IDENTIFICATION, PREFERENCE AND NUTRITIONAL EVALUATION OF ACACIA SPECIES AS BROWSE FEED FOR GOATS IN ASAL REGION, BARINGO COUNTY - KENYA

KANDIE HEZEKIAH CHEPTUMO

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DECLARATION

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Kandie Hezekiah Cheptumo

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AGR/PGA/002/15 **Date**

Declaration by Supervisors

This thesis has been submitted for examination with our approval as University supervisors.

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Prof. George W. Oduho Oliech. **Date**

April 22th 2022

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Prof. James Ombiro Ondiek **Date**

DEDICATION

This thesis is dedicated to my wife Joyce and children; Victor, Terry and Nicole, whose prayers, support and encouragement kept me working to the fruitful end.

ABSTRACT

The pastoralist communities in the ASAL regions of Sub-Saharan Africa face significant constraints arising from insufficient nutritious livestock feeds, which in turn limits livestock productivity. Nonetheless, grass, shrub bushes and fodder trees are primary feed resources for livestock in a wide range of production practices. This study sought to identify and evaluate the nutritive value of five common *Acacia* browse species; *A. brevispica*, *A. senegal*, *A. tortilis*, *A. mellifera* and *A. nilotica* in Marigat sub-county, Baringo County. The study examined the preference rating of Acacia spps, among goats. Their nutritive value was determined by proximate analysis using AOAC (1995) on DM basis of leaves, bark and pods and reported in percentage content as DM, CP, CF, Ash, EE. The *In-vitro* DM degradability (IVDMD) was also determined and measured by 200 mg dry matter in duplicates at 39.2^0 C after, 0, 3, 6, 9, 12, 24, 48, 72, 96 and 120h of incubation and fitted to the exponential model, $GP(t) = a + b(1 - e^{-c(t - L)})$. The statistic, Kruskal-Wallis, H test, (χ^2 (4) = 182.6) at 0.05 significance levels indicated significant differences in preferences between the *Acacia spps*. *A. brevispica* being ranked the highest in preference while *A. senegal* ranked the lowest. ANOVA results, F (4, 475) = 62.61, $p<0.05$ showed significant differences in browsing preference. *A. brevispica* was highly preferred while *A. senegal* was least preferred. Results of proximate analysis indicated that DM was high for all samples and ranged from 97.21% in *A. nilotica* leaves to 94.13% in *A. tortilis* pods. The CP ranged from 23.9% in *A. senegal pods to* 2.76% *in A. nilotica* bark while CF ranged between 43.18 % in *A. Senegal* bark, to 9.66% in *A. nilotica* leaves, EE ranged between 5.21% in *A. nilotica* leaves to 0.31% in *A. nilotica* bark. Lastly, the IVDMD analysis indicated that *A. nilotica* leaves had highest gas production followed by *A. mellifera* and lastly *A. brevispica*. *A. mellifera* pods were highly degradable followed by *A. nilotica*, and *lastly, A. tortilis. A. nilotica* bark was highly degradable followed by *A. senegal,* and lastly *A. tortilis* bark. There were significant differences in the degradability of *Acacia spps*($p \leq 0.05$) with *A. nilotica* leaves, *A. brevispica* pods and *A. nilotica* bark being highly degradable. Based on the statistical results, the study rejected all the null hypotheses and concluded that some *Acacia spps* have comparable nutritive value that may meet the feeding requirements of the browsers. The study recommends that *A. nilotica A. brevispica and A. tortilis* be developed for use in feeding goats in the arid and semi – arid regions. Further studies on anti-nutritional factors and Animal Response Trials for production values needs to be done.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

ADF	Acid Detergent Fibre
ADL	Acid Detergent Lignin
ANF	Anti-Nutritional Factors
AOAC	Association of Official Analytical Chemist
ASAL	Arid and Semi-Arid Lands
CF	Crude Fibre
CP	Crude Protein
DM	Dry Matter
EE	Ether Extract
DM	Dry Matter
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GP	Gas production
IVDMD	in-vitro Dry Matter Degradability
ME	Metabolic Energy
MS	Mean of Squares
NDF	Neutral Detergent Fibre
NV	Nutritive Value
OM	Organic Matter
OMD	Organic matter digestibility
SD	Standard Deviation
SE	Standard Error
SEM	Standard Error of Mean
SCFA	Short Chain Fatty Acids
SS	Sum of Squares

KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
Spp(s)	specie(s)

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Livestock serves various roles in the livelihoods of rural households that include food security, economic, and other societal functions. In particular, goats and cattle perform a critical socio-economic function (Dambe *et al.,* 2015), such as the production of milk meat, draught power and as a major income source and social status (Abay & Jensen, 2020). Livestock husbandry is a predominant economic activity and employs over 90% of the local population in the Arid and Semi-Arid Lands in Kenya (Kidake *et al.,* 2016).

The arid and semi- arid regions receives an annual precipitation of between 600- 250 mm of rainfall and are water-deficient due to the higher evaporation rates arising from high temperature and therefore, they are not suitable for rain-fed agricultural activities (Mwangi, 2019). The semi-arid rangelands are highly degraded because of changes in the use of land, incessant grazing and changes in climatic condition (Hassen *et al.,* 2017). The seasonal fluctuations in the weather patterns and soil condition determine the availability of feed resources in the ASALs (Kidake *et al.,* 2016) and constraints livestock production (Ndathi *et al.,* 2012).

Consistent availability of affordable feeds in adequate quantities is a major requirement for livestock production (Ndathi *et al.,* 2013). However, the nutritional performance of the domesticated ruminants in ASALs in the tropics is constrained by the lack of vital feed resources. Even with limited access, the fibrous feed resources such as mature grasses and cereal crop residues cannot sustain ruminating livestock

(Osuga et al 2008), because of the lower nutritive value of the forage (Mphinyane *et al.,* 2015). Because of nutrient deficiency, livestock lack sufficient energy and protein (Abdalla *et al.,* 2014; Melaku *et al.,* 2010).

Due to the environmental challenges, natural browse plant species have served as quality livestock feed for livestock production in the ASALs areas (Dambe *et al.,* 2015). There is a large reserve of plant species that could be serve as potential livestock feed resource. However, the importance of browse foliage as livestock feed is dictated by their availability, nutritive value and palatability (Shenkute *et al.*, 2012). Several fodder trees and shrubs are vital component of livestock production in ASALs, as the provide feed supplementation in terms of the quantity and quality of browse and serve as an effective insurance against seasonal feed shortages(Abusuwar & Ahmed, 2010).

Although nomadic migration helps improve the utilization the scarce feed resources, the changing climatic condition is relegating the use of nomadic migration as an alternative approach to the management of the livestock feed resources in the ASALs. Further, communal conflicts are becoming more frequent as the communities fight for land especially during droughts (Ndathi *et al.,* 2013). Furthermore, the traditional approaches to land use management are crumbling due to socio-economic factors, changing land use patterns and climate variability (Kidake *et al.*, 2016).

Utilization of *Acacia* spp can be improved through selection, fodder accessibility and the reduction in the secondary anti-nutrition compounds. The effective selection process requires screening several *Aca*cia tree species to determine each species nutritional quality and preference (Dynes & Schlink 2002). However, there has been limited focus on the *Acacia* trees species as forage and this has restricted their establishment and exploitation as feed supplements in different context (Gebeyew *et al.,* 2015; Khan *et al.,* 2014).

The chemical composition and nutritional values of the different browse species varies according to rainfall patterns and distribution, topography, altitude, soils and land use conditions (Belachew *et al.,* 2013). Despite the changing climatic and environmental conditions, there is no clear strategy for the development of alternate source of fodder in the ASALs (Kidake *et al.,* 2016). Further, there is the lack of information on the nutritive value of the indigenous plant feed species when compared to the exotic feed species.

Despite the availability of the information, most pastoralists lack access to information on pasture and fodder production. Thus, there is lack of information on the most appropriate browse species, establishment, management and dissemination of pasture and fodder technologies in the ASALs (Kidake *et al.,* 2016). Therefore, the documentation of the livestock feed resource and feeding systems becomes crucial in designing the appropriate interventions (Teklu *et al.,* 2011).

Despite the empirical studies on pastures and utilization of crop residues and supplementation, livestock nutrition in sub-Saharan Africa is a major constraint to productivity (Kidake *et al.,* 2016). For instance, the grass *Cynondon spp.* is an important grass species in the ASALs (Ndathi *et al.,* 2012). Mangara *et al.,* (2017) reported that *Cumbretum adenogonium* and *Ziziphus spina-christi* could serve as an important dietary sources to supplement low quality forages.

1.2 Statement of the Problem

A review of drought situation for a period of 33 years in Marigat, Baringo County showed that droughts have prevailed for over 50% of the study period and became more frequent after 2000 (Kosonei *et al.*, 2017). As a result, pasture grasses and shrubs have declined, leaving the ground bare. In addition, the composition of the browse changes due to degradation of rangeland, climate and land use. The inadequate supplies of quality feed in ASALs is aggravated by erratic and unreliable rainfall patterns that limit forage biomass production, thus, the livestock face significant challenges due to the low nutritive value of the existing forage. Empirical studies have evaluated several indigenous browse species in different regions and have found several browse species with the potential to act as supplementary livestock feed resources (Hassen *et al.*, 2017). Acacia *Spps* are known to be drought tolerant and can serve as an alternative feed resource during the dry season. Thus, there is an urgent need to disseminate knowledge on the identification and establishment of browse trees and shrub as livestock feed resource identification to the pastoralists. Therefore, this study focused on identification and screening the potential *Acacia* browse plants and analysing their nutritive value as preferred by the goats in Baringo County

1.3 Justification of the Study

Inadequacy of nutritious feeds for livestock in ASALs in the tropics is a major constraint to livestock productivity. Fodder trees and shrubs are crucial livestock feed resources for a wide range of livestock production systems in Africa (Franzel *et al.*, 2014). This research was undertaken to identify and list *Acacia* tree species that are preferred as forage by goats in Marigat in Baringo South Sub-County, Baringo County in Kenya and to evaluate their nutrient content and levels using proximate analysis and rumen degradation test, respectively.

Livestock lose their body condition and become less productive, susceptible to diseases and some die of extreme malnutrition leading to loss of productivity. In addition, there is lowered reproductive performance as animals lose their body conditions. The studies and nutritive analysis are few in the literature and therefore once properly screened, identified and evaluated, pastoralist will be able to selectively plant and manage these *Acacia* trees as fodder crops for feeding their livestock in the ASALs.

1.4 Objectives of the study

To contribute to the feed – base by identifying and evaluating the nutritive value of Acacia species for improved livestock production in ASALs in Kenya

1. To identify, record and mention edible *Acacia* species preferred by goats in Marigat, Baringo County.
2. To establish the rank preference for the *Acacia spps* under natural (in-situ) browsing in Marigat, Baringo County.
3. To evaluate the nutrient composition of parts of the preferred *Acacia spps* in Marigat, Baringo County.
4. To determine the *In-vitro* dry matter degradability of the edible parts of preferred *Acacia spps* in Marigat, Baringo County.

1.5 Hypotheses

1. **Ho:** There are no identifiable browsable Acacia species of plants that can be used as livestock feed in Marigat, Baringo County.
2. **Ho:** There are no significant differences in preferences of goats for the forages of different *Acacia spps* during browsing in Marigat, Baringo County.
3. **Ho:** There are no significant differences in nutrient composition of the edible parts of the preferred *Acacia spps* in Marigat, Baringo County.
4. **Ho:** There are no significant differences in *In-vitro* dry matter degradability of the edible parts of the preferred *Acacia spps* in Marigat, Baringo County.

1.6 Justification of the Study

Livestock production hold a lot of potential for improved nutrition, and poverty alleviation through increased income for the poor, and thus plays a role in economic development. The challenge facing the livestock production in the ASALs is the lack of information on modern husbandry practices. The introduction of forage feed by the study could assist stakeholders and farmers to access alternative feed formulations for smallholder livestock production.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Livestock Production in ASALs

Arid lands make up 41.3 % of the earth's surface area while the arid and semi-arid lands make up to 43% of Africa's land area with an estimated 268 million people. Globally, rangelands support about 50 % of the livestock population while cultivated lands support another 44 % of the population. In particular, the Sub-Saharan African holds an approximately 240 million agro-pastoralists and 25 million pastoralists. Around 40 % of the earth's land surface has been degraded thereby destroying the livelihoods of 2 billion people and, in particular, women and youth comprising 90% living in developing countries (van de Steeg, 2012).

Generally, in rangelands of sub-Saharan Africa, the livestock feed resources comprise natural pastures, forb and some browse shrubs and trees (Abusuwar & Ahmed, 2010). In particular, the ASALs hold a wide variety of natural pastures as well high quality feed materials from browses and trees. However, the changing climatic conditions affect these feed sources (Ndathi *et al.,* 2013). Due to this factor, the livestock productivity in the tropics intensively use low quality, naturally growing forage which differ from country to country (Abusuwar & Ahmed, 2010).

Within these rangelands, three main animal husbandry systems exist; nomadic, semi-nomadic or settled with owners being largely full pastoralist owning large herds or sedentary or settled agro-pastoralist with small herds (Abusuwar & Ahmed, 2010).
Studies have shown that within the dry rangelands, a rich biodiversity of nutritious plant species can support improved livestock production (Ndathi *et al.,* 2012). In

particular, the parts of the browse species such as leaves, fruits, flowers, twigs or pods are an important feed resource for ruminant livestock (Dambe *et al.,* 2015). However, most pastoralist in these rangelands release their animals into the grazing areas and make little or no plans to address the feed crisis during the dry seasons (Ndathi *et al.,* 2013).

Grassland in East Africa are crucial for livestock production as well as wildlife production and contribute 54 - 90% of the agricultural gross domestic productivity and at least 45% of countries' GDP (Mwangi, 2019). The disappearance of good pastures and fodder during dry seasons is a major challenge in rangelands (Tessema et al., 2011) as the livestock production is most vulnerable to weather shocks (Abay & Jensen, 2020). The palatable plant species in the ASALs are being lost and are being replaced by exotic plant species (Teklu, Negesse & Angassa, 2011).

2.2 Overview of Forage Utilization in ASALs

The increasing frequency of droughts in the ASALs have a direct effect on availability of natural pastures due to their depletion. In particular, the traditionally adapted fodder species are rapidly disappearing due to overgrazing and climate changes. In its place, is the annuals, bushes, shrubs, bare patches and unpalatable species. Further, there is minimal supplementation in these regions and due to this situation, the farmers' capacity to provide sufficient feed for the livestock is constrained (Kidake *et al.,* 2016).

Pastures and feeds that are abundant during the rainy seasons are degraded by poor management strategies. The uncontrolled usage of communal grazing areas in dry land rangelands contributes to land degradation and depletes the available feed resources for the livestock (Abusuwar and Ahmed 2010). In some areas, feed resources are sufficient during the rainy seasons, but in some cases, there insufficient and irregular feed supplies throughout the year. This problem is exacerbated by the seasonal fluctuations in the quality of available forage quality (Hassen *et al.*, 2017).

Ruminating livestock require a basal diets containing not less than 7% crude protein (CP) (Ondiek *et al.,* 2000). However, in ASAL regions, forages have low crude protein (CP) content, thus the only alternative is browse trees and shrubs (Abdalla *et al.,* 2014). These alternatives include browse tress, which are well adapted to adverse climate conditions. In these regions, fodder trees and shrubs supply the bulk of nutritional requirements to caprines and dromedaries while supplementing the diets of bovines and ovines with vitamins, protein and minerals (Abdalla *et al.*, 2014; Dambe *et al.,* 2015).

In Kenya, the livestock production in the ASALs occur in extensively communal - owned lands. The studies indicate that pastoralists do not conserve feed resources because of lack of information and skill, but the communal ownership of land resource and the large herds of livestock is a hindrance (Ndathi *et al.,* 2012). In these regions, livestock productivity is hindered by the variability in the quantity and quality of feed resources (Abay & Jensen, 2020; Kemboi *et al.,* 2017).

Therefore, there is the need to identify indigenous plant species that can support livestock production in the ASALs as the identification and characterization of these the plant species will increase their value (Ndathi *et al.,* 2013). However, other challenges arising in the identification of browse species is the presence of secondary compounds such as alkaloids, amines, cyanides, fluoroacetates, oxalates, tannins, saponins and other unidentified toxins (Dynes & Schlink, 2002). The leaves of browse tree species have low tannin and phenolic contents (Mangara *et al.*, 2017). However, the presence of these toxins varies from species to species and plant parts (Abdulrazak *et al.*, 2000).

The changes, frequency and duration of rainfall patterns manifested by droughts, which directly affect the livelihoods of pastoral communities (Gikaba, Muthoni & Bebe, 2014). The changing climatic conditions has devastated the ecosystems in the ASALs as exhibited by the reduction in the grass species and commensurate increase in the woody plant species *(*Ndathi *et al.*, 2012). Empirical studies indicate leaves of browse plant species provide supplementary energy and proteins when the grasses mature and have low nutritional value (Abay & Jensen, 2020). In particular, browse plants have high mineral and crude protein (CP) contents, which are crucial for the ruminants (Abusuwar & Ahmed, 2010; Mangara *et al.*, 2017) and therefore, meet their nutritional needs and supplement feed resources for the grazing ruminants (Shenkute *et al.*, 2012).

Because of these challenges, several organization and institutions including government, research institutions, and private-sector organizations among others have intervened in the livestock productivity arrangements in ASALs. The interventions include the development and dissemination of pasture and fodder technologies such as natural pasture improvement, establishment of range pastures, production of seed, processing and storage of seed pasture, and conservation, preservation and utilization of range fodder (Kidake *et al.,* 2016).

Several remedies to the nutritional challenges have been proposed and this include controlled usage (Abusuwar & Ahmed 2010), migration (Ndathi *et al.,* 2013), feed formulation, (Kidake *et al.,* 2016) and many more. In many different countries, research, extension service and farmers have advanced and promoted the usage of fodder tree. For instance, over 200,000 smallholder farmers in the Eastern African highlands use fodder trees. However, the key challenges to the uptake of fodder trees is the limited number of browse species that can be grown in different agro-ecological zones particularly the ASALs, the lack of knowledge and skills among the pastoralist among many other reasons (Franzel *et al.,* 2014).

The ASALs) in Kenya is characterized by erratic and low rainfall and are associated with recurring droughts. Due to this scenario, the livestock – based economies of the pastoral communities takes a dramatic turn for the worse. In fact, the government of Kenya declared five drought – related disasters between 1993 and 2011 (Gikaba *et al.,* 2014). With the prevailing climatic changes, the browse species are favoured over grasses. Thus, there is the need to identifying the browse species that could contribute more to livestock feeding. This includes the identification of pods or leaves in supplementary feeding formulations (Ndathi *et al.*, 2012).

2.3 Browse Trees and Plants as Livestock Feed

Indigenous browse species are becoming the major feed resources in semi-arid rangelands (Hassen *et al.,* 2017) and have reduced the seasonal feed resource limitation because of their adaption to hash climatic condition (Shenkute *et al.,* 2012). In comparison to pastures, browse plant species are less affected by the changes in climatic condition due to their extensive root system. However, some browse plant species may contain secondary compounds such as phenols and tannins, which act as anti-nutritional components and this limits their utilization as forage (Basha *et al.,* 2015; Belachew *et al.,* 2013).

Fodder shrubs and trees have played a key role in providing forage with nutritive value to the grazing ruminants (Gebeyew *et al.,* 2015; Khan *et al.,* 2014) and hold an enormous potential as a forage feed for cattle, goats, sheep and camels, as a source of nectar for honey production in ASAL areas. They have the capability to extract nutrients and water from deeper soil profiles because of their deep roots and hence their ability to remain green for longer during drought (Jamala *et al.,* 2013). The inclusion of browse leaves help mitigate against crude protein deficiency and improve the utilization of low quality feed resources (Rubanza et al 2003).

Browse plant species generally have higher minerals and protein content during dry season and offer a more stable feed resource when compared to the pasture grass (Dambe *et al.,* 2015). Browse leaves are a natural dietary component for ruminating livestock species and are traditionally used as livestock feed in Africa, Asia and the pacific regions. These species serve as complete feed sources or supplementary feed sources as they possess the desired nutritional values and agronomic characteristics (Mangara *et al.,* 2017). The differences in preference depend on the animal adaptation to the large variances in the nutritional status of the forages. Some browse species have higher fodder availability during specific periods only (Osuga *et al.,* 2008).

In Australia, browse plant species provide critical nutritive values for grazers and browsers alike (Dynes & Schlink, 2002). In Botswana, these natural browse are quality feed for the livestock all year round (Dambe *et al.,* 2015). In Kenya, Abdulrazak *et al.,* (2000) affirmed that browse plants are the common feed resource for livestock production in the ASALs and include the natural pastures, locally available legumes and browse species comprising trees and shrubs (Ndathi 2012; Ndathi *et al.*, 2013).

The differences in the chemical composition of the browse forages are attributable to several factors including the plant part, growth stage, soil type, climate and season (Dambe *et al.,* 2015). High CP and lower fibre composition in the browse plants indicate the potential for nitrogen supplementation for ruminants feeding on low quality roughage (Abebe *et al.,* 2012; Mangara *et al.*, 2017). Browse leaves have higher CP range of 12-30 % which is comparatively higher than the CP content of mature grasses that ranges from 3-10 % (Dambe *et al.,* 2015). However, the CP content tend to decrease significantly during the dry season (Hassen *et al.*, 2017). Browse plant species also have average ash content but a high ether extract (Shenkute *et al.,* 2012). For instance, in the pastoralist zones of Southern Kenya, the use of *Digitaria macroblephara* species is extremely impacted by droughts (Gikaba *et al.*, 2014).

Melaku, Aregawi & Nigatu, (2010) identified several browse such as; *Acacia tortilis, Acacia oerfota, Boswellia papyrifera, Balanites aegyptiaca, Terminalia brownii Sterculia africana, and Ziziphus spina-christi* which ranked highly for their nutritive value. Aregawi *et al.,* (2008) identified *Acacia lahai, Acacia oerfota, Acacia tortilis,* *Acacia asak, Dichrostachys cinerea and Ziziphus spina-christi as well as Sterculia africana. Acacia brevispica Berchemia discolor, Balanites aegyptiaca, Maerua angolensis and Grewia hostii* have sufficient sources of crude protein (Kemboi *et al.*, 2017).

Empirical studies have explored the value of browse plant species in different context including Kenya (Kemboi *et al.*, 2017; Ndathi *et al.*, 2013; Ndathi *et al.*, 2012; Osuga *et al.*, 2008), Sudan (Mangara *et al.*, 2017), Botswana (Dambe *et al.*, 2015), Nigeria (Olubukola *et al.*, 2013) and Ethiopia (Abebe *et al.*, 2012; Shenkute *et al.*, 2012; Hassen *et al.*, 2017) among others. Some of the important findings from these studies is that *Balanite aegyptiaca*, *Grewia mollis* and *strychnos spinosa* have low CP content and high CF levels (Mangara *et al.*, 2017). Ndathi *et al.*, (2013) reported that several plant species including *Acacia drepanolobium*, *Acacia tortilis*, *Cordia quercifolia, Cordia sinensis*, *Cyathulia coriacea*, *Grewia tenax*, *Indifoera ambelacensis*, *Lecariodiscus flaxinifolius, Lwsonia inermis*, *Pluchea discoridis*, *Prosopis juliflora*, *Terminalia orbicularis*, *Salvadhora persica*, *Securinega virosa*, and *Terminalia brevipes* have been used browse in ASALs in Kenya.

The studies in Kenya have examined several browse species includin *Acacia brevispica*, *Balanites aegyptiaca*, *Berchemia discolor*, *Grewia hostii* and *Maerua angolensis* (Kemboi *et al.*, 2017). Osuga *et al.*, (2008) examined the following browse forage; *Acacia mellifera, Acacia brevispica, Berchemia discolor, Maerua angolensis* and *Zizyphus mucronata.* The findings showed that the browse species *A. brevispica* has sufficient nutritive values to support livestock productivity.

The studies in South Sudan evaluated the nutritive potential of the following indigenous browse foliage of *Balanite aegyptiaca, Acacia nilotica, Cumbretum adenogonium, Ziziphus spina-christi and Sclerocarya birrea* (Mangara *et al.,* 2017). While in Botswana, Dambe *et al.,* (2015) examined several plant parts including leaves and bark of 16 browse foliage that included fresh leaves of *A. mellifera, Combretum imberbe, Grewia bicolor, Combretum hereroense, Lonchocarpus capassa, Combretum apiculatum and Peltophorum africanum, old leaves of A. nigrescens, A. tortilis* among others and bark of *A. mellifera, G. bicolor* and others. In Nigeria, Olubukola *et al.,* (2013) examined the chemical composition *Ficus capensis, Ficus mucoso, and Spondia mombin*.

The studies in Ethiopia examined the comparative seasonal nutritive value of several browse foliage that included *Acacia robusta Carissa spinarum, Combretum molle, Commicarpus plumbagineus, Jasminum grandiflorum, Opuntia* ficus indica, *Grewia tembensis, Cordia monoica, Grewia ferruginea, Rhus natalensis,* and *Prosopis juliflora* (Hassen *et al.,* 2017). Abebe *et al.,* (2012) examined the chemical composition for several browse foliage that included *A. brevispica, A. tortilis, A. seyal, B. aegyptiaca, G. bicolor, G. tembensis and R. natalensis*. Shenkute *et al.,* (2012) examined several browse that included *A. tortilis, A. mellifera, Balanites aegyptica, Celtis africana, Capparis fascicularis, Dichrostachys cinerea, G. bicolor, Olea europaea* and *Ziziphus mucronata.*

These studies made several observations relating to the nutritional value of the browse species. The different browse species have varying chemical composition. First, some species have high mineral content (Mangara *et al.,* 2017), second, some species have higher CP values, (*Cumbretum adenogonium* and *Z. spina-christi*) (Mangara *et al.,* 2017), 23.9% CP *in Lonchocarpus capassa* (Dambe *et al.,* 2015), third, some species have relatively higher dry matter content, *Acacia nilotica, B. aegyptiaca and C. adenogonium* (Mangara *et al.,* 2017), and fourth, some species have high crude fibre content*;* 39% in *C imberbe* (Dambe *et al.,* 2015), *C. adenogonium* (Mangara *et al.,* 2017). Further, the crude protein content was specifically higher during the rainy season (Abebe *et al.,* 2012).

On the contrast, several anti-nutritional factors were detected by the studies; *Balanite aegyptiaca* and *S. birrea* had high fibre content (Mangara *et al.,* 2017). Some browse species had exceptionally high tannin content. For instance, Ndathi *et al.,* (2012) found that the tannin content of *C. exalatum* was exceptionally high and thus it depresses its digestibility and palatability. Tannins affect the preference of browse forage by determining its palatability. For instance, high concentration of tannins in the browse forage reduce ruminal and post-ruminal digestion of protein (Min *et al.,* 2003), while low concentrations prevent extensive proteolysis in the rumen and increase in intestinal absorption of amino acids (Osuga *et al.,* 2008).

Difference ruminants have differential ruminal metabolism of anti-nutritional substances for instance goats can mitigate the anti-nutritional effects of cell wall lignification in their diets. In other cases, the ruminants prefer different foliage, for instance, goats consume more browse species than sheep or cows (Rogosic *et al.,* 2006). Any phenolic and tannin contents that are higher than 50 g kg^{-1} DM pose as anti-nutritional factors (Mangara *et al.,* 2017).

Accessibility to browse foliage is affected by the plant height which a limits animal access. Animals are able to access the available part of the plant, thus impediments arising from height tend to restrict the animals from consuming its leaves (Dambe *et al.,* 2015). Spikes and thorns in *Acacia spps* are physical deterrents and tend to reduce bite size and biting rate (Dambe *et al.,* 2015).

2.4 Acacia Species as Livestock Feed

From more than 900 *Acacia Spps*, only a limited number are utilized extensively as fodder for ruminants (Gebeyew *et al.*, 2015). *Acacia spp* trees and shrubs are native to Australia, which holds more than two thirds of the species, while the tropical and sub-tropical regions hold the remaining species (Zia-Ul-Haq *et al.,* 2013). However, *A. nilotica* is the most prevalent species in Africa (Bond *et al.,* 2001). The feed value of *Acacias spps* depends on the availability and the agglomeration of essential nutrients and secondary compounds (Tibbo, 2000).

Acacia species provide much - needed nutrients to domestic herbivores (Gebeyew *et al.*, 2015). The *Acacia spps* remain green and provide better nutritive value particularly during the dry season when all other plant species such as grasses and herbaceous species have withered (Aregawi *et al.,* 2008). Because the *Acacia* species have deeper root that allows these plants to extract water and nutrients from deeper soil profiles (Melaku *et al.,* 2010). *Acacia* spp grows in diverse habitats including salt-affected areas and serve as alternative feed source (Dynes & Schlink, 2002).

A. nilotica, *A. tortilis* and *A. seyal* are used as livestock browse in the ASALs (Abdulrazak *et al.,* 2000). In another study carried out in Baringo County, Kenya, Osuga *et al.,* (2008) found that *Acacia brevispica* is the most preferred browse species in most ASALs in Kenya. . In Ethiopia *A. senegal* is a feed supplement (Mengistu *et al.,* 2016) since their pods are highly digestible than foliage but tend to have lower crude protein content (Dynes & Schlink, 2002).

In Ethiopia, Melaku *et al.,* (2010) reported that *A. amara, A. tortilis, A. asak,* and *A. oerfota,* have crude protein range of 10.3% to 17.7%. However, the use of the *Acacia spp* as browse foliage is widespread notwithstanding the following limitation; *A. tortilis and A. lahai* are thornier, *A. asak* causes digestive disorder to cattle while *A. oerfota* has a pungent smell (Aregawi *et al.,* 2008). In general, the leaves of *Acacia spp* have good mineral and protein content (Mengistu *et al.,* 2016).

The *Acacia spp* leaves and pods are thought to be rich source of minerals; however, they tend to vary because of several factors, which include plant profile, species and variety, soil characteristics and seasonal or climatic conditions (Abdalla *et al.,* 2014). The foliage from trees and shrubs that contain low cell wall cellulose have higher effective degradability and are highly consumed by the ruminants (Ramírez *et al.,* 2000). Even, though the growth designs of the *Acacia spp* trees and shrubs is a limiting factor to grazing animals, the animals tend to increase their consumption to offset the reduction in bite size. However, harvesting difficulties is not compensated for by the bite size (Dynes & Schlink, 2002). Furthermore, in heavily bushy sites, impenetrable *Acacia* species may be rendered unavailable to livestock (Kgosikoma and Mogotsi 2013).

Acacia Spps have several uses that include; pasture, fallow, wildlife habitat, sources of shade, soil stabilization, wind shelter, live fence, mulch, bee forage, resins, fuel source, fibre, timber, dyes, tannins, human feed, human and veterinary medicine, soil nutrient recycling and other farm diversifications (Jamala *et al.,* 2013). *Acacia spp*s promote the protection of the environment by preventing the erosion of soils and help mitigate against climate change and desertification by sequestering carbon and reducing greenhouse gas emissions (Abdalla *et al.*, 2014).

Other benefits of *Acacia* trees include; soil and water conservation, provision of timber materials, shade against scorching sun to humans and livestock, fuel in form of wood or charcoal, medicines that cure diseases, wax and gums such as gum Arabic for use in tanneries and food processing, apiculture in honey production, boundaries and live fences, land reclamation and rehabilitation and as forage sources for herbivorous wildlife (Luseba *et al.,* 2006; Jamala *et al.*, 2013). *Acacia* trees also provide food to human beings who eat their pods, seeds and leaves as vegetables in dry areas.

2.5 Nutritional Value of the Acacia Spp

The feed value of forage is contingent on the amounts of feed ingested, the quantity of dry matter, crude fibre content, crude protein content, mineral and vitamins in the feed. However, depending on the regularity of the feed ingested by the animal, the forage can either improve or lower the growth performance of the animal. High variability in the nutritive value of any browse species is attributable to several factors including the plant part, the location, the season and the period of ingestion (Shenkute *et al.,* 2012).

Other factors influencing the feed value include plant species characteristics such as its availability, chemical composition and presence or absence of secondary compounds (Dynes & Schlink, 2002), the soils and growth stage (Dambe *et al.*, 2015). But the most critical aspect is that at less than 55% IVD levels, there are physical limitations in terms of eating and digesting and passing, therefore live weight loss in inevitable since feed intake is restricted (Tibbo, 2000).

Acacia trees are leguminous and therefore have a higher crude protein content when compared with grasses hence are able to serve as the only feed material that can keep livestock healthy and reasonably productive for longer (Gebeyew *et al.*, 2015). Its feed value depends on the ease of digestibility, essential nutrients and the concentration of anti-nutritional compounds (Dynes & Schlink, 2002). Majority of the *Acacia spp*s are considered rich in crude protein with ranges of 7.0% and 29.3% which are adequate for animal needs but the CP content varies according to the species.

*Acacia spp*s pods have a high CP content of about 18.8%, while the seedpods have lower CP concentration but have a higher digestibility than foliage (Shenkute *et al.*, 2012), The ash content (minerals) of the *Acacia Spps* vary according to species with some species having inadequate mineral content for animal productive performance, while others are considered toxic to animal health (Tibbo, 2000). Furthermore, *Acacia* species contain anti-nutritional factors(ANFs) such as tannins, but the utilization of wilted leaves and dried pods is known to reduce the effects of ANFs (Dambe *et al.*, 2015).

The dry matter potential degradability for *Acacia spp*. in Kenya ranged from 40.1 to 59.1% with *A. brevispica* and *A. mellifera* being of high nutritive value (Abdulrazak *et al.*, 2001) while the *A. anuera* is reported to have digestibility levels of between

39% and 64% (Dynes & Schlink, 2002). Abdulrazak *et al.*, (2000) ordered the *Acacia spp*s according to their degradability and reported that *A. Nubica* was highly degradable while *A. nilotica* was least degradable. Therefore, based on the crude protein content and degradability, the *Acacia spp*, hold potential for feed nutrition. In Australia, *A. albida* and *A. tortilis* have comparative higher crude protein content (Tibbo, 2000).

Abdulrazak *et al.*, (2001) ranked the *Acacia spps* found in Kenya according to their palatability in the following order: *A.*brevispica > *A.*mellifera > *A.* tortilis > *A.*senegal > *A.*nilotica. While in Sudan, *A. seyal* serves as a potential fodder source for livestock production as it has high crude protein with the following concentration levels; 31.05% CP; 24.34% CF; 5.13% fats; 9.76% starch; and a host of essential minerals to meet the nutritional requirements (Abdalla *et al.*, 2014). Shenkute *et al.*, (2012) reported that *A. tortilis* pods contain about 18.8% CP and are rich in the micro-elements such as Mn, Mo, Zn, Co, Cu, Fe and Se (Abdulrazak *et al.*, 2000).

Whereas most Acacia species contain a myriad of anti-nutritional compounds, the utilization of withered leaves and pods, tend to counter the effects of the anti-nutritional factors (Shenkute *et al.,* 2012). *A. nilotica,* and *A. sieberiana* have phenolic and cyanidin compounds, which tend to lower feed intake and reduced growth rates (Tibbo, 2000). The Anti-nutritional factors affect the feed value of any forage or browse by interfering with the ingested feed quantities, digestive processes and feed metabolic utilization. However, the use of parts of *Acacia spp* such as dried pods help lessen the impact of anti-nutritional compounds (Dambe *et al.,* 2015). Low dry matter degradability is attributable to anti-nutritional compounds (Dambe *et al.*, 2015).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Location and Characteristics

The study was carried out in Marigat, Baringo South Sub – county, Baringo County in Kenya. Marigat is located at 0°28´N. It is 39 km east of Kabarnet town, which is the headquarters of the Baringo County. Marigat is 20km from both Lake Baringo and Lake Bogoria and covers 1663 Km² and a human population of 95286 people. The area has an elevation of 1,062 meters with an bi - annual average rainfall of 625mm between the months of May to July and October to November. The average temperature is 28°C.

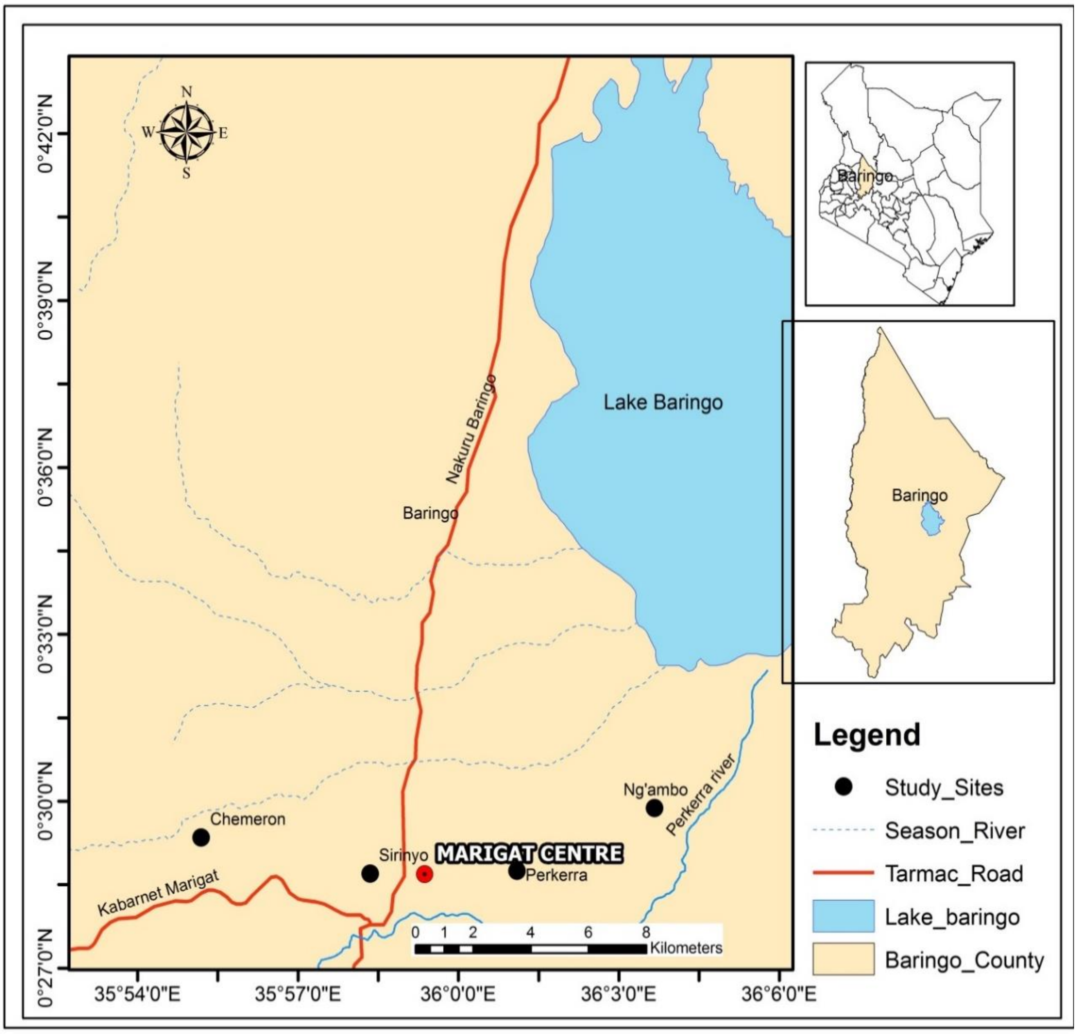


Figure 3.1 Map of the study area
Source: Baringo County, (2017)

The main vegetation include the indigenous bushes of *Acacia spp*, *Acalypha fruiticosa, Maera edulis, Balanites glubra, Cordia sinensis, Balanites aegyptica, Grewia bicolor and Prosopis juliflora* that were introduced among others. Grass cover is mainly made of *Cenchrus ciliaris*, *Cynodon dactylon*, *Erogrostis spp, Digiteria velutina*, *Cympopogon spp* and *sedges such as Cyperus spp*. The soils are poorly drained and very deep and are mainly sandy, sandy loams and clays. The main livestock activities include rearing of goats, sheep, indigenous Zebu and Sahiwal with a few improved dairy crossbreeds. Pastoralist also keep indigenous ecotype chicken, camels, donkeys, ducks and practice bee keeping for honey production.

The study location in Figure 3.1 was chosen because the area is considered arid and semi-arid region that is mainly populated by *Acacia* browse species. The specific sites identified included Chemeron, Perkerra, and Sirinyo. The study site was assessed by random visits, walks and photographed in order to identify and collect specimens and samples such as leaves, twigs, pods and barks of the Acacia tree species.

Table 3.1: Livestock population figures for Marigat sub-county- 2019

Type	Species	Marigat ward	Mochongoi ward	Mukutani ward	Ilchamus ward	Total
Cattle	Dairy/crosses	620	2710	62	255	3672
	Zebu	5590	31670	8703	14,990	60350
Goats	Dairy/crosses	60	44	10	50	164
	Meat	40300	55718	29800	49,910	175,728
Sheep	Hair	3590	16500	19820	28,335	68,245
	Wool	0	374	0	0	374
Camels		44	0	25	0	65
Donkeys		170	2580	360	930	4040
Poultry	Indigenous	43,997	29,490	29,950	38,460	141,897
	Layers	713	2200	200	100	3213
	Broilers	400	212	0	0	612
	Ducks	56	0	0	4	61
	Turkey	0	0	0	0	0
	Geese	0	15	0	0	15
Pigs		0	0	0	0	0
Rabbits		26	15	0	0	41
Beehives	KTBH	400	170	260	20	850
	Langstroth	680	229	45	45	999
	Log hives	9,040	12,200	14,200	1590	37,030

Source: - Sub-County Livestock Production Officer. Personal communication

3.2 Type of Study

The study used two techniques; field trails and experimental designs to account for the different study objectives.

3.2.1 Experiment One and Two: Field trials

The study used a randomized field trial where the subjects were randomly assigned to one or more groups with different interventions (Boruch, 2003). The interventions in this case was the type of browse allowed in the natural habitat. Randomized field trial permit for fair comparison of the estimates of the differences in outcome among the intervention. Furthermore, the randomized field trial permits the researcher to make a inferences based on the results. That is, the variability can be taken into account using conventional statistical methods.

3.2.2 Experiment Three and Four: -Laboratory Analysis

The study used laboratory analysis where the proximate analysis and *in-vitro* DM degradability experiments were carried out.

3.3 Methods and Procedures

3.3.1 Objective One: -To identify, record and mention edible *Acacia* browse species preferred by goats in Marigat, Baringo County.

The procedures involved the identification of the species by the research, followed by the collection of samples and specimens and later photography of the plant parts. The mentioning of the *Acacia Spp*s was carried out with the assistance from the resident pastoralist and Egerton University staff based at Chemeron Field Station.

The following information was collected:

- Local name (Tugen Sub-tribe of the Kalenjin)
- Botanical name
- Scientific name
- Indigenous pastoralist’s knowledge on its use

3.3.2 Objective Two: -To establish the rank preference for the *Acacia spps* under natural (*in-situ*) browsing in Marigat, Baringo County.

The preference testing process involved the use of three flocks of goats in the following sites; 283 goats in Chemeron site, 275 goats in Sirinyo site and 153 goats in Perkera site. The field trial ran from 9:00 AM to 12:00 PM with the assistance of the pastoralists. The flocks of goats were released at 9.00 AM, and were allowed to randomly browse on any vegetation of their liking. The researcher was assisted by four assistants from Egerton University, Chemeron Field Station, Marigat and local pastoralists who only directed the flock to the different field sites and did not interfere with the choice of the browse selected by the goats. Once the goats had settled to browsing, the research team only started making observations on the random browsing preferences by the goats. This process took three days to be completed.

The method involved documentation of ophthalmologic observation data of every *Acacia spps* plant browsed by goats at intervals of 5 minutes for a period of 3 hours. The field ophthalmologic observations data captured during the field trial were recorded as illustrated in Table 3.2. The technique was used because it allowed for the natural preference outcomes as opposed to the cafeteria method, which controls the selected outcomes.

The data obtained were analysed and tested using Kruskal-Wallis test in order to establish the ranking preference of the Acacia species by goats. The test uses ordered rank of elements by the way of examining the presence of statistical differences between groups. The statistical tool was appropriate when the assumptions of ANOVA cannot be met and that the tool distinguishes the group differences through ranking.

Table 3.2: Data Collection Form for Acacia Preference

Day 1	Number of observation	Number of goats browsing on *Acacia spp*						
Observation frequency (after every 5 minutes)		A1	A2	A3	A4	A5	…	A15
5th Minute	1							
10th Minute	2							
15th Minute	3							
20th Minute	4							
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
160th Minute	32							
Total								
Mean								

Where A1 to A15 represent the Acacia Spp

3.3.3 Objective Three: -To assess the nutrient composition of the edible parts of the preferred *Acacia spps* in Marigat, Baringo County.

The edible samples collected include leaves, pods and bark from the selected *Acacia spp* that were preferred by goats. These were carefully collected from the trees and put into cloth bags and thereafter rinsed in distilled water. The samples from each of the Acacia species were air dried under a shade for up to five days and being turned twice daily to effect uniform drying. For laboratory analysis, 200 gms samples were further dried in a hot air oven at 65°C for 24 hrs. The samples were ground using a laboratory mill into powder that passed through a 1mm sieve, then packed in dry airtight polythene bags and labelled well. The powdered samples were used for the determination of nutrient content by proximate analysis and i*n-vitro* dry matter degradability (IVDMD).

The leaf from the stems were picked by hand into cloth bags. Only those leaves of the species which could be accessed by the goats were sampled. The stems were cut to enhance the picking of the leaves. The leave samples were then cleansed with distilled water, oven-dried, ground and then taken for proximate analysis and rumen degradation test.

The pods were collected by picking directly from the trees or by cutting the stems to enhance the picking or by shaking the stems in order for the pods to fall down and be collected by hand. The pod sample were then cleansed with distilled water, oven-dried, ground and then taken for proximate analysis and rumen degradation test. The barks were acquired from the trees by peeling them off the stem, cleansed with distilled water, oven-dried, ground and then taken for proximate analysis and rumen degradation test.

Dried samples were ground to fine particles using a laboratory mill until a uniform powder was obtained by sieving through a 1mm pore sieve. The powder was immediately stored in dry air tight polythene bags. The samples were subjected to proximate analysis according to the AOAC (1995) procedures. The samples were also subjected to *in-vitro* dry matter degradability test (IVDMD).

The sample leaves, pods and barks of the preferred *Acacia Spps* were taken for proximate analysis procedures which determine the quantities of dry matter, crude fibre, crude protein, ash and lipids (ether extracts) present in the samples based on the Association of Official Analytical Chemists (AOAC, 1995) procedures. The crude fibre content was analysed by the Van Soest fibre analysis technique(Van Soest, Robertson & Lewis, 1991). Once the procedures were completed, the data derived from proximate analysis was subjected to an ANOVA test with the comparison of the means being done using Fischer's LSD at $p < 0.05$ significance level.

3.3.4 Objective Four: -To determine the i*n-vitro* dry matter degradability of the edible parts of the preferred *Acacia spps* in Marigat, Baringo County.

The *in-vitro* dry matter digestibility (IVDMD) procedure was carried out at Animal Science Nutrition Laboratory, Egerton University using the technique by Tilley and Terry, (1963) which was modified by Menke and Steingas (1988). The method involves incubating the samples in thermostatically controlled water circulating bath (Chibinga & Nambeye, 2016). The study assumed that, there are no significant difference in results of rumen degradation using rumen liquors from Bovines, Caprines and Ovines as the inoculums (Aderinboye *et al.,* 2016).

The laboratory technique involved the use of a Holstein steer aged 4 years and fitted with a ruminal canula to provide the rumen liquor for use in the *In-vitro* DM degradation and gas production. The steer was restrained and fed for 2 days with *Chloris gayana* hay plus vetch *ad libitum* plus 2 kilos cotton seed cake meal and 8 kilos dairy meal to improve the quality of the rumen liquor. Ruminal liquor obtained from the steer was transported in a vacuum flask to the laboratory and immediately squeezed through a four-layer cheese cloth. A buffer mixture was added to the rumen liquor at ratio of 1:2 rumen liquor: buffer and the resultant mixture was purged with carbon dioxide (CO_2) gas to de-oxygenate before being used as inoculums.

Two hundred milligrams (200mg) dry matter of each sample was weighed in duplicate into 100ml calibrated glass syringes. 30mls of the rumen-buffer mixture was pippeted into the syringes. Thereafter, glass piston plungers lined with vaseline petroleum jelly were fitted into the syringes and pushed in gently to de-aerate the syringes. The mixture was then swirled to mix well and the syringes incubated in a water bath at 39.2°C (±0.5°C). The gas volume produced in the syringes was recorded at 0, 3, 6, 9, 12, 24, 48, 72, 96 and 120 hours of incubation as described by Boga *et al.,* (2014).

Using this technique, the following digestibility parameters were determined: -

1. Digestibility factor a+b
2. Organic Matter Digestibility (OMD %)
3. The Short Chain Fatty Acids (SCFA) composition of the forage

The data from the rumen degradation were subjected to one-way analysis of variance with the Turkey's test being used to compare the mean at 0.05 significance level (Steel *et.al.*, 1996). The net gas volume was calculated by subtracting gas production in the blank syringes i.e. those with rumen fluid plus buffer without forage samples, from the gas volume recorded in syringes containing forage samples.

Data obtained from gas production was fitted to the exponential model proposed by Ørskov and McDonald (1981) where $GP(t) = a+b(1-e^{-c(t-L)})$ based on Neway computer program (X.B. Chen Rowett Research Institute, Aberdeen) Where: GP (*t*) is the gas produced at time *t*, ‘*a*’ is gas produced by the soluble fraction, ‘*b*’ is gas produced by the insoluble but slowly fermenting fraction, ‘c’ is constant gas production rate, ‘L’ is the lag period, ‘t’ is time of sample fermentation, when ‘a’ was negative. Metabolizable energy (MJ/kg DM) content of feeds and short chain fatty acids (SCFA) was calculated using equations of Aiple *et al.,* (1996); McDonald *et al.,*(1995), Menke and Steingass (1988); Mc Donald, (1981) and Menke*et al.,* (1979) in which ME (MJ/kg DM)= 2.20+0.136GP+0.057 CP +0.0029 CF, OMD 48HR: *In-vitro* Dry Organic Matter degradability was computed by the following equation: OMD (%)=18.53+0.9239*(gas production at 48hrs) +0.0540*CP (Menke and Steingass, 1988) for all feeds, SCFA (m mol/200mg DM) =0.0222 GP-0.00425, Where GP is 24h net gas production (Ml/200 mg DM).

3.5 Ethical Considerations

- None on samples
- The use of rumen-canulated animal to supply rumen liquor. The researcher sought permission from the veterinary office of Egerton University’s Tatton Agriculture Park.
- Care was taken to ensure that drawing of the rumen liquor was treated with utmost diligence and free from any distress.

CHAPTER FOUR

RESULTS

4.1 Objective One: Identification and mentioning of edible *Acacia* browse species

4.1.1 Acacia plant species in Marigat Sub- County

Table 4.1 shows the identified 14 Acacia species in Marigat and the way the pastoralists know them and their uses locally. Most of these *Acacia* species are still in their natural settings and have not been selected for establishment as forages in a farming situation but are widely used as browse feed by pastoralists. In this study, the researcher mentioned 14 *Acacia* species in Marigat by providing their local names and information on the local uses.

Table 4.1: Table of identification and local uses of *Acacia spps.*

SCIENTIFIC NAME	COMMON NAME (English)	LOCAL NAME (Tugen)	PASTORALISTS KNOWLEDGE ON USES
Acacia albida	Ana tree/ Faidherbia	-	Flowers as Bee forage, forage for goats
Acacia brevispica	Wait-a-bit Acacia thorn	Kornessiet	Forage feed for livestock and bees, roofing materials, wood fuel
Acacia drepanolobium	Whistling Acacia thorn	Ngowoh	Wood fuel, bee forage, fencing materials
Acacia elatior/ Acacia tiryon	River acacia	Tiryon	Timber materials, wood fuel, high quality charcoal, shade
Acacia gerrardii	Red thorn acacia	-	Shade, firewood, bee forage, herbal medicine
Acacia hockii	White thorn acacia	Tilatiliet	Forage feed for livestock and bees, firewood, charcoal, fencing materials, herbal medicine
Acacia mearnsii	Black wattle	-	Firewood, herbal medicine
Acacia mellifera	Black thorn, Honey Acacia	Ng'orore	Forage feed for livestock and bees,herbal remedy, fence material,
Acacia nilotica	Nile thorn Acacia	Chebeiwa	Herbal remedy, timber, fuel, shade, forage feed for livestock and bees, vegetable
Acacia nubica	-	Sebeiwet	Herbal remedy
Acacia reficiens	False umbrella tree	Barsol	timber, fence material, firewood
Acacia Senegal	Gum-Arabica tree	Chemang'a	Gum-Arabica, forage feed for livestock and bees, fence material
Acacia seyal	Red acacia, Shittar tree	Len'gne	forage feed for livestock and bees, fuel, material for fencing,
Acacia tortilis	Umbrella Acacia	Kipkores /Kipenwo/ Sessie	forage feed for livestock and bees, fuel, shade, fencing, bee forage

Plate 4.1 Goats browsing on *Acacia spp.* in Chemeron-Marigat, Baringo County. Source: Author, (2018)

4.1.2 Selected *Acacia spps*

The observed preferences clearly showed the *Acacia spps* that were either heavily or lightly browsed on by goats as shown by plate 4.1 above. Based on Kruskal-Wallis browsing preference (Table 4.2), some five Acacia species stood out and are presented in detailed description below. The presentation is in the order of their preference as follows:

4.1.2.1 *Acacia brevispica:* Wait-a-bit thorn, Korness

Acacia brevispica plant in plate 4.2 is a shrub that has thin twigs and does not grow into a big tree. It grows to a height of 2m to 5 m high and forms a thicket in its surrounding and can easily blend and twine into other trees to form some thickets.

Plate 4.2 ***Acacia brevispica*** **twig (a), leaves (b) and flowers (c) and trunk (d)**
Source: Author, (2018)

The stems are greyish in colour. The thorns are characteristically small and hooked or sickle shaped with a wait-a-bit like hook that can prick and hold clothes. The thorns are scattered along the twigs with smaller ones in the twigs and leaf stalks. The leaves are large, compound with small and very many leaflets. The leaves are bipinnate and are densely arranged in pinnae (rachis) in pairs of small leaflets of 20 to 30 pairs per rachis. The leaves are intense green in colour when fresh and retain this colour when harvested and dried under a well aerated shade.

The flowers are rounded and whitish to yellowish-white in colour and are formed on the branching twigs and occupy a few centimetres, up to 10cm, from the tip of the stalks. The flowers are scented and easily conspicuous from far. The pods are thin, a little broad and pinkish-green when young with some splits in between the seeds that make the seeds inside them to be easily noticed. Each pod has 5 to 7 seeds that are fairly large and dark-brown in colour. As the pods mature, they turn brown with a rough coat. As was noticed, the pods split open in the stem and release the seeds into the environment. The bark is greyish on the outside. When peeled, it is thin with its inside part being creamish-white to light green.

The leaves are preferred by goats and camels in plate 4.3 and hence appear to be the most preferred Acacia spp. as a browse plant. Goats eat the young twigs, flowers and pod a lot and easily clear edible parts that are reachable. When the barks are debarked, they are easily eaten especially during drought. Partial debarking does not kill the plant.

Plate 4.3 Animals feeding on *Acacia brevispica; goats* (a) and camels(b)
Source: Author, (2018)

4.1.2.2 *Acacia tortilis:* Umbrella thorn, Sesie

Acacia tortilis is a small to medium size shrub tree, which can grow into a tall tree of up to 25 m high. It develops a flat-topped canopy, which is supported by some well-developed branches at heights that are almost at the top of the tree which support the umbrella-like crown as shown in plate 4.3. Its leaves are evergreen and can easily be noticed from far during drought when other Acacia trees shed their leaves. In Marigat, there are three different sub-species of *Acacia tortilis* as was observed and narrated and their differentiating factor is the period of flowering and prodding.

While others produce flowers and pods in April to July, others flower in October and produce pods in December to January. The tree trunk is rough, dark to dark-brown with fissures. Young stems are smooth. Young branches are thorny with two types of thorn formation; one with two pairs of thorns that are long, straight and white while the other pair is short, hooked and brownish.

The leaves are compound and are formed just above the base of the thorns. The leaf stalks have 2 to 10 pairs of pinnae (raches) with each rachis having 4 to 22 pairs of leaflets depending on the length of the rachis. The leaves are greenish-grey in colour and this colour is retained when the harvested leaves are dried in a well-ventilated shade. The flowers are whitish to pale yellowish-white and with globose or rounded heads that look hairy and soft. The flowers are scented and attract a lot of foraging bees. During flowering, a lot of these flowers fall to the ground especially when there are strong winds.

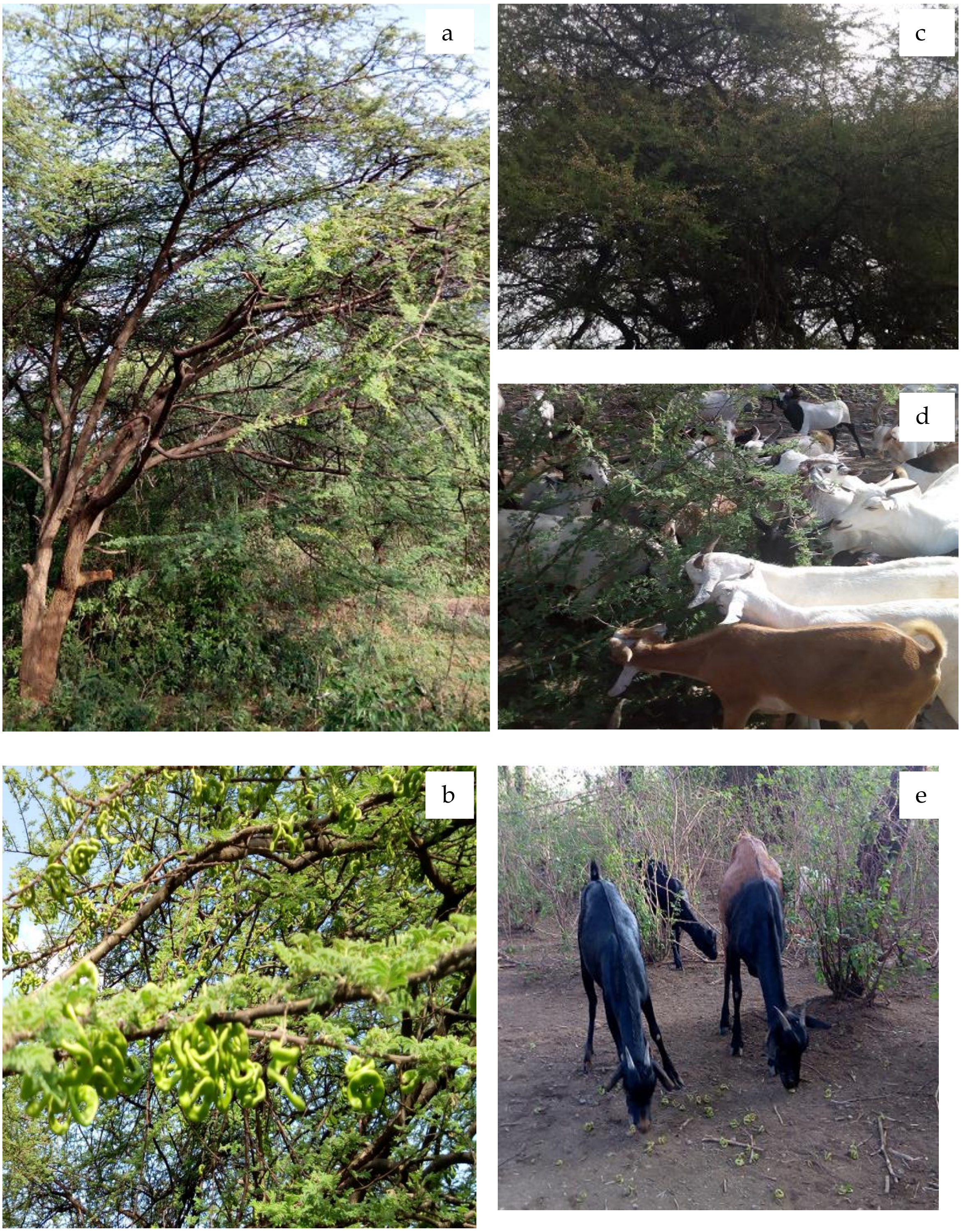


Plate 4.4 Acacia *tortilis* plant (a), pods (b) and flowers (c). Goats feeding on leaves (d) and pods (e)
Source: Author, (2018)

The pods in plate 4.4b are variable in number and are spirally twisted or coiled with visible constrictions between seeds. The pods form clusters in the stems with each pod having 8 to 10 seeds each constricted between the folds and which can be easily observed and be counted. Young pods are green in colour and become brownish when mature. When mature, the pods detach from the stem and fall off to the ground. Strong winds aid in massive falling of the mature pods. As the pods fall down, they produce a characteristic shaking sound that can easily be heard indicating that the seeds detach from the pods at maturity. Because of the characteristic sound produced by the falling pods, the local people in Marigat refer to them as ``sheshawik''. Pods split open to release seeds.

The bark of Acacia *tortilis* is dark to dark-brown in colour and thick allowing the tree to store a lot of water. This makes the tree to be green all the year around. Old barks are fissured while the young barks are smooth and greenish grey to light brown. When debarked, the inner part is creamy white and retains this colour when dried under the shade.

The main forage parts preferred by goats are the leaves and the pods. The leaves can be well accessed by the goats especially when the plants are still young shrubs. Older trees and tall ones can be made available through selected pruning and coppicing. Camels also feed a lot on the leaves and can access up to 4m high. When mature pods fall, goats and sheep feed on them. They are highly preferred and goats quickly rush to pick them as soon as they are released to the field. The local pastoralists also collect a lot of these pods and store them and later on feed them to their livestock. Others collect them for sale to other pastoralists. Goats and sheep also eat the flowers that fall to the ground during flowering.

4.1.2.3 *Acacia nilotica:* Nile thorn, Chebeiwe/Chebiwa

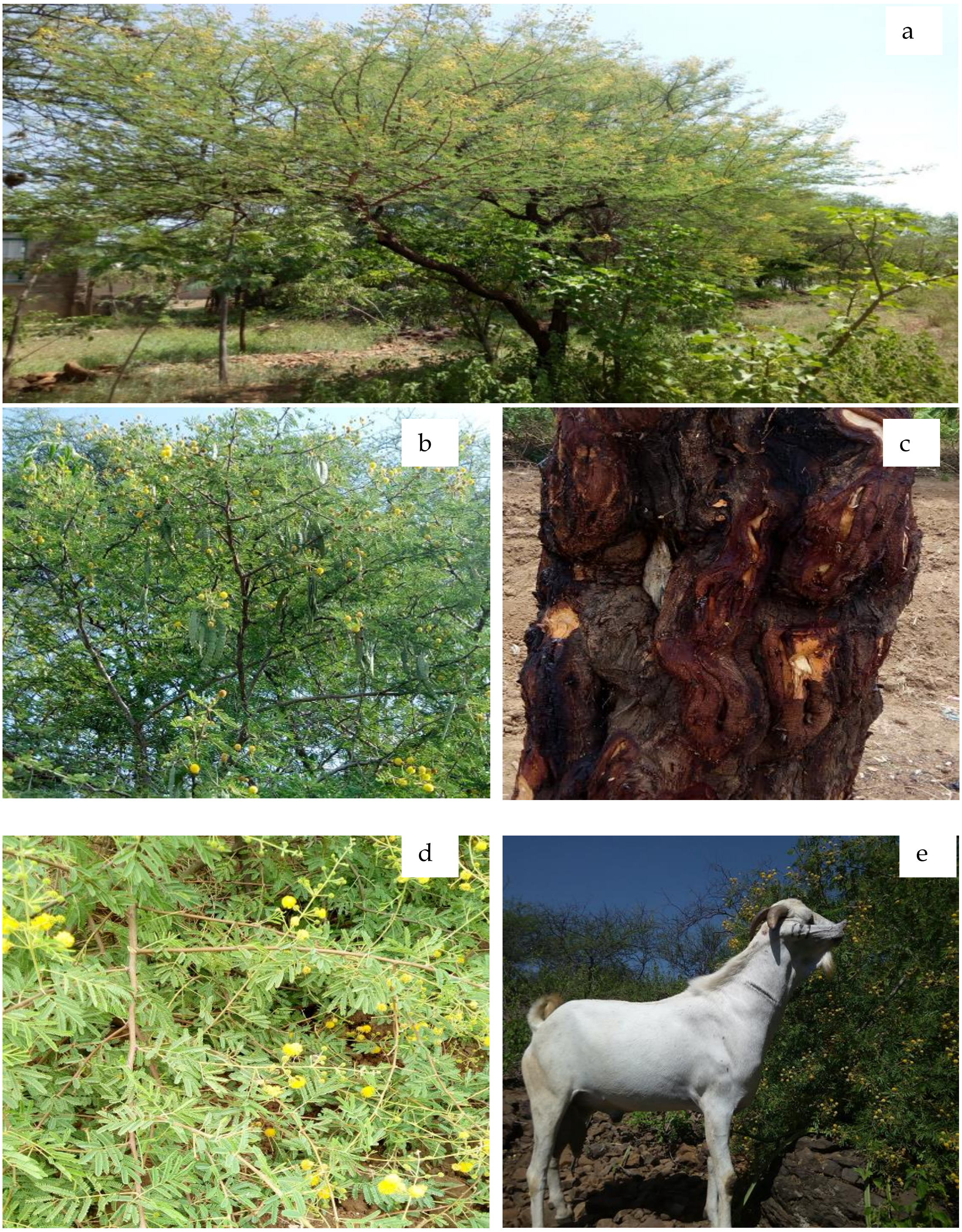


Plate 4.5 Acacia *nilotica* plant (a) pods (b), bark peeled for herbal use (c) leaves and flowers (d) and goat feeding leaves and flowers (e).
Source: Author, (2018)

Acacia nilotica in plate 4.5 is a tree that grows to 5m to 10m high and with spherical canopy that is green and with a crown formation. The tree trunk as it grows develops several branches which give rise to several other small branches toward the top that gives rise to a dense canopy. The tree trunk is cylindrical, dark to dark-cray and fissured with longitudinal fissures. When the bark is removed, the trunk or stem appears to be pinkish, reddish or reddish yellow with some reddish gum exuding from the debarked side. The stems have two different thorn formations; one pair being thin, long and pointed backwards on the main stems while the other pair is small, and sickle-shaped and mainly develops on the twigs. Mature trees develop stems and twigs that have leaves and flowers and with no thorns at the canopy but have young and thorny branches at the bottom.

There are two sub-species of *Acacia nilotica* in Marigat and their identifying feature is the shape of their pods. One sub-species has beads-like pod formation with strong constrictions between the seeds in the pod while the other sub-specie has pods that are less constricted, long and straight.

Acacia nilotica has compound leaves that are bipinnately arranged in an axis with 2 to 14 pairs of pinnae (raches) with each having10 to 25 pairs of small leaflets. The leaves are green with greyish hairs that give it a greyish-green look. The leaves retain their characteristic colour when harvested and dried under a well-ventilated shade. The flowers are very many in the tree and can be seen from far. Flowers are characteristically yellowish to golden-yellow in colour and are globose, hairy, scented and with a lot of pollen. Flowers form along the young twigs at their ends. The flowers attract a lot of foraging bees.

Pods are long, narrow, straight and velvet-like in nature. They are pulpy and thick and are covered with grey hairs on the outside to give it the velvet-like look. The pods are constricted at points between the seeds. Mature pods become dark in colour and each pod has 4 to14 seeds that are rounded in nature. Pods break apart at the constrictions to release the seeds and are not dehiscent.

The bark is dark to dark-brown in colour with older trunks and stems having longitudinal fissures. Young stems have reddish-brown bark. The bark is hard to peel and cannot easily flake off. When debarked, the inside is reddish-brown. Local people use the bark as traditional medicine and is thought to cure many diseases such as stomach upsets, pains, heart ailments and urinary tract infections.

The leaves, young shoots, flowers and the pods are highly preferred by goats as forage browse feed. Coppicing enhances accessibility and the goats eat a lot. Pods are preferred when mature and pastoralists call them ``sacaram’’ and they harvest and feed them to their livestock.

4.1.2.4 *Acacia Senegal:* Gum-Arabic tree, Chemanga

The plant is a small tree that forms thickets or bushes of up to 5 meters high as shown in plate 4.6. The thickets are not easily penetrable by animals and humans. Tree trunks are yellowish to pale brown and the stems are grey in colour. Older trunks are scaly and cracked with the scales being yellowish and the crack producing gum-Arabic. Stems have short re-curved thorns that are dark and in pairs facing downwards or in groups of 3 with the centre one facing downwards and the other two facing forward. The tree trunk produces short stems that branch into other branches and into many shoots that branch into many upright shoots and twigs to form a crown that is umbrella-like at the top. The stems and the twigs intertwine into each other to form a thicket-like canopy.

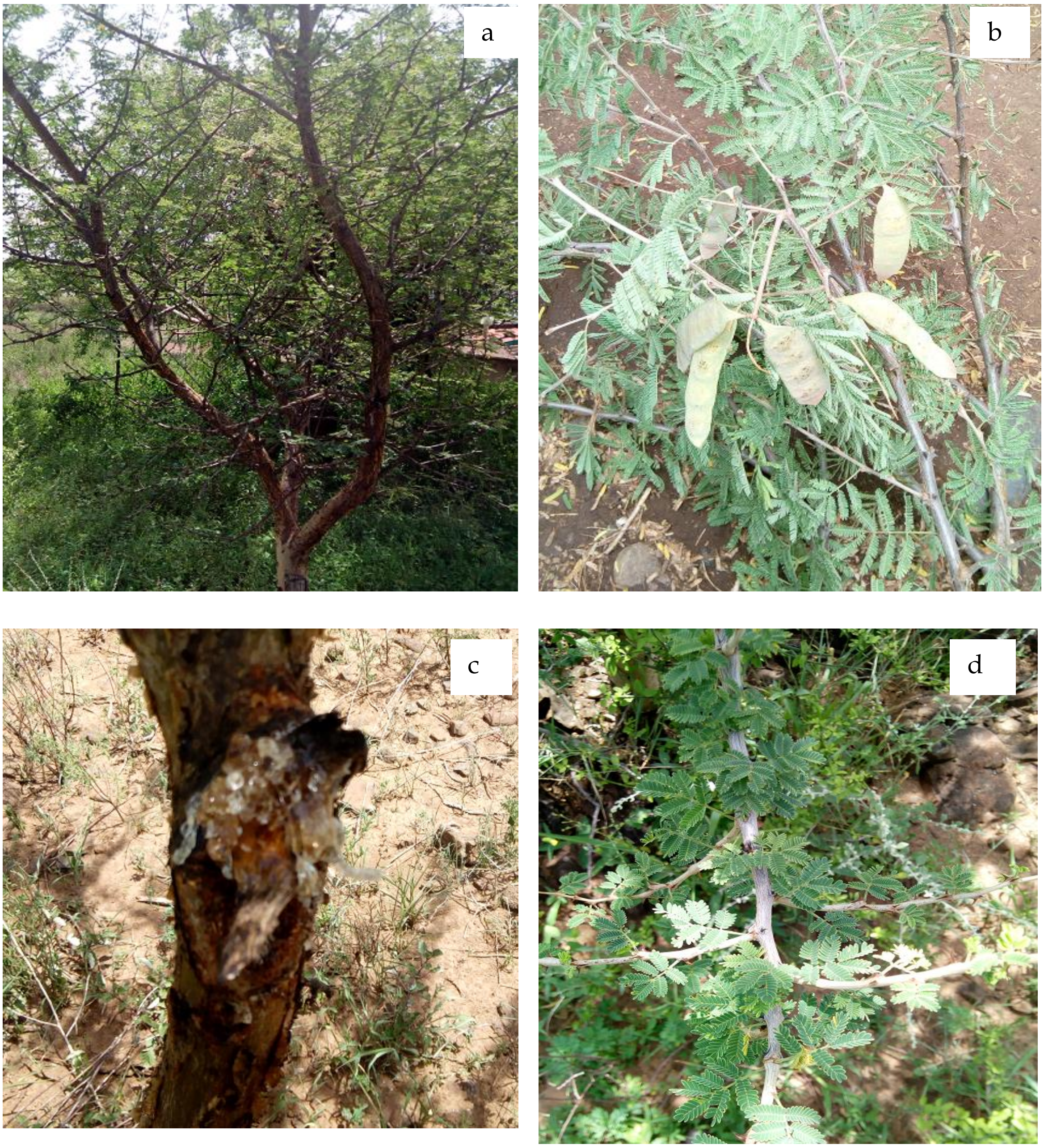


Plate 4.6 Acacia *senegal* plant (a), leaves and pods (b), trunk with gum-Arabic (c) and stem with leaves (d).
Source: Author, (2018)

The leaves are greyish-green in colour. Leaves are compound in nature with each compound leaf having 3 to 6 pairs of pinnulae or raches. Leaves form in pairs in a bipinnate manner and arranged in pairs in each rachis with each having 10 to 25 pairs of leaflets. The leave base is formed just above the dark prickles. The main leaf stem bears very small prickles. *Acacia senegal* flowers are borne on long cylindrical spike that have many white flowers in a compounded way.

The pods are flat, thin and sharp or constricted at both ends. Pods are greenish-grey when young but become brownish when mature. Pods are papery or light with each having 3 to 6 seeds that are flat and rounded. The seeds become brown when mature and the pods dehisce to release them. The bark is yellowish to light brown in colour and rough in older trunks and stems with young stems being smooth and grey. Older barks have cracks that produce Gum-Arabic. *Acacia senegal* trunks produce a lot of Gum-Arabic on their cracked barks. Slight cuts or an incision on the bark stimulates a lot of exudates of gum-Arabic. This product currently goes to waste in Baringo because of lack of use or market for it. No interests have been given into it as a source of livelihood.

Pods and leaves are preferred by goats as forage but are not easily accessible because of the thickets they form and the thorns they have which make them inaccessible as browse. Goats do not waste much time in them when they are not accessible and prefer to move to other browse plants whose browse parts are easily accessible. However, when cut down, the goats feed on them.

4.1.2.5 *Acacia mellifera:* Black thorn/Honey acacia, Ng'orore

Acacia mellifera in plate 4.7 is a shrub that is small and grows up to 3m to 5m high. It develops into dense thickets that are not easy to penetrate. The tree is multi-stemmed especially from the base of the stem and forms a spherical crown. The tree is very thorny with very sharp black thorns that are in pairs and sickle shaped. The thorns are curved downwardly and inwardly and are formed just below the base of the leaves.

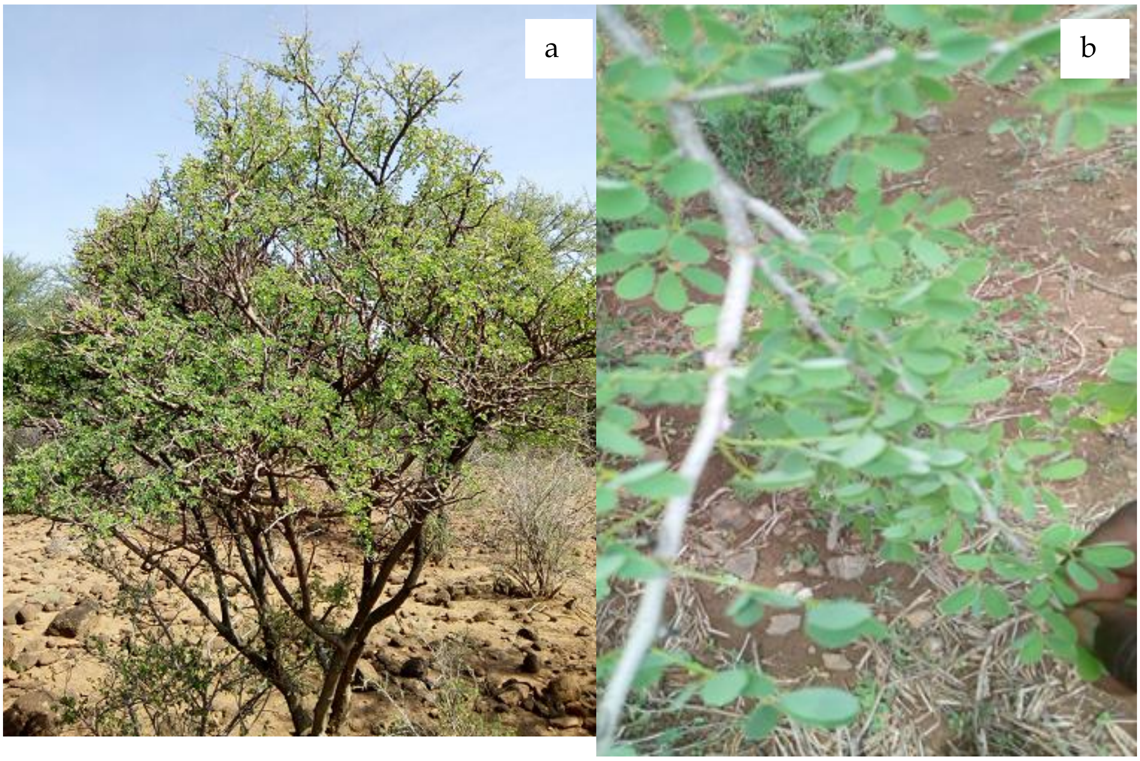


Plate 4.7 Acacia *mellifera* plant (a), stem and leaves (b)
Source: Author, (2018)

The leaves are compound and bipinnate with two pairs of pinnulae each with a pair of leaflets giving rise to eight leaflets in each compound leaf. The small leaflets are oval and greenish-grey in colour. The flowers are creamy-white, elongated and hanging downwardly forming a dense compound-like cluster of flowers. They are sweetly scented and attract a lot of foraging bees that produce a lot of honey.

Pods are flat, long and papery with constrictions that are visible in between the seeds. Each pod contains 2 to 3 seeds, which are small, oval and flat-shaped. Mature pods are brown in colour. The bark is blackish in colour and becomes ash-grey on the young branches and tends to be grey-white on the tender shoots.

Goats love to eat it but the thorns somewhat discourage browsing. Goats tend to ignore it and browse on other plants that are leafier and less thorny. Table 4.2 relates to the frequency of distribution of the animal as per preference during the browsing time.

4.1.3 Frequency of Browsing Observations

The distribution in Table in appendix IV shows the frequency of observation per plant. For instance, *A. millifera* had the following observations; 60 observations of a one animal per plant, 27 observations of two animals per plant, 8 observations of three animals per plant and one observation of four animals per plant. The highest frequency of 60 observations of a single (one) animal browsing on a single plant species was observed in *A. mellifera* and *A. senegal*. On the converse, there was lowest frequency of one observation of 15 animals browsing on a single plant species of *A brevispica.* In *A brevispica*, *A nilotica* and *A tortilis,* the number of animals browsing in a single plant species increase gradually with lowest frequency of observations being 15 animals per plant in *A brevispica*, 11 animals per plant in *A. nilotica* and 11 animals per plant in *A tortilis.*

As illustrated by the figure in Appendix IV which shows that total number of animals observed browsing on *Acacia spps* As indicated, *A. brevispica* was most browsed while both *A. mellifera* and *A. senegal* were least browsed.

4.1.4 Ranking Preference Test for the *Acacia Spps*

The result in Table 4.2 shows an order of preference of *Acacia spps* The Kruskal-Wallis (H) statistic shows that there were statistical significant differences in the distribution of goats browsing on the different Acacia species, (χ^2 = 182.6, p< 0.01). The ordered ranking of the *Acacia spps.* begins with *Acacia brevispica, Acacia nilotica, Acacia tortilis, Acacia mellifera* and lastly *Acacia senegal*.

Table 4.2: Ranking Preference Test for the *Acacia spps*

Species	Number of observation	Mean rank
Acacia brevispica	96	351.54[a]
Acacia nilotica	96	293.09[b]
Acacia tortilis	96	277.54[b]
Acacia mellifera	96	140.80[c]
Acacia senegal	96	139.53[c]

The H – test statistic, χ^2 (4) = 182.6, p< 0.01
a,b,c,d difference significant at p < 0.05

4.2 Objective Two: Browse preference of the *Acacia spps* by goats

4.2.1 Descriptive Statistics on Goat Browsing Distribution on *Acacias spps.*

The statistics on Table 4.3 reports the results of the mean statistic for the distribution of preferred browse by goats. The mean statistic of *Acacia brevispica* was 5.917 indicating that there were on average six goats browsing on it at any given moment. Next, was *Acacia nilotica* with a mean of 4.094 indicating an average of four goats browsing on it at any given moment. The order of the browse preference was *Acacia* *tortilis* (Mean = 3.854) implying an average of three goats at any given time, *Acacia mellifera* (Mean = 1.479) and *A. senegal* (Mean = 1.469) with an average of two animals browsing on it at any given time.

Table 4.3: Descriptive Statistics on Goat Browsing Distribution on *Acacias spps.*

	Mean	**Standard Deviation**	**Maximum**	**Range**
Acacia brevispica	5.917	3.454	15	14
Acacia nilotica	4.094	2.684	11	10
Acacia tortilis	3.854	2.718	11	10
Acacia mellifera	1.479	0.696	4	3
Acacia senegal	1.469	0.710	5	4

4.2.2 Differences in Browsing Preference of the *Acacias spps.*

The Tukey's comparison test indicates the preference can be categorized into three groups; the highly preferred was *A. brevispica* and the least preferred being *A. mellifera*.

Table 4.4:Tukey's Comparison for Difference in Browsing Preference

	Species	N	Subset for Species, α= 0.05		
			A	B	C
Tukey B[a]	*A. Mellifera*	96	1.4583		
	A. senegal	96	1.4688		
	A. tortilis	96		3.8438	
	A. nilotica	96		3.9479	
	A. brevispica	96			5.8021

N represents the number of the chronological observation that were conducted

4.3 Objective Three: Nutrient Composition of the Parts of the Preferred *Acacia spps.*

4.3.1 Nutrient composition of the parts of the preferred *Acacia spps*

The results in Table 4.5 show that the leaves of the *A. tortilis* had the highest DM content at 96.46% while *A. nilotica* had the lowest content at 94.77%. The Ash content in *A. mellifera* was 7.83% being the highest while *A. nilotica* had the lowest content at 4.19%. Regarding the CP, *A. Nilotica* had the lowest CP content of 10.16% with *A. senegal* having the highest at 23.9%. *A. tortilis* had the highest CF content of 26.60% while *A. Nilotica* had the lowest content at 12.76%. Further, *A. nilotica* had the lowest Ether content at 0.81% while *A. tortilis* had highest ether content at 2.15%.

Table 4.5: Nutrient Composition of *Acacia* species leaves, pods and barks

Acacia spps	%DM	%Ash	%CP	%CF	%EE
Leaves					
A. brevispica	97.07^{b}	7.01^{a}	21.63^{b}	28.12^{c}	3.66^{a}
A. tortilis	96.85^{ab}	10.73^{ab}	15.36^{a}	18.68^{b}	4.89^{b}
A. nilotica	97.21^{ab}	5.41^{a}	14.40^{a}	9.66^{a}	5.21^{c}
A. senegal	94.91^{a}	15.59^{c}	16.59^{a}	16.96^{ib}	4.01^{a}
A. mellifera	95.42^{a}	10.38^{ab}	22.00^{b}	16.97^{b}	4.88^{b}
SEM	0.99*	3.70*	3.37*	6.23*	0.62*
Pods					
A. senegal	95.20^{ab}	7.30^{bc}	23.90^{c}	26.15^{bc}	1.92^{bc}
A. nilotica	94.77^{a}	4.19^{a}	10.16^{a}	12.76^{a}	0.81^{a}
A. mellifera	95.47^{ab}	7.83^{c}	20.16^{b}	26.60^{bc}	1.88^{b}
A. tortilis	96.46^{b}	6.19^{b}	12.70^{a}	27.78^{c}	2.15^{c}
A. brevispica	95.61^{ab}	4.82^{a}	21.96^{bc}	17.15^{b}	1.66^{b}
SEM	±0.5656	±1.4954	±5.2957	±5.5845	±0.6831
Barks					
A. senegal	96.09^{ab}	14.12^{c}	10.02^{b}	43.18^{c}	0.41^{b}
A. tortilis	97.07^{b}	15.33^{d}	8.11^{b}	43.16^{bc}	0.41^{b}
A. nilotica	94.92^{a}	7.96^{a}	2.76^{a}	24.54^{a}	0.31^{a}
A. brevispica	95.62^{a}	7.52^{a}	6.41^{ab}	36.81^{b}	0.56^{c}
A. mellifera	95.87^{ab}	11.13^{b}	15.51^{c}	39.53^{b}	0.45^{b}
SEM	±0.7375	±3.3211	±4.4447	±7.2548	±0.0926

** $p \leq 0.05$ Significance levels*

a, b, c, d, Column means with the different superscript are significantly different ($p<0.05$).

Concerning the pods of the *Acacia spps*, the results showed that *A. tortilis* had the highest DM content at 96.46% while *A. nilotica* had the lowest content at 94.77%. The Ash content in *A. mellifera* was 7.83% being the highest while *A. nilotica* had the lowest content at 4.19%. Regarding the CP, *A. nilotica* had the lowest CP content of 10.16% with *A. senegal* having the highest at 23.9%. *A. tortilis* had the highest CF content of 26.60% while *A. nilotica* had the lowest content at 12.76%. Further, *A. nilotica* had the lowest Ether content at 0.81% while *A. tortilis* had highest ether content at 2.15%.

Concerning the pods of the *Acacia spps*, the results show that all *Acacia spps* had over 94% DM content with *A. tortilis* having the highest content at 97.07% while *A. nilotica* had the lowest DM content of 94.92%. *A. brevispica* had the lowest Ash content at 7.52% while *A. tortilis* had the highest content at 15.33%. The lowest CP content was in the bark of *A. nilotica* at 2.76% while the highest was *A. mellifera* at 15.51%. *A. nilotica* had the lowest CF content at 24.54% while the highest CF content was in the bark of *A. senegal* at 43.18%. Further, *A. nilotica* had the lowest ether content at 0.31% with the bark of *A. brevispica* having the highest ether content at 0.56%.

4.4 Objective Four: *In-vitro* dry matter degradability of the edible parts of preferred *Acacia spps*

4.4.1 i*n-vitro* gas production of parts of preferred Acacia species browse

The OMD% was calculated based on Menke and Steingass (1988), while ME represent the maximum amount of energy that is available for an animal (Sundstøl

1993). SCFA are also the building blocks for fat formation, gluconeogenesis and lactogenesis (Aluwong *et al.*, 2010).

As shown by the results in Table 4.6, there was differences in gas production among the leaves of the Acacia browses. There were statistical difference in gas production among the difference Acacia browses. The initial gas production (A) and rates of gas production (C) significantly differed ($p < 0.05$) between the different Acacia browses. The results from *In-vitro* gas production measured from 3 to 120 hours for the assessed Acacia tree browses is shown in Fig 4.2a (Leaves). At 24 Hrs, the rate of gas production was highest in *A. nilotica* at 77.15% followed by *A. senegal*, *A. tortilis*, *A. mellifera* and lastly *A. brevispica* leaves at 60.29% gas production. At 48 Hrs fermentation, *A. nilotica* was highest at 60.29% gas production followed by *A. mellifera*, then *A. senegal*, *A brevispica* and lastly *A. tortilis* at 25.81% gas production. The browse with highest gas production at 24 and 48 Hrs was *A. nilotica* leaves (77.15 ml and 60.29 ml per 200mg DM respectively.

The actual gas production during fermentation (B) was highest in *A. nilotica* leaves with 36.74% gas production followed by *A. mellifera, A. brevispica, A. tortilis* and lastly *A. senegal* at 15.98%. The total gas production (A+B) did not follow the same pattern, however, *A. nilotica* registered 40.98% followed by *A. mellifera*, *A. brevispica*, *A. senegal*, and the least *A. tortilis* with 21.3% gas production. The rate constant gas production(C) indicates the differences in the degradability of the forage, with *A. tortilis* leaves showing the highest (0.089%H^{-1}).

The Residual Standard Deviation (RSD) showed variation with *A. brevispica* having the least at 5.81, followed by *A. tortilis*, *A. senegal*, *A. mellifera*, and lastly *A. nilotica* at 33.73. This shows that although *A. nilotica* leaves were highly degradable, the RSD was high. The low RSD for *A. brevispica* may be related to results registered during preference tests. It was high for *A. nilotica* (75.01%) followed by *A. mellifera, A. brevispica*, *A. senegal*, and the least was *A. tortilis* at 43.21%. All the *Acacia spp*s had more than 50% OMD except for *A. tortilis* which may be attributed to presence of anti-nutritional factors such as tannins, phenols and suppressants of digestion.

Table 4.6: *in-vitro* gas production and Calculated Metabolizable Energy (ME) and SCFA (ml/200mg DM)

	Total Degradation (%)		Fermentation Characteristics							
Sample	**24 Hrs**	**48 Hrs**	**A**	**B**	**A+B**	**C (%/H)**	48 HR **OMD%**	**RSD**	ME (MJ/kg DM)	SCFA
Fermentation characteristics of leaves of preferred Acacia species browse										
A. brevispica	30.91^{a}	35.45^{ab}	2.97^{a}	25.86^{ab}	28.83^{ab}	0.011^{a}	52.45^{a}	5.81	3.650	0.682
A. tortilis	56.79^{ab}	25.81^{a}	2.93^{a}	18.37^{a}	21.30^{a}	0.089^{b}	43.21^{a}	20.76	3.266	1.256
A. senegal	57.95^{ab}	41.61^{bb}	8.56^{b}	15.98^{a}	24.54^{a}	0.025^{a}	57.87^{ab}	23.07	3.331	1.282
A. nilotica	77.15^{b}	60.29^{b}	4.15^{a}	36.74^{b}	40.89^{b}	0.060^{ab}	75.01^{b}	33.73	3.185	1.708
A. mellifera	52.40^{ab}	45.72^{ab}	2.40^{a}	27.98^{ab}	30.38^{ab}	0.015^{a}	61.96^{ab}	25.13	3.639	1.159
SEM	±16.50	±12.78	±2.52	±8.26	±7.46	±0.034	±11.77			
Fermentation characteristics of pods of preferred Acacia species browse										
A. tortilis	53.12^{a}	26.56^{a}	6.24^{b}	13.34^{a}	19.57^{a}	0.099^{b}	43.87^{a}	17.95	3.637	1.273
A. brevispica	57.53^{ab}	35.69^{a}	5.51^{ab}	15.75^{a}	21.26^{a}	0.015^{a}	52.69^{a}	19.99	3.774	1.162
A. senegal	52.52^{a}	45.76^{ab}	2.65^{a}	25.41^{ab}	28.06^{a}	0.026^{a}	62.09^{ab}	20.63	2.952	1.050
A. nilotica	47.48^{a}	30.55^{a}	2.76^{a}	32.54^{ab}	35.30^{ab}	0.100^{b}	47.31^{a}	26.36	3.562	1.391
A. mellifera	62.85^{b}	50.47^{b}	4.27^{a}	36.89^{b}	41.16^{b}	0.041^{a}	66.25^{b}	29.82	3.245	1.175
SEM	±5.78	±10.09	±1.61	±10.24	±9.18	±0.04	±9.53			
Fermentation characteristics of barks of preferred Acacia species browse										
A. tortilis	25.75^{a}	23.45^{a}	3.91^{a}	9.07^{a}	12.98^{a}	0.085^{b}	40.64^{a}	11.23	3.032	0.715
A. senegal	32.41^{a}	27.41^{a}	6.42^{ab}	14.13^{a}	20.55^{a}	0.058^{ab}	44.39^{a}	14.61	2.564	1.516
A. nilotica	68.48^{b}	60.54^{b}	8.48^{b}	26.97^{b}	35.45^{b}	0.068^{ab}	74.61^{b}	29.67	2.808	0.808
A. brevispica	36.60^{a}	25.69^{a}	3.37^{a}	15.39^{a}	18.76^{a}	0.030^{a}	42.61^{a}	13.34	3.265	0.642
A. mellifera	29.09^{a}	15.65^{a}	4.31^{a}	13.99^{a}	18.29^{a}	0.079^{b}	33.82^{a}	14.67	2.923	0.567
SEM	±17.25	±17.36	±2.12	±6.64	±8.45	±0.022	±15.83		±0.354	±0.341

SEM: Standard error of the Means

a, b, c are constants in the equation (Ørskov and McDonld, 1979)

$^{a, b, c,}$ *Means with the same letter superscript in a column are not significantly different ($p<0.05$).*

OMD: Organic Matter Digestibility (calculated from Menke and Steingass, 1988 formula

RSD: Residual Standard Deviation; A is initial gas produced; B is actual gas produced during DM degradation; A+B is the total gas produced during fermentation; C%H^{-1} is the rate of gas production per hour; OMD (%) = 18.53 + 0.9239(gas production at 48 Hrs) + 0.0540* CP (Menke and Steingass, 1988)*

* *$p \leq 0.05$ Significance levels*

ME (MJ/Kg DM) = 2.20 + 0.136GP + 0.057CP + 0.0029CF (Aiple *et al.*, 1996; McDonald *et al.*, 1995; Menke and Steingass, 1988)

SCFA (m mol/200 mg DM) = 0.0222GP – 0.00425, Where GP is 24 Hr net gas production (Ml/200 mg DM)

Table 4.6 shows that there were differences in gas production of the pods of the Acacia browses. There were significant differences ($p \leq 0.05$) in the initial gas production (A) and rate constant gas production (C) among the pods of the different Acacia browses. The results from in – vitro gas production measured from 3 to 120 hours for the studies Acacia tress browse are shown in Figure 4.7b. The rate of gas production, at 24hrs, was highest for *A. mellifera* (62.85%) and lowest for *A. nilotica* (47.48%) with the pattern in gas production showing *A. mellifera >A. brevispica >A. tortilis >A. Senegal >A. nilotica*. At 48 hours, *A. mellifera* was still high (50.47%) followed by *A. senegal*, *A. brevispica*, *A. nilotica* and lastly, *A. tortilis* at 26.56%.

The actual gas produced during fermentation (B) was highest for *A. mellifera* (36.89%) and least for *A. tortilis* (13.34%). Total gas produced (A + B) followed the same pattern with *A. mellifera* (41.61%) >*A. nilotica*>*A. senegal*>*A. brevispica*>*A. tortilis* (19.57%). The Residual Standard Deviation (RSD) for the pods (Figure 4.7b) showed variation with *A. tortilis* having the least followed by *A. brevispica* at 17.95 and 19.99 RSD respectively. The pods with the highest RSD were *A. mellifera*. This may explain the difference for the *A. tortilis* and *A. brevispica*. As for the Percentage Organic Matter Degradation (OMD %), the highest was for *A. mellifera* (66.25%) and least *A. tortilis* (43.87%).

Lastly, there were significant differences ($p < 0.05$) in the initial gas production (A) and rate constant gas production (C) differed among the barks of the different Acacia browses. The results from in – vitro gas production measured from 3 to 120 hours for the studies Acacia tress browse are shown in Figure 4.7c. At 24hrs and 48hrs, the highest gas production was recorded in *A. nilotica* at 68.48% and 60.54%

respectively. The rest were low with *A. tortilis* recording 25.75% at 24hrs and 23.83% at 48hrs respectively. *A. mellifera* showed 15.65% at 48hrs and was the lowest.

4.4.2 Metabolizable Energy (ME) and Short Chain Fatty Acids (SCFA)

SFCA also known as Volatile Fatty Acids (VFA) are products of anaerobic fermentation of complex carbohydrates and is a source of 80% of Maintenance Energy requirements in ruminants. SFCA are also the building blocks for fat formation, gluconeogenesis and lactogenesis (Aluwong *et al.*, 2010).

According to *In-vitro* gas production data, the ME ranged between 3.65 MJ/ kg DM in *A. brevispica* leaves, being the highest, to the lower of 2.564 MJ /kg DM in *A. nilotica* bark. There is more energy in leaves and pods than in the barks. The results shows *A. mellifera* pods had the highest SCFA at 1.391 m mol/200 mg DM while *A. nilotica* pods had the lowest at 1.050 m mol/200 mg DM. The leaves of *A. nilotica* had SFCA at 1.708 m mol/200 mg DM while the lowest was *A. brevispica* at 0.682 m mol/200 mg DM. Their barks had generally low SFCA with the exception of *A. nilotica* at 1.516 m mol/200 mg DM.

4.4.3 Dry Matter Degradability of plant parts of preferred *Acacia Spps* browse

4.4.3.1 Dry Matter Degradability of leaves of preferred *Acacia Spps* browse

Figure 4.8a shows the trends in fermentation of leaves for selected Acacia species with *A. nilotica* leaves showing highest degradation followed for *A. mellifera, A. senegal*, *A. tortilis*, and finally *A. brevispica*. However, *A. tortilis* registered the same degradability up to 9 hours, after which *A. tortilis* became more degradable up to 96 hours.

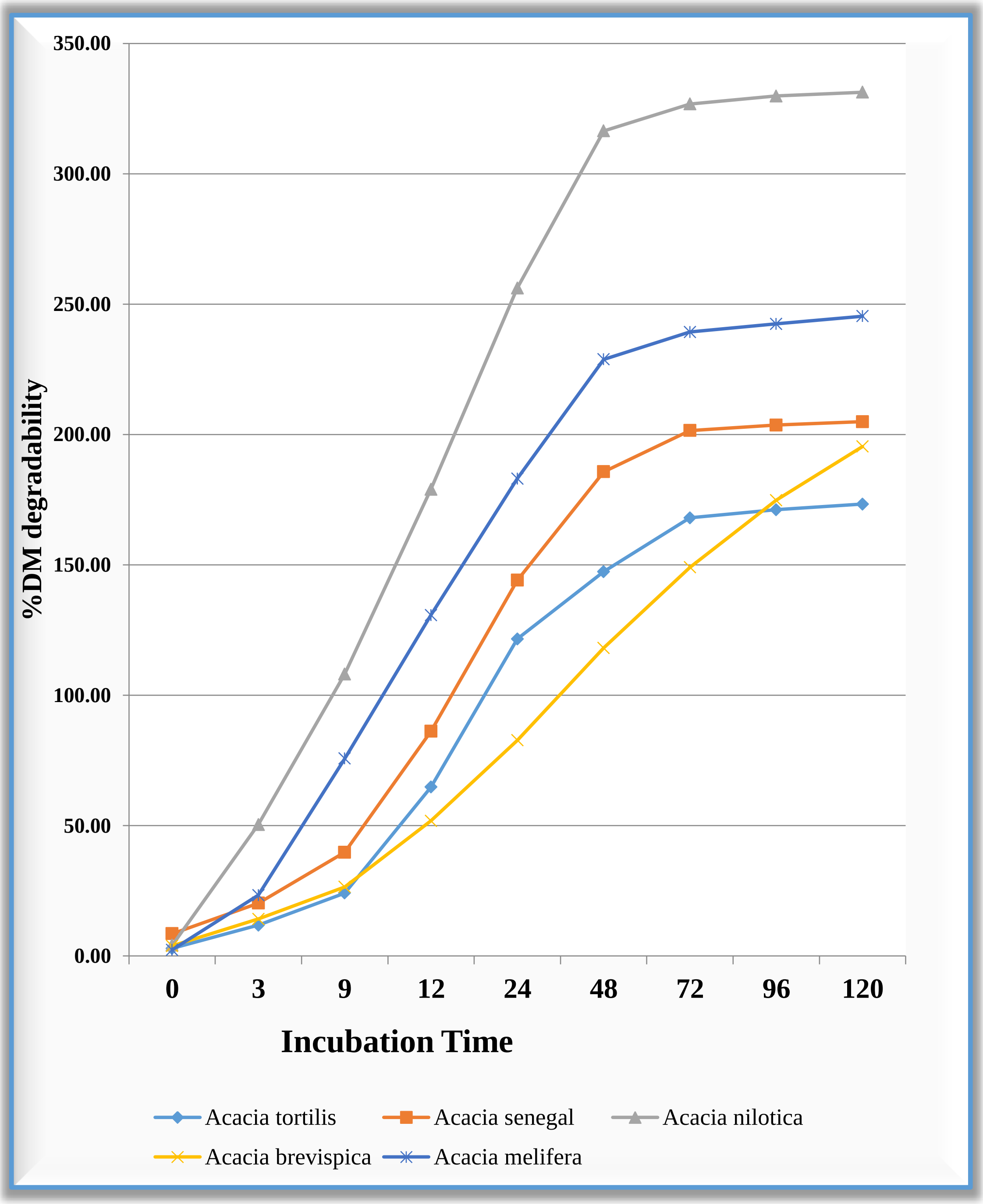


Figure 4.2a: Dry Matter degradability of leaves for selected Acacia species

The results from i*n-vitro* gas production measured from 3 to 120 hours for the Acacia tree browses is shown in leaves, pods and bark. Further, incubation time and the type of browse species significantly ($p<0.05$) influenced the *in-vitro* gas production for the different browse species.

4.4.3.2 Dry Matter Degradability of pods of preferred *Acacia Spps* browse

Figure 4.2b shows the rate of gas production in pods. The figure shows that *Acacia mellifera* pods ranked highly degradable followed by *Acacia nilotica*, which was ranked second highly degradable followed by *Acacia senegal, Acacia brevispica* and *lastly, Acacia tortilis* pods. *Acacia senegal*, *Acacia brevispica* and *Acacia tortilis* pods showed same rate of degradation up to the 9th hour after which *Acacia senegal* showed more degradation with *Acacia tortilis* and *Acacia brevispica* more or less showing similar trends for the rest of the period.

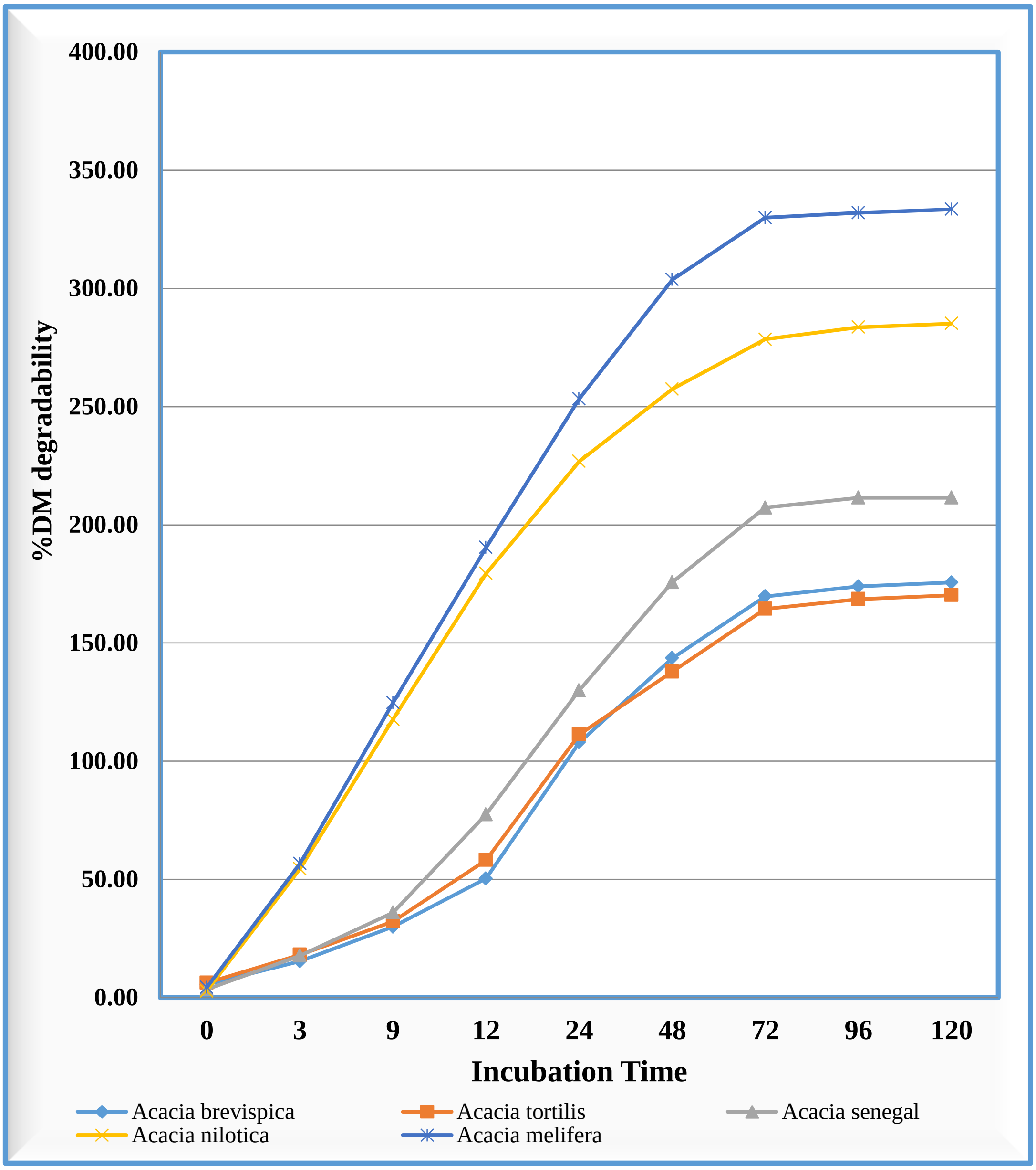


Figure 4.2b: Dry Matter degradability of pods for selected Acacia species

4.4.3.3 Dry Matter Degradability of barks of preferred *Acacia Spps* browse

Figure 4.2c shows the rate of gas production in the bark of five Acacia browse species. The figure shows that *A. nilotica was* ranked highly degradable followed by *A. senegal, A. mellifera, A. brevispica* and *A. tortilis* bark. There were mixed trends in the rate of degradation for *A. senegal, A. brevispica, A. mellifera* up to 24 hours with *A. mellifera* showing more degradation up to 9th hour after which it slowed down.

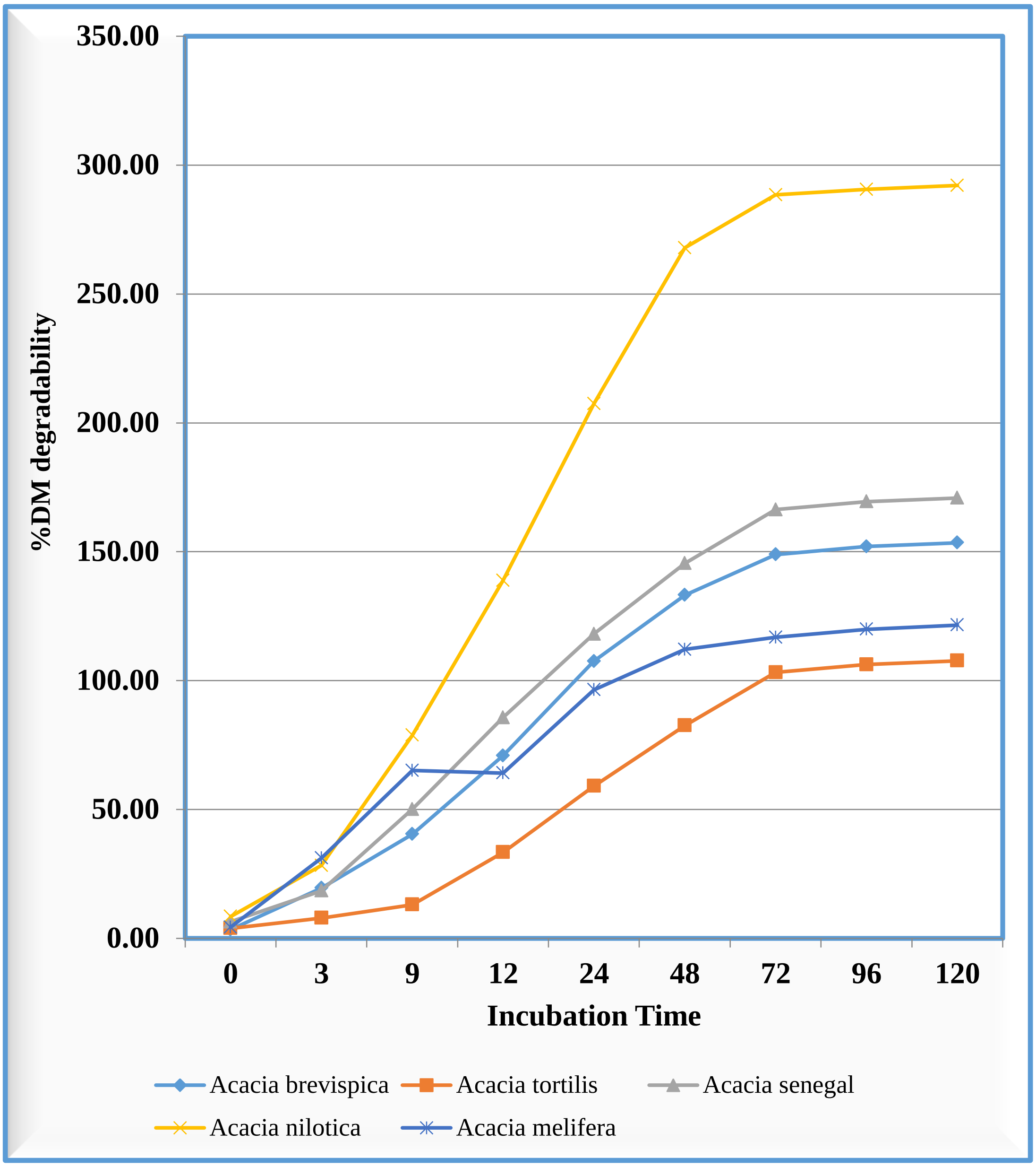


Figure 4.2c: Dry Matter degradability of bark for selected Acacia species

This shows that the barks have low degradation and may not be preferred as feeds. This may agree with Tibbo (2000) that, at less than 55% IVDMD levels, physical limitations on the eating and digestion rate and passage occur leading to inevitable live weight loss since feed intake is restricted.

The results in Table 4.8 shows that According to *In-vitro* gas production data, the ME ranged between 3.65 MJ/ kg DM in *A. brevispica* leaves, being the highest, to the lower of 2.564 MJ /kg DM in *A. nilotica* bark. There is more energy in leaves and pods than in the barks.

CHAPTER FIVE

DISCUSSION

5.1 Hypothesis Testing

5.1.1 Hypothesis One

Since the Kruskal - Wallis test result was statistically significant, χ^2 (4) = 182.6, $p < 0.05$, the study finding therefore rejects the null hypothesis that there are no potentially large numbers of browseable Acacia species of plants that can be used as livestock feed in Marigat in Baringo County and concludes that certain number of browseable *Acacia spp*s can be used for feeding livestock.

The study used a random field trial method, which allowed the goats to browse naturally in the field and were then documented based on the observable differences in their browse preference. This method was appropriate as it allowed the observable natural preference by goats as opposed to the cafeteria method under controlled housing. The method of direct observation brought in curiosity and unique reality in increasing aspiration for more accurate and objective browsing preference.

Based on Kruskal-Wallis test statistic, the acacia trees are preferred by the ranking in the order of the ranking from first *A. brevispica,* followed *A. nilotica, A. tortilis, A. mellifera* and lastly *A. senegal*. Several *Acacia* species were identified by the researcher and the findings is in line with the following studies which highlighted the *Acacia Spps* browse as one of the important forage for livestock (Abebe *et al.,* 2012; Dambe *et al.,* 2015; Kemboi *et al.,*2017; Osuga *et al.,* 2008, Mangara *et al.,* 2017; Shenkute *et al.,* 2012; Hassen *et al.,* 2017). Other studies have highlighted different leguminous plants as forage in different context (Ndathi *et al.,* 2013; Ndathi *et al.,* 2012; Olubukola *et al.,* 2013).

5.1.2 Hypothesis Two

Since the Tukey's test result was statistically significant, the study finding therefore rejects the null hypothesis that there are no significant differences in preferences of goats for the forages of different *Acacia spp* during browsing and concludes that there are significant differences in preference of browseable *Acacia spps* by goats. Empirical studies supporting this finding include those done in Kenya by Osuga *et al.,* (2008) which showed that preference of *Acacia brevispica* over the other browse species. In Pakistan, Khan *et al.,* (2012) showed that *Acacia nilotica* was highly preferred browse.

In several context, *Acacia Spps* such as *A. senegal* (Mengistu *et al.,* 2016), *A. amara, A. tortilis, A. asak,* and *A. oerfota* (Melaku *et al.,* 2010) have been shown to be preferred by different ruminants. There are morphological differences that exist within the species (Shenkute *et al.,* 2012). Thus, it can be inferred that the ease and size of the bite affects the browsing preference since *Acacia brevispica* has larger and easily accessed leaves when compared to *Acacia senegal* whose leaves are tiny and less accessible because of the hooked spikes on their stems.

Further, the presence of spikes in the branches of the tree species influenced browsing patterns of the browsers. The findings by Skarpe *et al.,* (2012) indicated that the highest bite rates occur in plants without thorns and hooks and lowest in plants with thorns and hooks. This finding is supported by Ndjamba, (2014) who reported that spiked plants were least browsed when compared with non-spiked plants. Thus, *A. brevispica* was preferred because they have more edible parts such as leaves with fewer spikes and hooks. On the converse, browsers have smaller biting size translating to low intake in spiked plants like *Acacia senegal*.

5.1.3 Hypothesis Three

Since the ANOVA test statistic was statistically significant, the study finding therefore rejects the null hypothesis that there are no significant differences in nutrient composition of the edible parts of the preferred *Acacia spp* and concludes that there are significant differences in nutrient composition of the edible parts of the preferred *Acacia spps* Though there were significant difference in the DM content all the *Acacia spps* having over 94% DM content. Regarding the Ash content, significant differences ($p<0.05$) existed with *A. Nilotica* leaves having the lowest Ash content at 5.41% while *A. senegal* leaves had the highest Ash content at 15.59%. The findings tally up with the findings by Melaku *et al.,* 2010 which reported Ash content range of 9.25% in *Acacia tortilis* (10.73% in our case here) to 14.4% in *Acacia oerfota*. Further, the results tallies up with the findings by Ondiek *et al.,* (2010) which reported that Acacia spps have sufficient CP and ash content.

The CP content of the *Acacia spp*s, indicate that *A. mellifera* had the highest CP% at 22.00% with *A. nilotica* having the lowest (14.40%). The finding show that the CP content was higher than the 7 – 8% required for rumen functioning (Van Soest, 1994) but was within the range of 13.4% to 21.3% reported by Abdulrazak *et al.,* (2000). Further, Melaku *et al.,* (2010) reported that a similar CP range of 12.8% in *A. lahai* to 22.8% in *A. oerfota*. Crude protein is particularly higher in browses leguminosae that includes *Acacia spps*. Indeed, during the rainy season the browse species that include; A. *asak, A. amara, A. oerfota* and *A. tortilis*, contained more than 15% CP levels required to support growth and lactation (Norton, 1982). The high CP content of the browse foliage and pods (10.16% to 23.90%) justifies their use as feed supplements (Osuga *et al.*, 2006).

As indicated in the results, *A. brevispica* had the highest CF at 28.12% while *A. Nilotica* (9.66%) was the lowest, while *A. brevispica* had the lowest ether extract at 3.66% with *A. nilotica* having the highest ether extract content (5.21%). The study reported of significant differences in the nutrient composition of the edible parts of the preferred *Acacia spps* and concludes that the organs of the preferred *Acacia spps* have differing nutrient composition. Based on the leaves and pods; the CP, DM, EE, CF and Ash content levels of the different *Acacia spp* were significantly different.

A. brevispica, *A. mellifera* and *A. nubica* have considerable crude protein content (Abdulrazak *et al.*, 2000). Kemboi *et al.*, (2017) reported that *A. brevispica* had 5.34% EE content, 13.2% CP while Olubukola *et al.*, (2013) reported that *Acacia spps* leaves have a generally higher CP content than that of barks. The importance of browse material for livestock feeding is determined by among others; the anti-nutritional content such as alkaloids, aromatics, phenolics and tannins, which alters their intake and palatability irrespective of their nutritional value (Ngwa *et al.*, 2003). However, Gwanzura *et al.*, (2011) observed that the nutrient content is an unreliable predictor of intake and palatability in that some forage high in condensed tannins gave higher intake and palatability indices.

5.1.4 Hypothesis Four

Since the ANOVA test statistic was statistically significant, the study finding therefore rejects the null hypothesis that here are no significant differences in *In-vitro* dry matter degradability of the edible parts of the preferred *Acacia spp* and concludes that there are significant differences in *In-vitro* dry matter degradability of the edible parts of the preferred *Acacia spp*

Total gas production showed variation in the forage degradability and digestibility potential, with *A. tortilis* leaves showing the highest (0.089%/H) and *A. brevispica* leaves the lowest (0.011%/H) which compares well with results reported by Abdulrazak *et al.,* (2000). *A. tortilis* leaves showed the highest degradability followed by *A. nilotica* bark, *A. mellifera* pods and *A. senegal* leaves at 24 hours (showing 77.15 ml, 68.48 ml, 62.85 ml and 57.95 ml per 200mg DM of forage respectively). *A. tortilis* bark (25.75 ml per 200mg DM) was least degraded at 24 hours while, *A. mellifera* bark (15.65 ml per 200 mg DM) was least degraded at 48 hours.

A. nilotica pods had the highest rate of gas production, ‘c’, at 0.100. The mean gas production at 48 hours for *A. nilotica* leaves, and *A. nilotica* bark were similar, but significantly different ($p<0.05$) from *A. brevispica* leaves, *A. brevispica* bark, *A. brevispica* pods, *A. senegal* leaves, *A. senegal* pods, *A. mellifera* leaves, and *A. mellifera* pods which were similar. The browse with highest gas production at 24 and 48 hours was *A. nilotica* leaves (77.15 ml and 60.29 ml per 200 mg DM, respectively). According to Dambe *et al.,* (2015), high CP content in the browse aids in raising the ruminal ammonia concentration, this in turn increase microbial growth and activity leading to enhanced dry matter digestibility.

A. nilotica leaves ranked highly in *In-vitro* DM degradability followed by *A. mellifera*, with *A. tortilis, A. Senegal* and *A. Brevispica* leaves, trailing each other in that order. Regarding pods, *A. mellifera* ranked highly in degradability followed by *A. nilotica*, with *A. senegal, A. brevispica* and *A. tortilis* pods ranking least in that sequence. As for the barks, *A. Nilotica* was ranked highly degradable followed by *A. senegal, A. mellifera, A. brevispica* and lastly, *A. tortilis.* Barks have not been documented as an alternative feed source except for information from interviews to the pastoralists who acknowledges use in extreme droughts.

The total gas production (A + B) was low except for *A. tortilis* (34.45%). As for RSD, *A. nilotica* bark had the highest at 29.67% and the rest were low with *A. tortilis* (11.23%) being the lowest. OMD% was highest in *A. nilotica* bark at 74.61% and the rest showing results below 50% with least in *A. mellifera*. This shows that the barks have low degradation and may not be preferred as feeds. This may agree with Tibbo (2000) that, at less than 55% IVDMD levels, physical limitations on the eating and digestion rate and passage occur leading to inevitable live weight loss since feed intake is restricted. The rate constant gas production(C) showed differences in digestibility and degradability of the forage, with *A. tortilis* leaves showing the highest (0.089%H^{-1}) while *A. brevispica* leaves had the lowest (0.011%H^{-1}). The results matches with the findings that were reported by Abdulrazak *et al.,* (2000).

Generally fresh leaves have highest IVDMD values than all the other parts of the plant species and the relatively higher digestibility in fresh leaves is partially attributable to higher crude protein levels of the browses (Dambe *et al.*, 2015). As per the observation by Kemboi *et al.*,(2017) *Acacia brevispica* had the lowest degradation levels at 8.15% 48hrs but the degradation potential of some forages tend to improve with time indicating that effective degradation occurs over longer periods of time. The IVDMD values are comparatively higher for browse species as compared to grasses. In particular, the IVDMD characteristics is significantly higher in A. nilotica, than in *A. seyal, A. tortilis,* or *A. brevispica* (Abebe *et al.,* 2012).

Hassen *et al.,* (2017) reported of the seasonal effects on the chemical composition and IVDMD characteristics of the browse species due to environmental stress during the dry season which reduces the uptake of essential nutrients. The phenolic content in the browses could contribute to lowered gas production (Kemboi *et al.,* 2017). Hassen *et al.,* (2017) observed that there are significant differences in the dry matter degradability of the different browse species. This differences is attributable to the species and the seasonal effects with browse species having higher DM degradability characteristics during the rainy season than in the dry season

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study found out that the Baringo ASAL region is endowed with large number of indigenous *Acacia* browse species which can play a crucial role in livestock nutrition and production.

i. The ordered rank preference in situ showed that showed that *A. brevispica* was mostly preferred and while *A. senegal* was least preferred. The order of preference was *A. brevispica*> *A.nilotica*> *A. tortilis*> *A.mellifera*> *A. senegal* with *A.senegal* being least preferred.

ii. The proximate analysis results showed that, the preferred *Acacia spp* browses had high DM content, which indicates high amounts of nutrients that may be available to the animals.

iii. The result also showed crude proteins to be high in the leaves and pods and generally low in the barks except for *A. mellifera* and thus Acacia species is a good source of crude protein. The CP content of leaves and pods of all the species preferred was more than 7 – 8% indicating that Acacias can be good sources of proteins and can further be used in feed supplementation in the ASALs where feeds are of low nutritional content and value especially during dry seasons when herbaceous coverage is low.

iv. As for the Ash content, the results showed high amounts with the bark having the highest followed by leaves and lastly, the pods. This indicates that the Acacias can be a good source of minerals.

v. The results of crude fibre (CF) were highest in the barks and this may be attributed to high lignin, cellulose and hemicelluloses deposits that formed over time. The CF for the leaves and pods was relatively high indicating that Acacias can be a reliable energy source for the browsers.

vi. As for ether extracts (EE), the results showed leaves to be highest and lowest in the bark indicating that the leaves can provide more energy followed by the pods and least by the bark.

vii. The IVDMD showed that, the highly degradable/fermentation browse was *A. nilotica* and the least was *A. brevispica* although the RSD results for *A. brevispica* was lowest which indicates that most of the *A. brevispica* browse is degraded and hence the positive preference.

Based on the findings of this study, there is need to develop and propagate these *Acacia spp*s as supplementary fodder in ASAL regions. These initiatives can take the forms of alleys, live fences, fodder banks or silvo-pastoral systems to provide fodder on a continuous basis or for harvesting and processing for use during droughts.

6.2 Recommendation

6.2.1 Recommendation for the study

i. The study recommends *A. brevispica*, *A. tortilis* and *A. nilotica* be used for livestock feeds in the ASAL regions, and thereby alleviate feed scarcities and reduce and/or solve livestock malnutrition. These *Acacia* species, especially *A. brevispica, can* be developed to provide fodder on a continuous basis or for harvest and processing for use in droughts. This can be done through intensive agro-forestry projects within the ASALs.

ii. There is need to account for the secondary anti-nutritional and limitation compounds and factors in these *Acacia spps*and find ways of reducing their effects on feed intake and digestibility through harvesting, processing and value addition for improved livestock productivity.

iii. Also, research on existing germplasm and development of new provenances of these species needs to be developed to overcome anti-nutritional limitations and broaden the fodder resource base.

iv. Further studies need to be done to enhance seed harvesting, nurseries establishments of seedlings, methods of planting and management of the preferred *Acacia spps* in order to increase forage biomass production in the ASALs.

v. Also, methods of harvesting, storage and feeding management of excess biomass for use during periods of scarcities needs exploration.

vi. Animal Response Trials for production values such as post-natal survival, growth rates and milk production need to be done under ASAL conditions to assure beneficial use.

6.2.2 Recommendation for further studies

Other studies may examine the different browse foliage in different parts in Kenya because there are differences in agro-ecological condition existing in these zones.

REFERENCES

Abay, K. A., & Jensen, N. D. (2020). Access to markets, weather risk, and livestock production decisions: Evidence from Ethiopia. *Agricultural Economics*, *51*(4), 577-593.

Abebe, A., Tolera, A., Holand, Ø., Ådnøy, T., & Eik, L. O. (2012). Seasonal variation in nutritive value of some browse and grass species in Borana rangeland, Southern Ethiopia. *Tropical and Subtropical Agroecosystems*, *15*(2), 261-271.

Abdalla, M. S., Babiker, I. A., Idris, A. M., & Elkalifa, K. F. (2014). Potential Nutrient Composition of Acacia seyal Fruits as Fodder for Livestock in the Dry Lands in Sudan. *Development in Analytical Chemistry*, *1*, 25-30.

Abdulrazak, S. A., Fujihara, T., Ondiek, J. K., & Ørskov, E. R. (2000). Nutritive evaluation of some Acacia tree leaves from Kenya. *Animal Feed Science and Technology*, *85*(1-2), 89-98.

Abdulrazak, S. A., Nyangaga, J., & Fujihara, T. (2001). Relative palatability to sheep of some browse species, their in sacco degradability and in vitro gas production characteristics. *Asian Australasian Journal of Animal Sciences*, *14*(11), 1580-1584.

Abdulrazak, S. A. and Fujihara T. (1999). Animal Nutrition, A laboratory manual, Kashiwagi Printing Company (Matsue-shi, Japan) pp 44.

Abusuwar, A. O. & Ahmed, E. O. (2010). Seasonal variability in nutritive value of ruminant diets under open grazing system in the semi-arid rangeland of Sudan (South Darfur State). Agricultural and Biology Journal of North America, 1(3): 243 – 249.

Aderinboye, R. Y., Akinlolu, A. O. , Adeleke, M. A., Najeem, G. O., Ojo, V. O. A., Isah, O. A., & Babayemi, O. J. (2016). *In vitro* gas production and dry matter degradation of four browse leaves using cattle, sheep and goat inoculation. *Slovak Journal of Animal Science,* 49, (1): 32–43

Agriculture and Food Research Council (AFRC), (1993). Energy and protein requirements of ruminants. CAB International, Wallingford, Oxon, England.

Aiple, K. P., Steingass, H., & Drochner, W. (1996). Prediction of the net energy content of raw materials and compound feeds for ruminants by different laboratory methods. *Archives of Animal Nutrition*, *49*(3), 213-220.

Akinfemi, A., Adu, O. A., & Adebiyi, O. A. (2009). Use of white rot-fungi in upgrading maize straw and, the resulting impact on chemical composition and in vitro digestibility. *Livestock research for rural development*, *21*(10), 162.

Aluwong, T., Kobo, P. I. & Abdullahi, A. (2010). Volatile fatty acids production in ruminants and the role of monocarboxylate transporters: *African Journal of Biotechnology*, 9(38), 6229-6232,

AOAC. (1995). *Official methods of Analysis*, 15th edition. Association of Official Analytical Chemists, Washington, DC

AOAC. Animal Feed." Chapter 4 in Official Methods of Analysis, 16th edition, AOAC International, Arlington, VI, USA, pp 30 (1995).

Aregawi, T., Melaku, S., & Nigatu, L. (2008). Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. *Livestock Research for Rural Development*, *20*(6), 86.

Ayantunde, A.A., Fernández-Rivera, S. and McCrabb, G. (eds). (2005). Coping with feed scarcity in smallholder livestock systems in developing countries. International Livestock Research Institute, Nairobi, Kenya. 306 pp.

Basha, N. A., Scogings, P. F., Fon, F. N., Ahmed, M. A., & Nsahlai, I. V. (2015). Effects of season and species on in sacco degradability of forages in the sub-humid subtropical savannah. *African Journal of Agricultural Research*, *10*(11), 1312-1319.

Belachew, Z., Yisehak, K., Taye, T., & Janssens, G. P. J. (2013). Chemical composition and in sacco ruminal degradation of tropical trees rich in condensed tannins. *Czech Journal Animal. Science*, *58*(4), 176-192.

Blummel M. and Ørskov E. R. (1993). Comparison of in vitro gas production and nylon bag digestibility of roughages in predicting feed intake in cattle. Animal *Feed Science Technology*. 40:109-119

Boga, M., Yurtseven, S., Kilic, U., Aydemir, S., & Polat, T. (2014). Determination of nutrient contents and in vitro gas production values of some legume forages grown in the Harran plain saline soils. *Asian-Australasian Journal of Animal Sciences*, *27*(6), 825-831.

Bond, W. J., Smythe, K. A., & Balfour, D. A. (2001). Acacia species turnover in space and time in an African savanna. *Journal of Biogeography*, *28*(1), 117-128.

Boruch, R. F. (2003). Randomized field trials in education. In *International handbook of educational evaluation* (pp. 107-124). Springer, Dordrecht.

Chibinga, O. C., & Nambeye, E. (2016). Nutritive value of some selected indigenous livestock browse species in the drylands of Southern Province, Zambia. *International Journal of Applied and Pure Science and Agriculture*, *2*, 61-66.

Cone J.W. & Van Gelder A. H. (1999). Influence of protein fermentation on gas production profiles. *International Animal Feed Science Technology*, 76, p. 251–264

Dambe, L. M., Mogotsi, K., Odubeng, M., & Kgosikoma, O. E. (2015). Nutritive value of some important indigenous livestock browse species in semi-arid mixed Mopane bushveld, Botswana. *Livestock Research for rural development*, *27*(10), 1-10.

Dynes, R. A., & Schlink, A. C. (2002). Livestock potential of Australian species of Acacia. *Conservation Science Western Australia*, *4*(3), 117-124

FAO, 2006. FAOSTAT, Statistic database. FAO, Rome, Italy

Fievez V; Babayemi O. J; Demeyer D. (2005). Estimation of direct and indirect gas production in syringes: A tool to estimate short chain fatty acid production that requires minimal laboratory facilities. *Animal Feed Science Technology,* (123-124): 197-210.

Franzel, S., Carsan, S., Lukuyu, B., Sinja, J., & Wambugu, C. (2014). Fodder trees for improving livestock productivity and smallholder livelihoods in Africa. *Current Opinion in Environmental Sustainability*, *6*, 98-103.

Gebeyew, K., Kibru Beriso, A. M., Melaku, S., & Worku, A. (2015). Review on the nutritive value of some selected Acacia species for livestock production in dryland areas. 3: 2-5

Getachew, G., Blümmel, M., Makkar, H. P. S., & Becker, K. (1998). In vitro gas measuring techniques for assessment of nutritional quality of feeds: a review. *Animal Feed Science and Technology*, *72*(3-4), 261-281.

Gikaba, J. M., Muthoni, K. S., & Bebe, B. O. (2014). Influence of drought duration on livestock feeding practices by Maasai pastoralists in Kajiado County, Kenya. *International Journal of Innovation and Applied Studies*, *8*(1), 225.

Gosselink, J. M. J.; J. P. Dulphy; C. Poncet; M. Jailler; S. Tamminga and J. W. Cone (2004). Prediction of forage digestibility in ruminants using *in-situ* and *In-vitro* techniques. *Animal Feed Science Technology*, 115: 227-246.

Gwanzura T., Ngambi J.W. & Norris D. (2011). Effects of Selected Legume Species and Forage Sorghum Hay Grown in Limpopo Province on Voluntary Intake and Relative Palatability Indices of Pedi Goats. *Asian Journal of Animal and Veterinary Advances, 6: 1249-1255.*

Hassen, A., Tessema, Z. K., & Tolera, A. (2017). Seasonal variations in chemical composition, in vitro digestibility and ruminal degradation of browse species in the Rift Valley of Ethiopia. *Livestock Research Rural Development*, *29,* 112.

Hemme T.and Otte J. (Eds.) (2010). Status of and Prospects for Smallholder Milk Production—A Global Perspective, FAO

Jamala, G. Y., Tarimbuka, I. L., Moris, D., & Mahai, S. (2013). The scope and potentials of fodder trees and shrubs in Agroforestry. *Journal of Agriculture and Veterinary Science*, *5*, 11-17.

Kaitho, J. R. (1997). Nutritive value of browses as protein supplement(s) to poor quality roughage. Ph.D thesis. Wageningen Agricultural University. Netherlands.

Kemboi, F., Ondiek, J. O., & Onjoro, P. A. (2017). Evaluation of nutritive value and in-vitro degradation of selected indigenous browses from Semi-Arid areas of Kenya. *Livestock Research for Rural Development. Volume 29, Article, 92.*

Kgosikoma, O.E. & Mogotsi, K. (2013). Understanding the causes of bush encroachment in Africa: the key to effective management of savanna grasslands. Tropical grasslands-forrajes tropicales, 1(2):215-219.

Kidake, B. K., Manyeki, J. K., Kubasu, D., & Mnene, W. N. (2016). Promotion of range pasture and fodder production among the pastoral and agropastoral communities in Kenyan rangelands: Experiences and lessons learnt. *Livestock Research for Rural Development*, *28*(8).

Kosonei, R. C., Abuom, P. O., J M, H., & Bosire, E. (2017). Effects of drought dynamics on vegetation cover in Marigat sub-county, Baringo county, Kenya. *International Journal of Scientific and Research Publications*, 7(5) 89 – 98

Krishnamoorthy, U., Soller, H., Steingass, H., & Menke, K. H. (1995). Energy and protein evaluation of tropical feedstuffs for whole tract and ruminal digestion by chemical analyses and rumen inoculum studies in vitro. *Animal Feed Science and Technology*, *52*(3), 177-188.

Kumar, K. (2011). Role of Tannins on Animal Performance: an Overview. *Journal of Natural Remedies*, *11*(2), 82-89.

Luseba, D., and Van der Merwe, D. (2006). Ethnoveterinary medicine practices among Tsonga speaking people of South Africa. *Onderstepoort Journal of Veterinary Research 73: 115- 122*.

Mahenya, O., Mathisen, K. M., Andreassen, H. P., & Skarpe, C. (2016). Hierarchical foraging by giraffe in a heterogeneous savannah, Tanzania. *African Journal of Ecology*, *54*(2), 136-145.

Mangara, J. L. I., Guliye, A. Y., Migwi, P. K., & Ondiek, J. O. (2017). Nutrient composition of selected indigenous tree browses in Central Equatoria State of the Republic of South Sudan. *Livestock Research for Rural Development*, *29*(4).

Mbatha, K. R., Lane, E. P., Tordiffe, A. S., Lander, M., & Corr, S. (2012). Preliminary evaluation of selected minerals in liversamples from springbok (Antidorcas marsupialis) from the National Zoological Gardens of South Africa. *Journal of the South African Veterinary Association*, *83*(1), 1-7.

McDonald I. (1981). A revised model for estimation of protein degradability in the rumen. *Journal of Agricultural Science, Cambridge* 96: 251-252

McDonald P., R. A. Edwards, J.F.D, Greenhalgh and C.A. Morgan (1995).*Animal Nutrition. Long Man Company*, London.

Melaku, S., Aregawi, T., & Nigatu, L. (2010). Chemical composition, in vitro dry matter digestibility and in sacco degradability of selected browse species used as animal feeds under semi-arid conditions in Northern Ethiopia. *Agroforestry systems*, *80*(2), 173-184.

Mengistu R. A. (2017). Identification of Suitable Trees and Shrubs for Sustainable Camel Production. *Journal of Camel Research and Production* vol.1 No. 1 ISSN (Print): 1858-8255.

Mengistu, U., Kefelegn, K., & Gebretnsae, W. M. (2016). Effects of Supplementing Cactus Cladode and Acacia Senegal Branches on Intake, Digestibility and Body Weight Gain of Tigray Highland Sheep Fed Barley Straw. *Journal of Fisheries Livestock Production*, *4*(191), 2.

Menke K H, Raab L, Salewski A, Steingass H, Fritz D and Scheider W. (1979). The estimation of the digestibility and metabolizable energy content of ruminant feeding stuffs from the gas production when they are incubated with rumen liquor in vitro. *Journal of Agricultural Science (Cambridge*) 93: 217-222.

Menke, K. H., & Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal research and development*. 28:7–55.

Menke, K. H. (1988). Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. *Animal research and development*, *28*, 7-55.

Mohamed, R., & Chaudhry, A. (2008). Methods to study degradation of ruminant feeds. *Nutrition Research Reviews,21*(1), 68-81.

Mogotsi, K., Nyangito, M. M., & Nyariki, D. M. (2011). The perfect drought? Constraints limiting Kalahari agro-pastoral communities from coping and adapting. *African Journal of Environmental Science and Technology*, *5*(3), 168-177.

Mphinyane, W. N., Tacheba, G., & Makore, J. (2015). Seasonal diet preference of cattle, sheep and goats grazing on the communal grazing rangeland in the Central District of Botswana. *African Journal of Agricultural Research*, *10*(29), 2791-2803.

Mwangi, D. M. (2019). Grassland and Livestock Production: The East African Case. The XXIII International Gr The XXIII International Grassland Congress (Sustainable use of Grasses (Sustainable use of Grassland Resource for Forage Production, , Biodiversity and Environmental diversity and Environmental Protection) took place in New Delhi, India from November 20th November 24, 2015.

Ndjamba, J. K. (2014). *Browsing by giraffe in relation to plant and animal traits in Arusha National Park, Tanzania* (Master's thesis).

Ngwa, A. T., Nsahlai, I. V., & Bonsi, M. L. K. (2003). Feed intake and dietary preferences of sheep and goats offered hay and legume-tree pods in South Africa. *Agroforestry systems*, *57*(1), 29-37.

Ngwa, T. A., Nsahlai, I. V., & Iji, P. A. (2004). Ensilage as a means of reducing the concentration of cyanogenic glycosides in the pods of Acacia sieberiana and the effect of additives on silage quality. *Journal of the Science of Food and Agriculture*, *84*(6), 521-529.

Norton, B. W. (1982). Differences between species in forage quality. In: Proceedings of international symposium held at St. Lucia, Queensland, Australia, 24–28 Sep 1981. Nutritional Limits to Animal Production from Pastures

Ndathi, A. J., Muthiani, E. N., Ndung'u, J. N., Ogillo, B. P., Kimitei, R. K., Manyeki, J. K., Katiku, P. N. & Mnene, W. N. (2013). Feed resources and utilization strategies in selected pastoral and agropastoral communities in Kenya. *Livestock Research for Rural Development*, *25*(12), 221.

Ndathi, A. J., Nyangito, M. M., Musimba, N. K., & Mitaru, B. N.(2012) Farmers' preference and nutritive value of selected indigenous plant feed materials for cattle in drylands of south-eastern Kenya. *Livestock Research for Rural Development. Volume 24, Article #28.*

Nyangaga, J. N. (2001). The nutritional level of selected Acacia leaves as nitrogen supplement to low quality roughage diets offered to goats. MSc Thesis, Egerton University.

Ørskov and McDonald (1981). The effects of protein degradability and food intake on milk yield and composition in Friesian cows in early lactation. *British Journal of Nutrition* 45, 547-555

Ørskov, E.R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science, Cambridge* 92, 499–503.

Olubukola, A. I., Omorogiuwa, L. E., & Okunade, S. A. (2013). Chemical evaluation of some browse plants eaten by local breeds of goats in Edo State, Nigeria. *The Pacific Journal of Science and Technology*, *14*, 406-412.

Ondiek, J. O., Abdulrazak, S. A., & Njoka, E. N. (2010). Chemical and mineral composition, in-vitro gas production, in-sacco degradation of selected indigenous Kenyan browses. *Livestock Research for Rural Development*, *22*(2), 2010.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Simons, A. (2009). Agroforestree Database: a tree reference and selection guide. Version 4. *Agroforestree Database: a tree reference and selection guide. Version 4.*

Osuga, I. M., Wambui, C. C., Abdulrazak, S. A., Ichinohe, T., & Fujihara, T. (2008). Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semiarid area of Kenya. *Animal Science Journal*, *79*(5), 582-589.

Osuga, I. M., Wambui, C. C., Abdulrazak, S. A., Ichinohe, T., & Fujihara, T. (2008). Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semiarid area of Kenya. *Animal Science Journal*, *79*(5), 582-589.

Osuga, I. M., Wambui, C. C., Abdulrazak, S. A., Ichinohe, T., & Fujihara, T. (2008). Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semiarid area of Kenya. *Animal Science Journal*, *79*(5), 582-589.

Ramirez, R. G., Haenlein, G. F. W., & Nunez-Gonzalez, M. A. (2001). Seasonal variation of macro and trace mineral contents in 14 browse species that grow in north-eastern Mexico. *Small Ruminant Research*, *39*(2), 153-159.

Ramírez, R. G., Neira-Morales, R. R., Ledezma-Torres, R. A., & Garibaldi-González, C. A. (2000). Ruminal digestion characteristics and effective degradability of cell wall of browse species from north-eastern Mexico. *Small Ruminant Research*, *36*(1), 49-55.

Rogosic, J., Pfister, J. A., Provenza, F. D., & Grbesa, D. (2006). Sheep and goat preference for and nutritional value of Mediterranean maquis shrubs. *Small Ruminant Research*, *64*(1-2), 169-179.

Salem, A. Z. M., Salem, M. Z. M., El-Adawy, M. M., & Robinson, P. H. (2006). Nutritive evaluations of some browse tree foliage during the dry season: secondary compounds, feed intake and in vivo digestibility in sheep and goats. *Animal Feed Science and Technology*, *127*(3-4), 251-267.

Shenkute, B., Hassen, A., Assafa, T., Amen, N., & Ebro, A. (2012). Identification and nutritive vale of potential fodder trees and shrubs in the mid Rift Valley of Ethiopia. Pakistan Agricultural Scientist's Forum. *The Journal of Animal & Plant Sciences*, 22(4): 1126-1132

Shenkute, B., Hassen, A., Assafa, T., Amen, N., & Ebro, A. (2012). Identification and nutritive vale of potential fodder trees and shrubs in the mid Rift Valley of Ethiopia, *The Journal of Animal and Plant Sciences*, 22: 1126-1132.

Skarpe, C., Bergström, R., Danell, K., Eriksson, H., & Kunz, C. (2012). Of goats and spines–a feeding experiment. *African journal of range & forage science*, *29*(1), 37-41.

Sundstøl, F. R. I. K. (1993). Energy systems for ruminants. *Icelandic Agricultural Science*, *7*, 11-19.

Steel R. G. D., Torrie J. H. and Dicckey D. (1996). *Principles and procedures of Statistics.* McGraw-Hill, New York.

Steel, R. G. D., Torrie, J. H., & Dinkey, D. A. (1996). *Principles and Procedures of Statistics* (2nd Ed.), McGraw

Teklu, B., Negesse, T., & Angassa, A. (2011). Effect of farming systems on livestock feed resources and feeding systems in Benishangul-Gumuz region, western Ethiopia. *International Research Journal of Agricultural Science*, *1*(1), 20-28.

Theart, J. J. F., Hassen, A., van Niekerk**,** W. A., Belete Shenkute Gemeda, B. S. (2015)**.** *In-vitro* screening of Kalahari browse species for rumen methane mitigation. *Science and agriculture*. (Piracicaba, Braz.) vol.72 no.6

Theodorou M. K. Williams B. A. Dhanoa M.S. McAllan A. B. and France J. (1994). A simple gas production method using a pressure transducer to determine the fermentation kinetics of ruminant feeds. Animal *Feed Science and Technology*, 48:185-197/9.

Tilley, J. M. A., & Terry, R. A. (1963). A two- stage technique for the in vitro digestion of forage crops. *Grass and forage science*, *18*(2), 104-111.

Tibbo, M. (2000, November). Livestock production constraints in a M2-2 sub-agro ecological zone with special reference to goat production. In *The Opportunities and Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia from November* (Vol. 10, pp. 92-106).

van de Steeg (2012). Livestock and climate change in the near east region. Measures to adapt to and mitigate climate change. Food and Agriculture Organization of the United Nations.

Van Soest, P.J. (1994) Nutritional ecology of ruminants, 2nd edn. Cornell University Press, Ithaca and London

Van Soest, P. V., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of dairy science*, *74*(10), 3583-3597.

Verma K.S., Pandey R. & Ayachi A. (2014). Nutritional assessment of different parts of A*cacia catechu* wild. collected from central India. *IJPSR; Vol. 5(7): 2980-2986.*

Von Kaufmann, R. (1986). An introduction to the sub-humid zone of West Africa and the ILCA sub humid zone programme. In: Livestock systems research in Nigeria's sub-humid zone. Proceedings of the second ILCA/NAPRI symposium held in Kaduna, Nigeria, 29 Oct. - 2 Nov. 1984. ILCA, Addis Ababa, Ethiopia

Zia-Ul-Haq, M., Ćavar, S., Qayum, M., Khan, I., & Ahmad, S. (2013). Chemical composition and antioxidant potential of Acacia leucophloea Roxb. *Acta Botanica Croatica*, *72*(1), 133-144.

APPENDICES

Appendix I: Proximate Analysis Results

The analyses of the samples were done from 08/07/2017 to 30/07/2017 and are as follows:-

DESCRIPTION	SAMPLE	%DM	%ASH	%CP	%CF	%EE
ABL	*Acacia brevispica* leaves	97.07	7.01	21.63	28.12	3.66
ABB	*Acacia brevispica* bark	95.62	7.52	6.41	36.81	0.56
ABP	*Acacia brevispica* pods	95.61	4.82	21.96	17.15	1.66
ATL	*Acacia tortilis* leaves	96.85	10.73	15.36	18.68	4.89
ATB	*Acacia tortilis* bark	97.07	15.33	8.11	43.16	0.41
ATP	*Acacia tortilis* pods	94.13	5.38	14.87	21.14	1.19
ATP 2	*Acacia tortilis* pods 2	96.46	6.19	12.70	27.78	2.15
ASL	*Acacia senegal* leaves	94.91	15.59	16.59	16.96	4.01
ASB	*Acacia senegal* bark	96.09	14.12	10.02	43.18	0.41
ASP	*Acacia senegal* pods	95.20	7.30	23.90	26.15	1.92
ANL	*Acacia nilotica* leaves	97.21	5.41	14.40	9.66	5.21
ANB	*Acacia nilotica* bark	94.92	7.96	2.76	24.54	0.31
ANP	*Acacia nilotica* pods	94.77	4.19	10.16	12.76	0.81
AML	*Acacia mellifera*leaves	95.42	10.38	22.00	16.97	4.88
AMB	*Acacia mellifera*bark	95.87	11.13	15.51	39.53	0.45
AMP	*Acacia mellifera*pods	95.47	7.83	20.16	26.6	1.88

Appendix II: Frame of Goats Used During the Experiment at Chemeron

Plate 4: Goats in a pen at Chemeron

Source: Author, (2018)

Appendix III: Proximate Analysis for *in-Vitro* DM Degradation

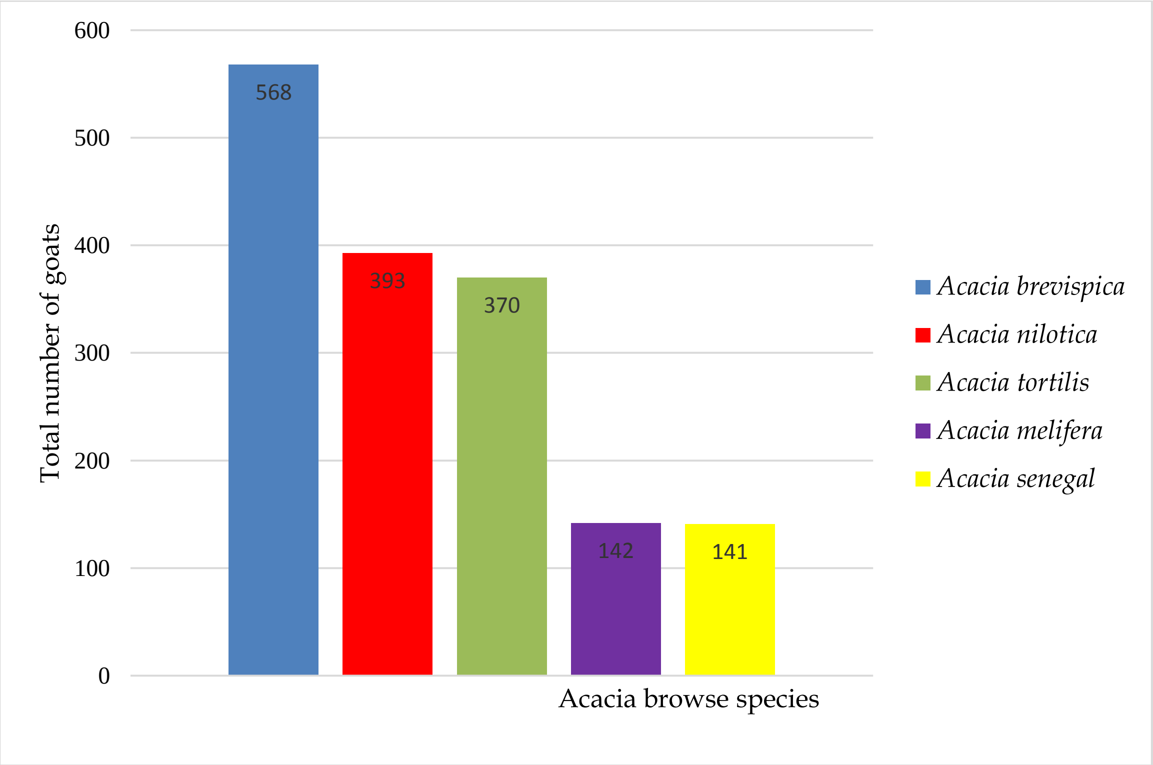
SAMPLE ORGAN	**0**	**9**	**12**	**24**	**48**	**72**	**96**	**120**	**a**	**B**	**c**	**a+b**	**RSD**
ABL	3.91	12.30	25.30	30.91	35.45	30.91	25.75	20.60	2.97	25.86	0.11	28.83	5.81
ABB	3.37	20.92	30.46	36.60	25.69	15.69	3.14	1.46	3.37	15.39	0.30	18.76	13.34
ABP	5.51	14.59	20.46	57.53	35.69	26.15	4.18	1.69	5.51	15.75	0.15	21.26	19.99
ATL	2.93	12.28	40.65	56.79	25.81	20.65	3.10	2.16	2.93	18.37	0.89	21.30	20.76
ATB	3.91	5.15	20.30	25.75	23.45	20.60	3.09	1.45	3.91	9.07	0.85	12.98	11.23
ATP	6.24	14.11	25.94	53.12	26.56	21.25	2.12	1.62	6.24	13.34	0.99	19.57	17.95
ASL	8.56	19.56	46.34	57.95	41.61	15.80	2.11	1.27	8.56	15.98	0.25	24.54	23.07
ASB	6.42	31.63	35.61	32.41	27.41	20.81	3.12	1.41	6.42	14.13	0.58	20.55	14.61
ASP	3.51	18.28	41.51	52.52	45.76	31.51	4.20	0.00	2.65	25.41	0.26	28.06	20.63
ANL	4.15	57.73	70.86	77.15	60.29	10.29	3.09	1.43	4.15	36.74	0.60	40.89	33.73
ANB	8.48	50.54	60.07	68.48	60.54	20.54	2.11	1.54	8.48	26.97	0.68	35.45	29.67
ANP	2.76	63.31	61.66	47.48	30.55	21.10	5.11	1.55	2.76	32.54	1.00	35.30	26.36
AML	2.40	52.40	54.96	52.40	45.72	10.48	3.14	2.96	2.40	27.98	0.15	30.38	25.13
AMB	4.31	33.02	31.29	29.09	15.65	4.72	3.13	1.65	4.31	13.99	0.79	18.29	14.67
AMP	4.27	68.08	65.71	62.85	50.47	26.19	2.09	1.47	4.27	36.89	0.41	41.16	29.82
				15.38	13.60				2.03	9.01	0.32	8.68	

Where ABL-*Acacia brevispica* leaves, ABB-*Acacia brevespica* bark, ABP-*Acacia brevispica* pods, ATL- *Acacia tortilis* leaves, ATB-*Acacia tortilis* bark, ATP-*Acacia tortilis* pods, ASL-*Acacias senegal* leaves, ASB-*Acacias senegal* bark, ASP-*Acacias senegal* pods, ANL-*Acacia nilotica*leaves, ANB- *Acacia nilotica*bark, ANP- *Acacia nilotica*pods, AML-*Acacia mellifera* leaves, AMB- *Acacia mellifera* bark, AMP- *Acacia mellifera* pods

Appendix IV: Ophthalmological Observation Data

Frequency of Observations on Preference of Goats for the *Acacia Spp*

Animal distribution/tree species/observation	*Frequency of observation/plant species*				
	A brevispica	*A mellifera*	*A nilotica*	*A senegal*	*A tortilis*
1	9	60	14	60	23
2	8	27	22	29	12
3	10	8	16	6	18
4	13	1	10	0	11
5	12	0	9	1	12
6	2	0	0	0	3
7	11	0	9	0	6
8	8	0	9	0	3
9	6	0	4	0	2
10	5	0	2	0	3
11	6	0	1	0	3
12	2	0	0	0	0
13	3	0	0	0	0
14	0	0	0	0	0
15	1	0	0	0	0



Ordered Rank Preference of *Acacia spps*

Appendix V: ANOVA Analysis

The ANOVA statistics on Table 4.1(Appendix VI) relates to the test for any significant differences in browsing preference according to the different *Acacia spps*

ANOVA analysis on Preference

Variate: Frequency

Source of variation	d.f	S.S	m.s	v.r	F pr.
Acacia spps	4	1317.217	329.304	62.61	<.001
Residual	475	2498.375	5.260		
Total	479	3815.592			

The statistic, $F(4, 475) = 62.61$, $p<0.05$ indicates that there are statistically significant differences in browsing preference according to the *Acacia spps.*

Appendix VI: Similarity Report

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