USEFULNESS OF DISCARDED WOODY MATERIALS OF SELECTED ENCROACHER TREE SPECIES OF SAVANNAH LANDSCAPES IN NAMIBIA

TEODOR N. KAAMBU

A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL STUDIES OF THE OPEN UNIVERSITY OF TANZANIA

2019

CERTIFICATION

The undersigned certifies that she has read and hereby recommends for acceptance by the Open University of Tanzania, a thesis titled: "***Usefulness of Discarded Woody Materials of Selected Encroacher Tree Species of Savannah Landscapes in Namibia"*** in fulfillment of the requirements for the degree of Master of Science in Environmental Studies of the Open University of Tanzania.

………………………...………….

Dr. Irene Aurelia Tarimo

(Supervisor)

……………………..……………….

Date

COPYRIGHT

DECLARATION

I **Teodor Ndilinane Kaambu,** Namibian identity 68090800637, do hereby declare that this thesis is my own original research work except where acknowledged. This research work has not been submitted anywhere before the award of the degree or other research purposes. Therefore, the thesis titled: **usefulness of the discarded wood materials of selected encroacher tree species of the savannah landscapes in Namibia** was carried out to fulfill the requirement of Master's Degree of Science in Environmental Studies of the Open University of Tanzania.

……………………………………………

Signature

……………………………………………

Date

DEDICATION

I have to dedicate this work of Masters of Science in Environmental Studies to my **late** mother Martha Ndadhikapo Theodor, who departed 31 years ago her soul rest in peace-AMEN. She brought me up and safeguarded my life style destine with word stating “Expectation is the root of all heartaches”. My father Johannes Kaambu at his age of 80 years continues to act as a teacher, mentor, guider and shaper of my actions on this planet. God gifted me with a very strong wife Mrs. Marina Kaambu, who declared her life partnership to support us with love, socially, physical, mentally and materials together with my five sons (Kleopas, Martin, Johannes, Roman and Theodor -Tulela). To my sons you stood firm and disciplined during my commitment to this studies, while pursuing your school work too. My dictum is “education is a key to have wisdom that leads to success in life endeavors’’.

ACKNOWLEDGEMENT

Foremost, as a Christian and Believer in Almighty God I should use this opportunity to be grateful to Him for everything He has done for me during my study time. I do recognize that this thesis work has been completed, because of immeasurable assistance, advices, guidance, financial and technical support from various individual people, farmers, business people, public and non-governmental institutions.

Appreciation goes to the Open University of Tanzania (OUT) for having admitted and enrolled me in to further my study for Master of Environmental Studies by thesis. In the same view, I should thank the Triumphant College in Namibia for having served as a link and facilitator between me and OUT during the two academic years. This opportunity has created a bond that continues to inspire me more to further the career. Special thank goes to my supervisor Dr. Irene Aurelia Tarimo, for her endless support and supervision roles. Her advice and guidance right from the proposal writing up, presentations, fieldwork and until completion of this thesis. I should also extend my appreciations to the Faculty of Science, Technology and Environmental Studies management especially the Coordinator of Maser's of Environment Studies programme Dr. Josephat Saria.

Allow me to send my utmost gratitude to the Government of Republic of the Namibia for allowing me to undertake this study and provide funding, laboratory services, transport and materials used in this noble work. Let me give immeasurable thanks to the Director of Forestry, Mr. Joseph Hailwa who recommended and made resources available and kept motivating me to study hard. I took note of the support and services rendered to me by the Directorate of Agriculture, Research and Training, laboratory division, Ms. Katrina Shiningavamwe for directing the process of sample analysis at laboratory. Utmost thanks further goes to the Namibian farmers, who openly shared information and experiences related to this study and also for their valuable time spent to interact with the Researcher. To the Researchers acknowledged in this study, public and Non-governmental organizations make information accessible your assistance and efforts are highly appreciated.

May the Almighty God Bless you all.

ABSTRACT

The study determined the usefulness of discarded woody materials from selected encroacher tree species in northern Namibia. The twigs, leaves and pods were collected from Omufituwekuta and Ehi-rovipuka community forest. The main objective was to determine proximate composition, energy values and farmer's perceptions on uses of discarded woody materials as bush-feed. Data was collected in October 2016, January & June 2017. One-way Analysis of Variance (ANOVA) was used to find mean difference between the four selected tree species. Questionnaire was used for farmer's perceptions on the use bush-feeds in relation to different seasons. Tree species encompasses of *Philenoptera nelsii*, *Baphia massaiensis, Acacia ataxacantha* and *Colophospermu mmopane*. Neutral-Detergent Fiber (NDF), Acid-Detergent Fiber (ADF), Ether Extracts (EE) Phosphorus (P), Calcium (Ca), Organic Matter Digestibility (OMD) and Metabolisable Energy (ME) were analysed. Results show that *Baphia massaiensis* has average of total ash (3.96%), EE (1.51%), CP (14.30 %), ADF (44.34%), NDF (54.02%), Ca (0.68%), P (0.07%), OMD (39.63%) and ME (5.47%). *Philenoptera nelsii* had total ash (5.31%), EE (1.66%), CP (15.7 %), ADF (43.75%), NDF (57.04%), Ca (0.97%), P (0.07%), OMD (43%) and ME (5.83%). *Acacia ataxacantha* had total ash of (5%), EE (2.20%), CP (12.99%), ADF (43.18%), NDF (54.93%), Ca (0.92%), P (0.08%), OMD (42.30%) and ME (5.87%). *Colophospermum mopane* recorded total ash of (6.41%), EE (8.82%), CP (9.40%), ADF (36.8%), NDF (47.10%), Ca (1.42%), P (0.10%), OMD (29.27%) and ME (6.27%). On farmer's perceptions 43% used bush–feed during summer, 34 % in autumn and 23 % in spring. Study found means of proximate composition and energy values for all tree species were equal. It is recommended that farmers should be educated on benefits of knowing chemical composition of tree species in developing various products. Information adds to their Indigenous Knowledge (IK) to better manage their animals during the dry seasons.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
ANOVA	Analysis of Variance
CBNRM	Community Based Natural Resources Management
CF	Community Forestry
CP	Crude Protein
EE	Ether Extracts
FMB	Forest Management Body
GIZ	“Gesellsschaff fur Intenationale Zusammernarbeit” (Germany Development Organization)
ICP	Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)
ME	Metabolisable Energy
NCPA	Charcoal Producers Association
NDP	National Development Plan
NDF	Neutral Detergent Fiber
OUT	Open University of Tanzania
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
TB	Tuberculosis
VIF	Voluntary Intake of Feed

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

The dry tropical forest of Africa is constituting about 38% of the continent and is characterized by an average of annual rainfall of not more than 600 mm. Approximately 45% of the Africa area is categorized as desert while the remained area constitutes of the arid and semi-arid zones which actually are the portion capable of supporting plants, animals and human life (Dicko and Sikena, 1981).

The evolution of human beings comes along with animal husbandry as source of meat, leather, draught power and kraal manure where their livelihood depends on. As people population expands, it goes parallel with demand of those basic products and services. The severe forages scarcity in dry tropical forest areas, herbivores are forced to eat anything including pieces of paper and plastic materials. Discarded woody materials are regarded as encroacher bush / tree twigs, leaves and pods, which farmers are cutting them down to waste. Encroacher tree / bush species are referred to as an excessive increase in density and cover of one or more indigenous woody species that exploit disturbances of the grass / bush balance at the expense of grasses (Neuberger, 2016).

Namibia’s rangeland is experiencing bush encroachment problem gradually taking over both in the communal and commercial land. Bush encroachment on savannahs landscape mainly caused by a reduction in the frequency of fires and overgrazing of livestock. The grass layer on savannahs loses its competitive advantage and its ability to utilize nutrients and water efficiently, because of higher infiltration of water and nutrients into the sub-soil. This situation may benefit bush and tree species, as well as the other plants. The population of people and livestock is noted to be on a steady increase, which results in serious challenge of availability of feed in the rangelands.

Grazing capacity of large area of the Southern African savannahs was reported to have declined, due to bush thickening. And often to such an extent that many previous economic livestock properties were now no longer economically viable (Smit *et al.*, 2016). Bush thickening is a serious ecological and economic problem of the rangelands in Namibia's livestock sector. According, to Smit *et al.* (2016), areas affected by bush thickening in Namibia are estimated to be between 260,000 km^2 to 300,000 $km^{2,}$ which means that a huge area of rangeland has been taken over by various encroacher species. It was estimated that Namibian farmers loose about N$1, 6 billion annually in foregone meat production, due to bush encroachment in the area.

However, many subsistence and commercial farmers were left with no option, but to strategize how to sustain their livestock especially during difficult situations of persistent drought spells. For the past decades, some commercial farmers have been trying to produce animal feeds by using the twigs, pods and leaves from the encroacher bushes. They were doing it by cutting the certain bush species, milling with a hammer mill and mixing the crushed bush with supplement such as molasses, urea or pods to increases its nutritive values. The option to produce animal feeds from encroacher indigenous trees and other bushes is a best way of adding value to forest products. Some commercial farmers have imported bush-feed processing machine from South Africa called "Bos- Kos" in Afrikaans language. The machine described as doing tremendous and incredible work, because it enables farmers to maintain number of livestock even during severe drought by utilize discarded woody materials.

Appendix II is displaying the example of Kos- Bos machine owned by African Wild dog Community Forest (AWCF). Farming in Namibia is traditionally and commercially dominated by rearing of small and large livestock. This study defined animal feeds as part of trees such as pods, leaves and tender twigs, which are palatable to animals.

According to Norton (1994), fodder trees provide significant natural source of feed for grazing animals especially ruminants in many different parts of the world. Yet, relative contribution to the diet will depend on both the availability and accessibility of tree fodder and the feed preference of the animal species at that particular time of the year. Bush-feed have been ignored in feeding systems for ruminants mainly because of inadequate knowledge on various aspects of their potential to be used as initiatives associated with the development of more innovative systems of feeding (Devandra, 1990). The term "composition and energy values" used in this study is comparable to the definition by Norton (1994), as the ability of feed to provide the nutrients required by an animal body for maintenance, growth and reproduction although this study did not assess the ability of species under study to do the same.

Composition values cover a wider range of amino acids, vitamins and others. This study focussed on certain basic values namely; ash, fat, calcium, phosphorous, fiber, crude protein, organic matter digestibility and metabolisable energy that measure nutritive level of the plants. Bush-feed making is opportunity for value addition to woody materials of which community forests have a prospective to generate income. These efforts have been done in a trial and error approach, which is surrounded by absence of guidelines and reliable knowledge to the farmers. Despite this, a number of farmers that are found practising bush-feed making in Namibia, without adequate knowledge of the proximate composition and energy values that tree can offer are many.

Community forestry is a programme that contributes to the Namibia's national development objectives of: poverty reduction, employment creation, and enhanced environmental and ecological sustainability (Namibia, Directorate of Forestry, 2012). According to Pandey and Padyall (2015), community forestry programmes were adopted worldwide as a branch of forestry that deals with the communal management of forests for generating income from timber and non-timber forest products. It also serves as source of goods while on the other hand regulating ecosystems. Downstream settlements benefit from watershed conservation, carbon sequestration and aesthetic values in the form of services. This study commissioned to determine proximate composition and energy values of the *Acacia ataxacantha, Colophospermum mopane, Philoneptera nelsii* and *Baphia massaiensis* species, which are regarded as encroacher bush in community forests landscapes.

The importance of investigating proximate composition value of selected indigenous tree species in the northern Namibia was envisioned to scientifically prove the elements found in the selected tree species. These elements can be a guiding document to the livestock farmers and feed producers to use them in animal feed production. The results of this study can contribute to the national database on tree composition information, which is vital to botanists, extension workers, farmers and scholars. This study is also aligned to the Forest Research Strategy for Namibia (2011-2015), which emphasizes on the potential of value addition to woody materials that have not yet been exploited (Directorate of Forestry, 2011). Forest Research Strategy also emphasizes on the effort to use such discarded woody materials to provide electricity, charcoal, firewood, fiber boards, vinegar and as well as bush-feeds. Apart from the potential to manufacture reconstituted wood products, there is a dire need to further research on the various wood based produces in Namibia.

The Government, through the National Development Plan (NDP 4), has committed to encourage farmers to carry out bush thinning in order to improve ground water recharge rates, create employment opportunities, increase livestock production and food security. This noble objective also responds to the President's Harambee Prosperity Plan, which aims to accelerate development efforts with regards to poverty and hunger reduction, youth unemployment, water and energy supply shortages. It is noted that clearing the encroacher bush without adding value to the biomass is a costly exercise that results in prolonged negative cash flows estimated up to 16 years for a harvester / farmers, regardless of the method used.

This study conceptualize on finding solutions that lead to improve income for community forests by identifying and defining end products that could be derived from discarded woody materials with economic values. The study field and laboratory work was fully supported by Ministry of Agriculture, Water and Forestry, through the Directorate of Research and Training. Laboratory division provided guidance on preparation of the composite samples and analysis. This study highlights the proximate composition and energy values, ideal harvesting season and why farmers prefer to use bush feed to better to socio-economic sustainable development.

Thus, this study help to share and help to meet the year 2030 world agenda of the Sustainable Development Goals (**SDGs**) 1; 2; 3; 6; 8; 12; 13 and 15. These **SDGs** in short states that: Goa l: End poverty in all its forms everywhere; Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Goal 3: Ensure healthy lives and promote wellbeing for all at all ages. Goal 6: Ensure availability and sustainable management of water and sanitation for all. Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. Goal 12: Ensure sustainable consumption and production patterns. Goal 13: Take urgent action to combat climate change and its impacts. Goal15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.

1.2 Statement of the Research Problem

Namibia has not been spared from any other African countries, whereby majority of its people are living in rural areas where their livelihoods purely depend on crops, livestock and forest resources. Encroacher bushes / trees are a serious problem in Namibia which has been developing into huge biomass resources estimated at 200 to 300 million tonnes (Development Consultants of Southern Africa, 2015). The Government of Namibia is embarking on rangelands restoration and controlling the indigenous invasion on the tree species. Many community forests and communal conservancies are also experiencing bush encroaching problem too. Hence, discarded woody materials that are harvested to waste are now converted into valuable products such animal feeds, charcoal, chips, composite to generate extra income for community forests and farmers. Development of these products is done without knowledge of proximate composition, energy values and its ideal season of harvesting for bush feeds. This study was therefore envisioned to determine the certain proximate composition and energy values of the selected encroacher native tree species namely: *Acacia ataxacantha, Colophospemum mopane, Philoneptera nelsii* and *Baphia massaiensis* which are dominant in the northern part of Namibia. Chemical composition values of these trees would ensure proper management and uses of discarded woody materials from encroacher trees / bushes as bush-feeds and other wood related products for the Socio-economic sustainable development of Namibia.

1.3 Research Objectives

1.3.1 General Objective of the Study

The objective of this study was to determine the usefulness of discarded woody materials of selected encroacher tree species as bush-feeds of savannah landscapes in Namibia.

1.3.1 Specific Objectives

(i) To analyze proximate composition and energy values in the selected encroacher tree species and its seasonality change.

(ii) To determine mean variation of the proximate composition and energy values between the selected tree species.

(iii) To assess farmer’s perceptions on the uses of discarded woody materials from selected encroacher tree species in relation to different seasons.

1.4 Research Questions

(i) How much proximate composition and energy values in the selected encroacher tree at a given season?

(ii) Are there mean differences of proximate composition and energy values of these selected trees?

(iii) How do farmers perceive the use of discarded woody materials from encroacher tree species as bush-feed in relation to different seasons?

1.5 Significance of the Study

Namibian woodland are administered into two categories namely; communal and commercial lands. The country has sixty one (61) community forests whereby thirty two (32) are registered, while twenty nine (29) are in the process of being registered all of which forms part of the communal land. Community forests and conservancies cover about 8.4 million hectares and an estimate of more than 500,000 people and more than 3 million livestock said to be directly benefiting from forest resources (Namibia, Directorate of Forestry, 2012).

This motivated the researcher to investigate the proximate composition and energy values of selected encroacher tree species that have the potential to be converted into animal feed. Proximate composition values of many fodder species are not known by fodder producers and end users by the livestock farmers. The outcomes of the research revealed the proximate composition and energy values of selected species and same time it provides guidance regarding the best time of the year of harvesting woody materials. The study also aimed in responding to the Forest Research Strategy for Namibia (2011 -2015), of which value addition to forest products is one of the thematic areas. A report on adding value to the Namibian encroacher bush-feeds, also made recommendations to identify species that are suitable for bush feed production (Development Consultants of Southern Africa, 2015). Study is also significant to the following stakeholders in relation to sustainable forest management and the world agenda of sustainable development goals by the year 2030:

(i) Forestry officials dealing with dissemination of information to and from communities. They would use the information as a model to advice and support farmers and Community Forest Management Bodies (FMBs) to makes appropriate planning.

(ii) Study outcomes would serve as reference to advise the Directorate of Forestry in order to convince donor institutions to support communities in developing forest based businesses that aim to improve people's livelihoods and creates employment opportunities. On another angle, the study results would help to influence the forestry policy makers in favour of addressing poverty.

(iii) Communities would use the information of composition and energy values to influence investors so that they attracted by this nature of business. It serves as eye opener and creates a link between them and business people in industries in the country.

(iv) Investors are crucial component in terms of development of new products out of any natural resources. It is therefore, very important for investors to be informed before engaging in any type of business. Hence, the research outcomes would serves as eye opener which could convince investors and communities to develop new products out of discarded woody materials if they find it significant. In that case, it gives assurance to the investors to explore the business viability, unlike the situation where tree proximate composition values are not known.

(v) The government plays a role of enforcing laws and regulations over all natural resources. At the same time they devolve rights to communities to sustainably use of forest resources. The study can help the governments on how to encourage farmers to manage and sustainably use the trees discarded materials as raw materials of animal feed production.

(vi) The results of this study can go to the national database for tree species especially those whose proximate composition and energy value information was limited that would be useful by botanists, farmers and scholars in future use.

1.6 Conceptual Framework

Study concerted on tender twigs including leaves and pods especially from discarded encroacher tree species that are cut down in order to restore rangelands. The study defined fodder trees as trees bearing leaves, pods / fruits and tender twigs which are palatable to livestock and wildlife animals. The study aims to discover certain proximate composition and energy values that translated into what is known as nutritive values of woody materials. This study highlights the certain proximate composition and energy value of selected encroacher trees that have potential to be processed for bush-feed or supplements for livestock and game during the dry seasons. As a result of de-bushing operations, which the Government of Namibia and individual commercial and communal farmers are embarking on to restore rangelands or pasture by removing unwanted bushes and trees. Those discarded wood materials are left to be decomposed instead of using them for useful product such as animal feed. For economic reasons, other woody parts could be processed further into various wood based products such as wood chips for electricity, fuel wood, droppers, poles and wood composite. Figure 1.1 demonstrates the application process of how to convert twigs into what is called bush-feed.

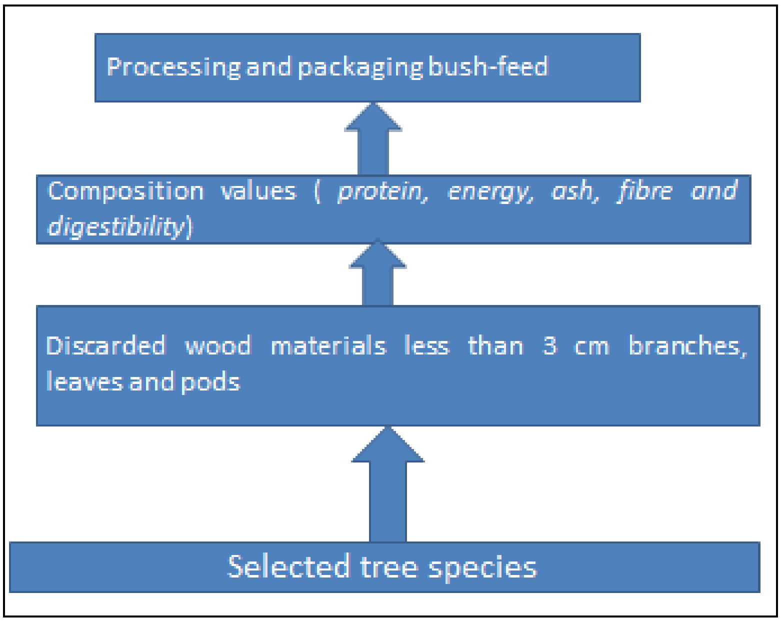

Figure 1.1: Conceptual Framework of the Study

Illustration above layout the ideal process of bush feed. The presence of nutrients such as nitrogen (N), phosphorus (P) and calcium (C) provide values, which is comparable to animal nutrient requirements. According to Devandra (1990), protein content falls rapidly with growth and reaches low level before flowering to extend, even below 7% in the dry matter. The level of protein in diets affects voluntary intake of feed (VIF) and low protein diets are not eaten by ruminants (Campling *et al.,* 1962); (Blaxter and Williams, 1963) as cited in (Devandra, 1990). Furthermore, estimation of the minimum requirement for crude protein of a poor quality diet with a digestibility of organic matter of 50% should be between 6.1 to 7.4 percentages. This study analysed composition and energy values content by determining the following parameters; protein, fats, ash, organic matter digestibility, metabolisable energy, phosphorus, calcium, neutral detergent fiber (NDF) and acid detergent fiber (ADF). For each of the following species; *Philoneptera nelsii, Baphia massaiensis, Colophospemum mopane,* and *Acacia ataxacantha* in consideration of seasonality (summer, spring and winter/autumn).

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

In most African countries livestock farmers in communal areas are heavily reliant on free rangelands where animals browse and graze on their own. This is a result of poverty in those areas and to address that, there is need to find the best way possible to adequately nourish the animals for their long term health and for them to have a good sale value. This can be achieved through feeding them with feed that is formulated using composition and energy values information gathered from studies like this one. Today many parts of world including Namibia, people are finding it difficult to feed their livestock, due to several factors such as severe droughts, erratic rainfall, competition of various land uses and increase in livestock population. People have developed various technologies to use bush and tree parts as feed in order to responds to the situation and maintain a reasonable number of their livestock during difficult times. The practice of bush feed has been going on for many years, yet people have less understanding of the proximate composition and energy values that bushes and tree can offer to the physiological development of animals. Information gathers from various scholars and that concluded in this study shall help to augment the conclusion and recommendation of the study about the composition and energy values of the selected encroacher tree species.

2.2 Proximate Composition and Energy Values of the Selected Tree Species

Tree leaves, pods and twigs form part a natural diet of many ruminant species and traditionally, they have been regarded as the major source of the foliage for domesticated and wildlife animals. During the dry season, livestock diets are limited by a shortage in the amount and quality of available forage and crop residues which result in reduction of livestock productivity in tropical countries (Njidda, 2010). Trees are playing a very important role in providing nutrient to grazing ruminants in semi-arid environments, especially where inadequate feeds are in constraint.

It has been proven that fodder tree maintain higher protein and mineral content during the growth in comparison with grasses which decline rapidly in quality with progress to growth (Shelton, 2004) as cited by (Njidda, 2010). Traditionally, farmers in the semi-arid part of Namibia allow their goats, sheep and cattle to browse on tree forages, in the rangelands and they also cut and feed these tree foliage as supplements based only on their experience and convenience. Most of these indigenous tree species endowed with coping ability, as natural restoration.

According toNorton (1994), many plants produce secondary metabolites, which are not directly involved in the process of plant growth, but act as deterrents to insects and fugal attack. Such compounds are also affect animals and the composition value of the feed. For example mycotoxins of fungal metabolites are produced by saprophytic and endophytic fungi, which serve as a source of toxin in the feed. The palatability of a feed is related to both physical characteristics in regards to hairiness and bulk density and the presence of compounds which may affect taste and appetite such as tannins and soluble carbohydrates which not covered in this study.

The utilization of feed is limited by high lignin, phenols content and the presence of anti-nutritional factor, which may be a toxic to ruminants (Njidda, 2010) and

(Macdonald *et al.*, 2010). However, the toxic compounds said to be harmful, when the materials constitutes a high proportion of the diet. Thus, the effects of high protein feed could override the effects of the toxic compounds when used as supplements in the diets. This section covers the proximate composition values of the four selected tree species, which are *Acacia ataxacantha, Colophospermum mopane, Philoneptera nelsii* and *Baphia massaiensis* all native to the northern parts of Namibia. According to an Animal nutrition expert from the Ministry of Agriculture, Water and Forestry, the following elements were the best measure of balanced nutrition for animal health.

Moisture content is defined by the wood in its natural state, which contains cell wall substance imbedded with free water and other extractives. There are always some seasonal changes, but the largest amount of shrinkage happens when drying wood material from "green" to normal humidity levels (Eckelman, 2017). This wood material is dried to prepare for subsequent treatments with preservatives or other chemicals, it is important to know how much water could be removed before subject it to the solution.

Ash is referring to the inorganic residue remaining after the water and organic matter removed by subjecting wood materials into high temperature in the presence of oxidizing agents. The process provides a measure of the total amount of minerals within a feed. Ash contents a measure of the total amount of minerals available within the feeds. While **mineral content** is referring to a measure of the amount of specific inorganic components present within a feed for example Ca, Na, K and Cl. The most widely used methods are based on the fact that minerals are not destroyed by heating, and that they have a low volatility compared to other feed components.

Ether extracts (EE) known as crude fat. Some vitamins are stored in the fat and releases as they are needed by the body. Fat-soluble vitamins can be stored for extended periods. They include vitamins A, D, E, and K. Vitamin A helps to maintain internal and external linings which also necessary for a healthy reproductive tract. According toViljoen (2001), vitamin A is not readily available in most feeds. Cattle with lack of vitamin A are identified by sign watery eyes, a rough hair coat, and a reduced growth rate.

According to the Centre for Agricultural and Enviromental, Research and Trainng, 2002, "vitamin D regulates the absorption of calcium and phosphorus whereby animals make their own vitamin D when exposed to sunlight". Similarly vitamin E known to promotes good health of animals and a lack of it causes failure in the reproductive system. Vitamin E can also be found in alfalfa. Vitamin K is important for blood clotting, and mostly produced by bacteria in the digestive system of animals.

Organic Matter Digestibility **(OMD)** is described as the amount of available energy in feeds for ruminants which its value is close to the corresponding digestibility of energy (Pojic *et al.*, 2016). Energy value of ruminant feeds and its bio-availability is of great importance for animal feed manufactures and end users. Amount of available energy in feeds for ruminants is described either by its metabolisable energy or by organic matter digestibility (Barber *et al.*, 1990) as quoted by (Pojic *et al.*, 2016). Organic matter digestibility is associated with volunteer feed intake by animals. Digestibility of feed stuff is affected by many factors such as stage of maturity of the crop, botanical composition, dry matter intake, supplements, processing, and chemical treatment (Devandra, 1990).

Metabolisable Energy **(ME)** is a concept that has been used to exemplify the nutritional value of the animal feedstuffs. It is an estimate of the energy available to an animal from digestion of a feed material, expressed in units of mega Joules per kilogram of feed (MJ/kg DM) as reported by Aldeman, 1993. Feed materials are contained a number of chemical components such as fats, proteins, carbohydrates of which are potentially metabolisable by an animal and contribute to the energy content of the feed (Moran, 2005). These components are said not all contribute equally, for instance fats have higher energy content than proteins and the concept of ME has been developed to account for or such differences. It is considered that ME is a better indicator of a feed's ability to support animal production than the simple measure of dry matter content (Aldeman, 1993).

Acid Detergent Fiber **(ADF)** is defined as a measure of the plant components in fodders that are the least digestible by livestock, which include cellulose and lignin. According to Van Soest *et al.* (1991), if ADF increases, the digestibility decreases, so fodders with high ADF concentrations are typically lower in energy which by boiling forages in an acid detergent solution, then measuring the residue remaining. In the same way, Neutral Detergent Fiber (NDF) is measured by boiling the forage in a neutral detergent solution, then measuring the insoluble residue (Van Soest *et al.*, 1991). Both; ADF and NDF are factor into the crude fiber of fodder, which is the measure of total fiber content. Understanding helps to know ADF and NDF percentages because they can accurately predict forage intake as it relates to bulk; in simply words, how much an animal will eat before its stomach getting full and it stops eating. They are also a key for measuring energy levels and animal performance.

Neutral detergent fiber **(NDF)** is termed as a structural components of the cell walls. It said to be free-choice of the livestock because it provides low-calorie filler. It advisable to choose forages with low NDF percentages because these levels increase as forages mature.

Nitrogen as crude protein is organic compounds that contain carbon, hydrogen, oxygen, and nitrogen and sometimes iron, phosphorus, and sulfur (Viljoen, 2001). These required in growing the new tissues and to repair old tissues in an animal. It is noted that every day, 3 to 5 percent of the body's proteins are rebuilt whereby the highest quantities of proteins are found in the muscles of animals. The researcher also pointed out that the most common nutrient deficiency is the proteins. Since most feedstuffs are low in proteins, supplements such as soybean meal, cottonseed meal, fish meal, and legume hay are necessary (Viljoen, 2001). The protein deficiency symptoms are anorexia, slow growth rate, decreased feed efficiency, low birth weight, and lower milk production. Researcher also reveals that young animals need diets with higher proteins contents than older animals. It also recommended that animals in gestation or lactation stages require higher levels of proteins in their feeds. Proteins are comprises of various combinations of up to 26 amino acids. The essential amino acids are arginine, *histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine* (Georgievskii *et al.*, 1982). However, ruminants are gifted to synthesize all amino acids by microbial action in their rumen.

Phosphorus is one of the most important minerals in animal nutrition. According to Georgievskii *et al*. (1982) phosphorus and calcium is the most ample element in an animal's body after calcium, where by its 80% and 99% make up the bones and teeth, while the least found in the body fluids and soft tissue. Table 2.1 explains the average total content of phosphorus and calcium in the adult animals.

Table 2.1 Average Total Content of Phosphorus and Calcium in the Selected Adult Animals

Selected adult animals		Calcium	Phosphorus
Laying hen	(2 kg)	22 g	13 g
Sheep	(50 kg)	550 g	280 g
Fattening pig	(100 kg)	750 g	460 g
Dairy cow	(600 kg)	7,000-9,600 g	3,600-5,000 g

Source: http://www.feedphosphates.org/index.php

Phosphorus and calcium are supporting bone formation, improved digestion, regulated excretion, protein formation, hormonal balance, improved energy extraction, cellular repair, optimized chemical reactions, and proper nutrient utilization (Georgievskii *et al.*, 1982). It works in association with calcium to create strong bones, which can withstand the normal wear and tear. It also helps in relieving serious problems like bone loss or the loss of mineral density, also known as osteoporosis. Phosphorus is one of the most important elements in the creation of proteins, which further support in the reproduction process.

In the same manner, it helps bodies to utilize carbohydrates as well as fats. The most deficiency symptoms of phosphorus are weak bones and discomfort in various body joints of animals. Lack of phosphorus contribute to lower feed intake, reduced fertility, irregular or suppressed ovulation, and lower conception rates in the cattle. Optimum calcium and phosphorus ratios in laying hens, chicken, pigs and dairy cows are outlined as the following.

Table 2.2 The Optimum Calcium and Phosphorus Ratios in the Selected Animals

Selected animals	Ca:P Ratio	Ca:P Ratio
Laying hens	4.1 – 5.8	11.4 – 12.3
Broilers, chickens, pullets	1.2 – 1.5	2.2 – 2.3
Piglets, sows and fattening pigs	1.2 – 1.5	2.9 – 3.0
Dairy cow (600 kg; 35 kg milk / day)	1.15 – 1.4	–

Source: http://www.feedphosphates.org/index.php

According to the University of Maryland Medical Centre (2017), protein-rich foods such as meat, milk, poultry, fish, eggs, dairy products, nuts, and legumes believed to be good source of phosphorus. In addition, grains, hard potatoes, dried fruits, garlic, cloves, and carbonated beverages also provide phosphorus to both animal and human beings. For children calcium deficiency may cause delay in the initial start of teeth formation and other deformation such as poor bone. Phosphorus is a mineral that form up about 1% of a person's total body weight. In case of limited supply of phosphorus, animal suffer from a phosphorus deficiency, the consequences of which are varied, but in all cases affect the animal's physical well-being, and its economic performance. Trees are regarded as the central source of these essential elements. It is against these scientific analysis trees associated with multiple uses that human being appreciating in their daily accomplishments.

2.2.1 Physiognomy of the Acacia Ataxacantha

According to Amoussa and Sanni (2014), *Acacia Ataxacantha* (Fabaceae) is wide spread notably of sub-Saharan Africa. It is described as very thorny shrub scandent 5 to 8 m in height, while leaves are alternate, pinnate with spine that carries 5 to 12 pairs of pinnae. Twigs have short spines which are clearly pointing down and white flowers with a long transition axillary 4 to 5 cm long and arranged on stem 10 to 15 mm are sometimes isolated in pairs. Pods seem to be flattened and brownish red in colour at dry state. The dough sheet is cultural used to treat abscesses. The leaf decoction is used orally in febrile convulsions while bark is used against tooth decay, and inhalation in case of bronchitis and cough. According to Macdonald *et al.* (2010), its pods and seeds were used against dysentery in Nigeria. While in Eastern Africa-Kenya the roots are used traditionally to treat joint, back pains and pneumonia for human being (Kereru *et al.,* 2007). Plate 2.1 shows the *Acacia ataxacantha* flower and leaves.

Plate 2.1: ***Acacia Ataxacantha*** **Leaves and Flowers**
Source: http://tsammalex.clld.org/parameters/acaciaataxacantha)

Plate 2.2: ***Acacia Ataxacantha*** **Dried Fruits**

Source**:**https://cdstar.shh.mpg.de/bitstreams/EAEA0-3E4D-7593-FA47-0/full.jpg

The dominant encroacher bushes in Namibia are the Acacia species which several literatures state that it has several uses of social and economic values. *Acacia ataxacantha* (Flame-thorn) has described as scrambling shrubs or small trees growing up to 4 meter in tall and they are quite common in the north-west of Namibia (Mannheimer and Curtis , 2009). Frame-thorn often forms dense thickets along the rivers. It start flowering around November to April whereby leaves are occasionally browsed by elands. Traditionally, wood is used as rafter in central northern Namibia and due to its strength and flexibility utilized for bow-making in the northwest. Instance, Acacia wood has been popular with builders and decorators for thousands of years, and the Bible even mentions that Noah has built the Ark with it. Its colors range from a darkly lustrous burnt umber to a lively yellow that is so vibrant that it is almost white. There are more than 1,300 species of Acacia trees in the world today, and they cover locations as exotic as the wood itself. From Hawaii to deep in the Sahara desert, you will find Acacia trees. It is also a strong wood that measures 2,400 on the Janka hardness scale. Its toughness as a wood floor is corresponding only by its magnificent beauty. A few Acacia species produce wood that suitable for furniture, ornaments, flooring, firewood and pulpwood in the paper industry. Acacia wood is exclusively prized for furniture, because of its durability, lustrous finish, and varied shades (Mannheimer and Curtis, 2009). Geographically most Acacia species are known to be native to Australia, and the rest grow in tropical and temperate regions around the world. Apart for the timber, Acacia species are producing other products such as gum, tannin, edible shoots, seeds and flowers with both culinary and medicinal uses. Acacia flowers have known with good properties for perfume and aromatherapy. Figure 2.1 shows its geographical distribution and Figure 2.2 represents phenology.

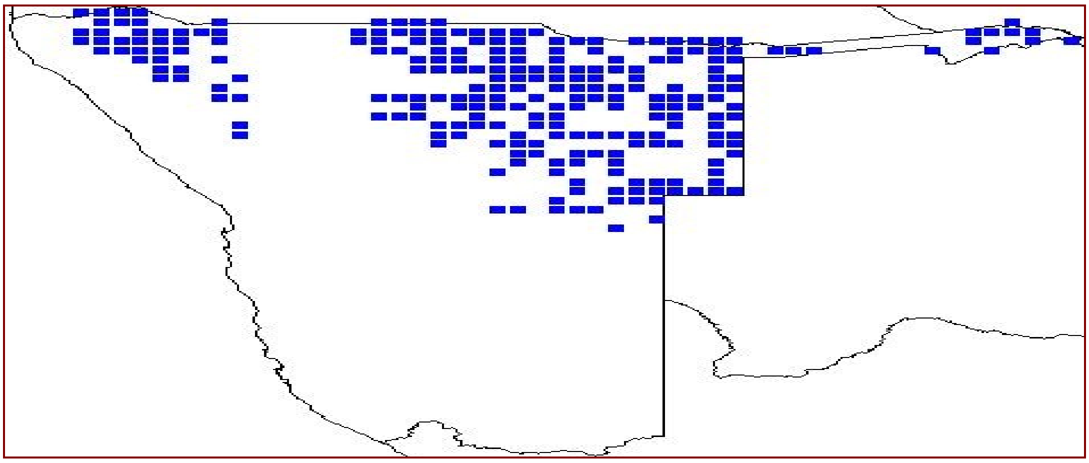

Figure 2.1: Distribution of *Acacia Ataxacantha* in Namibia
Source: http://www.biodiversity.org.na/taxondisplay.php?nr=3015

Figure 2.2: Phenology of *Acacia Ataxacantha* in Namibia
Source**:** http://www.biodiversity.org.na/taxondisplay.php?nr=3015)

Mineral Content of Acacia ataxacantha: Although the proximate composition and energy values of *Acacia ataxacantha* are largely scarce, some studies have shown that the composition of minerals in *Acacia ataxacantha* is significant for livestock. Macdonald *et al.* (2010) concluded that the leaves of *Acacia ataxacantha* have the potential for grazing, browsing and good feed sources that contribute to the diet of animals. Animals required minerals in trace amount but can be supplement from other sources if needed in high concentration. According to Daben *et al.(*2017), state that mineral composition of sodium is 0.01mg/100 g, iron and potassium is 0.02 mg/100 g even though are low, their values for normal body functions and animal nutrition is significant.

Sodium (Na) is useful as transport minerals and electrolytes. Iron (Fe) is an essential trace element for haemoglobin formulation, normal functioning of central nervous system and oxidation of carbohydrate, protein and fats. Potassium (K) is for normal retention of protein during humane growth (Amoussa and Sanni, 2014). Calcium, Zinc and Manganese concentration levels are low as 0.03mg/100 g for *Acacia ataxacantha*. Calcium is used for bone formation while Zinc and Manganese are useful for vitamins stabilization. Concentration levels of Magnesium and Phosphorus are (0.30%) and (3.95%) respectively are higher in *Acacia ataxacantha* leaves. Manganese (Mg) support normal growth while Phosphorus (P) is for bone formation according to their study.

2.2.2 Physiognomy of the *Colophospermummopane (Mopanetree)*

Colophospemum Mopane (mopane) is deciduous to semi-deciduous tree growing up to 15 m tall and dominant in eastern Caprivi (Zambezi region) and northwest of Namibia. It flowers around November to April, but the flowering season can be erratic, sometimes the trees in a whole area might not produce flowers for several years which symbolize low rainfall. The bark is said to contain approximately 8.7% of tannins and is traditionally used to tan leather (Mannheimer and Curtis , 2009). Young shoots are eaten by elephants, springbok, cattle and goats. It is also reported that in serious drought conditions sugary substances secreted by plant lice are found on leaves and is which regarded as a sign of high nutritional value. Leaves are also known to have various medicinal uses such wound disinfectant and stop excess bleeding.

According to Madzibane and Potgieter (1999), VaVhenda people live in South Africa, they described the mopane tree as multipurpose with several uses such firewood, poles, grain storage, pestle and medicinal. When women are travelling for long distances they chew the young, white inner bark (cambium) or the leaves of mopane and then apply the juices on the chaffing. Outer part of mopane is crushed with stone and then boiled in water for approximately 30 minutes and they drink to cure stomach pains. The red inner bark of mopane is boiled for treat sores or cancer. Thin secondary roots of mopane are also boiled and extract is used as mouth wash or drink as tea to treat gum breeding. The young mopane roots are boiled and extract drunk to treat kidney stones it also given to babies to stop diarrhea and vomiting. On the veterinary uses young secondary roots of mopane are boiled to treat cattle swollen limbs.

“In Namibia, during the Ovaherero ancestral worshiping ceremonies, the headman decants water into bowl with mopane leaves to perform their rituals. Ashes from burnt wood are high in calcium (15.5 %) and are used as fertilizer” (Mannheimer and Curtis, 2009). Mopane wood is one of southern Africa's heaviest and difficult to work on, because of its hardness, which makes it termite resistant. Its hardest properties make mopane suitable for construction houses, fences, railway sleepers and pit props”. The termite-resistance and reddish colour quality also make it popular for flooring. While outside Africa, mopane is gaining popularity as a heavy, decorative wood, its uses including aquarium ornaments, bases for lamps or sculptures, and garden accents (Madzibane and Potgieter, 1999). It is further stated that mopane wood is in demand to be used in the manufacturing of musical instruments, especially woodwind. The wood is also popular to make charcoal for braai meat. Plate 2.3 display characteristic of mopane tree stand and leaves and Plate 2.4 display the seeds.

Plate 2.3: ***Colophospenum mopane*** **Tree Stand and the Leaves**

Source: http://tropical.theferns.info/image.php?id=Colophospermum+mopane

Plate 2.4: ***Colophospermum mopane*** **Seeds**

Source: http://tropical.the ferns.info/image.php?id=Colophospermum+mopane

Mopane trees are main source of the mopane worm's food, known as the caterpillar of the moth *Imbrasiabelina*. Caterpillars are rich in protein and people are eating them, which even sold in the local market as a delicacy. When the cattle eat the silky cocoons of these moths together with the leave they may die. Butterfly-shaped or bifoliate leaf together with thin seedpod make mopane tree distinctive and easy to differentiate. In terms utilization mopane categorized one of the three regionally important firewood trees, together with Camel thorn and Leadwood.

"The mopane worm is distributed throughout Mozambique, Malawi, southern Zimbabwe, northern South Africa and north, east, central Botswana and northern Namibia, but not entirely restricted to, the distribution of the mopane trees (*Colophospermum mopane*). Adults of the mopane worm are described as large and robust moths with wingspans of approximately 120 mm" (Veldtman *et al.*, 2017). The moth identified by colored wings, which vary from fawn to shades of the green and brown to red. On both fore and hind wings, there are white and black bands, which isolate the eyespots. The hind wings orange spots are much bigger than the forewings eyespots. The males have feathery antennae, which they use to detect females if they are nearby. Larvae (caterpillars) can grow to be as big as 10 cm and approximately 1cm in diameter. They can be described as dominantly black in colour with scales that are round and appear in blurry, irregular reddish, yellowish and sometimes whitish bands and they also have short red or blackish spines, which is covered in white hairs which are fine.

Colophosphermum mopane is the tree whose name was used to name the worms owing to their preferred host plant. They however feed on other tree species like *Carissa* spp.*, Diospyros* spp.*, Ficus* spp.*, Searsia* spp.*, Sclerocaryacaffra, Terminalia* spp. And *Trema* spp. unless the tree is completely defoliated due to large numbers; the caterpillars have a tendency of staying on the same tree on which the eggs they hatched from were laid. Normally summer is the hatching season for the eggs and when they hatch, they grow into becoming caterpillars, which will feed on the leaves or foliage while foliage stocks last. If they completely defoliate the tree, they will move to the nearest tree as they go through the four molts and the fifth larvae stage. The best stage to harvest the mopane worms is during the fourth molt.

Surviving mopane worm burrow itself underground where they pupate. The mopane worm spends the entire winter in its pupal stage, after which there is a complete transformation into being an adult moth. These adult moths are short-lived (3-4 days) so they do not feed and this time is utilized by mating and females laying eggs. Mopane worms also help the Mopane dominated ecosystems in that they convert plant matter into nutrients that are available to other animals and plants. Local people also benefit economically from these abundance occurring worms, which are an affordable but rich protein source. However, they are not without their drawbacks as in years in which they occurs the most they deplete foliage which other browsing animals depend on. They however have a defense mechanism of burrowing underground to pupate so as to escape the harsh winter and reduce the risk of being over harvested by people. The ecosystem has a way of preserving the depletion of the Mopani worm species due to the large number of eggs laid by the female moths and the large number of caterpillars hatching.

Mopani worm is bivoltine in most areas that is; two generations are produced each year. The first major outbreak of mopane worm is being between November and January followed by a minor second outbreak between March and May (Van Voorthuizen, 1976). YetVan Voorthuizen (1976) pointed out that Mopani worm population numbers vary from year to year at a single locality. Although Robert

(2002), also pointed out that the population numbers are on the decrease as a result of increase in their exploitation, declining selective harvesting and general decrease on the Mopani woodlands due to deforestation. Essentially, *G. belina* requires ecological harvesting so as to ensure a good crop for the following season. According to Dube (2010), a woodlot of 4,000 hectares would support 19 million worms, which would translate to 193 tonnes of Mopane worms. Normally, G. belina life cycle start in October when the eggs hatch marking the first generation (Wiggins, 1997), (Timberlake, 1996) and (Toms, 2001) confirmed that, young Mopane worms or larvae feed on the leaves of the Mopane trees where they hatch and as they grow, molt 4 times and there are five larval stages before they reach their maximum size.

According to Durst *et al.* (2010), "Mopane worms are gathered by hand from the ground and from the trunks, branches and leaves of the trees. In some cases trees or branches are cut and the larvae harvested." The Mopane worm has a tough skin and is protected by black or dark reddish brown spines, which are painful and cause lacerations and the spines and associated hairs have a slight rusticating effect. In addition, when the larvae are handled, they often exude a slimy green fluid from the mouth (Mujuru *et al.,* 2014). According to Kozanayi and Frost (2002) the fluid irritates any scratches on the hand, so hand protection (by use of gloves) helps their harvesting and degutting. Stack *et al.* (2003), noted that, traditional method of degutting by hand is common and faster, hence the most preferred method. Plate 2.5 displays the mopane worm at harvestable stage. Figure 2.3 shows geographical distribution of mopane species in Namibia. While, Figure 2.4 indicates seasonal phenology of mopane species.

Plate 2.5: *Imbrasiabelina* (Mopane Worm)

Source: https://en.wikipedia.org/wiki/Mopane#/media/File:Mopane_worm_on_mopane_tree.jpg

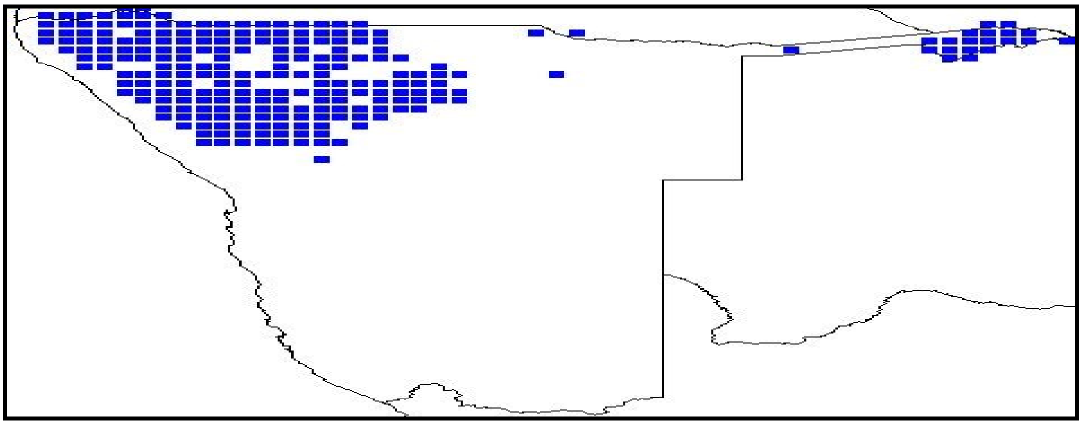

Figure 2.3: Distribution of Colophospenummopane in Namibia

Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=119

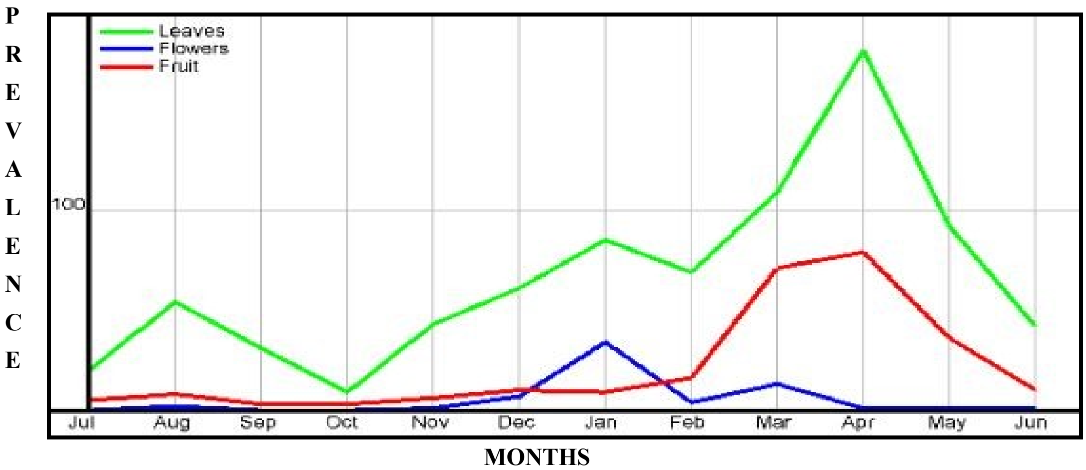

Figure 2.4: Phenology *Colophospermum Mopane* in Namibia

Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=119)

Mineral content of *Colophospernum mopane:* According to Hogan (2017), “Mopane leaves, twigs, seeds and pods are nutritious and provide essential browse for herbivores, especially during the dry season”. The nutrient concentration in mopane does not vary that much over the year, however there is a sizeable variation in secondary metabolites concentrations throughout the year.

Browsers ability to digest mopane during the dry season is high but drops during the summer season, which is influenced by high amount of secondary metabolites. Mopane develop secondary metabolites during the budding period so as to limit browsing pressure, which thus enables it to grow and produce with minimal browsing disturbances. It is further concluded in this review that the variation in mopane leaf quality is proportional to the growth rate and age of the leaf, as determined by rainfall, which defines the growing seasons.

Although their study concentrated on the nutritive value of the Mopane tree to animals, their study offers valuable information into the importance of the Mopane tree to humans as well. Their study concluded that green mopane leaves contain high amounts of tannins and phenols, as opposed to reddish-brown aged leaves. Another study in South Africa concluded that on average, mopane foliage contained “5.8 g ash; 14.1 g crude protein, 38.0 g neutral detergent fiber, acid detergent fiber 30.7 g, acid detergent insoluble N 1.0 g, acid detergent lignin 14.6 g and ether extract 4.2 g. The mean content of macro-nutrients in the foliage has been estimated per 100 g dry matter at: Ca 1.0 g, P 0.16 g, K 0.8 g, Mg 0.2 g, and Na 0.004 g. The mean content of micro-nutrients was assessed per 100 g dry matter at: Cu 0.8 mg, Co 0.3 mg, Mn 5.6 mg and Se 0.01 mg per 100 g dry matter” (Palgrave *et al.*, 2003). Foliage contains relatively high concentrations of condensed tannins, which tend to diminish in older leaves, making them more acceptable to browsers during the dry season. In addition small amounts of leaves added to the diet of young pigs increased their growth rate and production.

2.2.3 Physiognomy of the *Philenoptera nelsii*

Philenoptera nelsii (kalahari apple-leaf) is a deciduous shrub or tree growing up till about 12 meter high and occurs in Kalahari sand areas which are frost free and conspicuous in autumn which turns leaves yellow (Mannheimer and Curtis , 2009). The leaves provide excellent browsing source of food for livestock and game especially eland. Additionally, outer flaky part of the bark is traditionally scraped off and put in milk to promote curdling. *Philenoptera nelsii*'s bark is "yellowish-grey, smooth to slightly roughish and the leaves usually unifoliolate, rarely 3-foliolate, oblong to ovate, up to 12 × 5.5 cm, stiff and leathery, usually nearly hairless above, more or less densely velvety below; margin entire" (Mannheimer and Curtis, 2009).

Inflorescences sprays, (axillary or terminal) up to 300 mm long, usually appearing before the new leaves. Flowers are described as mauve, lilac or purplish. Pod flattened linear, 5-9 × 1 cm, finely velvety, straw-coloured, and indehiscent. (Mannheimer and Curtis , 2009) argued that; "The Kalahari apple-leaf is conspicuous from September to October when covered in a cloud of purple to pink flowers humming with large black bumble bees and a variety of other insects. The large, leathery leaves look much like the leaves of apple trees, hence the common name in the various European languages spoken in Namibia." He further indicated that *Philonepthera nelsii*'s general occurrence is common on sandy soil prevalent in northern Namibia especially the line connecting Epupa, Omaruru, Okahandja and Buitepos. Along the B1 road, the tree occurs inside the road reserve on the hill at the southern part of the Okakararaturn-off (C22 Road), while its prevalence can be seen also along the B2 road to the north of Otjiwarongo. *Philenoptera nelsii* is usually a single-stemmed tree with a circular crown and it can grow up to heights above 10 m. The dull greyish-yellow stem is well smoothened and the rectangular leaves are relatively large, it can be up to 12 x 5 to 6 cm, and rounded at both ends. Rough hairs cover the younger leaves, which disappear upon maturity. While young they are covered with rough hairs, which disappear as they mature. The veins are well pronounced on the underside than on the upper side of the leaves. In winter the leaves become yellowish and only fall just before the new buds appear in spring.

According to Hoffmann (2015)“numerous purple, pink and sometimes white pea-like flowers are borne on branched sprays in September and October before the reemergence of the leaves. They attract black bumble-bees, bees and many other insects. Having fallen, they form a mauve carpet under the tree and are eagerly eaten by the Damara dik-dik. Before the flowers open, the velvety, softly grey buds look like lace against the blue sky and are a lovely sight.” This assessment of the tree species shows that the leaves’ nutritional value begin to be experienced between September and October. Boiled bark can sometimes be drunk by the Heikumas a remedy for coughs and other chest infections. The leaves can be placed on boils and sores. The leaves can be used sometimes as a remedy when chewed for TB.

This practice is also done by the Ovaherero for the treatment of coughs, and the Himba people curdle their milk by adding the outer bark to the milk. Plate 2.6 was taken along the Okahao–Omakange main road in Omusati region during October 2016. It is easy to confuse the Kalahari apple leaf with other Combretum species but it is very important to note that the latter have opposite leaves and lack shoots or stipules, bear cream tinted flowers arranged with small spikes and developed into four-winged fruit so typical of the Combretum genus. Plate 2.7 displays the characteristic of its leave and Plate 2.8 shows flower. Figure 2.5 shows geographical distribution in Namibia, while Figure 2.6 indicates it's seasonally phenology.

Plate 2.6: ***Philenoptera nelsii*** **Tree Cattle Feeding on Dropping Flowers & Leaves**

Plate 2.7: ***Philenoptera nelsii*** **Leaves**

Source: http://www.zimbabweflora.co.zw/speciesdata/image-display.php?species_id =131210&image_id=6

Plate 2.8: *Philenoptera nelsii* Flowers
Source: http://www.flickriver.com/photos/tags/philenoptera/)

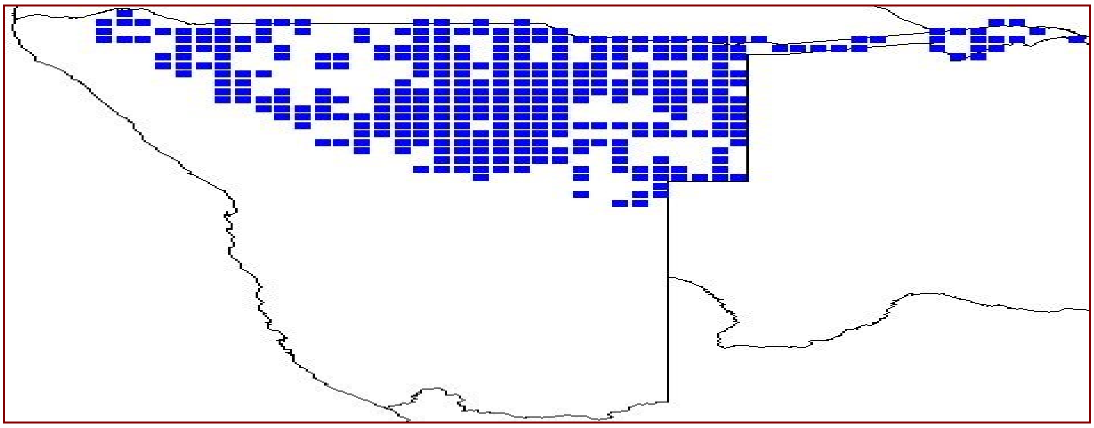

Figure 2.5: Distribution of *Philenoptera nelsii* in Namibia
Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=457)

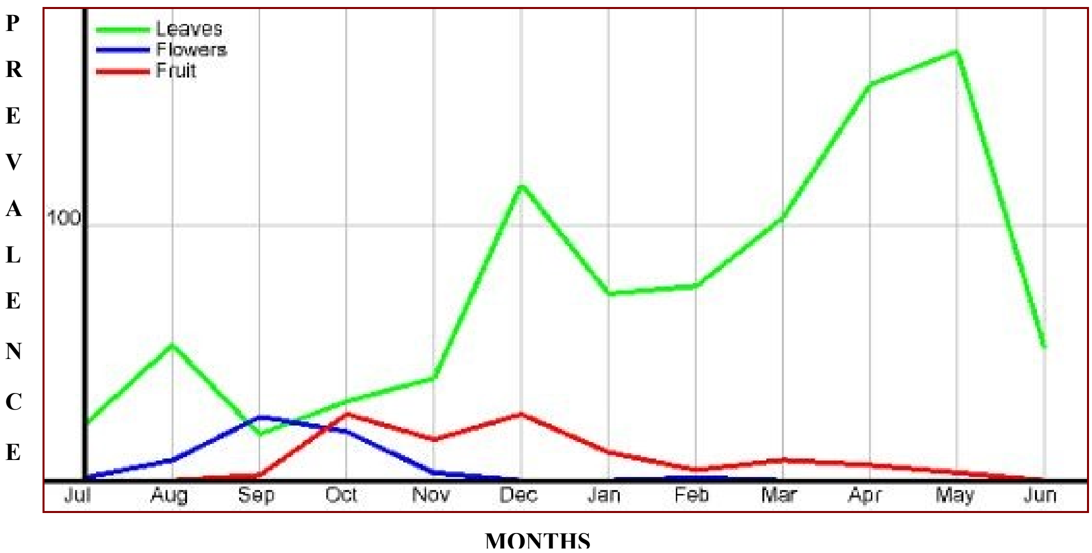

Figure 2.6: Phenology of *Philenoptera nelsii*

Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=457)

2.2.4 Physiognomy of the *Baphia massaiensis*

Baphia massaiensis is commonly known as Sand cam wood, and its leaves and flowers are browsed by goats, cattle and eland, except during the winter (Mannheimer and Curtis, 2009). They are described as semi-deciduous or evergreen shrubs, which occasionally occur as a small tree that can grow up to 10 meter tall. They are abundant on Kalahari sand in northern, central and northeast of Namibia.

According to Fern (2014), "The tree is sometimes harvested from the wild for local use as a coffee substitute and for making toothbrushes. The plant is quite attractive, producing flowers in attractive short sprays, these are white with a yellow spot at the base of the standard petal, and are sweetly jasmine-scented." Plate 2.9 displays a shrub followed by Plate 2.10, which shows flower and Plate 2.11 the seeds.

Plate 2.9: *Baphia massaiensis* tree

Source: http://www.southernafricanplants.net/plantdata_sub.php?Mspec_ID=682

Plate 2.10: ***Baphia massaiensis*** **Leaves and Flowers**

Source: http://www.zambiaflora.com/speciesdata/image-display.php?species_id=127290&image_id=6)

Plate 2.11: ***Baphia massaiensis*** **Seeds**

Source: https://toptropicals.com/catalog/uid/baphia_massaiensis.htm

Figure 2.7 Display the Geographical Distribution of *B. masiensis*in Nambia

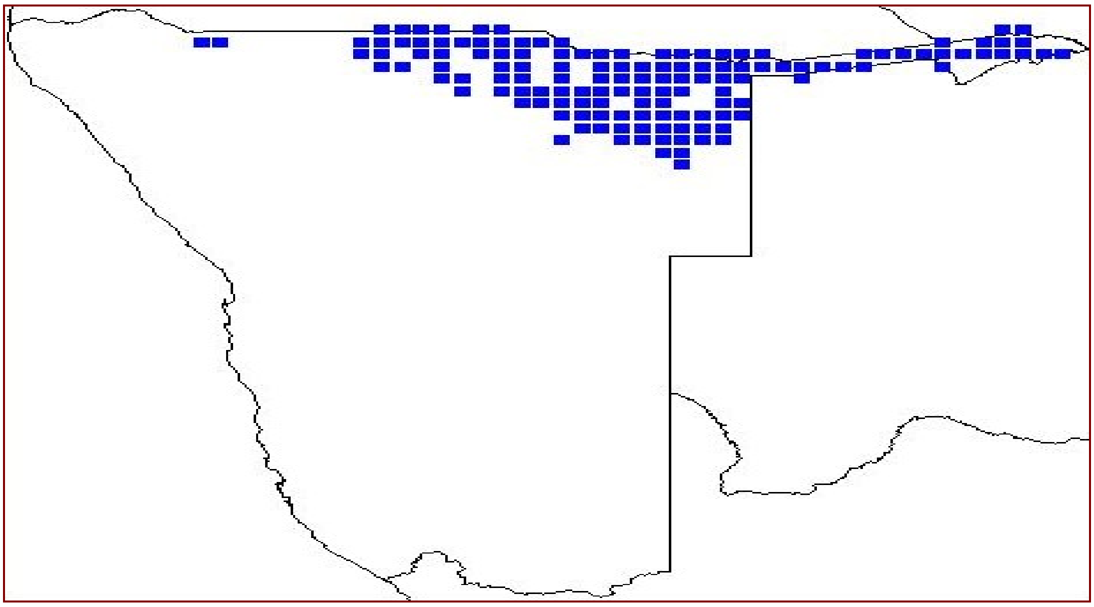

Figure 2.7: Prevalence of the *Baphia massaiensis* Tree in Namibia

Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=75)

Figure 2.8 indicates seasonally phenology of *B. massaiensis*

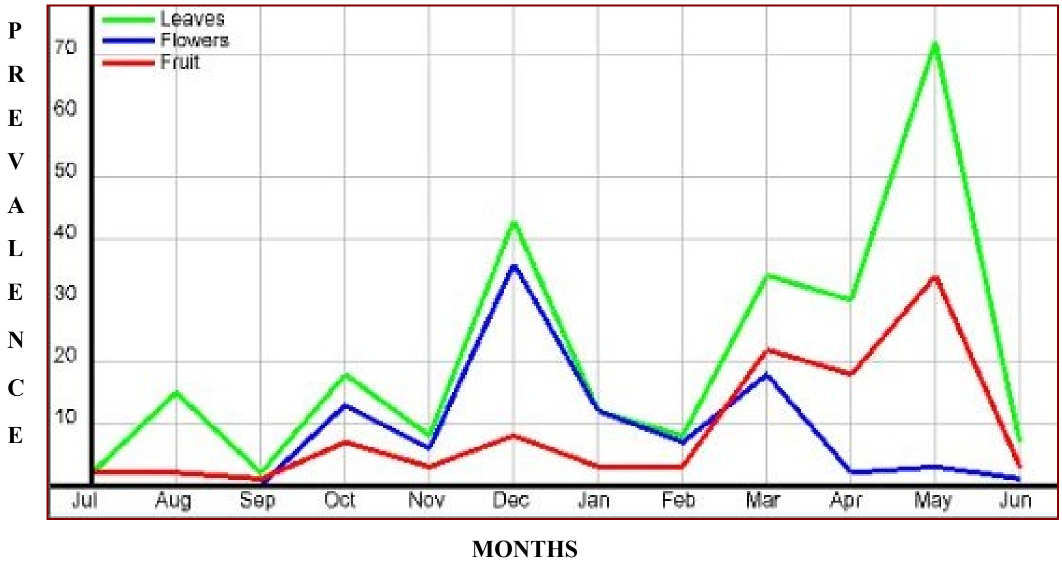

Figure 2.8: Phenology of the *Baphia massaiensis* Tree

Source: http://treeatlas.biodiversity.org.na/viewspec.php?nr=75)

2.3 Theoretical View of uses Plant Species from Savannah Woodland of Namibia

Bush feed production from encroacher/dominant tree species/bushes seems to be controversial point of discussion in Namibia. There are no formal value chains that produce animal feed from woody materials (Development Consultants of Southern Africa, 2015). The bush feed demand is highly depend on the annual rainfall and price of it in the market. According to Development Consultants of Southern Africa (2015) stated that the fluctuation demand has been demonstrated by import of feed from the bush in Namibia, which was about 2,000 tonne in 2012, 14,600 tonne in 2013 and 32,000 tonne in 2014. Experts are estimating that demand of feeds is ranging between 10 000 tonnes per annum for normal rainy season to as much as 150,000 tonne per annum of drought (Development Consultants of Southern Africa, 2015). The strength is that it has been concluded that technical production of animal feed from tree/bush is possible in Namibia.

In 2017, a survey for bush-based animal feed was conducted in Namibia by De-bushing Advisory Services (DAS) under the Ministry of Agriculture, Water and Forestry, which revealed that some farmers has been practicing bush -based feed, since 1972. Bush feed has been used by many farmers not only as drought emergency feed. Furthermore, about 50% farmers interviewed responded that they used it as supplement feed all year round as well as a feedlot feed (Namibia, Support De-bushing Project, 2017).

Farmers have attested to the fact that bush feed production eases the pressure on the rangeland and grazing. It is also allows maintenance of the herd size during times when there is shortage of fodder. The use of local pods and drought resistant fodder crops such as *Acacia erioloba* pods and spineless *prickly pears* as additions to bush feeds have demonstrated to be very suitable options to enhance the nutritive value for bush feed. In addition *molasses* is also used as affordable sources of energy and to enhance palatability and reduce dustiness in feed (Namibia, Support De-bushing Project, 2017). The survey also revealed that 60 % of the farmers interviewed acknowledge that they dry milled bush and store it which they mix with supplements before feeding while other farmers mix milled bush rights after harvesting. Fewer farmers are said to pelletize the mixture in order to increase storability.

2.4 Challenges of Establishing Suitable Tree species for Animal Feeds

The challenge for farmers and feed producers is to identify the best suitable tree species / bushes for producing animal feed. Therefore, steps taken to determine proximate composition and energy values of selected tree species can recommend the best tree and appropriate time for production. According to Development Consultants of Southern Africa (2015) there are challenges such as lack of reliable information regarding use of parts or whole edible bushes as well as production process. The wooden part may have lignin that hamper the digestion process of ruminants. The minimum requirement of ruminants for phosphorus varies from 1.2 to 2.4 g/kg feed dry matter depending on physiological functions whereby tree leaves generally have high concentrations (Norton, 1994). "Trees with a low Neutral Detergent Fiber (NDF) content (20-30%) are usually of high digestibility while species with high lignin contents are often of low digestibility and stem known to have higher lignin contents than leaves and are less digestible" (Norton, 1994). In the same view, Sulphur (S) in plant materials is mainly found in the form of sulphur amino acids and is required, together with nitrogen for microbial protein synthesis in the rumen. This goes to say that concentrations considered adequate are those greater than 1.5 g/kg dry matter or N:S ratio less than 15. It is a fact that tree leaves and pods form a natural part of the diet of many ruminant species and are traditionally used as source of forage for livestock especially in Asia, Africa and the Pacific (Norton, 1994). Approximately 200 species of leguminous trees which are reported to be used as forage mostly come from the *genera of Acacia, Albizia, Calliadra, Desmanthus, Desmodium, Gliricidia, Leuceana, Prosopis* and *Sesbania* (Brewbaker, 1986) as cited in (Norton, 1994).

In Australia most studies have been reported to be center around native tree species, which are generally of low nutritive value with *Leuceana* present as a high quality forage species at Northern Australia (Jones, 1979) as cited by (Norton, 1994). A similar study on nutritional analysis of local preferred fodder trees conducted in Nepal concluded that "nutrient content are fairly high in trees, however, their amount differs noticeable from one species to another" (Amatya *et al.,* 2012). It also found out that there is differences in proximate composition contents in between tree species occur with a change in seasons.

2.5 Establishment of Commune Forests in the Savannah Landscapes of Namibia

In Namibia the concept of establishing community forests is mainly to preserve communal land as rangelands and habitants for wild life animals. This study conceptualize on finding solutions that lead to improve income for community forests by identifying and defining end products that could be derived from discarded woody materials with economic sound. The results of inadequacies in management are small and often yield insufficient economic returns to keep the program afloat and furthermore keep communities interested in activities. In line with Namibia's initiative on Community Based Natural Resources Management (CBNRM) which is built on the basis of espouses sound environment and promotes the sustainable use of natural resources (water, wildlife and forest). CBNRM is constituted in such a way that endows local communities to manage and benefit from forest resources sustainability (Namibia, Directorate of Parks and Wildlife Management, 2013).

The approach is responding to the Constitution of the Republic of Namibia as second amendment of 2013. The article 100 of the constitution gives a provision of sovereign ownership of natural resources which states that all natural resources below and above the land in the continental shelf and within economic zones of Namibia belong to the state if they are not lawfully owned. The policies and legislation such as Forest policy, National Policy on Community Based Natural Resource Management and Forest Act of 2001 as amended in 2005, which has been in effect, empowers communities to conserve the natural resources in their conservancy areas so as to use them for the benefit and improvement of community's and individual livelihoods to mitigate poverty.

The review of the case studies on community-based forest management has shown that it emerged from the ineffectiveness of states over controlling forest resources. It was revealed that most states have been practicing the centrally-planned approaches to address conservation problems and crisis in demand of natural resources which often result in high levels of exploitation of natural resources (Hailwa, 2002). Since then, community-based forest approach has been widely adopted in conservation and management of forest resources.

Furthermore, forest management bodies fail to take full advantage of community-based enterprises due to constrain of cross-sectoral policies, legislation and absence of business development service providers. The Forest Research Strategy emphasizes on effort to use such tree species to provide electricity and the potential for manufacturing reconstituted wood products, which are exciting and need to be researched on.

The progress made in study has resulted in some of non-wood products such fruits and oil- producing nuts that have been used traditionally and have now found their way into the formal market and created much needed rural income. Some of these products include juice and oil from *Sclerocaryabirrea* (marula) that have been regionally and internationally marketed for decades. Most recently, natural gum from C*ommiphora wildii* has been also found their way into the cosmetic industry. These products are mainly harvested from shared land and community forests and local people are benefiting in the communal areas. In relation to the findings of above mentioned practices, Namibia is described as the 6th largest exporter of charcoal to the United Kingdom.

In the same view Kleinhas and Mbaurum, (2016) further revealed that country produces about 200,000 tonnes of charcoal annually mostly from commercial farms while communal land is not allowed or done illegal without records. The German Development Organization "Gesellsschaff fur Intenationale Zusammernarbeit" (GIZ) is in partnership with the Namibian Charcoal Producers Association (NCPA) helping them to manufacture/develop the new kilns that emits less smoke (Kleinhas and Mbaurum, 2016).

2.6 De-bushing of Government Owned Farms in Namibia

Namibia has taken a step to de-bush some of Government owned farms to increase agricultural productivity and youth employment creation. The Ministry of Agriculture, Water and Forestry Annual Report 2014/2015 reveals that a total of 2,650 hectares of land was de-bushed costing N$7, 5 million (Namibia, Ministry of Agriculture, Water and Forestry, 2015). De-bushing operation is an expensive exercise in term of manpower and machineries costs; while the materials were left scattered in the area or burned down. Grazing capacity of Southern African savannah is reported declining, due to bush thickening, often to such an extent that many previous economic livestock properties are now “no longer economically viable (Smit *et al.*, 2016). Bush thickening has since been dubbed a grave ecological and economic problem in Namibia’s rangelands. Area affected by bush thickening in the country is estimated to between 260,000 km^2 to 300,000 km^2 which is considered to have taken over large areas (Smit *et al.,* 2016). As a result, it is estimated that Namibian farmers loose N$1.6 billion annually in foregone meat production due to bush encroachment. Therefore determining proximate of certain composition and energy values of these species will respond positively to the Forest Research Strategy for Namibia (2011-2015) which indicates the existing potential that a country has not pursued such as a value addition to woody materials (Directorate of Forestry, 2011).

Government, through the National Development Plan (NDP 4), has committed to encourage and conduct de-bushing amongst others, to improve ground water recharge rates, increase livestock production, create employment and increase food security. These objectives also respond to the President’s Harambee Prosperity Plan to accelerate development efforts with regards to poverty and hunger, youth unemployment, water and energy supply shortages (Namibia, Ministry of Agriculture Water and Forestry, 2016). Thus, the study was made to determine usefulness of the discarded wood materials from the selected encroacher tree species that provide information on the potential of specific tree have and determine the best time of harvesting them for producing bush feed.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Location of the Study Areas

The study has been carried out in Namibia, formally known as South West Africa. In 1990, Namibia got its political independence from South Africa. Namibia is bordering with Atlantic Ocean on western; it's also sharing land borders with Angola and Zambia to the north, Botswana to the east and South Africa to the south. Namibia has a total area of about 824,292 sq km^2 of which 823,290 sq km^2 is land and 1,002 sq km^2 is sea water (Curtis & Mannheimer, 2005)Study samples materials were collected from two (2) classified forested areas called "community forests" (CF) located in the northwest and north-central of Namibia. A community forest is a forested area under the management of local people. Omufituwekuta community forest covers about 29,179 hectares (29.179 km^2) of the forested land and described as dry forest. It is located in North-central about 170 kilometers from Eenhana town and about 60 kilometers east of Okongo village council in Okongo constituency of Ohangwena region. Another study area was Ehi-rovipuka community forest, which covers about 222,014 hectares (222.014 km^2) and geographically located in northwest Namibia approximate 100 kilometers south of Opuwo town. It is administered from the Sesfontein constituency of the Kunene region. Ehi-rovipuka has been regarded as part of communal land until 2001 when it was registered as Ehi-rovipuka conservancy. The conservancy map is 100 % overlap with community forest.

Forest Management Body (FMB) members of the African wild dog community forest were interviewed to capture views on bush-feed experiences. The reason to select the study areas was based on the following factors: Availability of up to date valid forest management plans; Area where donor projects are supporting communities, in this case; African wild dog community forest are piloting animal feed processing; Accessibility in term of roads and telecommunications; Geographical location including rainfall gradient and species diversity also played role in selection of study areas. Figure 3.1 shows the geographically locality of Omufituwekuta and Ehi-rovipuka community forest in Namibia context.

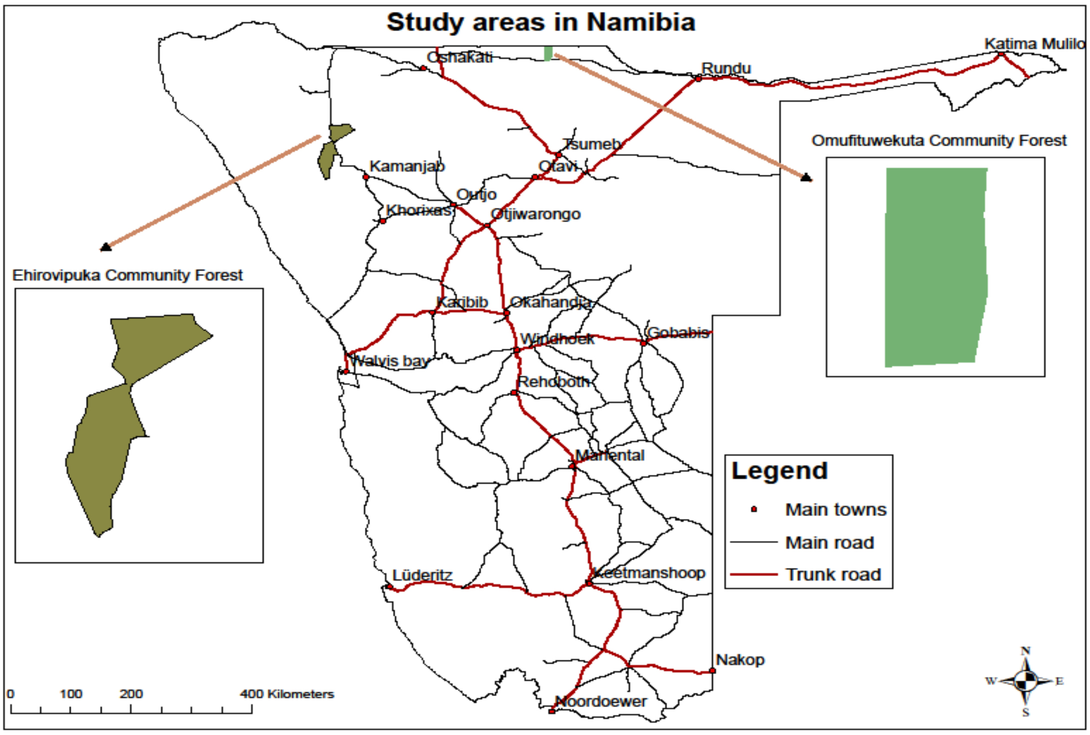

Figure 3.1: Map Showing The Location of the Study Areas in Namibia

3.2 Geology and Topography of the Study Areas

3.2.1 Omufituwekuta Community Forest

The topography of Omufituwekuta community forest features few pans, plain areas and hill tops. The plain is a typical topographic feature of the north central part of Namibia, although pans and hilltop also occur in patches. The soil is categorised as *ferralicarenosols* overlying sands and calcrete (Mendelson *et al.*, 2003). The landscape is described as flat with some small dune valleys and sand dunes. Soil texture is sandy and the soil colour differs due to different mineral content. Due to the coarse texture, the soils have high drainage and low nutrient content. The dominant soil textures ranges from sandy loam to loamy clay. Most of the areas have soils derived from deep Kalahari sands (Mendelson *et al.*, 2003). The altitude above sea level around 1,156 metres. The main land use ranges from settlement (homesteads), forest, cattle posts and hunting areas but now people have started to integrate livestock, wild animals and rain fed crops such as *pearl millet, soya bean, sorghum* and *maize.* Clearing of the forest is noticed at an alarming rate especially for cropping and settlements; despite community forest condition of use by-law prohibits permanent settlements to avoid deforestation.

3.2.2 Ehi-rovipuka Community Forest

Geology of Ehi-rovipuka community forest/conservancy has been classified into three main types of soils namely; *rock outcrops*, *eutricregosols* and *petriccalcilsols*. The geology has been classified as Damara super group and Gariep complex (Mendelson *et al.,* 2003). Ehi –rovipuka landscape features in what is locally known as Etendeka Mountains and Kalahari sand in the south and north respectively. The average altitude above sea level is approximately 1,269 metres. There are couple of ephemeral rivers are that keep rain water for few months after the rainy season. Embonde River in the southern part is regarded as the main water course that facilitate run off toward the Atlantic Ocean. Livestock farming activities are concentrating along the ephemeral streams and fountains, thus signs of overgrazing and browsing observed during study.

3.3 Climate, Drainage and Vegetation

3.3.1 Omufituwekuta Community Forest

Namibia has been categorized as an arid to semi-arid and subtropical country in Southern Africa. It very important for people to appreciates uniqueness of different environmental conditions, because the climate has a major influence in all aspects of life. It affects the availability of water, where and when crops can be grown, pasture for grazing as well as the distribution and abundance of animals and other plants.

The mean annual rainfall of Omufituwekuta community forest is characterized by a long dry season from March to October, while November to February is regarded as the wet season. Rainfall ranges between 450 mm and 650 mm per annum, but most seasons receive below average (Mendelson *et al.,* 2003). The monthly average rainfall ranges from 30 mm to 140 mm between the months of October and April. The monthly average maximum temperature ranges from 16 $^{\circ}$C to 23 $^{\circ}$C during summer while the monthly average minimum temperature ranges from 8 $^{\circ}$C to 17 $^{\circ}$C during winter. Frost occurs annually between June and August (Mendelson *et al.*, 2003). Frost has been known to kill fruit trees especially exotic species which farmers want to introduce as cash crop in the areas. Vegetation in the area is described as heterogeneous forest which consist of about 40 tree species, whereby *Pherenoptera nelsii*, *Combretum collinum, Dycrostachis cinerea, Terminalia sericea* and *Pterocappus angolensis* are dominant tree species *(Negumbo et al.,* 2010).

3.3.2 Ehi-rovipuka Community Forest

The mean annual rainfall of Ehi-rovipuka community forest / conservancy varies from 150 mm to 250 mm per annum (Mendelson and Obeid, 2005). In comparison with other part of the country, Ehi-rovipuka community forest is one of the areas that receives very low rain fall, forcing farmers to do cropping only along the streams where the soil retains moisture for a long time. Precipitation occurs in two seasons of October to December (short season) and mind January to April (long season). The average minimum temperature ranges from 20 $^{\circ}$C during cold months, June to August and the average maximum can reach 40 $^{\circ}$C during warm months (Mendelson and Obeid, 2005). The Kunene region has been categorised as frost free, which means many exotic fruit tree would survive well where water is available. Vegetation types include the northern desert, north-western escarpment highlands dominated by *Colophospermum mopane*, *Acacia species*, *Terminalia prunoides, Combretum species* and *Comiphora* species (Mendelson *et al.*, 2003).The tree species found in the area are used as source of poles, droppers and fuel woods.

Apart from basic uses, C*olophospermum mopane* seed has been used as perfume or scent that is exported to European countries among others. Forest inventory conducted recently in 2016 revealed that *Colophospermum mopane* has biggest share of the live stems (61%) followed by *Terminalia prunioides* (13%), *Sesamothamnus guerichii* (6%), *Commiphora glandulosa* (5%), *Combretum apiculatum* (4%) and *Commiphora glaucescens* (3%) (Tjikundi and Frans, 2016).

3.4 Research Design

Research designed as "a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings (Bruns and Groove, 2011). Case study design is an in-depth exploration of a bounded system which seeks to develop an in depth understanding of a case by analysing data gathered from a number of participants (Creswell, 2012). This is a case study on the usefulness of discarded wood materials of the selected encroacher tree species designed as basic research that deals with the discovery of advancing knowledge of certain composition and energy values. The quantitative research method was applied to construe the observations of concentration of the proximate composition and energy values in the tree samples. Questionnaires and interview schedule were used to assess respondents perceptions on why and what the best season of uses of bush-feeds.

3.5 Sampling Method

A sample is a smaller but representative collection of units from a population used to determine truths about that population (Field, 2005). For this study, sampling was done in two: Sampling of tree species and sampling of respondents as they are discussed:

3.5.1 Sampling of Tree Species

Samples of leaves, pods and twigs from four selected tree species (*Philoneptera nelsii, Baphia massaiensis, Colophospemum mopane,* and *Acacia ataxacantha)* were collected. For each tree species, a young tree, a middle aged tree and a matured tree were selected randomly from the circular sample plot of 31,416 m^2 (from centre point at distance of hundred (100) meters apart and in different directions). Then, ten (10) replicates were collected from those ten (10) individual sample trees of each species and mixed together. Collecting samples from different trees of the same species in the same area gives better representation and avoid bias. Thereafter one sample representative was handpicked and later chuffs into small pieces ready for drying. The same procedure was applied repeatedly during the sample collection. Aforementioned species were selected, because its domination characteristic invasive in that specific area and most browsed species by both domestic and wild life animals.

The first sample was collected during October 2016 (spring season) while most trees were preparing for sprouting /nascent with very few old leaves or none. Only mopane trees had emerging young leaves during the collection time. Other three species were not having any leaves and pods. The second sample collection was done in January 2017 (summer) except mopane trees, which had young leaves and flowers by then, the rest species had upcoming small leaves. Third round of collection was done in June 2017 in autumn/ winter with all tree species having matured leaves and pods, which form part of composite. The following pictures demonstrate techniques used in sample collection. Plate 3.1 depicts sample collection of *B. massiensis* and *P. nelsii* collected at Omufituwekuta community forest.

Plate 3.1: ***Samples of Baphia massiensis (left) and Phelenoptera Nelsii*** **(Right) Collected During Summer**

Plate 3.2 shows mopane stand as alternative source of forage to livestock taken during summer, and literally no grass available.

Plate 3.2: ***Colophospermum mopane*** **Stand During Summer Season at Ehi-ropuka Community Forest**

Woody sample of about 3 cm in diameter together with its leaves, bark, flower and pods were cut in small pieces (chuffs) using pangas (can knife) and pruning scissor. Composite samples were chuffed into short lengths, thoroughly mixed and quartered down to approximately 200-300g. All samples were dried under full sun light for seven consecutive days, for all seasons before being packaged in ventilated plastic bags labeled with the scientific name on for each species, date of collection and collector name. Then, samples were dispatch to the Ministry of Agriculture, Water and Forestry laboratory, head office in Windhoek.

Thereafter, composite samples were grinded in the hammer mill to pass through 1 mm sieve. Plate 3.3 and 3.4 demonstrates how samples were prepared together with tools used in collection before taken to the laboratory.

Plate 3.3: Samples of *Acacia ataxacantha* (left) and *Baphia massiensis* (Right) Prepared for Drying

Plate 3.4 shows the grinded samples ready for laboratory analysis. They were placed into transparent plastic bottles where the name of species and processing number as identities of the samples were written on. The samples were accompanied by detailed explanations of the elements to be determined.

Plate 3.4: Samples of *Phelenoptera nelssii* (left) and *Colophospermum mopane* (Right) Prepared for Drying

Plate 3.5 display packaged samples and hand tools used in collection of samples.

Plate 3.5: Samples (Chuffs) Packages and the Hand Tools used

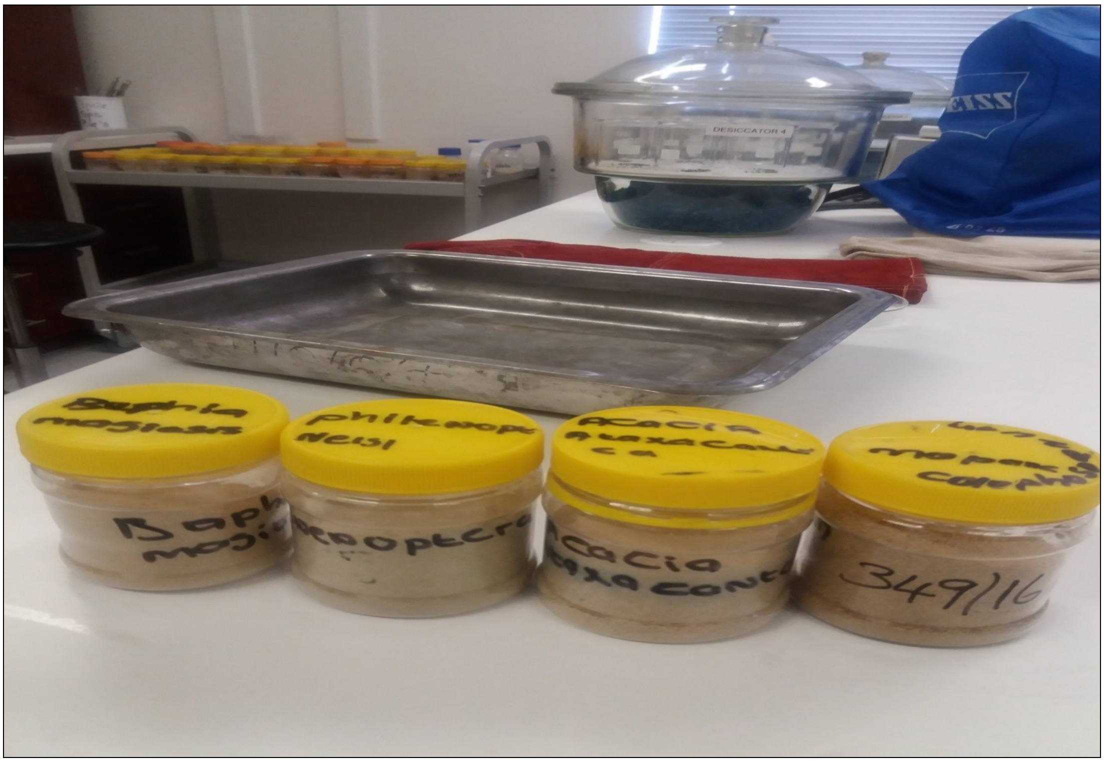

Plate 3.6: Samples Hammer Milled/Grinded into fine Particles Ready for Laboratory Analysis

3.5.2 Sampling of Respondents

The study used a method of purposive sampling to develop the sample of the research under discussion. According to this method, which belongs to the category of non-probability sampling techniques, sample members are selected on the basis of their knowledge, relationships and expertise regarding a research subject (Freedman *et al.,* 2007). Whereby, 45 of the Forest Management Body members from three selected community forests were targeted and 40 respondents interviewed which make up 88.9%. In addition 4 commercial farmers who are practicing bush feeds were also interviewed.

3.6 Data Collection

Study used primary data from questionnaire and laboratory observations of sample, in order to determine the certain proximate composition, energy values and assess farmer's perceptions on the uses of discarded woody materials of the selected encroacher tree species as bush-feed in northern Namibia.

3.6.1 Research Instrument

A questionnaire (Appendix I) designed with the research titled "Uses of forest product in relation to seasonality" was used in the study. The content of the instrument was based on the research objectives and aligned with the literature reviewed in chapter two of the study. A questionnaire allows uniformity of questions asked as well as the response given (Brink *et al.*, 2012). The questionnaire consisted of two sections. Part 1: Consisted of area of study descriptions & Part 2: Consisted of in-depth interview questions.

3.6.2 Observation of the Proximate Composition and Energy Values of the Selected Encroacher Tree Species

The study used observation procedures in order to determine the proximate composition and energy values in accordance to the standardized analytical procedures by (Agri Laboratory Association of Southern Africa, 2007). It is an animal feeds laboratory able to analyze and test samples content of *moisture content, total ashing, ether extract, acid detergent fiber, neutral detergent fiber, total nitrogen, digestibility and metabolisable energy, phosphorus* and *calcium*. The procedure, materials and detergent solutions used in this process are elaborated hereunder:

3.6.3 Observation Procedure for Moisture Concentration

Wood in its natural state contains cell wall substance imbedded with free water and other extractives. To determine moisture content of plant tissue sample were weighed and about 2- 3g of samples grounded to pass a 1 mm sieve and dried in oven at 105ºC overnight. The dried samples were then weighed again after being removed from the oven and cooled to a room temperature in desiccators.

The moisture of samples was calculated as follows:

$$M (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W1= dish, W_2 = sample + dish; W_3 = sample + dish after drying

3.6.4 Observation Procedure for Ether Extract (EE) / Crude Fat Content

Ether extract (EE) was determined according to the standardized analytical procedures by (Agri Laboratory Association of Southern Africa, 2007). Ether extract (EE) content of each sample was determined by weighing about 2g of samples ground to pass a 1 mm sieve into clean dried extraction thimbles (velp solvent extractor). Glass cotton wool was inserted in a thimble to keep the sample in place during extraction and then placed the extraction thimbles containing the samples in the extractor. Clean and dried Soxhlet flasks were weighed and connected to the extraction apparatus and filled about 2/3 of its capacity with petroleum ether. The cooling water supply and heating mantle was turned on and the temperature adjusted to achieve a condensation rate of ether at 5-6 drops per hours for at least 4 hours. As the cool water condensed the ether vapours it dropped onto the sample place into the extraction thimble and the fat extracted by the ether dropped back into the flask. After the extraction period, the remaining ether evaporated and the flasks was put in a drying oven at 100°C to dry overnight. The flasks were then cooled in desiccators and weighed again to determine the extracted residues.

3.6.5 Observation Procedure for Ash Concentration

Muffle furnace was used to determine the total ash or inorganic matter content of each sample. After weighing the dried samples, crucibles plus dry samples were placed in a muffle furnace, and incinerated overnight at 550°C. Finally, crucibles plus ash were cooled to room temperature in desiccators and weighed again:

$$\text{Total ash (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W1= mass of pre –dried crucible, W_2 =mass of sample+ crucibles; W_3 = mass of sample+ crucible after ashing.

3.6.6 Observation Procedure for Acid-Detergent Fiber (ADF) Concentration

Acid-detergent fiber (ADF) was analysed according to procedures described by (Robertson & Van Soest, 1981). Then Velp raw fiber extractor was used to determine lignocelluloses and silica of the composite samples. Samples of about one (1)g was weighed into sintered glass crucibles and placed in the extraction unit. The machine and cooling system was turned on and cold acid detergent solution (ADS) added to each crucible with the sample residue and then boiled for an hour.

The solution was drained out by suction and the samples washed three times with boiling water and then rinsed twice with acetone. The remaining residues dried overnight in a drying oven at 100°C. Dried samples were taken out from the oven and put in desiccators to cool before being weighed. The samples were incinerated in a muffle furnace overnight at 550°C. The ashed samples were removed from the furnace, allowed to cool in desiccators, and weighed. The ADF content of samples was calculated as per formula:

$$ADF\ (\%) = \frac{W_2 - W_3}{W_1} \times 100$$

Where: W1= mass of original sample in g, W_2 = mass of residue in crucible after drying, in g, W_3 = mass of residue in crucible after ashing, in grams.

3.6.7 Observation Procedure for Neutral-Detergent Fiber (NDF) Concentration

Neutral-detergent fiber (NDF) of feeds was determined according to standardized analytical procedures by (Agri Laboratory Association of Southern Africa, 2007) and (Robertson & Van Soest, 1981). Velp raw fiber extractor was used to determine the insoluble portion of the analysed samples consisting of hemicelluloses, cellulose, lignin, cutin and silica of the cell wall fraction. Sample of about one (1) g was defatted by using acetone, basically to remove the fat. Then the samples were weighed into sintered glass crucibles and place in the extraction unit. The machine and cooling system were turned on and cold neutral detergent solution (NDS) was added to each crucible, and boiled for 30 minutes. The NDS was drained out by suction and the samples washed with hot water and then rinsed with acetone.

After completing the drying process with vacuum extraction, samples were place in a drying oven to dry overnight at 105°C and cooled for 30 minutes and weigh (W_2). Dry samples were removed from the oven and placed in desiccators to cool and weighed again before being placed in a muffle furnace and incinerated overnight at 550°C. The incinerated sample was taken out from the furnace, cooled for a minimum 4 hours in a desiccator, and weighed (W_3) again.

The percentage protein of the diets, was calculated using the formula below:

$$\text{NDF (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where: W1= mass of original sample in g, W_2 = mass of residue in crucible after drying, in g, W_3 = mass of residue in crucible after ashing, in grams.

3.6.8 Observation Procedure for Crude Protein (CP) Concentration

The DUMAS combustion method for Nitrogen determination is known to replaces the previous laborious and hazardous wet chemistry acid digestion method of Kjeldahl.

The dry combustion method (Lecco CHN628) based on transformation of the sample to a gas phase by extremely rapid and complete flash combustion of the sample materials. The tube contains a granulated chromium III oxide combustion catalyst and was held at 1,200 ºC. A pulse of pure O_2 was admitted with each sample, which enclosed in a ultra-pure tin combustion capsule. Nitrogen bearing combustion products include N_2 and various oxides of nitrogen nitrate (NO_3) and these pass through a reduction column filled with copper wire at 600 ºC in which the nitrogen oxide give up the oxygen to the copper and emerge as N_2. Water vapour from the sample was removed by a gas trap containing magnesium perchlorate.

3.6.8 Observation Procedure for Organic Matter Digestibility (OMD)

Organic matter digestibility of the feed was estimated using In Vitro gas test according to the procedure of (Menke *et al.,* 1979). A composite sample about 300g grinded to pass through 1 mm sieve weigh and placed into the glass syringes in duplicates. Rumen liquor was introduced into the syringe. The syringe was then incubated in an incubation apparatus maintained at 39 ºC. The gas production readings were recorded for the first 8 hours of incubation, the clip was opened and the position of piston move back 30 ml position. The first reading was taken after 24 hrs.

ODM calculated using the formula:

ODM % = 14. 88 + --gas production (GB) + -crude protein (CP; g/kgDM +--crude ash XA; g/kg DM).

3.6.9 Observation Procedure for Metabolisable Energy (ME)

The quantity of net energy available for production is controlled by three related factors; the quantity of feed eaten, proportion of each unit of feed that is digested and efficiency of the products of digestion (Devandra, 1990). Metabolisable energy of the feed was estimated using In Vitro gas test according to the procedure of (Menke *et al.*, 1979). A composite sample about 300 g grinded to pass through 1mm sieve weigh and place into the glass syringes in duplicates. Rumen liquor was introduced into the syringe. The syringe was then incubated in an incubation apparatus maintained at 39 ^{o}C. The gas production readings recorded the first 8 hours of incubation, the clip was opened and the position of piston move back 30 ml position. The first reading was taken after 24 hrs.

Metabolisable Energy (ME) calculation is almost similar to organic matter digestibility:

ME (MJ/KG) = 1.242 + --gas production (Gb) +--crude protein (XP: g/kg DM) + --crude lipids (XL; g/kgDM.

3.6.10 Observation Procedure for Phosphorus Concentration

Phosphorus is the most important macro element when it comes to nutritive value of animal feeds. Acid digestion method is used to determine content of phosphorus. The procedure to determine elements is according to (Agri Laboratory Association of Southern Africa, 2007) as adopted by Ministry of Agriculture, Water and Forestry laboratory.

(i) Finely grinded samples of twigs were weighted to 2-3 grams in a porcelain crucible and dried in the drying oven for overnight, then weighted to determine the dry matter.

(ii) Sample collected from the furnace and let it to cool were then weighed to determine the organic matter. After the weighing deionised water was sprinkled, in order to wet the sample thereby preventing it from fizzing when Hydrochloric Acid (HCl) applied and also to prevent samples from blowing away in the fume cupboard.

(iii) Then 5 ml of HCl was added to each sample and placed on the hot plate until the sample dried for three (3) hours

(iv) 100 ml volumetric flasks, filter papers and funnels together with crucibles contain were given identity number for easily identification.

(v) 5 ml of HNO_3 was the poured in to each crucible. The crucibles were place in hot plate until it boils. Then the content of the crucible were poured into the 100 ml volumetric flask through the filter pare on the funnel. Then residue on the filter paper was flashed out with hot water of deionised water.

(vi) Filter papers were removed, and then cold water is poured till the mark / meniscus. The volumetric flask was covered and contents mixed.

The contents of the volumetric were poured into tubes that later placed on the auto-samplers of the ICP machine for element analysis. The ICP machine has pre-installed instructions on how to detect amount of an element in a given sump. ICAP 6,000 series ICP spectrometer was used to analyse level of phosphorus.

3.6.11 Observation Procedure for Calcium Concentration

Calcium is also most important micro element when it comes to nutritive value of animal feeds. Acid digestion method is used to determine content level of calcium. The procedure to determine element according to (Agri Laboratory Association of Southern Africa, 2007) is that adopted by Ministry of Agriculture, Water and Forestry laboratory.

(i) Finely grinded samples of twigs were weighed to 2-3 grams in a porcelain crucible and dried in the drying oven for more than five hours or overnight, then weighted to determine the dry matter.

(ii) Sample collected from the furnace and let it to cool were then weighed to determine the organic matter. After the weighing deionised water was sprinkled, in order to wet the sample thereby preventing it from fizzing when Hydrochloric Acid (HCl) applied and also to prevent samples from blowing away in the fume cupboard.

(iii) Then 5ml of HCl was added to each sample and placed on the hot plate until the sample dried for three (3) hours.

(iv) 100 ml volumetric flasks, filter papers and funnels together with crucibles contain were given identity number for easily identification.

(v) 5 ml of HNO_3 was the poured in to each crucible. The crucibles were place in hot plate until it boils. Then the content of the crucible were poured into the 100 ml volumetric flask through the filter pare on the funnel. Then residue on the filter paper was flashed out with hot water of deionised water.

(vi) Filter papers were removed, and then cold water is poured till the mark (meniscus). The volumetric flask was covered and contents mixed.

The contents of the volumetric were poured into tubes that later placed on the auto-samplers of the ICP machine for element analysis. The ICP machine has pre-installed instructions on how to detect amount of an element in a given sump. UV/VIS 916 spectrophotometer was used to analyse calcium level in samples.

3.7 Data Analysis Methods

In order to analyze proximate composition and energy values in the selected encroacher tree species and its seasonality change; and to assess farmer's perceptions on the uses of discarded woody materials from selected encroacher trees species in relation to different seasons Microsoft Excel was used, using the results data obtained from the laboratory. The study used Microsoft Excel to create Tables, bar charts and graph lines for the simplicity of interpreting results. The study also used Statistical Package for Social Sciences (SPSS) version 23 to formulate a One-way Analysis of Variance (ANOVA) in order to determine the relationship of the proximate composition and energy values between the selected tree species.

The study constructed at 95 percent confidence level. ANOVA is used to determine whether there are any statistically significant differences between the means of two or more independent variable (Freud's, 2004). This was helpful in making comparison of four means which enables a researcher to draw various results and predictions about four tree species. A Post-hoc tests that helped find out where these differences lie should there be any. Post hoc comparisons procedures (or post hoc tests, multiple comparison tests) are tests of the statistical significance of differences between group means calculated after ("post") having done ANOVA that shows an overall difference (Sawyer, 2007). Multiple comparison methods are designed to investigate differences between specific pairs of means (Cabral, 2008). This provides the information that is of most use to researchers.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Proximate Composition and Energy Values in the Selected Encroacher Tree Species Observed During Winter, Spring / Autumn and Summer Seasons

Table 4.1: Proximate Composition and Energy Content Levels of the Four Tree Species

Certain composition and energy values of selected tree species presented as percentage %.										
Seasons	**Moist**	**Ash**	**Fat**	**CP**	**ADF**	**NDF**	**Ca**	**P**	**OMD**	**ME**
1. Baphia massaiensis										
Winter	8	4.7	1.8	15.9	37.7	48.2	0.67	0.09	42	5.8
Spring/ autumn	4.9	4.18	1.62	17.3	41.1	51	0.74	0.12	41	5.6
Summer	4.4	3.01	1.11	9.71	54.2	62.8	0.64	0.01	35.9	5
mean	**5.74**	**3.96**	**1.51**	**14.30**	**44.34**	**54.02**	**0.68**	**0.07**	**39.63**	**5.47**
2. Philenoptera nelsii										
Winter	8	4.7	1.8	15.2	37.7	48.2	0.80	0.11	42.5	5.8
Spring/ autumn	5.8	5.75	2.16	21.2	42.2	54.8	1.01	0.10	46.4	6.3
Summer	4	5.49	1.03	10.7	51.3	68.1	1.09	0.02	40.1	5.4
Mean	**5.9**	**5.31**	**1.66**	**15.7**	**43.75**	**57.04**	**0.97**	**0.07**	**43**	**5.83**
3. Acacia ataxacantha										
Winter	6.6	5.5	1.72	15.9	40.7	54.1	0.703	0.09	49.5	6.8
Spring/ autumn	6.4	5.19	3.32	**16.1**	32.4	42.6	1.007	0.12	41.8	5.9
Summer	4.4	4.32	1.57	6.98	56.5	68.1	1.054	0.02	35.6	4.9
Mean	**5.81**	**5.00**	**2.20**	**12.99**	**43.18**	**54.93**	**0.92**	**0.08**	**42.30**	**5.87**
4. Colophospermum mopane										
Winter	5.9	5.87	11.4	12.1	31	44.3	0.98	0.16	33.1	8.5
Spring/ autumn	4.2	6.46	8.01	9.4	39.2	47.6	1.60	0.10	27.1	5.3
Summer	5.8	6.9	7.06	6.71	40.2	49.6	1.67	0.04	27.6	5
Mean	**5.29**	**6.41**	**8.82**	**9.40**	**36.8**	**47.1**	**1.42**	**0.10**	**29.27**	**6.27**
Moist= % moisture (100-moisture= % dry matter), Ash=% ash (100-Ash) = organic matter), Fat= %fat, CP= % crude protein, ADF = % Acid detergent fiber, NDF= %Neutral detergent fiber, Ca= % calcium, P = % Phosphorus, OMD= % Organic matter digestability, ME = % Metabolisable energy										

4.2 Determine Variation of the Proximate Composition and Energy Values of Selected Tree Species of the Savannah Landscapes in Namibia

Analysis of variation (ANOVA) was performed at 5% level of significance to determine the mean variation between the selected four trees species.

Table 4.2: Comparison for Composition and Energy Values between the Four Tree Species

One-way Analysis of Variance (ANOVA) Mean					
Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.866	3	14.955	.037	.990
Within Groups	14,379.407	36	399.428		
Total	**14,424.272**	**39**			

Hypotheses

H_0:

$\mu_{\text{Colophospermum mopane}} = \mu_{\text{Baphia massaiensis}} = \mu_{\text{Acacia ataxacantha}} = \mu_{\text{Philenoptera nelsii}}$

H_1: At least one μ_4 is different.

The null hypothesis state that: All means are equal and alternative hypothesis state that at least one mean of the tree species is different from the others.

4.3 Farmer's Perceptions on the uses of Encroacher Trees Species in Relation to Different Seasons and their Reasons

Figure 4.1displays the perceptions of respondents, on use bush-feed during spring/Autumn, summer and winter season.

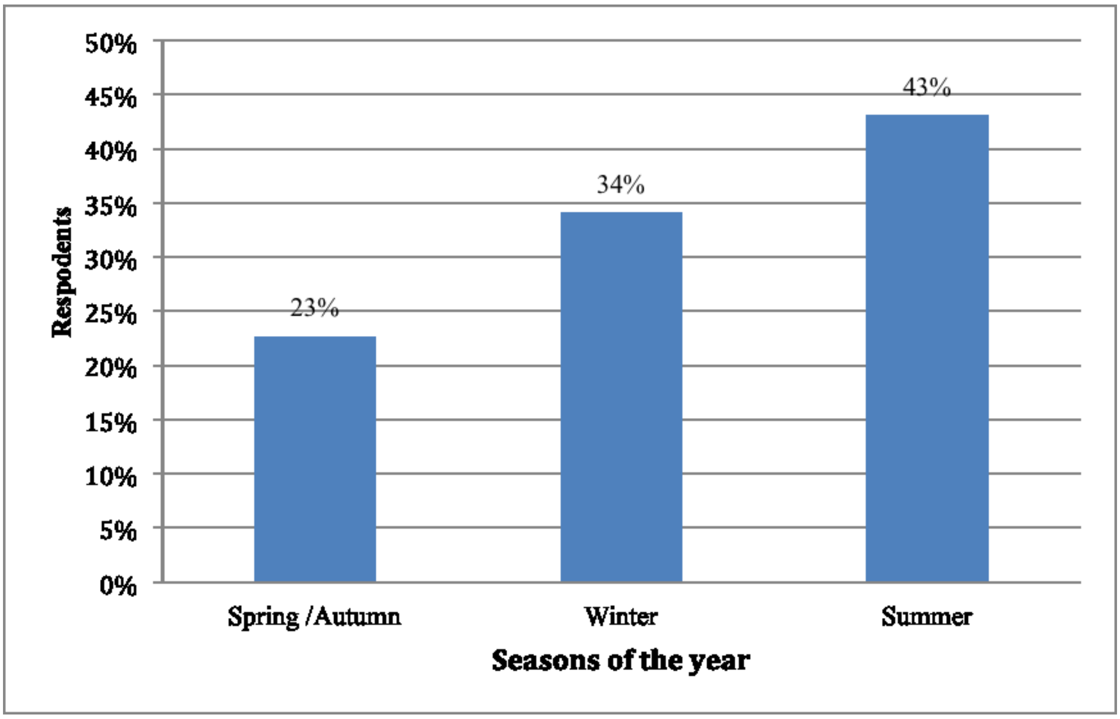

Figure 4.1: Harvesting of Trees Based on Seasonal Variation

Figure 4.2 unveil number of respondents and their reasons of making use of bush feed.

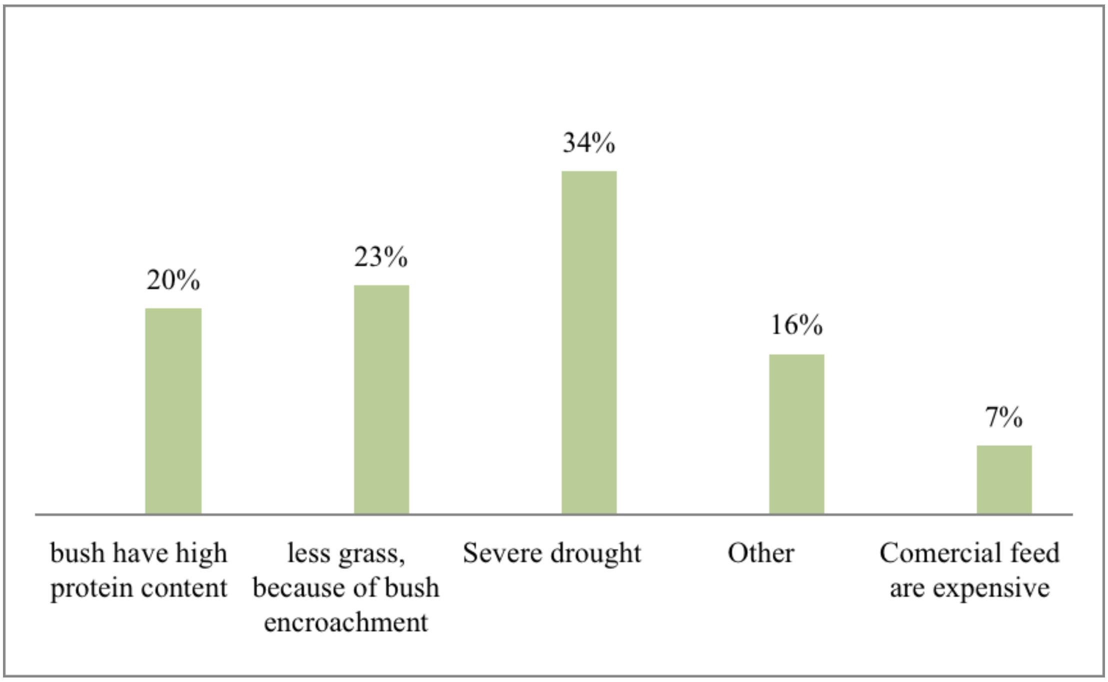

Figure 4.2: Reasons that Made Farmers to Make use of Bush Feeds

4.4 Discussion of the Proximate Composition and Energy Values of the Selected Encroacher Tree Species of the Savannah Landscapes in Namibia

4.4.1 Moisture

Moisture contents of *Baphia massaiensis* averaging at 5.74% in (Table 4.1). Study conducted in northern Botswana by Sianga and Fynn (2017); on same plant species recorded an average of 11.6% more than this study finding. Lowest moisture contents observed in summer was 4.39% and the highest being in winter 7.95% as illustrated in (Figure 4.3). This is mainly due to the fact that during winter the leaf stomata are largely closed due to less photosynthesis taking place during the winter. During summer there is more exposure to intense sunlight therefore there is more photosynthesis and the stomata are open so they lose more moisture.

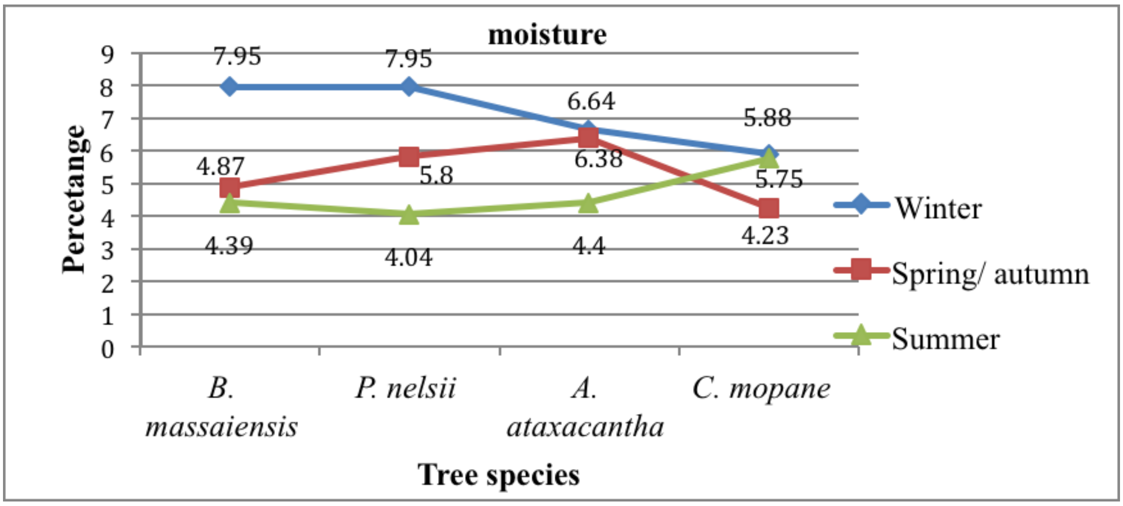

Figure 4.3: Moisture Content of the Selected Tree Species

Study shows that *Philenoptera nelsii* has average moisture of 5.93% (Table 4.1). The lowest moisture being in summer 4.04% and the highest being in winter 7.95%, same as *Baphia massaiensis* (Figure 4.3). In the semi-arid Kalahari sands of Namibia, cattle preferred to do relatively browsing on *Philenoptera nelsii*, than grazing in hot dry seasons (Katjiua and Ward, 2006). This could be as a result of low moisture content in the leaves of the plant species in summer. According to Curtis and Mannheimer (2005), *Philenoptera nelsii* has high moisture content during winter largely due to the amount of leaves, which it has around June (winter).

According to Daben *et al. (*2017), moisture content of *Acacia ataxacantha* leaves was 6.47% which confirms with this study's findings too. On average *Acacia ataxacantha*has 5.81% although it peaks in winter, which is 6.64 % (Table 4.1). Lowest moisture contents being in summer 4.4% and the highest being in winter 6.64% (Figure 4.3). According to Kasale (2013), *Acacia ataxacantha* has moisture content (11.66 g/100 g), which translates to 11.66% moisture. The greater the surface area of material exposed to the environment, the faster the rate of moisture removal (Grutteridge and Shelton (2001). It corresponds with this study as all broad leaf species lost a lot of moisture and the drought / dry season cattle should be fed on species with narrow leaves like *Acacia ataxacantha.*

Study demonstrates that *Colophospermum mopane* has average moisture of 5.29% (Table 4.1). Lowest moisture contents being in spring/autumn 4.23% and the highest being in winter 5.88% (Figure4.3). Kasale(2013), finding in mopane on average was 10.4% of moisture content, huge differences may occur due to geographical location and rainfall pattern whereby Zambezi region receives 700 mm while Kunene region receives less than 250 mm on average per annum. *Colophospermum mopane* has a defense mechanism where it produces an odor and sour taste to scare away browsing animals. Harvesting for *Baphia massaiensis, Acacia ataxacantha, Colophospermum mopane* and *Philenoptera nelssii* should be done in winter to supply metabolic water to the animals during the dry season. Alternatively, during summer moisture content at its lowest to avoid fungal build up.

4.4.2 Ash

On average *Baphia massaiensis* has the highest level of ash in winter than in summer with this study having an all season average of 3.96% with 4.7% as the highest (Figure 4.4).

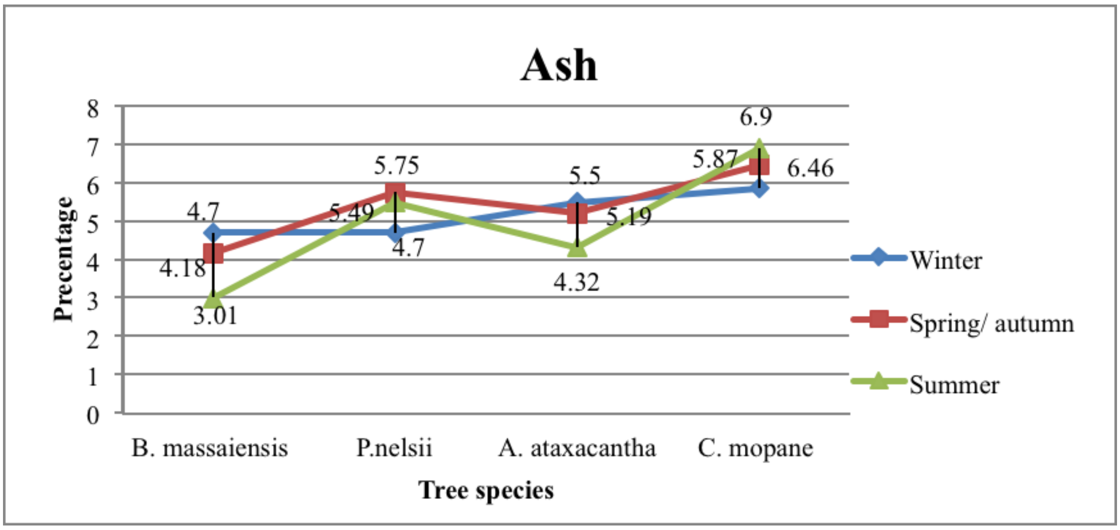

Figure 4.4: Ash Content of the Selected Tree Species

This study's findings are an exact mirror image of Kasale (2013) study, whose ash content for *Baphia Massaiensis* was pegged at 4.46 against this study's 4.7%. This study therefore concludes that during winter, that is when *Baphia Massaiensis* is at peak ash content so that is when the plant can be harvested for production of livestock feed.

Philenoptera nelsii has the highest level of ash in spring/autumn than in summer or winter. The average ash content for all seasons was found to be 5.30% with 5.75% as the highest (Table 4.1). Although there was a higher nutrient content in autumn, the difference between the seasons is insignificant with the range being 0.9%. This study therefore conclude that unless the ash content alone is the ingredient needed in *Philenoptera nelsii,* otherwise other nutrients may have to be taken into consideration if one is to determine which season to harvest the tree species.

This study found that the amount of ash in *Acacia ataxacantha* is highest in winter at 5.5% and lowest in summer at 4.32%, while average for all seasons is 5% (Table 4.1). This is in agreement with other similar studies conducted elsewhere. This proves that in general, *Acacia ataxacantha* has the highest level of ash in winter than in summer. This study's findings are in tandem with Daben *et al.* (2017) study, whose ash content for *Acacia ataxacantha* was pegged at 4 % against this study's average of 5% and 4.32 % during summer (Figure 4.4). The study reveals, during winter at its peak 5.5 %. The study concludes that during winter, is when *Acacia ataxacantha* at its peak of ash content so that is when the tree can be harvested. This is an evidence that *Acacia ataxacantha* leaves contain reasonable minerals which are useful for animals nutrition. *Colophospermum mopane* has the highest level of ash in summer 6.9% with this study having an all season average of 6.41% and 5.87% in winter (Table 4.4). This study's findings also agree with Kasale(2013) study, whose ash content for *Colophospermum mopane* was pegged at 7.34% against this study's 6.9%.

The study therefore suggest that during winter, is when the ash content at less and at the highest in summer so in summer that is when the plant can be harvested, in any case that time the strain from the mopane worms will have been reduced. Mopane tree observed slightly high of ash concentration than other species under this study. On average mopane species obtained highest ash concentration than other species under this study.

4.4.3 Fat (Ether Extract)

The study found out that the fat content of *Baphia Massaiensi a*verage is 1.51% for all seasons yet it peaks at 1.8% in winter (Table 4.1). This is largely due to a drop in temperature as well as low transpiration and energy use. Macdonald*et al*. (2010), asserts that fat supplies on average 2.25% more energy than traditional carbohydrates and although *Baphia massaiensis* does not have high fat content its importance in livestock feed cannot be underestimated especially in the dry season when they rely more on dry grass (hay) which is very low in soluble sugars. From a nutritional point of view, fats are highly important reserve foods in shrubs because they contain twice much energy per unit of weight as proteins or carbohydrates (Kramer and Kozlowski, 1960). Also, fats serve as an important food reserve for the shrubs themselves. Fats may account for as much as 70% in shrub seeds, but they rarely make up more than 5% of the stem and leaf components. Fats tend to decrease in shrubs with seasonal progression through mid-summer, then increase winter (Dietz *et al.*, 1962). Ruminants are not dependent upon fat in shrubs since fat is synthesized in the rumen from carbohydrates and proteins.

The findings shows the small window of opportunity that exists between winter and spring to harvest the tree for livestock feed. If that window of opportunity is missed, the fat content will greatly drop to levels below the vital during summer when the temperatures surge to above 30 $^{\circ}$C especially in northern Namibia. The study found out that the fat content of *Philenoptera nelsii* averages 1.66% for all seasons (Table 4.1), yet it peaks at 2.16% in spring/autumn and is lowest during summer at 1.03% (Figure 4.5).

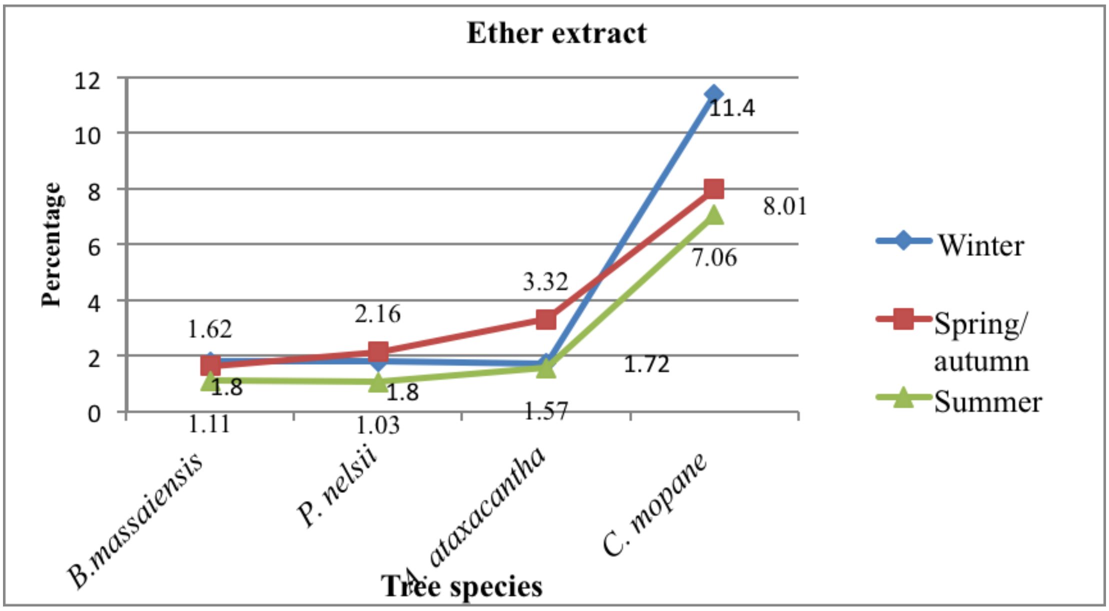

Figure 4.5: Ether Extract of the Selected Tree Species

When there is too much sunlight, there is too much transpiration and more plant food is produced and few is stored as fat because when it is required it can be produced. Again this study is a ground breaker as no other previous study examined the fat content of this tree species before. This study's contribution to the body of knowledge is vital since it fills the gap that existed with regards to the fat content of *Philenoptera nelsii.* The result shows the season ideal for the harvesting of *Philenoptera nelsii* which between winter and summer. In the absence of other studies, this study therefore concludes that this tree species has a key fat ingredient, which for the purposes of fodder can be harvested during the spring/autumn.

On *Acacia ataxacantha*, Dabenet *al.* (2017), argue that dietary fats increase the palatability of food for absorbing and retaining flavor meaning the higher the fats the better the stock feed especially during dry seasons. Study found out that the fat content of *Acacia ataxacantha* averages 2.20% for all seasons (Table 4.1), yet it peaks at 3.32% in spring /autumn and is at its lowest during summer at 1.57% (Figure 4.5).

This finding also shows the small window of opportunity that exists between winter and summer to harvest the tree leaves. If that window of opportunity is missed, the fat content will greatly drop to insignificant level.

According to Daben *et al* (2017), the crude fat content in *Acacia ataxacantha* seed is 13.24%, yet this study's findings recorded an average fat content of 2.2%. This disparity is largely, due to the fact that this study analyzed the leaves, twigs and pod which may dilute the fat concentration found in the other study.

This study concludes that the fat content of *Colophospermum mopane* averages 8.82% for all seasons yet it peaks at 11.4% in winter and is at its least in summer at 7.06% (Table 4.1). As mentioned the defense mechanism of *Colophospermum mopane* makes it less browsed by cattle therefore less fat are used to restore browsed leaves hence the accumulation of fats during winter. *Colophospermum mopane* has the highest fat content therefore its importance in stock feed for that purpose is established. The finding shows the time (winter) where the fat content is at its peak yet it is not the best time to harvest because of it less palatability, due to the defense mechanism by the species.

According to Kasale (2013), high fats and oil content of *Colophospermum mopane* are an important source of energy for animals during the dry season when they rely more on dry grass (hay) which is very low in soluble sugars. This fact is testimony to Kunene region condition where animals heavily survive on browsing of mopane during dry season. In most plants storage lipids are in the form of triglycerides. There are many different types of triglyceride, with the main division between saturated and unsaturated types. Saturated fats are "saturated" with hydrogen all available places where hydrogen atoms could be bonded to carbon atoms are occupied. These have a higher melting point and are more likely to be solid at room temperature. Unsaturated fats have double bonds between some of the carbon atoms, reducing the number of places where hydrogen atoms can bond to carbon atoms.

These have a lower melting point and are more likely to be liquid at room temperature. During summer, plants loose fat due to stress and over browsing and high temperature yet during winter they can accumulate fats and oils. At this point, Mopane have highest observations of fat than other species under the study.

4.4.4 Crude Protein (CP)

The main features of Baphia massaiensis are their high Crude Protein (CP) and mineral contents. It accrued highest content of 15.9% among the trees species under review and it is part of fodder trees of Southern Africa. The concentration of CP in the leaves and fruit of the majority of fodder trees is above 10% even in the dry season when it tends to decrease.

The role of trees and shrubs in the supply of vitamins is indirectly demonstrated in dry tropical Africa by the fact that browsers such as goats and camels seldom contract photophobia or eye inflammation which make many cattle are prone to during the dry season. According to Kasale (2013) crude protein for Baphia massaiensis is 16.18%, which is closer to this study’s average of 14.3% with the highest protein content happening during spring at 17.3% (Table 4.1).

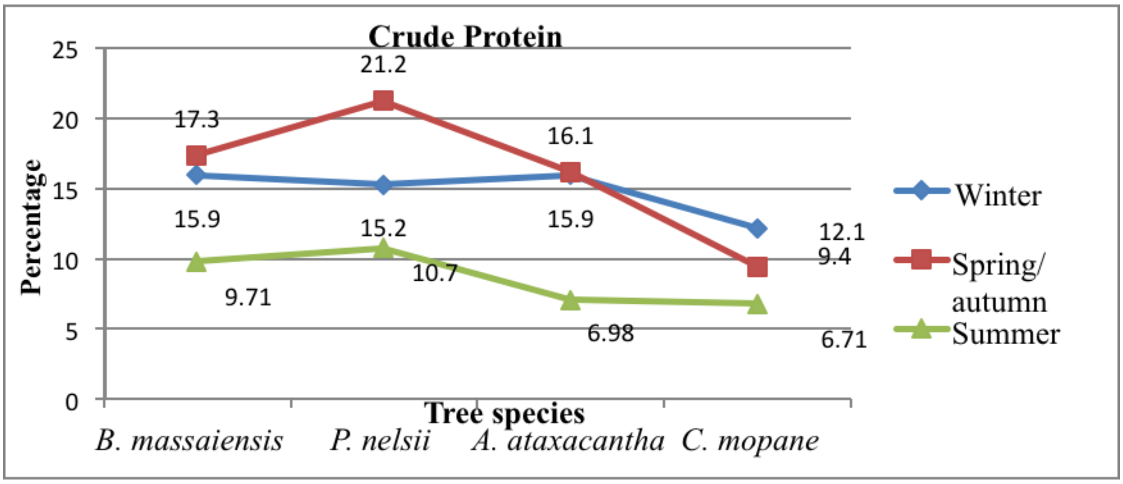

Figure 4.6: Crude Protein Content of the Selected Tree Species

The harvest should be done in spring/autumn when its nutrient content is at its peak of 17.3% (Figure 4.6). Protein is the most important nutrient component, although nitrogen and its various substances are of more concern in ruminant nutrition than proteins and amino acids, which are synthesized by both domestic and wild ruminants (Viljoen, 2001). The amount of nitrogen compounds present in trees and shrubs varies with the environmental factors, the kind of tissue, the age or stage of development, and the season of growth. The pods and the meristematic tissues of the fodder trees like *Baphia massaiensis* contain higher percentages of crude protein than leaves or other parts. Higher CP values were observed in spring/autumn and lower in winter and summer. It is obvious that the higher the protein, the higher the fodder quality. This is mainly due to cell wall and its derivatives (cellulose, hemicelluloses and lignin) being, lower in summer and higher in winter. In general, leaf fraction has lower circulating water than stem fraction in all seasons.

This study revealed that Crude protein for *Philenoptera nelsii*is very high reaching its peak spring/autumn at 21.2% (Figure 4.6). It is however at its least in summer where it is 10.7% and the all season average is 15.7 (Table 4.1). The harvest should be done in spring/autumn when its CP content is at its peak at 21.2% this is the highest CP among all the species under review.

According to Katjiua and Ward (2006), CP content of this species was 29.4%. The disparity with this study could be either season related or different areas under study. Other reasons for high protein content could be attributed to low browsing pressure under enriched soil fertility (Katjiua and Ward, 2006). CP level is also not affected by defoliation which normally happens during spring/autumn, actually increased. This study revealed that the crude protein for *Acacia ataxacantha* at 16.1 % the highest in spring and 6.98 % the lowest in summer, while the average CP across all seasons was found to be 12.99% (Table 4.1). The best time to harvest is either towards the end of winter or at the beginning of spring autumn.

According toDaben *et al.* (2017) crude protein for *Acacia ataxacantha* is between 10-12% which is closer to this study's average of 12.99% with the highest protein content happening during spring/autumn at 16.1%. Generally, animal feeds are rich in microelement, based on species, plant parts and seasonal changes, which will influence their mineral concentration. Based on this information, this study concludes that *Acacia ataxacantha* has the potential to use discarded wood materials as source livestock feed. The minerals concentration suggests that the plant leaves can effectively contribute to the diets of animals. Animals require minerals in trace amount but can be supplement from other sources if needed in high concentration and harvesting *Acacia ataxacantha* in spring will be idea especially if the feed is meant for growing livestock.

This study shows that crude protein for *Colophospermum mopane* was equally high at 12.1% during winter and low 6.71% during summer (Figure 4.6). In a study carried out in Botswana, it was found out that *Colophospermum mopane* had an average CP of 8.93% (Macala *et al.*, 1992). In another study carried out by Kasale, (2013) crude protein for *Colophospermum mopane* is 12.1%, which is closer to this study's average of 9.4% with the highest protein content happening during winter at 12.1% (Figure 4.6). The result highlights the season in which *Colophospermum mopane* has highest (CP) concentration should be harvested for purpose of stock feeds, which is winter for the sake of feeding livestock in summer.

The harvest must be done in winter when its CP content is at its peak at 12.1%. Since protein is considered to be the best nutrient for growing livestock, it is important to highlight that this species is best for young livestock as a supplement. Nutritional value of *Colophospermum mopane*, browsing is mainly during the dry season, when secondary metabolites such as total phenols, condensed tannins and protein-precitating tannins are relatively low (Makhando *et al.*, 2016). The higher the proteins in the tree species, the higher the quality of the fodder. This is mainly due to cell wall and its derivatives (ADF, cellulose, hemicelluloses and lignin) being lowered in summer and higher in winter. *Philenoptera nelsii* garnered higher observations of Crude protein than other species in this study; this species would serve as substitute to others when crude protein is necessary.

4.4.5 Acid Detergent Fiber (ADF)

ADF is the fibrous component that represents the least digestible fiber portion of forage or other roughage. This highly indigestible part of forage and includes lignin, cellulose, silica and insoluble forms of nitrogen but not hemicelluloses. It is used to calculate digestibility, Total Digestible Nutrients (TDN) and/or Net Energy for Lactation (NEL).

Forages with higher ADF are lower in digestible energy than forages with lower ADF (Van Soest *et al.,* 1991). That means, as the ADF level increase, digestible energy levels decrease. *Baphia massaiensis'*s ADF is highest in summer at 54.18% and lowest in winter at 37.72% (Figure 4.7).

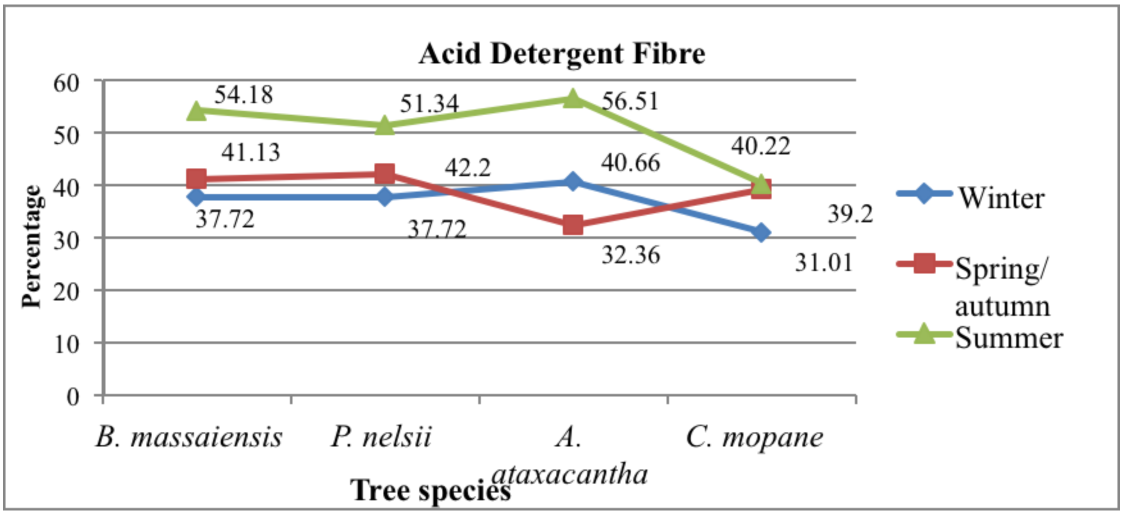

Figure 4.7: Acid Detergent Fiber of Selected Tree Species

At this point it is important to note that the greater the ADF the lower the organic matter digestibility (OMD) and Metabolisable energy (ME). The finding shows the period with which this fodder tree can be harvested for purpose of getting the maximum possible ADF nutrients in *Baphia massaiensis.* Acid Detergent Fiber being the high percentage of the plant material in the forage that is difficult for the livestock to digest. This indigestible part contains cellulose, lignin, and silica. It said woody with high ADF properties is suitable for construction materials. *Colophospermum mopane* and *Acacia ataxacantha* are used for construction, because its strength properties but records lower values of ADF compare to others. ADF is more in summer than in winter due to increased levels of food production within the plant makes plant growth more evident. *Philenoptera nelsii* shows highest ADF in summer season at 51.34% and the lowest being in winter at 37.72% (Figure 4.7). This species is also known to have the highest ADF as per figures obtained. Result shows winter ideal period of tree to be harvested for purposed of getting the maximum possible ADF nutrients. This is in line with Katjiua and Ward (2006), findings on the same tree species of 35.2%. This shows that this species can be used in terms of improving the digestive system of livestock since it is high on dietary fiber. ADF for *Acacia ataxacantha* is highest during winter at 56.51% and lowest during spring at 32.36% with an average of 43.18 % (Table 4.1).

Since ADF is used to gauge the digestibility of the fodder, various studies have proven that *Acacia ataxacantha* is one of the best species to use for fodder due to its high digestibility although research has also proven that the higher the digestibility, the lower the Metabolisable energy. Summer is the best time to harvest the species for purposes of stock feed mainly due to its high transpiration and plant food production due to abundant sunlight during summer.

*Colophospermum mopane'*s ADF is highest in summer at 40.22% and lowest in winter at 31.01% with an average of 36.81% across all seasons (Table 4.1). The result shows the winter season this fodder tree can be harvested for purposed of getting the maximum possible ADF nutrients. Wessels (2007) and Kasale (2013) indicated that the level of fiber in mopane leaf is primarily associated with the growth of the leaf. Based on Cooper *et al.,*(1988) notion that fiber influences the digestibility as well as acceptability of the leaves by browsers, it is therefore suggested in this paper that mopane leaves can be easily digested during winter season, when the leaves are dry, as opposed to summer season when the leaves are still growing. The amount of fiber shows little change throughout the year, but seems to be at its greatest during the summer season, and then declined during the winter season.

4.4.6 Neutral Detergent Fiber (NDF)

NDF together with ADF are very important in establishing the nutrient content of the plant species. The NDF of *Baphia massaiensis* is high 62% in summer and low 48.24% during winter with an all season average of 54.02% (Table 4.1). This is in line with the Nigerian study's, which found out the ADF of the same species as 57% or 57g/100g (Burkill, 1995). The finding shows the importance of harvesting the species in winter the animals will need to consume less to be full and benefit from more Metabolisable energy. The higher the ADF and NDF the lower the organic matter digestibility and the Metabolisable energy. NDF for *Baphia massaiensis* is lower during winter than during summer for similar reasons as the ADF.

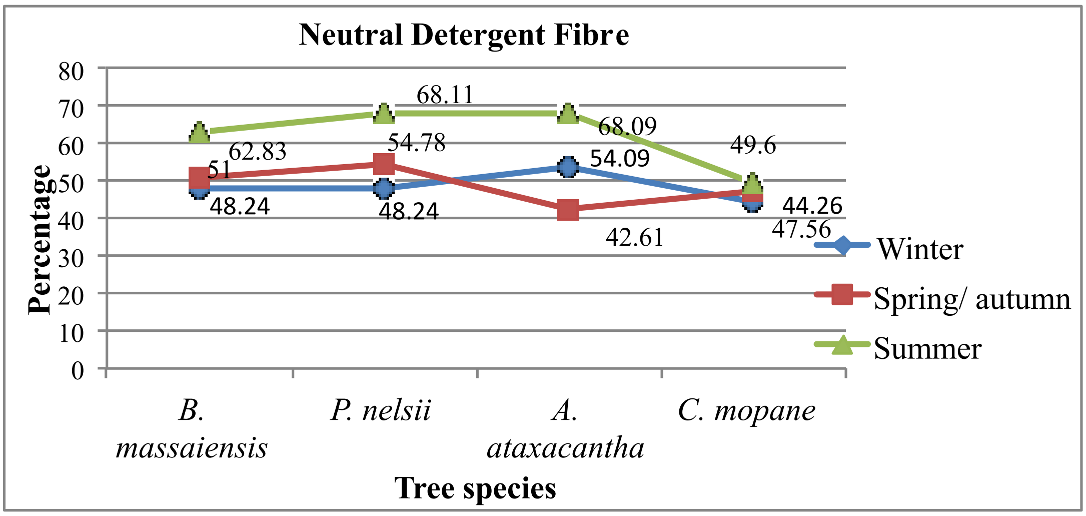

Figure 4.8: Neutral Detergent Fiber of Selected Tree Species

When the food production is lower, slow plant growth is experienced therefore low fiber produced. The NDF of *Philenoptera nelsii* is high 68.11% in summer and low 48.24% during winter with an all season average of 57.04% (Table 4.1) and (Figure 4.8).

The diagram shows the importance of harvesting the species in summer when the NDF is at its highest. NDF for *Philenoptera nelsii* is lower during winter than during summer for similar reasons as the ADF where food production is lower and therefore plant growth is experienced low fiber. Other studies like (Katjiua and Ward, 2006) concluded that the NDF for *Philenoptera nelsii* is 48% which is closer to this study's 57%. The difference could be attributed to soil nutrient content in the semi-arid Kalahari sands and this study's northern Namibia soils which are largely loamy soils. Other contributing factor could a different on sample materials used, whereby this study include twigs, leaves and pods, while other used leaves only.

The NDF of *Acacia ataxacantha* is high 68.09% in summer and low 42.61% during winter with an all season average of 54.93% (Table 4.1). The finding shows the importance of harvesting the species in summer to benefit from maximum amount of nutrients. According to Norton (1994), best trees species for fodder are those with a low NDF content ranging (20-30%). Those are trees with high digestibility, while species with high lignin contents are often of low digestibility and stem known to have higher lignin contents than leaves. This study finding the minimum average is 47.1%, thus could be stem materials dominated the samples. The NDF of *Colophospermum mopane* is high 44.26% in winter and low 47.56% during spring/autumn with an all season average of 47.14% (Table 4.1). This is less than to

Kasale (2013)'s results whose NDF for *Colophospermum mopane* is 61.7%. The result shows the importance of harvesting the species in winter the animals need to consume less to be full and benefit from more Metabolisable energy. The higher the ADF and NDF the lower the organic matter digestibility and the Metabolisable energy. NDF for *Colophospermum mopane* is lower during winter than during summer for similar reasons as the ADF. When the food production is lower, slow plant growth is experienced therefore low fiber produced. The relatively high presence of ADF and NDF gives a sign of the low digestibility and metabolizing energy. *Philenoptera nelsii* was the highest NDF than other species even though it is locally categorized as a fodder species.

4.4.7 Calcium

The calcium content of *Baphia massaiensis* was found to be highest 0.74% in spring/autumn and lowest in summer 0.64% and the average of 0.68% (Table 4.1). It is confirming with Wright*et al.* (1997), who found calcium concentrations in *Baphia massaiensis* fluctuate from 0,744 to 0,821%. Calcium content in *Baphia massaiensis* is high during spring/autumn and lowest in summer. Harvesting of the species for purposes of calcium must be done during spring/autumn where calcium is at its highest possible.

This plant can be harvested for purposes of giving to growing animals, which need more of calcium for their growth in bones and teeth. Calcium is not mobile within the plant. Plant relies on the process of transpiration in which roots take up the soil solution and transports it to new growth. Anything that slows transpiration, such as high humidity or cold temperatures, can induce calcium deficiency even if the calcium levels are normal in the growing medium. Parts of the plant that transpire little water, i.e. young leaves and fruit, will display calcium deficiencies first. Result shows that calcium concentrations changed little during all seasons. Harvesting time should consider other factors rather than time. There was no evidence found of study in Namibia that determined the calcium content of *Philenoptera nelsii.* This study determines that the highest calcium content is observed during summer at 1.094% and lowest in winter at 0.799% (Figure 4.9).

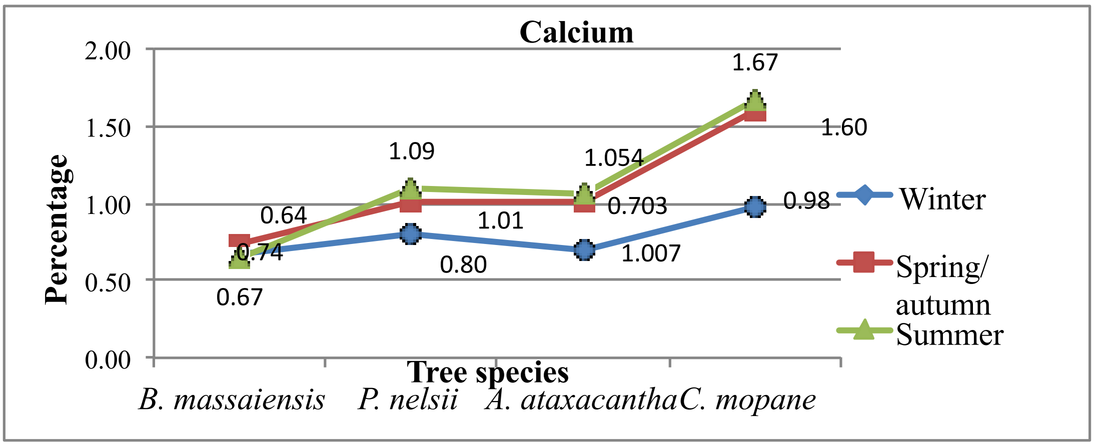

Figure 4.9: Calcium Content of the Selected Tree Species

The result shows that calcium content in *Philenoptera nelsii* is high during summer and lowest in winter. Harvesting of the species for purposes of calcium must be done during summer where calcium is at its highest possible. According to Harty (2014) the main function of both calcium and phosphorus is skeletal. Nearly 99% of the calcium in the body is found in the skeleton, while 80% of the phosphorus is in bones and teeth. In growing livestock diets it becomes even more critical to test feeds and balance minerals accordingly. The calcium content of *Acacia ataxacantha* was found to be highest 1.054% in summer and lowest in winter 0.703% and the average of 0.92% (Table 4.1). Study conducted Amoussa and Sanni(2014), revealed that the

Calcium, Zinc and *Manganese* concentration levels on leaves were lower than 003mg/100g which translated into 0.03 %. Calcium content in *Acacia ataxacantha* is high during summer and lowest in winter. Harvesting of this species should be done during summer where calcium is at its highest concentration. According to Harty (2014) Calcium plays a vital function in maintaining healthy bones and teeth. The concentration of calcium in mopane leaves range from a minimum of 0.51% in January to a maximum of 3.23% in September (Timberlake, 1996). This is in harmony with this study, which also found that the calcium content of *Colophospermum mopane* was highest at around 1.67% in summer and lowest in winter at 0.982% with an average of 1.42%. The fact that calcium content in *Colophospermum mopane* is high during summer and lowest in winter, harvest should be done during summer to support livestock in dry seasons.

4.4.8 Phosphorous (P)

Baphia massaiensis has low levels of phosphorous throughout the year with the highest being 0.123% during spring/autumn and lowest during summer at 0.011% (Figure 4.10).

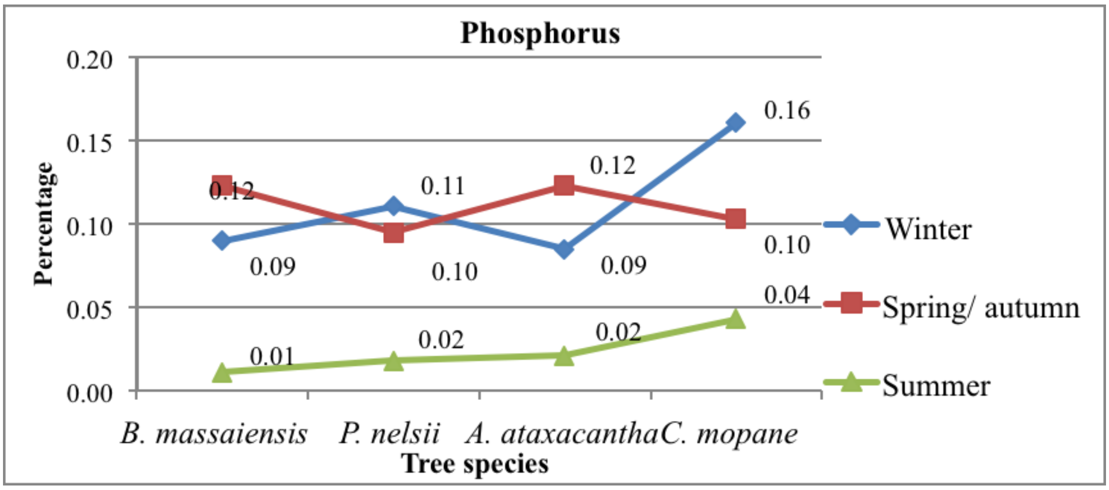

Figure 4.10: Phosphorus Content of the Selected Tree Species

The West African study found 0.2% in the same species (Aganga *et al.,* 2000). *Baphia massaiensis* leaf meal is a potentially important browse feedstuff for growing animals that require a lot calcium, potassium and phosphorus for of bone development and growth (Kasale, 2013). Spring/autumn could be the ideal season of harvesting when P is at its highest level.

Philenoptera nelsii shows low levels of phosphorous throughout with the highest being 0.111% during summer and lowest during 0.018%. The average of P for all season is 0.075% (Table 4.1). Winter season could be the ideal season of harvesting, when P is at its highest concentration. Katjiua and Ward (2006), obtained phosphorus concentration of 0.11%, equally to this study finding in winter season.

Phosphorus in *Acacia ataxacantha* displays low levels throughout season's highest in spring/autumn and lowest summer. Amoussa and Sanni (2014), study, the average phosphorus content was 3.95 % which above this study, contrary to Daben *et al.* (2017) and Wright *et al.*(1997), findings of 0.029% and 0.14% which is in agreement of this study. According Norton(1994) minimum requirement of ruminants for phosphorus varies from 1.2 to 2.4 g/kg feed dry matter. The concentration of phosphorus in leaves seems to be constant and does not appear to vary significantly throughout the year.

According to Macdonald *et al.*(2010), concentration of phosphorus in *Colophospermum mopane* leaves range from a minimum of 0.43% slightly high to this study result, disparity may cause by type of sample used.

4.4.9 Organic Matter Digestibility

Organic matter digestibility in *Baphia massaiensis* observed high value in winter 42% and lower during summer 35.9% (Figure 4.11).

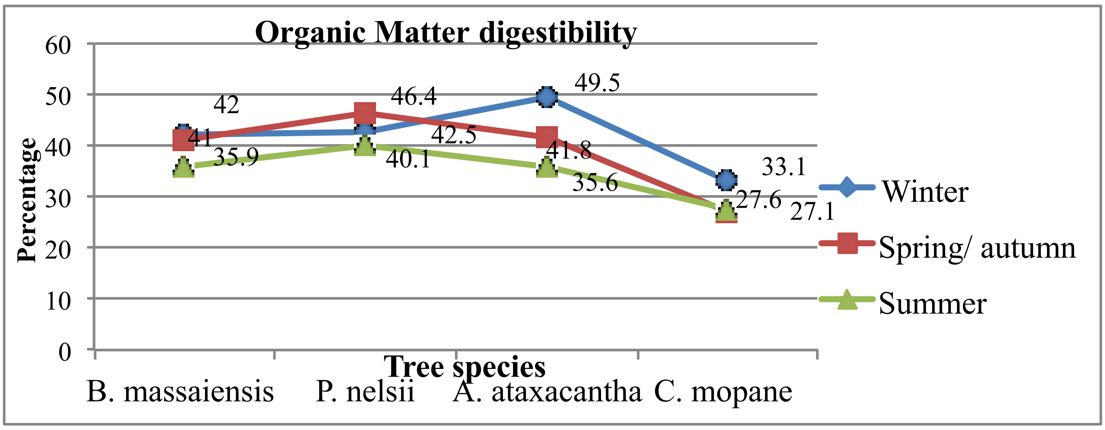

Figure 4.11: Organic Matter Digestibility of the Selected Tree Species

OMD is a sum of the digestible fiber, protein, lipid, and carbohydrate components of a feedstuff or diet. OMD is directly related to digestible energy and is often calculated based on ADF. OMD is useful for beef cow rations that are primarily forage. OMD values tend to under predict the feeding value of concentrate relative to forage i.e. all seeds from plants have high OMD (Kasale, 2013). Meaning if livestock are fed with this species harvested during winter, they are likely to benefit the most from the digestible nutrients.

Organic matter digestibility in *Philenoptera nelsii, occurs* high during spring/autumn at 46.4% and it's lowest in summer 40.10% (Figure 4.11). Harvesting of this species could be ideal during spring/autumn season. *Acacia ataxacantha,* observed highest values of organic matter digestibility in winter 49.5% and its lowest during summer 35.6%. According to Macdonald *et al.* (2010), *Colophopermum mopane* leaves can be easily digested during winter season, when the leaves are dry, as opposed to summer season when the leaves are still growing. This study result also shows that the highest value of organic matter digestibility occurs during winter season. Meanwhile Kasale (2013), obtained almost double of the OMD against this study. Harvesting of *Colophospermum mopane* should be done during summer when it is away from the strain of weather and mopane worms.

According to Kasale (2013), decline in pasture digestibility can make cattle lose weight at an increasing rate as the dry season progresses. This leads to the deterioration of animal body condition, higher susceptibility to diseases and death during extended dry periods. This nutrient is very important to animals if farmers want their animals to be healthy. Rising temperatures increase lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species the digestible fiber, protein, lipid, and carbohydrate components of a feedstuff (Kilcher, 1979). This means that OMD decreases with increasing temperatures.

4.4.10 Metabolisable Energy (ME)

The study shows that *Baphia massaiensis* has a peak of ME during winter of 5.8% and least in summer season. This study on average ME observed at 5.47%, slightly less than Kasale (2013), findings of 8% in the same tree species. This could be attributed to the difference in climatic and soils type in Zambezi region and Ohangwena region. Results shows that for the greatest ME, *Baphia massaiensis* must be harvested during winter. The ME is at its highest in winter due to the species withholding vital nutrients because of lower transpiration levels as well as lower nutrient uptake. The holding of nutrients will result in high ME which will be offloaded during summer when transpiration levels become high again.

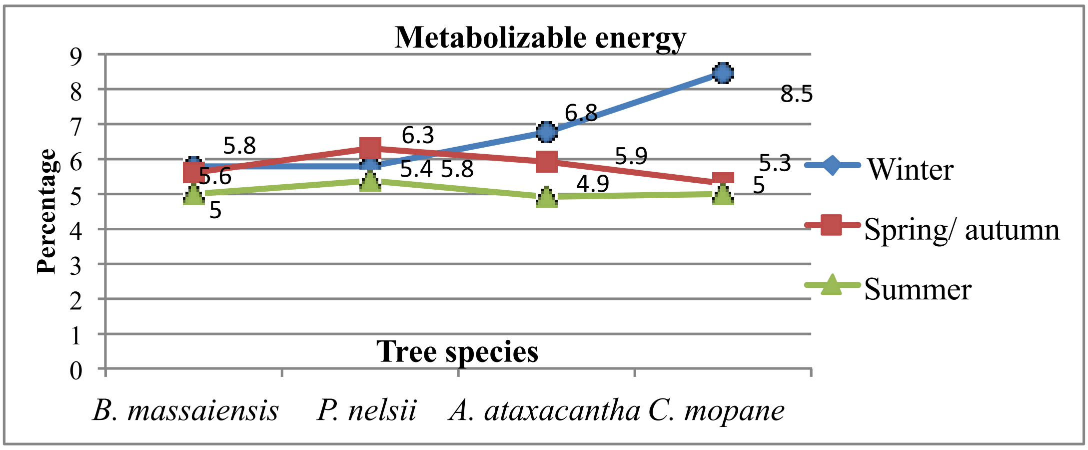

Figure 4.12: Metabolisable Energy of the Selected Tree Species

Philenoptera nelsii shows a peak of ME concentration during spring/autumn of 6.3% while during summer that is where there the least of 5.4% (Figure 4.12). The graph line shows that for the greatest ME, *Philenoptera nelsii* should be harvested during spring/autumn. The holding of nutrients will result in high ME, which will be offloaded during summer when transpiration levels become high again.

Acacia ataxacantha has a peak of ME during winter of 8.5% while least during summer of 5% averaging at 6.27% (Table 4.1). Study conducted in Syria by Al-Masri and Mardini (2013), the ME for *Acacia ataxacantha* was found to be 7.63%, which is close to this study's average. The finding reflects that for the greatest ME, *Acacia ataxacantha* must also be harvested during winter. Winter season this species withholding vital nutrients because of lower transpiration levels as well as lower nutrient uptake. The holding of nutrients results in concentrations of ME, which will be offloaded during summer when transpiration levels become high again.

Result shows *Colophospermum mopane* has peak of ME during winter and it reduce its concentration in summer. *Colophospermum mopane* has consistently shown that its best values happen during winter, farmers should use this opportunity. Winter season there are no caterpillar cocoons that might poison the animals. Harvesting in winter allows the tree to heal when there is no rain. Harvesting in summer or rainy season, fungi infection may cause diseases to the mopane tree.

During winter mopane worms are not yet fully developed to start consuming the mopane leaves. Winter harvesting also allows for the leaves to sprout again leading to restoration of the velds / pasture. According to (Aubrey, 2004), pods seeds ripen between April and June during winter in most of Southern Africa landscapes and it allows for the seeds to receive the best genetic programming. On dry year mopane trees start losing its leaves as early as June and where late rain fallen, Mopane will hold its leaf longer (Vincenti *et al*., 2013).

The concentration of composition values in all of the four species does not vary significantly over the seasons; even though this study could not determine secondary metabolites that influences organic matter digestibility.

4.5 Mean Variation of the Proximate Composition and Energy Values Between the Selected Encroached Tree Species of the Savannah Landscapes in Namibia

The results show that the null hypothesis **(H_0):** $\mu_{\text{Colophospermum mopane}} = \mu_{\text{Baphia massaiensis}} = \mu_{\text{Acacia ataxacantha}} = \mu_{\text{Philenoptera nelsii}}$ and the alternative (H_a): At least one μ_i is different.

The rejection region of the ANOVA used was to reject the null hypothesis if p-value ≤ 0.05. From the output, F-test = 0.037 with 3 and 36 degree of freedom. P-value = sig = 0.990. Since p-value = 0.990 >0.05, we fail to reject the null hypothesis at $\alpha = 0.05$ level of significance; there exist enough evidence to conclude that there is no significance difference in the mean values of the four tree species (*Colophospermum mopane*, *Baphia massaiensis*, *Acacia ataxacantha* and *philenoptera nelsii*). Since we failed to reject the null hypothesis that the means are equal, the study will no longer perform a Post Hoc test (Tukey-Kramer) multiple comparison analysis.

4.6 Farmer's Perceptions on the uses of the Encroacher Trees Species for Bush Feed in Relation to Different Seasons

Results show that summer season is in favour of majority of the respondents, who perceive bush feed as a better supplement in absent of grass. Winter season also perceived ideal time to harvest when trees leaves and pods matured. Least respondents are in favour of spring/autumn season, when trees are at blooming stage with tender shoots and young leaves as shown in Figure 4.1.

The reasons for using bush feeds (Figure 4.13), this study demonstrate that majority of respondents strongly feel that severe drought is the main driver that might force farmers to make use bush feed. Followed by the respondents who feel bush encroachment is reducing Namibia rangelands productivity and should be measured as an opportunity to convert unwanted bush into animal feed. Some respondents feel tree are keeping its greeneries even during dry season, hence they serve as a source of protein. Few respondents perceived bush feed feeds as an additional income generation activity to farmers and it is appropriate to be used in feedlots. Result displays least of respondents indicate that they prefer to use bush-feed, for the reason being that commercial feeds are expensive and not available in rural areas.

The comparison is drawn from the report by Namibia, Support De-bushing Project. (2017). *Bush - Based Animal Feed Survey report.* Windhoek: Ministry of Agriculture, Water and Forestry. Figure 4.13 shows the results on reasons given by the farmers.

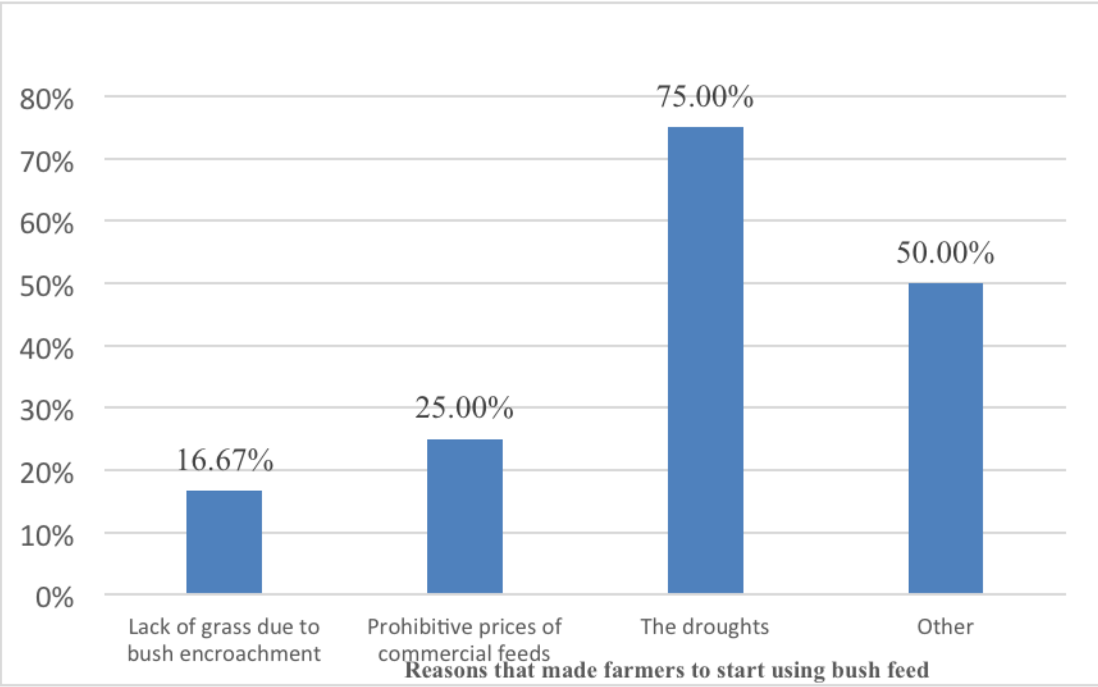

Figure 4.13: Reasons that Made Farmers to Start using the Bush Feed in Namibia

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study safely conclude that no tree species had all the elements at high level but rather each tree species was strong in one element and weak in another. On average, *Baphiamassaiensis* is relatively rich in moisture, ADF and NDF, while *Philenopteranelsii* is high in moisture, crude protein, NDF and OMD. *Acacia ataxacantha* is rich in phosphorous and metabolisable energy. *Colophospermum mopane* is rich in ash, fat, calcium, phosphorous and metabolisable energy. All the four tree species prove to contained relative high digestible and metabolisable energy which is very useful in the bush feed making. This study found that one can use a tree species rich in a certain elements to complement each other. The best time for harvesting bush feed depends on season when composition and energy values are at high level, this study winter shown best results.

Other factors should be considered before harvesting operation take place like infection trees by fungi during rainy season, Mopane worm prevalent during summer and Mopane tree excretion anti-nutritional substances during spring/Autumn season. The digestibility of mopane tree is high during the dry season, but declined during the summer season, which possible influenced by high amount of secondary metabolites. The composition and energy values were in consistence with other studies carried out on the same tree species. Climatic condition during the study was below average rainfall, which may affect the mineral uptake. This study found that the means of all tree species are equal, which imply that there does exist enough evidence to conclude that there is no significance difference in the mean values of the four tree species. Results show that summer season is in favour of majority of the respondents, who perceive bush feed as a better supplement in absent of grass. Winter season also perceived ideal time to harvest when trees leaves and pods matured. This study demonstrate that majority of respondents strongly feel that severe drought is the main driver that might force farmers to make use bush feed.

5.2 Recommendations

It is important for all parties/stakeholders, that is the researchers, extension workers, scholars, and farmers to work collectively for the purpose of building a database of efficiency utilization of discarded woody materials from the encroacher tree species.

(i) The institutions responsible for dissemination of information should promote the use of discarded woody materials into valuable products such as animal feed, composite, poles, treated droppers, charcoal and electricity in order to create employment to people.

(ii) Ministry responsible for forestry should encourage farmers involving in de-bushing operations where possible to make joint ventures with the investors who are interesting in animal feed businesses.

(iii) Farmers should be educated on the benefits of knowing chemical composition, so that they develop valuable products and to avoid any toxicity. Incentives should be initiated to support farmers who are interested to farm with trees by apply bush encroachment sustainable management control systems.

(iv) This study shows that no single tree species has all high level of proximate composition and energy values; hence, there is possibility to complement this species stand chance to make good quality bush feeds. Bush feeds stand a chance to bring much needed income that reduce poverty among communities in the rural areas and at the same time it encourage people to participate in sustainable management of the natural resources especially the forests to curb deforestation, hence climate change and global warming.

(v) The de-bushing operations should be accompany by comprehensive silvic cultural practices for sustainability of forest resources and maintain the stable environment. This study laid a foundation for a study to explore ecological factors influencing these tree species physiological characteristics.

(vi) This study recommends that another study is needed on the palatability, growth performance and technologies that can be used to pellet the feeds so that can be stored for a long time. The study further, recommends weighing other macro elements like carbohydrates, chlorine, magnesium, sodium, sulphur and potassium which are not covered by this study.

(vii) Similar studies should be applied to other dominant tree species such as *Barkea africana, Baikiaea plurijuga, Combretum sp. as well as Terminalia prunoides.* The study suggest that similar study must be conducted over a long period of time including the time when there are good rains, because it was noted that during the study climatic condition shown below average rainfall which may have the effect on the minerals uptake of the trees under study.

(viii) Further studies must be carried out on the anti-nutritional constituents of these tree species. In other words, the poisonous/toxicity aspects of the tree species must be determine especially the *Colophospermum mopane* which sometimes make it-self unpalatable due to higher levels of secondary metabolites such as phenols and tannins as a defense mechanism to prevent over-browsing during the growing seasons.

REFERENCES

Aganga, A. A., & Adogla-bessa, T. (2000). Milk Production of Tswana Goats Feed Diets Containing Different levels of Energy. *South Africa Journal of Animal Science, 4(30)*, 77-81.

Agri Laboratory Association of Southern Africa. (2007). *The Agri Handbook.* Cape town: SAHB Publishing (Pty) Ltd.

Aldeman, G. (1993). *Energy and Protein Requirements of Ruminant.* Wallingford: Acribia S.A.

Al-Masri, M. R., & Mardini, M. (2013). Anti-nutritional components in leaves of some indigenous oak species at different growth stages. *Livestock Research for Rural Development , 25*(2), 301-307.

Amatya, S., Dhoubdhel, S., & Pradhan, P. (2012). Monthly variation in nutrient contents in four fodder trees commonly grown in Nepal. *Nepal Journal of Science an Technology, 13*(2), 39-44.

Amoussa, A. M., & Sanni, A. (2014). *Acacia Ataxacantha (bark)* . Retrieved October 06, 2017, from Chemical Composition and Antibacterial activity of the extract: http://www.reseachegate.ne/publication/287380330.

Anderson , H. (2016, May 12). *Forange Nutrition 101:*. Retrieved June 12, 2017, from Acid Detergent Fiber, Neutral Detergent Fiber: https://www.anderson-hay.com/blog/forage-nutrition-101-acid-detergent-fiber-neutral-detergent-fiber

Aubrey, A. (2004). *Phoenix Reclinata Jacq- South African National Biodiversity Insittute*. Retrieved 09 28, 2017, from http://www.plant zafrica.com/ plant phoenix rec.htm.

Brink, H., Van der, W., & Van Rensburg, G. (2012). *Fundementals of research methodology for Heathcare Proffessional (3rd Ed).* Cape Town: Juta.

Bruns, N., & Groove, S. (2011). *The practice of social research.* Cape Town: Oxtord university press.

Burkill, H. (1995). *The Usefull Plants of West Tropical Africa.* Richmond: Royal Botanic Garden Kew.

Cabral, H. J. (2008). Multipuple Comparisons Procedures Circulation. 698-701.

Centre for Agricultural and Enviromental, Research and Trainng. (2002). *The Importance of Proteins, Minerals and Vitamins*. Retrieved June 05, 2017, from http://www.silversageffa.com/uploads/2/1/3/3/21332862/nutrients_eunit.pdf

Cooper, S., Owen-Smith, N., & Bryant, J. (1988). Foliage Acceptability to Browsing Ruminants in Relation to Seasonal Changes in the Leaf Chemistry of Woody Plants in a South African Savanna. *Oecologia, 75*(3), 336-342.

Creswell, J. W. (2012). *Research design.* Los Angeles, London: SAGE Publications.

Curtis, B., & Mannheimer, C. (2005). *Tree Atlas of Namibia.* Windhoek: NBRI.

Daben , J., Dashak, D., Praise, O., Obole , E., & Agba, M. (2017). Assessment of the Proximate and Mineral Composition of Acacia ataxacantha Leaves. *International Journal of Science and Research (IJSR) , 6*(5), 899-903.

Devandra, C. (1990). *Nutritional potential of fodder trees and shrubs as protein sources in ruminants nutrition*. Retrieved October 09, 2016, from http://www.fao.org/livestock/agap/frg/ahpp102/102-95.pdf

Development Consultants of Southern Africa. (2015). *Adding Value to Namibia Encroacher Bush: Turning the challenge of Bush into an opportunity.* (Neuberger, Ed.) Windhoek, Namibia: John Meinert Printing (PTY) Ltd.

Dicko, M., & Sikena, L. (1981). *Fodder trees and shrubs in range and farming systems in dry tropical Africa.* Rome: Food and Agriculture Organization.

Dietz, D., Udall, R., & Yeager, I. (1962). *Chemical Composition and digestability by Mule Deer of selected Forages species.* Colorando: Colorado Fish and Game Deptment.

Directorate of Forestry . (2012). *Community Forestry Manual.* Windhoek: Directorate of Forestry of Ministry of Agriculture, Water and forestry.

Directorate of Forestry. (2011). *A Forest Research Strategy for Namibia (2011-2015).* Windhoek: Directorate of forestry of Ministry of Agriculture, Water and foresty.

Dube, C. (2010). Towards improved utilization of macimbi Imbrasia belina Linnaeus, 1758 as food and finacial resource for peope in the Gwanda district of Zimbabwe. *Zimbabwe Journal of Science and Technology, 5*, 38-36.

Durst, B., Johson, V., Leslie, R., & Shono, K. (2010). Forest insect as food: Humans bite back proceedings of a Workshop on Asia- Pacific resouces and their potential for development 19-21 February 2008, Chiang Mai. (p. 115). Bangkok: Food and Agriculture Organization of the United Nation for Asia and Pacific.

Eckelman, C. (2017). *The shrinking and swelling of wood and its effect on furniture.* Retrieved May 25, 2017, from Forestry and Natural Resources: https://www.agriculture.purdue.edu/fnr/faculty/eckelman/documents/FNR-156b.pdf.

Fern, K. (2014). *Baphia massaiensis* . Retrieved June 29, 2017, from Useful Tropical Plants: http://tropical.theferns.info/viewtropical.php?id=Baphia+massaiensis

Freedman, D. A., Pisani, R., & Purves, R. A. (2007). *Statistics 4th edn.* New York: W.W.Norton & Company.

Freud's, J. E. (2004). *Mathematical Statistics with Application; senth Edition.* London: Pearson Prentice Hall, Pearson education LTD.

Georgievskii, V., Annenkov, B., & Samokhin, V. (1982). *Studies in the Agricultural and Food Sciences: Mineral Nutrition of Animals.* London: Butterworths.

Grutteridge, R. C., & Shelton, H. M. (2001). *Forage Tree Legume as in Tropical Agriculture,.* Oxon 0X108DE, UK: CAB International Wallingford.

Hailwa, J. (2002). Tropical Secondary Forest Management in Africa : Reality and perspectives Namibia Country Paper. *Workshop on tropical Secondary forest management in Africa 9-13 December 2002.* Nairobi, Kenya: Food and Agriculture Organization of United Nation.

Harty, A. (2014, January 27). *Importance of Calcium and Phosphorus in the Ruminant Diet.* Retrieved August 10, 2017, from iGrow:A service of SDSU Extension: http://igrow.org/livestock/beef/importance-of-calcium-and-phosphorus-in-the-ruminant-diet/

Hoffmann, L. (2015, May 07). *The Kalahari apple-leaf (Philenoptera nelsii = Lonchocarpus nelsii):.* (e. @. Namibian.com, Ed.) Retrieved June 30, 2017, from The Namibian Newspaper: https://www.livescience.com › Animals.

Hogan, C. (2017). *Flora of Zimbawe: Colophospermum mopane* . Retrieved June 23, 2017, from EOL Encyclopidia of Life: http://eol.org/pages/418082/details.

Kasale, F. (2013). *Determinetion of nutritive values of browsable plants utilised by cattle during dry season in Sibinda Consttuency of the Zambezi Region (Unpublished master thesis).* Windhoek: Unversity of Namibia.

Katjiua, M., & Ward, D. (2006). Resistance and tolerance of Terminalia sericea trees to stimulated herbivore damage under different soil nutrient and moisture conditions. *Journal of Chemical Ecology, 32*(7), 1431-1443.

Kereru, P., Kenji, G., Keriko, J., & Mungai, G. (2007). Traditional medicines among EMBU and Mbere people in Kenya. *African Journal of traditional , Complementary and Alternative Medicine (AJTCAM), 4*(1), 75 -86.

Kilcher, M. (1979). Plant Development, Stage of Maturity and Nutrient Composition. *Journal of Range Management, 34*(5), 363-364.

Kleinhas, T., & Mbaurum, B. (2016, May 20). Charcoal production and marketing in Namibia. *Informate Newspaper*, p. 1.

Kozanayi, W., & Frost, P. (2002). *Marketiing of Mopane Worm in Southern Zimbabwe Internal Report: Mopane woodlands and the Mopane Worm: Enhancing rural livelihood and resource sustainability, DFID Project No. R7822.* Environmental Studies, University of Zimbabwe. Harare: Division of Biology, Imperial college, London.

Kramer, P. J., & Kozlowski, T. T. (1960). *Physiology of trees.* Newyork: McGrowhill.

Macala, J., Sebolai, A., & Majida, R. R. (1992). Colophospermum mopane browse plant and sorghum stover as feed resources for ruminants in Botswana. *The complimentary of feed resources for animal production in Africa. Proceeding of the Joint Feed Resources Network Worshop* (151–161.). Addis Ababa, Ethiopia: ILCA.

Macdonald, I., Joseph, O., & Harriet, M. (2010). Documentation of medicinal plants sold in the markets in Abeokuta, Nigeria. *Tropical Journal of Phamaceutical Research, 9*(2), 110-118.

Madzibane, J., & Potgieter, M. (1999). Uses of Colophospermum mopane (Leguminosae: Caesalpinioideae) by the Vhavenda. *South africa Journal of Botany, 65*(5), 440-444.

Makhando , R. A., Potgieter, M. J., & Luus-powell, W. J. (2016). Nutritional value of Colophospermum Mopane as source Browse and its Chemical diferences against browsers. *The Journal of Animal and Plant Sciences, 26*(3), 569- 576.

Mannheimer, C., & Curtis , B. (2009). *Le Roux and Muller's Field Guide to the Trees and Shrubs of Namibia.* Windhoek: Macmillian Education Namibia.

Mendelson, J., & Obeid, S. (2005). *Forests and Woodlands of Namibia.* Windhoek: Sing Cheong Printing, Hong Kong.

Mendelson, J., Roberts, C., Robertson, T., & Jarvis, A. (2003). *Antlas of Namibia: Aprotrait of the land and its people.* Cape town: New Africa books (PTY) Ltd.

Menke , H., Raab, L., Sleewski, A., Steingass, H., Fritz, D., & Scheinder, W. (1979). The estimation of the disgestibility and metabolisable energy content of ruminant feeding stuffs from the gas production when they are incubated with rummen liquor in vitro. *The Journal of Agriculture Science, 93*(1), 217-222.

Moran, J. (2005). *Tropical Dairly Farming: Feeding Management for Small Holder Frmers in the Humid Tropic.* Chicago: Csiro publishing.

Mujuru, F., Kwiri, R., Nyambi, C., Winini, C., & Moyo, D. (2014). Microbiological quality of Gonimbrasia belina proceed under different traditional practices in Gwanda, Zimbabwe farming mopane worm-a householg guide. English version. *International Journal of Current Microbiology and Applied sciences, 3*(9), 1085-1094.

Namibia, Directorate of Forestry. (2012). *Community forest manual.* Windhoek: Solitaire Press.

Namibia, Directorate of Parks and Wildlife Management (2013). *National Policy on Community Based Natural Resource Management.* Windhoek: Ministry of Environment and Tourism.

Namibia, Ministry of Agriculture Water and Forestry. (2016). *National strategy for optimisation of rangeland management and encroacher bush utilization and ministerial submission resources mobilization.* Windhoek: Ministry of Agriculture, Water and Forestry.

Namibia, Ministry of Agriculture, Water and Forestry (2015). *Annual Report of 2014/2015 Financial Year.* Windhoek: Ministry of Agriculture, Water and Forestry.

Namibia, Support De-bushing Project (2017). *Bush - Based Animal Feed Survey report.* Windhoek: Ministry of Agricultulture, Water and Forestry.

Negumbo, F., Aushona, A., Mulofwa, J., & Hilfiker, K. (2010). *Participatory Rural Apraisal Report.Using the Directorate of Forestry library.* Eenhana: Ministry of Agriculture, Water and Forestry.

Neuberger, I. (2016). Quantifying Harvestable Encroacher Bush: Determining the balance between environmental sustainability and economic feasibility of bush utilisation in Namibia. Windhoek: John Meinert Printing (PTY) Ltd.

Njidda, A. A. (2010). Chemical Composition, Fiber Fraction and Anti-Nutritional Substances of Semi-arid Browse Forages of North - Eastern Nigeria. *Nigerian Journal of Basic and Applied Science, 18*(2), 181-188.

Norton, B. (1994). Forage trees legumes in tropical Agriculture. In D. o. Queensland, *Nutritive Values and Animal Production from Fodder Trees* (pp. 177-1991). Wallingford, UK: CAB international.

Palgrave, K., Drummond, R., Moll, J., & Palgrave , M. (2003). *Trees of Southern Africa* (3rd ed.). Cape town, South africa: Struik Publishers.

Pandey, G., & Padyall, B. (2015). *Protecting Forest, Improving Livelihoods - Community Forstry in Nepal.* Nepal: Global Alliance of Community Forestry, Green Foundation Nepal.

Pojic, C., Palic, D., Mastilovic, J., & Hajnal, E. (2016). Food and Feed Research: The introduction of a method for determination of organic matter digestability in feeds into routine laboratory practice. *Journal of the Institute of Food Technology in Novi Sad, 42*(1), 73 -81.

Robert, C. (2002). Long-term costs of the Mopane worm harvest. *Oryx, 32*(1), 6-8.

Robertson, J., & Van Soest, P. J. (1981). *The analysis of dietary fibbre in food (eds.* Newyork: Dekker.

Sawyer, J. F. (2007). Analysis of Varance: The Fundamental Concepts. *The Journal of Manual and Manipulative Therapy: 17(2),* 55-71.

Sianga, K., & Fynn, R. (2017). *The vegetation and wildlife habitant of the Savuti-Mababe Linyati ecosystem.* Nothern Botswana: Unversity of Botswana , Okavango Research Institute.

Smit, G., Deklerk, J., & van Eck, J. (2016). *Quantifying harvestable encroacher bush: Determining the balance between environmental sustainability and economic feasibility of bush utilization in Namibia.* Windhoek: John meinert Priting (PTY) Ltd.

Stack, J., Doward, A., Gondo, T., Frost, P., Taylor, F., & Kurebgseka, N. (2003). Mopane Worm (MW) Utilisation and Rural Livelihoods in Botswana Preliminary Field Survey Report. *The International Coference Rural Livelihoods, Forest and Biodiversity, 19-23 May 2003.* Bonn, Germany: Unpublished report, Veld Products Institute.

Timberlake, J. (1996). *Colophospermum mopane.annoted bibliography and review.* Retrieved August 08, 2016, from International Information System for the Agricultural Science and Technology: http://www.fao.org/library/library-home/en/.

Tjikundi, C., & Frans, H. (2016). *Forest Resources Inventory Report for Ehi-rovipuka Community Forest.* Windhoek: Directorate of Forestry of the Ministry of Agriculture, Water and Forestry.

Toms, R. B. (2001). The Mopane worm and the wonder of matamorphosis. *Zimbabwe Journal of Science and Technology, 5*, 28-36.

University of Maryland Medical Centre (2017). *Phosphorus*. Retrieved June 08, 2017, from Health Information: https://www.umm.edu/Health/Medical/Ency/Articles/Phosphorus-blood

Van Soest, P., Robertson , J., & Lewis, B. (1991). Methods of Dietary Fiber , Neutral Detergent Fiber and Nonstarch Polysaccharides in Relation to Animal Nutrition. *Journal of Dairy Science, 74*(10), 3583-3597.

Van Voorthuizen, E. G. (1976). The Mopane tree: Botswana notes and records. *OA African Journal Archive, 8*(1), 223-230.

Veldtman, R., Nethavhani, Z., & Foord, S. (2017, June). Harvesting of mopane worm in Limpopo and underlying ecological infrastructure. *Mombolo Mdhluli* *conference centre.* Skukuza camp, Kruger National park: South African National Biodiversity Institute.

Viljoen, J. (2001). Qualiy of Feed Phospahate Suplements of Animal Nutrition. *South Africa Journal of Animal Science, 2*(1), 13-19.

Vincenti, B., Ickowitz, A., Powell, B., Kehlenbeck, K., Termote, C., Termote, C., et al. (2013, March 24). *Background Paper for the International Conference on Forests for Food Security and Nutrition FAO, Rome 13-15 May 2013.* Retrieved 09 28, 2017, from The Contribution of Forests to Sustainable Diets: http://.fao.org/forestry/37q32-051da8e87e54f379de4d7411aa3a3c32a. pdf

Wessels, D. V. (2007). Induced Chemical Defences in Colophospermum mopane trees. *African Journal of Range and Forage Science , 24*(3), 141 -147.

Wiggins, D. A. (1997, September). Fluctuating asymmetry in Colosphospernum mopne leaves and oviposition preference in an Africa Silk Month Imbrasia belina. *Oikos, 79*(3), 484-488.

Wright , D., Jessen , H., Bruke, P., & De Silva Garza, H. (1997). Tree and Liana Enumeration and Diversity on a one hectare Plot in Papua New Guinea. *Scientific Journal for Association Tropical Biology and Conservation, 29*(3), 250- 260.

APPENDICES

Appendix I: Questionnaires-Uses of Forest Product in Relation to Seasonality

Name of Community forests: -----------------------Constituency …………….Region

Geographical Position coordinate S………………………. and E……………………

Part one

1. Area of study descriptions

(i) Climate (temperature and rainfall conditions)

(ii) Geology (hydrology and soils)

(iii) Vegetation characteristics

(iv) Infrastructure

(v) Population

2. Who are the stakeholders (identifying participants for resource management &dialogues)

3. Where are the management areas? (Spatial analysis allows research to focus his attention to the precise management area its important resources, communities involved and pressure within it).

4. What are the constraints and opportunities for improving the productivity of the Forest; (ways of better understating forest resources production)

Part two: Interview questions

1. Why farmers make use of bush-feeds?

(a) Bush have high protein content

(b) Less grass, because of bush encroachment

(c) Severe drought

(d) Commercial feed are expensive

(e) Other

2. Which is the best period of harvesting bush /trees?

   (a) Spring,

   (b) winter/autumn and

   (c) Summer

3. Other product that could be produced from encroached bushes?

   (a) Firewood

   (b) Charchoal

   (c) Pulp wood

   (d) Chips

   (e) Bushblock,

   (f) Pellets

   (g) Curios

   (h) Timber (lumber)

   (i) Animal feed

   (j) None

4. What wood products are produced for own use?

5. Which tree species produce those products?

6. Where are they selling those products?

7. How they market and sell wood products
8. Do you support the idea of further processing woody materials into *chips, parquet, animal feed, pulpwood, bushblock, pellets, Charcoal, firewood and fiber board? (Circle the number)*
   - (i) strongly agree
   - (ii) Agree
   - (iii) Disagree
   - (iv) Strongly disagree

9. What products you are supporting and why? List the products you prefer most.
10. Who will be involved in wood processing?
11. Are there enough trees/ bush to support production of those products?
    - (i) More than enough
    - (ii) More
    - (iii) Less
    - (iv) Very less

12. How do you support the above answers?

Thank you for your acceptance and the responses

Appendix II: Acacia mellifera Trees De-Bushed for Processing Bush-Feeds

…………………… END …………………..