00	9.15	9.30
M22.5	3	11.60	12.10	12.60	13.15	13.50	13.90	14.20
M30	1	8.00	8.35	8.60	8.90	9.15	9.45	9.80
M30	2	9.50	9.80	10.25	10.55	10.90	11.15	11.40
M30	3	15.70	15.90	16.35	16.65	17.00	17.30	17.50

Appendix IV

Experiment: Daily mean Napier grass, legume and total dry matter intake (g/day)

TRT	REPS	M GERM	PANICUM	LGM	TDMI
Control	1	90.00	106.07	0.00	196.07
Control	2	90.00	120.40	0.00	210.40
Control	3	90.00	190.36	0.00	280.36
Madras thorn	1	90.00	97.48	136.68	324.16
Madras thorn	2	90.00	98.66	145.13	333.79
Madras thorn	3	90.00	141.56	205.20	435.29
gliricidia	1	90.00	127.81	159.54	378.68
gliricidia	2	90.00	130.59	158.79	379.53
gliricidia	3	90.00	126.23	192.18	408.48
leucaena	1	90.00	150.99	135.82	376.71
leucaena	2	90.00	144.70	138.41	373.11
leucaena	3	90.00	178.59	172.88	437.04

Appendix V

Experiment 2: Daily mean CP intake (g/day) and diet digestibility (g/kg)

TRT	REPS	M GERM	PANICUM	LEGUME	FEED N	DMD	OMD
Control	1	1.35	3.71	5.06	0.81	591.99	602.8
Control	2	1.35	4.21	5.56	0.89	596.00	605.1
Control	3	1.35	6.66	8.01	1.28	607.65	608.9
Madras thorn	1	1.35	3.41	36.20	5.79	629.81	601.6
Madras thorn	2	1.35	3.45	38.18	6.11	625.51	611.6
Madras thorn	3	1.35	4.95	53.50	8.56	632.43	581.7
gliricidia	1	1.35	4.47	42.52	6.80	603.89	585.4
gliricidia	2	1.35	4.57	42.44	6.79	657.47	624.2
gliricidia	3	1.35	4.42	49.97	7.99	645.03	595.7
leucaena	1	1.35	5.28	37.87	6.06	601.82	581.0
leucaena	2	1.35	5.06	38.25	6.12	624.78	605.1
leucaena	3	1.35	6.25	47.36	7.58	633.90	599.1

Appendix VI

Experiment 2: Weekly (1-7) live weight of growing goats (kg)

TRT	REPS	1	2	3	4	5	6	7
Control	1	8.20	7.90	8.00	8.10	8.15	8.20	8.25
Control	2	9.70	9.70	9.50	9.60	9.70	9.70	9.75
Control	3	9.80	9.90	10.00	9.90	10.00	9.90	9.95
Madras thorn	1	8.30	8.60	8.70	8.90	9.10	9.35	9.55
Madras thorn	2	9.00	9.20	9.40	9.60	9.80	10.00	10.10
Madras thorn	3	13.35	13.50	13.70	13.85	14.00	14.10	14.20
gliricidia	1	8.50	8.70	8.90	9.00	9.20	9.40	9.60
gliricidia	2	9.00	9.10	9.25	9.35	9.45	9.55	9.65
gliricidia	3	10.60	10.70	10.90	11.10	11.30	11.50	11.60
leucaena	1	8.80	9.00	9.20	9.45	9.70	9.90	10.00
leucaena	2	9.00	9.30	9.50	9.70	9.90	10.00	10.15
leucaena	3	11.50	11.80	12.10	12.20	12.40	12.65	12.85