EFFECTS OF *PROSOPIS JULIFLORA* SEEDPOD MEAL SUPPLEMENT ON WEIGHT GAIN OF WEANER GALLA GOATS IN BARINGO DISTRICT, KENYA

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DECLARATION

I hereby declare that this thesis is my own original work and has not been presented for examination for a degree in any other university.

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ABSTRACT

This study was conducted at Kenya Agricultural Research Institute (KARI), in Baringo district, Rift Valley Province. Baringo is one of the arid and semi-arid districts of Kenya. Pastoralism is the main economic activity. The goat is the main livestock species. The district is heavily invaded by *P. juliflora*, a woody shrub that has taken over the grazing land. This study was conducted to determine the effects of increasing amounts of *P. juliflora* seedpod meal on feed intake, digestibility and growth rate of weaner Galla goats to establish the maximum substitution level of the pods to avoid deleterious effects on livestock. The study further sought to assess the feasibility of incorporating *P. juliflora* seedpods into the livestock feeding system.

The experiment involved 20 weaner Galla goats of similar age (6 months) and weights (11-14 kg) which were randomly assigned to four treatments of five goats each. The treatments were T_1 (Control treatment-- No *P. juliflora*), T_2 (100 g /goat /day of *P. juliflora* seedpod meal), T_3 (200 g /goat /day *P. juliflora* seedpod meal), and T_4 (400g /goat /day *P. juliflora* seedpod meal). Supplementation involved providing the goats with their respective portions of *P. juliflora* seedpod meal in the morning before the grass hay was offered. The animals were weighed on a weekly basis and the average weight gain calculated as the difference between that week's weight and the previous week's weight divided by five. The experiment lasted for 70 days. Overall, all the supplemented groups exhibited higher average weekly weight gains than the control group. However, these differences were only statistically significant ($P<0.05$) from the fifth week onwards Overall, treatment T_3 exhibited highest total weight gain (3.96kg), followed by T_4 (2.70kg). The cost benefit analysis of the treatments indicated that T_2

is the most profitable seedpod supplementation level with a cost-benefit ratio (BCR) of 1.50. Treatment T_4 was the least effective (BCR =0.57). Results of this study indicate that about 200g/goat/day of *P.juliflora* seedpod is the maximum that should be fed to this breed of goats at this age. It was also found that feeding more than this amount can be detrimental to the health of the animals

CHAPTER ONE

INTRODUCTION

1.1 Study background

Trees and shrubs have provided many benefits to man and his animals throughout the ages. Their leaves, flowers, pods and tender twigs (browse) have from time immemorial been an important source of wildlife and livestock feed. In many arid and semi-arid lands, this component is sometimes the major source of forage for these animals. Le Houerou (1978) pointed out that nearly one third of the world's land surface is natural grazing land and to varying degrees the shrub-tree component is a crucial source of animal feed. In the same document, analyzing data from various world locations, Le Houerou (1978) found a high dependence of rangeland grazing animals on trees and shrubs to satisfy their protein requirements, especially during the dry seasons. The author concluded that, without these plants to complement other forage plants, the entire livestock production system would be jeopardized.

The foregoing situation is most likely going to be amplified further by the unfolding climate change phenomenon. Already, trees and shrubs are under serious threat, especially in the Sahel region, owing to increased periodic droughts and fast growing human and animal populations, leading to overexploitation. Other contributing factors include the emerging trend where more nomadic or transhumant communities are settling down to sedentary livelihoods resulting in increased pressure on these plants through expansion of cultivated areas and disappearance of fallows.

In general, although trees and shrubs are the most visible plant life forms in arid lands, they have been neglected in almost all spheres of scientific research (McKell, 1974) and land management policies (Le Houerou, 1972). Motivated by a desire to increase livestock forage, numerous research efforts have been concentrated on methods of shrub eradication (Cook, 1958) or control (Scifres *et al.*, 1973). The magnitude of these efforts have inclined many students, research workers and land managers towards the myopic view that most, if not all, shrubs are of low-value and only by converting shrub lands to grasslands, can a productive grazing system be created. This view grossly overlooks the crucial role of trees and shrubs to, not only provide forage, but also 'even-out' the rampant nutrient supply deficits between the dry (dormant) and wet growing seasons. This prejudiced view towards ligneous plants in general may be attributed to the low appreciation of the tremendous value that they offer to mankind, inadequate knowledge of their biology and potential responsiveness to management. An international symposium on the biology and utilization of wild land shrubs (McKell *et al.*, 1972) attempted to correct this bias, but there was need for follow-up effort

Despite the past and current 'injustices' to trees and shrubs, it is obvious that they are a crucial component of all natural grazing systems throughout the world. In fact, it is inconceivable to visualize natural grazing lands devoid of these plants. Unlike grasses and forbs, ligneous plants, especially the evergreen types, provide livestock with fresh (green) forage during the dry season which is more nutritious than the then usually available 'dead' (dry) herbage. They serve as rich sources of proteins, vitamins, energy and minerals at a time when the preferred grasses and forbs are either not available or unable to provide these nutrients. With no supplementation, browse represents at least 20% of livestock diets during the dry season in the

Sudano-Sahelian zone. Livestock keepers have in the past utilized these plants to make up for nutritional shortfalls that occur during the dry seasons. From a strictly pastoral point of view, without these trees and shrubs, there would be no pastoralism as we know it today. The herd structure would be different as browsers like goats and camels, which survive and thrive in the driest parts, would be missing. Healthy management of tree-shrub ecosystems, aimed at maintaining the balance between browse and grass cover as well as trees and shrubs is therefore a celestial obligation. While it is apparent that ligneous plants have generally not received the research attention they deserve, man has relentlessly continued to utilize them Over the ages, he has discovered practices that foster their utilization – sustainable or unsustainable. For instance, their utilization by livestock has been restricted to seasons when re-growth ability is not destroyed. On the other hand, lopping of branches, which is a common dry-season practice among pastoralists, is done on a rotational basis to allow time for regeneration and return of vigour. This is achieved through herding of livestock to prevent overuse of certain plants. There is also the practice of harvesting the pods from trees and shrubs in the dry lands for storage and use as livestock feed during the dry seasons when little or no other forage is available.

1.2 The research problem

P juliflora (Sw.) DC, commonly referred to as *Prosopis*, is an evergreen tree endemic to South America, Central America and the Caribbean. It was first introduced in Kenya in 1973 for the rehabilitation of quarries in Mombasa (Choge *et al.*, 2002). Later it was introduced in the semi-arid districts such as Baringo, Tana River and Turkana in the 1980s (Anderson, 2005). *P juliflora* is widely distributed in the arid and semi arid areas of Kenya (about

600,000 ha). Pasiecznik, (1999) reported that *P. juliflora* has invaded, and continues to invade, millions of hectares of rangeland in East Africa. The tree is aggressive with a superior competitive advantage over the local tree species, resulting in loss of the important plant species that were reliable sources of livestock forage. Rapid invasion by *P. juliflora* has resulted in loss of biodiversity as well as vital dry season grazing areas of the communities. This has serious implications on food security and livelihoods of the local communities. Some members of the local communities in Baringo have gone to the extent of suing the government for introducing it in their area and sought compensation for general damages attributed to this plant. These include loss of teeth and/or death of the animals due to consumption of *P. juliflora* browse. *P. juliflora* thorns are considered poisonous and hence injurious to human beings and livestock. The Invasive Species Specialist Group of the IUCN, (2004), rated *P. juliflora* as one of the world's top 100 least wanted plant species.

Despite the foregoing controversies, when viewed from a positive perspective, *P. juliflora* has many important uses, in different parts of the world. For instance, *P. juliflora* plays a critical role in providing livestock feed during the dry seasons in the arid and semi arid rangelands of India, Pakistan and other countries. In Kenya *P. juliflora* has not been fully utilized as livestock feed. The tree also provides many other services and products including charcoal, fuel wood, timber for furniture, construction material, soil stabilization, shade, nitrogen fixation, bee forage (honey), and human food, among others.

Arid and semi arid areas face the challenge of fluctuations in forage supply between the dry and wet seasons. During the latter seasons, there is surplus forage and animals are able to meet their nutritional requirements and hence gain weight. However, during the former seasons there is inadequate and poor quality forage resulting in malnutrition of livestock. Therefore, judicious integration of the locally available forage resources such as *P. juliflora* into the livestock production systems at the right time can go a long way towards the closing of this feed and nutrition resource gap in the livestock production sector. However, this is only possible when there is adequate knowledge about this feed resource and its interaction with livestock.

The overall objective of this study was to assess the feasibility of incorporating *P. juliflora* seedpods into the local livestock production system. Specifically, the study sought to determine the maximum amount of *P. juliflora* seedpods that can be fed to weaner Galla goats without adversely affecting their growth rate; the effect of the seedpods on the goats' feed intake and digestibility; and the economic viability of feeding the seedpods to these animals which is a common practice among the pastoralists.

1.3 Objectives

The broad objective of this study was to contribute to the improvement of livestock production in the arid and semi-arid zones of east Africa through strategic integration of *P. juliflora* seedpods in the livestock production systems

Specific objectives

1. To determine the effects of increasing amounts of *P. juliflora* seedpod meal in weaner Galla goat diets on dry matter intake, *in vivo* digestibility and growth rate.

2. To determine the economic feasibility (cost-benefit ratio) of feeding *P. juliflora* seedpods to weaner Galla goats.

Hypotheses

1. Too much *P. juliflora* seedpod has adverse effects on dry matter intake, digestibility and the overall performance (growth rate) of goats.

2. Feeding of f *P. juliflora* seedpods to goats is profitable.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Supply of adequate quantity and quality of feed for livestock has been a major challenge throughout the world. Consequently, forage production has been the theme of many studies throughout the world, particularly in the dry tropics where this problem is pronounced. The constraint of feed supply has led to low livestock productivity in most developing countries. Considering the vast arid and semi arid lands that form most of the rangelands in the tropics, the goats are one of the most adapted livestock species in these areas owing to their adaptive capacity to these environments. The range goats that are managed under semi-arid climatic conditions mostly rely on a variety of native forages to meet their nutritional requirements. However, these animals face great variability in supply of forage and nutrients throughout the year (Juarez *et al.*, 2004). In the same areas, trees and shrubs are prominent sources of forage for range ruminants (Bhatta *et al.*, 2004) and are mostly utilized as protein supplements in the arid and semi arid lands (Makkar, 2003). This study is geared towards assessing the effectiveness and benefits of supplementing goats with *P. juliflora* seedpods. The literature reviewed here focuses on improvement of livestock production in the arid and semi-arid zones through strategic integration of locally available feed resources such as *P. juliflora*.

2.2 Distribution and uses of *Prosopis juliflora* (Sw.) DC in Kenya

Prosopis juliflora (Sw.) DC common name; (Meskit, Mesquite in America) is an evergreen tree, a native of South and Central America and the Caribbean. It produces a variety of valuable goods and services including construction materials, charcoal, soil conservation and rehabilitation of degraded and saline soils. *P. juliflora* was first introduced in Africa in 1822 in

Senegal, followed by South Africa in 1880 and Egypt in 1900. *Prosopis juliflora* and *Prosopis pallida* were introduced in Kenya in 1973 for the rehabilitation of limestone mines in Mombasa. They were later introduced in the semi-arid districts of Baringo, Tana River and Turkana districts in the early 1980s to provide ground cover (biomass) in areas that had none. *P juliflora* would also provide wood for domestic use, and generally improve the environment for human habitation (Choge *et al.*, 2002). Currently, the districts with the greatest *P. juliflora* populations are Garissa, Wajir, Mandera, Baringo, Turkana, Taita Taveta and Tana River. *P. juliflora* has a high potential of providing quality forage to livestock in the semi arid areas of Kenya owing to the high nutritive value of its pods and leaves all year round (Pasiecznik *et al.*, 2001).

2.3 *Prosopis juliflora* as a source of forage for livestock

Lack of adequate and high quality forage is one of the major constraint to livestock production in the tropics (FAO, 1981), particularly the lack of adequate protein during the dry season. According to Mahgoub *et al.* (2005), *P. juliflora* pods contained 127 g/kg CP, 254 g/kg CF, 26 g/kg EE and 48 g/kg ash. This shows that *P. juliflora* seedpods are relatively high in protein content and hence if incorporated into animal feeds, will improve growth and productivity of livestock. Other studies have confirmed that *P. juliflora* seedpods are a good source of protein, with 12-14% crude protein content (Wood *et al.*, 2001a).

P juliflora retains all its leaves during the dry season, showing even satisfactory output levels of the seedpods. Therefore, the introduction of this species will partly offset fodder scarcity during the dry season, thereby improving livestock raising prospects in the dry areas where this plant species is abundant, and the pods can be collected at low costs (Primo *et al.*, 1984).

Digestibility of forages is related to their protein content and this relationship is exponential (Kinuthia, 1982).This implies that, *P. juliflora* which has high protein content, will result in an increase in digestibility and thus intake by livestock. *P. juliflora* seedpods lend themselves better to feeding livestock when ground and turned into flour; thus increasing their digestibility and acceptability to animals. Andersson, (1978) . *P. juliflora* seedpods are sweet, nutritious and have low concentration of tannins and other unpalatable chemicals and have moderate to high digestibility (Mooney and Cleland, 2001). In natural grazing lands where *P juliflora* seedpods are abundant, livestock consume the seedpods voluntarily during grazing and browsing, and in many species the seedpods contain a sweet, dry yellow pulp. The seeds contained in the pods are high in protein 34-39% (Gutteridge and Shelton, 1998).

The seedpods can sustain livestock in dry seasons when little other feed is available. However, when pods of some species (*Prosopis pallida* and *Prosopis glandulosa*) are fed as an exclusive diet for long periods, livestock, particularly cattle, can become malnourished and show ill-thrift symptoms. Thus, it is recommended that livestock consuming *P juliflora* pods should also have access to other feeds to balance their diet (Gutteridge and Shelton, 1998). It is also reported that Leguminous browse plants, such as *P. juliflora* species, generally contain higher levels of crude protein than other shrub families (Wilson, 1969), and are often good sources of forage reserves.

2.4 The role of *P. juliflora* browse in livestock feeding

Supplementation is a management tool used by livestock producers to supply nutrients during periods of deficiency. The major nutrients required by animals are proteins and energy. Also minerals like phosphorus, calcium, iron, and selenium are important for animal performance and growth. When there is deficiency of these nutrients, animals perform poorly – they lose weight, have low fertility and morbidity. Supplementary feeding should provide animals with nutrients in amounts and combinations that the then available pasture is not providing (Anderson, 1978). Supplemental feeding on the range is an economic question to be decided upon by balancing the cost against incremental production (Korir, 2008). Supplementation is profitable when it increases the reproductive rate of breeding herds, production of milk, growth rates or reduces death losses. And more so, when locally available, low-cost forage resources can be used in the place of more costly commercial feeds (Primo *et al*., 1984).

Previous studies have shown that *P. juliflora* has the potential of being used as livestock supplement, though much needs to be done to find out the actual optimum level of supplementation for the different regions and species of *P. juliflora*. Research studies by Mahgoub *et al*. (2004) on *Prosopis* supplementation showed that during the experiment, animals were in excellent condition throughout the trial. They found that feeding *Prosopis* pods to Omani sheep did not affect their health although it contained *Prosopis* pods, which was reported to cause health problems in goats by other studies (Mahgoub *et al*., 2004).

Roughages, especially standing hay have a low crude protein content and poor digestibility (Karue, 1974, and Momanyi, 1993). This results in reduced intake of digestible nutrients and consequently poor animal performance. Thus, integrating *P. juliflora pods* in the feeding programme can ameliorate this situation by improving the quality and intake of roughages due to its high protein content. It is reported that a sporadic period of nutrient deficiency causes mortality surges in livestock especially small ruminants (Momanyi, 1993), which, in turn, reduce the farmers' profits and increase production costs. Supplementation to poor quality roughage increases the intake of useful nutrients (Anderson, 1978) which, in turn, supports higher levels of animal performance.

A study by Silva *et al.* (1983) involving progressive replacement of wheat bran with *P. juliflora* pods in proportions of 25%, 75% and 100% in rations of bovines showed better dry matter, crude protein, digestible protein, and total digestible nutrient conversions between 25% and 100% pod content. Primo *et al.* (1984) investigated dietary interactions between *Opuntia ficus indica*, elephant grass hay (*Pennisetum purpureum Schum*) and complemented with 500 g of *P. juliflora* seedpods per goat/day during the dry season. They found that all combinations furnished the necessary nutrients for goat maintenance. Corroborating these findings, studies by Lima *et al.* (1984) tested several combinations of *Opuntia* and mature elephant grass hay on confined ovine's, complemented with 500 g of *P. juliflora* pods per animal/day, and found that any one of the combinations tested can be recommended for ovine supplementation during the dry season.

Studies by Mahgoub *et al.* (2005) on the supplementation of Omani goats with *P. juliflora* seedpods concluded that *P. juliflora* pods at 200 g/kg of diet maximized feed intake, body weight gain and feed conversion. Studies with *P. juliflora* in Brazil showed that *P. juliflora* seedpod meal could replace up to 600 g/kg of wheat flour in rations of lactating cows and that dry matter intake (DMI), weight gain and milk production increased with increasing proportions of the seedpod flour (Mahgoub *et al.*, 2005). In beef cattle diets, the studies showed that it was possible to totally replace wheat flour with ground *P. juliflora* seedpods. A study in Mexico where sorghum flour was replaced with *P. juliflora* seedpod flour up to 450 g/kg, showed a significant increase in body weight gain (BWG) in sheep. A study in Brazil demonstrated that replacement of sugarcane molasses with *P. juliflora* pods at 0, 150, 300, 450 and 600 g/kg of total ration was most effective in terms of body weight gain at 300 and 450 g/kg *P. juliflora* levels (Mahgoub *et al.*, 2005).

In conclusion, it is evident from the few studies cited here that *P. juliflora* seedpods can be strategically utilized as supplementary feed for livestock including the small ruminants (sheep and goats). In Kenya, *P. juliflora* preponderance provides a potential supplement feed resource in the arid and semi-arid areas, such as Baringo, Garissa, Moyale, Isiolo, Turkana, and Marsabit where the production of small ruminants is a key economic activity.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

This study was conducted at Kenya Agricultural Research Institute at Marigat/ Perkerra Centre, in Baringo district, Rift Valley Province, Kenya. In terms of climate, the district is classified as arid to semi-arid. According to Herlocker *et al.* (1994), Baringo District falls within agro-climatic zone IV and V and is located between latitude 00° 30' N and longitude 36° 00' E. The district is classified as lower midland (LM) livestock-millet zone, which is best suited for livestock production. The district was selected for this study because of the high abundance of *P. juliflora*. On the other hand, goats were selected for the study because they are the most dominant livestock species in the district.

3.2 Experimental animals, supplements and protocol

Twenty weaner Galla goats of similar age (6 months), sex (male) and weight (11-14 kg) were randomly assigned to the four treatments resulting in five animals per treatment. The animals were assigned a number that was selected by simple random sampling for the different treatments. The experimental animals were housed in individual pens of approximately 2.5m wide and 3.5m long. The pens were constructed from *P. juliflora* poles. Each cage was provided with a feed and water trough.

Prior to bringing all the animals to the pens, they were injected with antibiotic (Adamisine) to minimize stress-induced ailments such as pneumonia. They were also dewormed and sprayed against ectoparasites. The latter was repeated every fortnight and the former after every 4 weeks during the entire study period.

The experimental animals were allowed 14 days to adapt to the cages. During this period, they were fed on mixed-species hay obtained locally. They were introduced to their respective treatment diets during the last three days of the adaptation period. The experimental duration was 70 days, and the animals were weighed every week.

The supplemental diets comprised *P. juliflora* seedpod meal. Grass hay was used as the basal feed. The pods were harvested by hand picking at the ripening stage in Baringo district, Njemps flat and stored under cool and dry conditions. They were then sun-dried for three days and then milled and stored. The pods were ground in a 2-3mm hammer mill.

Plate 1: Experimental animals feeding on *P. juliflora* seedpod meal

The treatments were, i) T_1 (Control - Hay only), ii) T_2 (100g of *P. juliflora* seedpod meal /goat / day), iii) T_3 (200g of *P. juliflora* seedpod meal /goat /day) and iv) T_4 (400g of *P. juliflora* seed pod meal /goat /day). Hay, water and minerals were provided *ad labium*. Feeding was done twice per day, at 0800 and 1500hrs. In the morning, the animals were offered their respective supplements and 1kg of hay. In the afternoon, they were only offered hay and the amount was adjusted according the previous day's intake.

3.3 Determination of feed intake, digestibility and animal weight gains

All the experimental animals were weighed every week at 0700 hrs after overnight fast and the weights recorded by treatment groups. Average weekly gains of the animals were later calculated as the total weight gained at the end of the experiment divided by experimental weeks. The amount of hay offered to each animal was recorded daily. Before fresh hay was offered, the feed troughs were cleaned out and orts (refusals) weighed and recorded. The orts were then thoroughly mixed and a sub-sample taken for chemical analysis and the rest discarded. The amount of hay consumed was then determined as the difference between the amount offered and the refuse. Total feed intake was calculated as the amount of hay and seed pod consumed. When a new batch of hay or pods was brought in, a sample was taken for chemical analysis later. Chemical analyses assayed the nutrient composition of the two feed components were determined.

Digestibility of the feed and nitrogen balance were determined using three of the animals from each treatment group. These were randomly selected and placed in standard individual metabolism crates. The animals were allowed seven days to adjust to the crate, followed by seven days of sample collection. All the feces produced by each animal was collected, weighed and a representative sample (about 10% of daily output) taken. The fecal samples were sun-dried and packed in plastic bags for chemical analysis later. In addition, all the urine produced by each animal each day (24 hours) was measured volumetrically. The urine was collected in a plastic bucket fitted under the metabolic crates. Approximately 15mls of 1M H_2SO_4 was added to each bucket of urine to reduce loss of nitrogen through volatization. A sub-sample {15% (v/v)} of the daily output was taken and bulked across the days. The samples were stored in a freezer t at -4° C for nitrogen content analysis later.

3.4 Body condition scoring procedure

At the end of the study period, all the experimental animals in each treatment were assessed for body condition and assigned a score. The body condition scoring (BCS) method used in this study was that developed by Spahr (2009) which uses a 1-5 ranking, where, 1 represents an animal in bad body condition (very thin) and 5 represents an animal in prime body condition (well fleshed). Table 1 presents the body condition scoring indexes used in this method. An average body condition score was calculated for each treatment group as the sum of the scores of each animal in the group, divided by 5.

Table 1: Body condition scoring criteria

Score	Spinous process	Rib cage	Loin eye
BCS 1 Very thin	Easy to see and feel, sharp	Easy to feel and can feel under	No fat covering
BCS 2 Thin	Easy to feel, but smooth	Smooth, slightly rounded, need to use slight pressure to feel	Smooth, even fat cover
BCS 3 Good Condition	Smooth and rounded	Smooth, even feel	Smooth, even fat cover
BCS 4 Fat	Can feel with firm pressure, no points can be felt	Individual ribs cannot be felt, but can still feel indent between ribs	Thick fat
BCS 5 Obese	Smooth, no individual vertebra can be felt	Individual ribs cannot be felt. No separation of ribs felt	Thick fat covering, may be lumpy and "jiggly"

Source: Spahr (2009)

3.5 Cost-benefit analysis of the supplementation programme

During the experimental period, all the costs associated with the supplementation were recorded. These costs included purchase of the seedpods, labour for drying and milling of the seedpods, cost of feeding the goats and the cost of variable inputs (feeding, dewormers, minerals and sprays). The benefits used were the live weight gained at the end of supplementation period. The prevailing price per live weight in the nearby shopping centre at that time was used in calculating the CBR. The benefits and costs of the supplementation were spread over a period of 4 years.

3.6 Chemical analysis of feed, faeces and urine

The feed and faecal samples were oven dried at 60°C for 24 hrs and then ground through a 1mm Wiley mill in preparation for chemical analysis. DM, OM, ash and N were determined using the proximate method (AOAC, 1990), while ADF and NDF were determined using the procedures of Goering and Van Soest (1982). Mineral content was determined using the AOAC (1990) procedures. Faecal N and DM content were determined on wet samples using proximate method (AOAC, 1990). The urine samples were thawed and pooled according to treatment groups, thoroughly mixed and a sub-sample taken for nitrogen content determination following the Macro-Kjedahl method (AOAC, 1990).

3.7 Data analyses

The experimental data on growth performance and feed intakes were analyzed by one-way analysis of variance (ANOVA) (Steel and Torrie, 1980). Where treatment differences were statistically significant, mean separation tests were conducted using Duncan's New Multiple Range Test (Steel and Torrie, 1980) at 5% level of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chemical composition of hay and *P. juliflora* seedpod meal

Table 2 below presents the average chemical composition of the *P. juliflora* seedpod meal (supplementary feed) and the hay (basal feed). Overall, the hay was higher in dry and organic matter than the seedpod meal. Notable also was the fact that the seedpod meal had about three times more CP. The two feed components were similar in terms of NDF and ADF. However, the hay had about three times more lignin than the pod meal. The *P. juliflora* seedpod meal was slightly higher in Ca, P and K than the grass hay. Mg, Fe, Zn, Cu and Na were almost similar in the two feed components. Both feed components were notably very high in K, but Ca and P were well above the daily requirements for sheep and goats.

Table 2: Average chemical composition (DM) of *P.juliflora* seedpod meal and hay

Chemical Component	*P juliflora* seed pods ±SE	Hay ±SE
DM (%)	88.4 ± 0.3	99.4 ± 0.2
OM (%)	83.2 ± 2.8	90.0 ± 4.6
CP (%)	18.5 ± 0.3	6.1 ± 0.3
ASH (%)	5.2 ± 0.7	9.4 ± 0.7
NDF (%)	51.8 ± 4.2	59.0 ± 5.9
ADF (%)	29.8 ± 0.1	26.8 ± 3.5
ADL (%)	3.2 ± 0.4	8.1 ± 0.5
Ca (%)	0.5 ± 0.1	0.3 ± 0.1
P (%)	0.2 ± 0.1	0.1 ± 0.1
K (%)	0.9 ± 0.1	0.6 ± 0.3
Mg (ppm)	760 ± 3.0	917 ± 5.5
Fe (ppm)	99 ± 2.8	219 ± 4.0
Zn (ppm)	1279 ± 6.4	1365 ± 29.9
Cu (ppm)	40 ± 4.0	38 ± 2.0
Na (ppm)	51 ± 3.0	56 ± 3.0

About 6% CP content is the minimum (7%) required for optimal microbial activity in ruminants (Abdulrazak *et al.*, 2006). Low N content in feeds is associated with low intake and digestibility of the feeds which, in turn, results in reduction in availability and assimilation of nutrients by the animal and, ultimately, low animal performance. There is, therefore, need to supply adequate nitrogen to ruminants feeding on poor quality forages. This improves the utilization of poorly digestible feeds. Nitrogen supply enhances the growth rate of rumen bacteria and increases the digestibility of feeds. When the microbial population is enhanced, there is increased rumen fermentation and hence nutrients availability to the host animal.

Lignin reduces the microbial activity in feeds ingested by the animal by bounding on the protein making it not easily broken down by rumen microbes and hence, the low digestibility of the feed. The hay used in this study was at the borderline in CP content and digestibility; and was high in lignin content. These factors were attributed to the poor performance of the goats. The minerals that animals require most are P, Ca and Mg (Kebede, 2002). They also require small amounts of other minerals such as Fe, I, Co and Cu. Both the feed components contained adequate amounts of these elements. The mineral contents of the *P. juliflora* seedpods used in this study were similar to those reported by Mahgoub *et al.* (2005). They were high enough to qualify them for use as supplement for livestock feed.

4.2 Dry matter intake (DMI), animal weight gains and feed conversion efficiency

The dry matter intake (Kg) and live weight gain (Kg) of the weaner goats are presented in Table 3. The control group consumed significantly ($P<0.05$) higher hay than T_4. The control group had to take more hay to meet its nutritional requirements, but due to the poor quality of the hay that was used, the weight gains were lower than those of the supplemented groups. However, T_2 and T_3 depicted about the same level of total hay intakes.

Table 3: Dry matter intake, animal weight gains and feed conversion ratio

	Total hay intake (Kg)	Total seedpod intake (Kg)	Total feed intake (Kg)	Total live weight gain (Kg)	Feed conversion ratio*
T_1	24.000^a	0.000^a	24.000^a	0.650^a	36.923
T_2	17.200^b	6.800^b	24.000^a	2.250^b	10.666
T_3	17.500^b	13.600^c	31.100^b	3.960^c	7.853
T_4	13.350^c	27.200^d	40.550^c	2.700^d	15.018

Treatment means followed by same superscript within columns are not significantly different ($P<0.05$).
Total feed intake (Kg)/Total live weight gain (Kg)

T_3 consumed the highest amount of hay (17.5Kg) and demonstrated the highest total weight gain (3.96Kg). These results are consistent with those of Mahgoub *et al.* (2004), who reported that goats fed 20% Ghaf (*Prosopis cineraria)* had higher feed intakes than those on 30% Ghaf. These high intakes of basal diet (hay) can be attributed to the fact that, the Ghaf provided appropriate energy: protein ratio, which not only increased the essential nutrients to maintain optimal rumen activity, but were also more rapidly degraded in the rumen. Ørskov and Dolberg, (1984) suggested that protein supplements should be highly digestible materials for them to have a positive effect on feeds with high cellulose and/or hemicelluloses content.

Animals in T_4 on the other hand, exhibited lower total hay intake than those in all the other treatments (13.4Kg). This outcome closely tallied with that of Mahgoub *et al.* (2004), where sheep fed on increasing amounts of Ghaf 0%, 15%, 30% and 45%, demonstrated a sudden drop in basal feed intake when the amount of Ghaf approached 45%. Horton *et al.* (1993) also observed a drop in feed intake in Omani sheep when the Ghaf level approached 29%. The authors attributed this to the increase in tannin and other phenolic compounds in the diet, which suppressed the appetite of the goats. This phenomenon could be similar to the T_4 group in this study, since *Prosopis* was reported to contain tannins and Lignin (Becker, 1982). The Presence of these compounds has been associated with reduced rumen microbial activity, digestibility and feed intakes. Ingested high fibre feed must be broken down through rumination, microbial fermentation or both to produce particles to small enough sizes to pass through the reticulo-omasal orifice (Blaxter *et al.*, 1956). The rates of breakdown and passage through the gastro-intestinal tract should be at fast passage rate for increased intakes of feed.

Feed conversion ratio (FCR) is a gross measure of feed utilization efficiency and is most often used as a tool to evaluate the cost of production and break-even prices in production operations. Animals that will convert at a high rate (lower FCR) are preferred to those with lower ratio In this study, T_3 animals exhibited the highest feed conversion ratio (7.853), while T_1 had the poorest ration (36.923). Diets with a low FCR are considered more economical in animal production. Thus animals with lower FCR would be preferred to those with higher FCR in the arid and semi arid regions which are overall feed resource-poor. This will enable them to survive the feed scarcity and guarantee some productivity. FCR is moderately heritable (Crews, 2005) and cow/calf producers who have this information can use it as a marketing tool for their livestock. The low FCRs observed in this study can be attributed to the fact that *P.juliflora* contributed the bulk of fermentable energy to the rumen in form of cellulose and hemicelluloses, which stimulate fibre digestion and hence nutrient released for growth (Silva and Ørskov, 1985).

4.3 Average weekly weight gains

The average weekly weight gains of the goats under different treatments for the 10-weeks feeding period are presented in Table 4. Overall, all supplemented groups exhibited higher average weight gains than the control group. However, the differences were not significantly different ($P<0.05$) during the first three weeks. Between the 5^{th} to the 10^{th} week, all the supplemented groups exhibited significantly higher growth rates than the control ($P<0.05$). T_3 had the highest average weekly weight gain (0.44Kg) followed by T_4 and T_2, with 0.30Kg and 0.25Kg, respectively. T_1 lost weight in the first four weeks, but gained during the last five weeks of the experiment (0.07Kg), which was lower compared to the supplemented groups. The enhanced weight gain observed in T_1 is associated with compensatory growth.

Table 4: Mean weekly live weight gain (Kg) of weaner Galla goats on varying amounts of *P. juliflora* seedpod meal

Treatment	Week 2	3	4	5	6	7	8	9	10	Mean
T_1	-0.20^a	-0.20^a	-0.16^a	-0.11^a	0.16^a	0.28^a	0.22^a	0.34^a	0.32^a	**0.07**
T_2	0.14^b	0.20^c	0.06^b	0.24^b	0.18^a	0.38^c	0.36^b	0.37^a	0.36^b	**0.25**
T_3	0.18^a	0.30^d	0.20^c	0.26^b	0.42^b	0.47^d	0.62^c	0.64^c	0.86^d	**0.44**
T_4	0.13^b	0.08^b	0.07^b	0.24^b	0.38^b	0.32^b	0.56^d	0.52^b	0.44^c	**0.30**

Treatment means in the same column with different superscripts are significantly different ($P<0.05$)

The overall superior performances exhibited by the supplemented treatment groups can be largely attributed to the high CP content provided by the seedpod meal. The results here demonstrate a direct relationship between the CP content and animal performance. The results also show a positive relationship between the dietary CP content, hay intake, and animal performance. The pick growth rates demonstrated by the T_3 were consistent with those of

Mahgoub *et al.* (2005) who reported that goats fed 20% Meskit pods had the highest weight gains, whereas those fed 30% had the lowest feed intake, which corresponds to T_4 in this study. They also reported that the goats fed rations with Rhodes grass hay as a major constituent of the diet, had lower feed intake than those fed 10 and 20% Meskit pods, possibly due to relatively higher fibre content. Of the supplemented animals, T_4 exhibited the lowest rate of weight gain, but this was outstanding during the last two weeks of the study. This weight loss was largely associated with lower feed intake which, in turn, was attributed to the high proportion of *P. juliflora* in the diet. The latter may also be attributed to low palatability of the hay combined with low energy: protein ratio which could not support consistent weight gains. As indicated above, this could also be ascribed to depressed feed intake due to reduction in palatability associated with the tannins and other phenolic compounds. Mahgoub *et al.* (2005) also observed loss of weight in goats fed on diets with 30% Meskit.

Figure 1 below presents the overall mean weight gain for each of the four treatment groups. It is clear that T_3 had the highest overall average weight gain, followed closely by T_4. This can be attributed to a combination of factors including high CP and high total feed intake. As expected, T_1 had the lowest overall weight gain which can also be attributed to several factors including low total feed intake and low CP content.

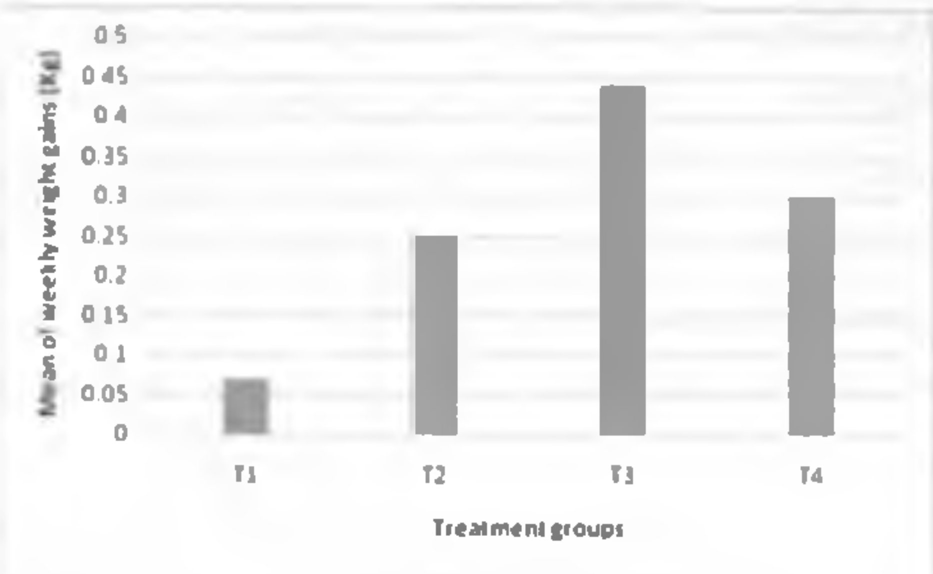

Figure 1.Mean of weekly weight gains for different treatments

4.4 *In vivo* dry matter digestibility (IVDMD) of the diets

Table 5 presents in *vivo* digestibility coefficients of DM, CP, ash, NDF, ADF and ADL of the treatment groups. Except for ADL, all the other nutrients exhibited a general increase in digestibility with increase in *P. juliflora* seedpod meal content. The control treatment had significantly ($p<0.05$) lower DM, ash, NDF and ADF digestibility than other treatments. The *In sacco* digestibility of *P. juliflora* seedpod meal was higher than that of hay, at 74.5 and 56.8%, respectively. This can be attributed to the high CP content of *P. juliflora* seedpods.

Table 5: Apparent *In vivo* digestibility (% DM) of diets

Treatment	DM	ASH	CP	NDF	ADF	ADL
T_1	62.9^a	24.2^a	41.2^a	61.6^a	51.6^a	31.4^a
T_2	68.3^b	34.6^b	64.3^b	63.3^b	59.1^b	28.2^b
T_3	73.2^c	42.1^c	72.3^c	71.8^c	66.2^c	25.3^c
T_4	71.4^c	38.8^d	66.5^d	69.2^c	62.3^d	32.1^d

Treatment means followed by same superscript within columns are not significantly different (P<0.05)

T_2, T_3 and T_4 with incremental levels of *P. juliflora* seedpod meal supplement at 100g/goat/day, 200g/goat/day and 400g/goat/day, respectively, had higher DM , CP and NDF digestibility than the control group. The apparent increase in digestibility of these feed components with increase in *P. juliflora* content was attributed to the corresponding increase in CP content in the diets. High protein content translates to adequate nitrogen for rumen microbial growth, high rumen microbial population and overall digestibility of the ingesta. Weiss *et al.* (2009) reported an overall increase in feed digestibility with increase in protein content in diets comprising alfafa and corn silage fed to cows. They also found out that increasing metabolizable protein (MP) increases nitrogen digestibility. Delcurto *et al.* (1990) demonstrated that DM and NDF digestibility increased with an increase in supplemental CP in steers. Studies by Sultan *et al.* (1992) have also shown that protein supplementation in low quality diets increases nutrient digestibility.

4.5 Nitrogen balance

Table 6 presents the nitrogen balance status of the goats relative to the different amounts of *P. juliflora* seedpod meal in their diets. Faecal and urinary N were significantly different ($P<0.05$) among all the treatment groups. The total nitrogen intake increased with the increase in the quantity of the *P. juliflora* seedpod meal in the diets. Treatment T_4 with highest amount of *P. juliflora* pod meal and hence the highest dietary N intake ($7.2gd^{-1}$), showed the highest level of faecal nitrogen (FN) loss (3.2g/day) and highest total loss which was significantly different ($P<0.05$) from the other treatments. The control group with the lowest dietary N intake (3. 2g/day) demonstrated the lowest N retention (0. 2g/day) and lowest total N loss.

These results closely agree with those of Freeman *et al.* (2009) who found that N retention was lower in un-supplemented goats than the supplemented.

Treatment group T_3 had the highest nitrogen retention rate (4. 5g/day) followed by T_4 and T_2 with 3.4 and 2. 2g/day, respectively. The presence of *P. juliflora* seedpod meal in the diets had significant effect ($P<0.05$) in the N retention. However, the total nitrogen loss was significantly ($P<0.05$) higher in the supplemented groups than the control group (T_1).

Table 6: Nitrogen budget of goats supplemented with various levels of *P. juliflora* seedpod meal

Diets	T_1	T_2	T_3	T_4
Ingested N (gd^{-1})	3.2^{a}	5.4^{b}	6.7^{c}	7.2^{d}
Faecal N (gd^{-1})	1.7^{a}	1.9^{b}	1.2^{c}	3.2^{d}
Urinary N (gd^{-1})	0.9^{a}	1.2^{b}	1.0^{c}	2.7^{d}
Total N loss (gd^{-1})	2.6^{a}	3.1^{b}	2.2^{c}	5.9^{d}
Retained N (gd^{-1})	0.6^{a}	2.3^{b}	4.5^{c}	3.4^{d}
Retained N as (%) of N intake	18.8^{a}	42.6^{b}	67.2^{c}	47.2^{b}

Treatment means followed by same superscript within rows are not significantly different ($P<0.05$)

The apparent increases in loss of N through the faeces and reduced N retention with increase in *P. juliflora* level were attributed to increased tannin intakes with the increase in amount of seedpod meal. Horton *et al.* (1993) also reported that tannins in *Prosopis cineraria* pods reduced feed intakes and digestibility in Omani sheep. *Prosopis glandulosa* was reported to contain trypsin inhibitor, which is concentrated in the seeds (Zolfaghari and Harden, 1982). Becker, (1982) also demonstrated that *Prosopis* seeds contain tannins, heat labile hemeaglutins and trypsin inhibitors. Most browses contain relatively high quantities of tannins which depress browse intake by decreasing its palatability and/or reducing the digestibility of proteins associated with them (Swain, 1979). Tannins have a propensity to form insoluble complexes with proteins which reduces the digestibility of forages by inhibiting digestive enzymes as well as causing a decrease in protein availability to the animal (McLeod, 1974). Working with blackbush (*Coleogyne ramosissima*), Provenza and Malechek, (1984) found evidence that tannins may have a greater effect on palatability than digestibility which can explain the phenomenon observed in T_4 which exhibited lower feed intakes, and lower N retention than T_3, despite the fact that it had the highest intake of N.

In terms of N retention vis-avis N intake, all the supplemented groups retained significantly higher ($P<0.05$) N than the control group T_1. T_3 retained the highest amount of N (67.2%). It was the best performing group in terms of weight gains and body condition, followed by T_4 and T_2 (47.2) and (42.6%), respectively. T_1 (control group) had the lowest N retention (18.8%) and hence the lower performance.

The superior N retention rate by T_3 is attributed to improved efficiency in the utilization of the diets due to increased CP content in the *P. juliflora* seedpods supplement which provided adequate energy: protein ratio that enhanced utilization. The two factors are suspected to have boosted the rumen microbial activities which, in turn, increased the digestive activity of the ingesta. A study by Shukla *et al.* (1984), on Kakrei bullocks, where cattle feeding on hay were supplemented with *Prosopis* pods at 0%, 15%, 30% and 45%, reported improvement in live weight gain and positive balances of N, Ca and P up to 30%, after which hay intake dropped drastically. In another study by Shukla *et al.* (1984) at 45% *Prosopis* seedpod content in the diet, a negative N and P balance, and reduced live weight gain were recorded. Freeman *et al.* (2008) observed low N retention in goats supplemented with secondary protein nutrients (SPN) at increasing proportions and attributed this to decreasing ruminal protein degradability.

A plant's cell wall content, also referred to as the neutral detergent fiber (NDF) and its degree of lignification (ADL) are the key determinants of forage quality, which is a function of feed intake digestibility (Van Soest, 1982). High levels of these compounds depress the digestibility of forages (Barton *et al.*, 1976). Lignin, which was fairly high in the *P. juliflora* seedpod meal, has been shown to be one of the forage components highly associated with reduced digestibility (Van Soest, 1982). It's fairly high content in the diet may partially account for the lower digestibility of the diet and subsequent low N retention observed in T_1 of our study. Wilson (1977) speculated that lignin may have some inhibiting activities on cellulases as well as antibacterial characteristics.

4.6 Average body condition scores by treatments

Table 7 below presents the average body score indices of the goats according to the treatments. The T_1 treatment group of animals exhibited the lowest body condition score while the T_3 group exhibited the best body condition score. T_2 and T_4 group of animals had the same score of 2. The body condition score index is a tool used to adjust feeding of animals. Management decisions involving livestock nutrition are important to achieve the best body condition at calving and later post calving reproductive success. The score is further used in trying to match feedstuff quality with the nutritional requirements of the animals at different reproductive stages for maximum performance. However, this should be done gradually since ruminant animals are very sensitive to change in diets and any change immediately affects their rumen micro-organisms (Spahr, 2009) which, in turn, affect the feed digestion and assimilation. Supplementary feeding can be adjusted upwards or downwards using the body condition scores

Table 7: Average body condition score indices of goats according to the treatment groups

Treatment	Body Score
T_1	1
T_2	2
T_3	3
T_4	2

A study by Zahraddeen *et al.* (2009) on the factors influencing milk yield of local goats under semi-intensive systems in northern Nigeria observed that the body condition score of the goats was positively correlated to milk yield – milk yield increased with increase in the doe's body condition score. Body condition scores can also be used to monitor nutritional regimes of livestock (Manuel and Greg, 2000). The score can be used to adjust the nutritional regime of the kind/class of animal to obtain the desired body condition at different stages of production (Manuel and Greg, 2000).

4.7 Cost-benefit analysis of the experiment

Table 8 presents the CBR associated with the four treatments of this study. T_3 had the highest CBR followed by T_2 and T_4, respectively. Treatment T_4 had the lowest CBR. This is because it was the most expensive treatment, and hence the lowest returns to investment. The break-even CBR is 1. According to the results of this study, T_3 was the most cost effective treatment followed by T_2 This implies that it would pay to supplement goats at 100 - 200g of *P. juliflora* seedpod meal per goat per day. Studies by Mesfin and Ledin (2004), comparing the cost benefit ratios of feeding cows on urea treated teff-barley straw and hay based diets showed that the latter was the most expensive diet, followed by the urea-treated teff straw diets. Furthermore, the hay-based diets had the lowest net return; while the urea-treated teff straw had the highest net return. Thus, a CBR can be used as a decision making tool.

Table 8: Cost-benefit analysis of the four experimental treatments

Treatment	Expected benefits (KES)	Expected costs (KES)	BCR
T_1	1,872.00	1985.00	0.94
T_2	5,040.00	3,430.80	1.47
T_3	15,444.00	10,692.40	1.50
T_4	7,776.00	13,723.20	0.57

KES-Kenyan shillings

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The results of this study clearly demonstrated that *P. juliflora* seedpods can be sparingly incorporated into the diets of growing goats up to 200 g/goat/day to improve their feed intake, feed conversion efficiency and body weight gain. This is largely attributed to the high protein content of the seedpods. The results further indicated that *P. juliflora* proportions higher than 200g are detrimental to the growth of the goats. The CBRs obtained in this study further indicated that *P.juliflora* seedpods can be included in the diets of growing goats to achieve profits. By extension, it can be concluded that the use of *Prosopis* pods or leaves as livestock feed offers an environmentally-friendly way of utilizing the tree. This and other uses of the tree will go a long way towards reducing the amount of negative attitude that the local communities have for the tree.

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