# DETERMINATION OF NUTRITIVE VALUES OF BROWSABLE PLANTS UTILISED BY CATTLE DURING THE DRY SEASON IN SIBBINDA CONSTITUENCY OF ZAMBEZI REGION - NAMIBIA

**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS**

**FOR THE**

**DEGREE OF MASTERS OF SCIENCE IN RANGELAND RESOURCES AND**

**MANAGEMENT**

**OF THE**

**UNIVERSITY OF NAMIBIA**

**FACULTY OF AGRICULTURE AND NATURAL RESOURCES**

**DEPARTMENT OF ANIMAL SCIENCE**

**BY**

**FABIAN KASALE**

**Student No: 201203803**

**NOVEMBER 2013**

**MAIN SUPERVISOR: PROF. IRVIN D.T. MPOFU**
**CO-SUPERVISOR: DR P. PETRUS**

**This thesis has been approved in terms of content and style by:**

**Main supervisor: Prof I.D.T. Mpofu …… Date …….**

**Co-Supervisor: Dr P. Petrus …….. Date ….....**

**ABSTRACT**

This study was conducted in the Sibbinda constituency of Zambezi region in Namibia to determine and contrast the nutritional values of available browsable plants and to recommend and promote the use of these browsable plants and plant parts as cattle feed supplements during dry seasons. In depth focus group discussions and interviews were conducted to glean indigenous knowledge on how cattle utilize the browse *in- situ*. A total of 200 households from the Sibbinda constituency were interviewed through a questionnaire to identify locally important browse species. Besides that, cattle were followed and observed while grazing and browsing undisturbed .This was done to confirm and validate the indigenous knowledge obtained from focus group discussion with communal farmers in the Sibbinda constituency. The palatability was determined through a structured experiment were the browse was offered in feeding pens. The palatability trial revealed contrast in the palatability of leaves and pods browsed by cattle during the dry season in Sibbinda constituency. Browsable tree and shrub leaves were collected for botanic identification, chemical composition analysis and feed evaluation. A total of 10 different browse species were identified. Ranking analysis revealed the following five browse species as the most common ones in order of importance; *Acacia erioloba, Dichrostachy cinerea, Guibourlia coleosperm and Colosphospermum mopane*. The chemical composition, digestable energy, metabolisable energy and the digestibility were compared by F-Test using the SPSS software version 21. The crude protein (CP) values of the edible components ranged between 9.4 to 27.2% and were significantly different ($P<0.05$) across browse species. The crude fibre (CF) content was also significantly different ($P<0.05$) across species and CF values ranged from 14 to 36%. The total digestible nutrients (TDN) also differed ($P<0.05$) with a range of 53-72%. Nitrogen values ranged from 1.51% to 4.37 ($P<0.05$).Generally the differences in chemical composition between different browse species were significant.

**Key words:** Browsable, cattle, dry season feeding, crude protein, crude fibre, palatability, digestibility, feed composition, feed evaluation.

**TABLE OF CONTENTS**

Pages

ABSTRACT…….....…ii
TABLE OF CONTENTS……..iv
LIST OF FIGURES…….....vii
LIST OF TABLES……..……viii
LIST OF APPENDECIES……ix
ACRONYMS…….....x
DEDICATION……..…….....xi
ACKNOWLEDGEMENTS…….....xii
DECLARATION…….……...xiii

**CHAPTER 1**

INTRODUCTION…….…1
1.1 Orientation of the study……..….....1
1.2 Statement of the problem and justification…….....2
1.3 General objectives…….....4
1.4 Objectives of the study…….....…….....4
1.5 Null Hypotheses of the study …….…….....4
1.6 Significance of the study…….....4
1.7 Limitations of the Research…….....…….5

**CHAPTER 2**

LITERATURE REVIEW……...….....6
**2.1 Introduction.....6**
**2.2 Nutritive value of forages.....7**
2.2.1 The factors affecting the nutritive value of forages.....8
2.2.3 Characteristics of a plant species……13
2.4 The role of ligneous fodder resources for ruminant husbandry in Africa…….....16
2.5. Anticipated climate change in Africa.....18
2.5.1 Consequences for farming systems in semi-arid zones.....….18
2.6 System vulnerability and adaptive capacity.....19
2.7 Communal Farmers' coping measures and adaptation strategies.....20

2.8 Effect of climate change on livestock……...22
2.9 Biodervesity (genetic and breeding)…….24
2.10 Importance of fodders.....26

**CHAPTER 3**

METHODOLOGY……..…28
3.1 Study site……...….28
3.2 Research Design ……..……...…28
3.3 Population of the study……..…….……...…30
3.4 The Sample……..…..30
3.5Research Instrument…….....30
3.6 A survey to obtain indigenous knowledge on browse plants…….31
3.6.1.Interviews…….……..……...……..……....31
3.6.1. Identification of all browsables tree species……...……....31
3.6.1Selection of Sample……..32
3.7 Experiments……...…….....33
3.7.1 Experiment 1: Chemical Analysis of the best five browse species…….....34
3.7.2: Experiment 2: Feed Evaluation (DE, ME, TDN, Palatability trial)……...34
3.7.3: Experiment 3: The palatability Trial……..34
3.8 Data Analysis ……..……...……...…..35
3.8.1 Qualitative Data……..……...…..35
3.8.2 Quantitative Data……..…….....35
3.10 Research Ethics……...….35

**CHAPTER 4**

RESULTS…….…….……..36
4. Evaluation of indigenous knowledge on browsables in Sibbinda Constituency…….....36
4.1 Comparisons of moisture and browsable material…….……...37
4.2 Comparison of Ash content of browsables…….……...38
4.3 Fat content of browsable material…….…….....40
4.4 Crude fibre content of browsables……..……...…41
4.5 Crude protein of browsables……..43
4.6 Total digestible Nutrients content of browse feedstuffs in percentage…….…45
4.7 Digestable Energy of the browsables…….…….....46

4.8 Metabolisable Energy MJ/kg…….....47
4.9 Palatability of the browsables……...49

**CHAPTER 5**
DISCUSSION…….…….....51
5.1 Palatability…….…….....51
5.1.1 Measuring Palatability…….....52
5.2 Ash and Moisture content of browse plants……...…52
5.3 Protein content of browse plants……..…..53
5.4 Crude fibre content of selected browse plants…….…...54
5.5 Crude fat of browse species……...…55
5.6 Total Digestible Nutrients (TDN) and Digestible Energy (DE) of browse plant…….....56

**CHAPTER 6**…….....58
6.1 Conclusion…….…58
6.2 Recommendations…….…….....59
REFERENCES……..…...61
APPENDICES……..…71

**LIST OF FIGURES**

FIG 1: Components of Forage……..…..…16

Fig 2: The researcher having an interview…….....32

Fig 3: comparison of moisture content…….…...38

Fig 4: Comparison of Ash content of browsables……...39

Fig 5: Comparison of fat content of browsables…….....41

Fig 6: Crude fiber content of the browsables……..42

Fig 7: Crude protein content of the browsables…….…..…..44

Fig 8: Total Digestable Nutrients content of browse feedstuff in percentage……..…..46

Fig 9: Digestible Energy Content of the Browsable materials…….....47

Fig 10: Metabolisable energy MJ/Kg…….....48

Fig 11: Palatability of the browsables…….....50

**LIST OF TABLES**

Table 4.0: Browse materials identified by communal farmers……36

Table 4.1: Comparisons of Moisture Content of the browsable material……37

Table 4.2: Comparisons off the ash content of browsables……..39

Table 4.3: Fat Content of browsable materials…….40

Table 4.4: Crude Fiber Content of the browsables……...42

Table 4.5: Crude Protein content of the browsables……43

Table 4.6: Total Digestable Nutrients content of browse feedstuff in percentage……...45

Table 4.7: Digestable Energy Content of the browsables……46

Table 4.8: Metabolisable Energy MJ/kg……..48

Table 4.9 Palatability of the browsables…..……..……..49

## LIST OF APPENDICIES

Appendix 1: Questionnaire……..…….71

Appendix 2: Analytical methodologies……...74

Appendix 3: Common names of browsable trees obtained from an interview……76

Appendix 4: Statistical Analysis print out……...77

Appendix 5: Focus Discussions with the communal farmers…….89

Appendix 6: Ratings and responses from focus groups……..89

**ACCRONOMYS**

| | |
|---|---|
| ADF | Acid Detergent Fibre |
| BCT | Bound Condensed Tannin |
| CF | Crude Fibre |
| CP | Crude Protein |
| DE | Digestible Energy |
| DM | Dry Matter |
| FAO | Food and Agricultural Organization |
| GLM | General Linear Models |
| MAWF | Ministry of Agriculture Water and Forestry |
| ME | Metabolisable Energy |
| MS | Mean Squares |
| NCA | Northern Communal Area |
| NGO | Non-Governmental Organisations |
| SCT | Soluble Condensed Tannin |
| SD | Standard Deviation |
| SE | Standard Error |
| SS | Sum of Squares |
| TCT | Total Condensed Tannin |
| TDN | Total Digestible Nutrients |
| UNAM | University of Namibia |

## DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, and Kelvin Matengu known as Mutale whose words of encouragement and push for tenacity ring in my ears. My friend Gloria Nasilele has never left my side and is very special.

I also dedicate this dissertation to my many friends and church family who have supported me throughout the process. I will always appreciate all they have done.

I dedicate this work and give special thanks to my best friend Dr B Mutumba for being there for me throughout the entire masters program.

**ACKNOWLEDGEMENTS**

It would not have been possible to write this Master's thesis without the help and support of the kind people around me, to only some of whom it is possible to give particular mention here. Above all, I would like to thank my technical assistant Kelvin Matengu who gave me his unequivocal support throughout, as always, for which my mere expression of thanks likewise does not suffice.

This thesis would not have been possible without the help, support and patience of my principal supervisor, Prof. Irvin D.T. Mpofu, not to mention his advice and unsurpassed knowledge in Animal Nutrition and Rangeland Resources and Management and his unwavering support in arranging the financing of the laboratory analyses. The good advice, support and friendship of my second supervisor, Dr. Patricia Petrus, has been invaluable, both at academic and at personal level, for which I am extremely grateful.

I would like to acknowledge the financial, academic and technical support of the University of Namibia, particularly the management of Katima Mulilo campus that provided the necessary logistical support.

I am most grateful to colleagues, classmates Elvin Masiku and James Nzehengwa for continuously shared knowledge, stimulating discussions and sleepiness nights we were working together before the deadline.

**DECLARATION**

I, Fabian Kasale, hereby declare that this study is a true reflection of my own research, and that this work has not been submitted for purposes of obtaining a degree in any institution of higher education.



…… ……

**Fabian Kasale** **Date**

# CHAPTER 1

# 1. INTRODUCTION

## 1.1 Orientation of the study

Livestock production occupies approximately 30% of global arable land (FAO, 2008a). With fast depletion of natural resources, ever-increasing population pressure and rising living standards, it has become extremely important to diversify the present-day animal agriculture to meet increasing demand for animal products.

Sibbinda constituency is found in Zambezi region of North Eastern Namibia, where annual rainfall ranges between 500-700 mm. The rainfall season extends from October/November to April. Less than 1% of total precipitation is recorded in June to September winter period (MAWRD, 1996). Temperature naturally varies with the seasons, and ranges from a maximum average of over 10ºc in winter, which rises to 36ºc or above in summer. Communal households in Zambezi lose a quarter of their income during the dry season due to live weight and in severe situation due to livestock mortality. The relative proportion of annual and perennial grasses shifts with wet and dry cycles. The preference of cattle for grass rather than for browse is obvious particularly during the wet season when cattle spend more than 95% of their grazing time on grass despite the simultaneous availability of abundant browse and grass. Browsing normally starts to increase beginning of dry season and increase steadily with a peak in the season (October) because of a flush of a great number of trees and bushes. Poor nutrition caused by inadequate amounts and low quality of feed is one of the major causes of low livestock productivity in tropical areas (Kaitho, 1997) and more specifically in the Zambezi region of Namibia. Conventional feeds such as grains and oilseed cakes are not produced in sufficient amounts to meet the requirements of man and livestock generally in the tropical areas (Abule et al., 2005a).

In the extensive communal arid and semi-arid rangeland, herbaceous plants are the major food source of grazers (Abule et al., 2005b). Forage plants that are usually consumed by domestic animals and wildlife consist mainly of grasses and woody plant browses. Despite the numerous benefits gained from livestock in the Zambezi region, scarcity of animal feed at certain times of the year seems to adversely affect the continuous supply of these benefits. In Namibia, Zambezi region, the major constraints to livestock production is dry season feed shortage. The annual growth rate of free ranging livestock is limited by forage quality and quantity especially in the dry seasons. The use of browse trees and shrubs as supplementary feed is therefore seen as a panacea in bridging this nutritional gap for livestock production in the region.

A challenge therefore, for animal nutritionist is to introduce and promote alternative feed resources that have high nutritive value and are adapted to harsh environmental conditions The on-going climate change is also expected to create harsher conditions: high temperature, droughts, floods and drastic climatic variations, with the greatest impact to be felt among 'subsistence' or 'small holder' farmers in developing countries, Namibia included (Morton, 2007). Wild under-utilized plant resources therefore must, receive more attention (Sansoucy, 1994). The nutrient value of range forage is dependent on botanical composition. Botanical and chemical composition and season of growth affect the digestibility of pasture, and the nature and quantities of the products of digestion. Generally, legumes have higher protein content than grasses and this declines only slowly with maturity (Norton, 1982). Corbett (1987) believed that desirable forage is green, leafy, and leguminous. These are the components of pasture preferred by animals. The first step for determining the nutritive value of feedstuff for livestock is to analyse the chemical composition of different species of plants preferred by livestock, and then to measure their digestibility and palatability. Hence the aim of this study was to determine and compare the nutrition value of forages in the study areas

and recommend and promote the use of natural browse plants and plant parts as cattle feed during dry seasons.

**1.2 Statement of the problem**

There is a problem of feed quantity and quality during the dry season in the North East and Central Regions of Namibia. The forages are normally dry and contain very little protein (<3% CP) and minerals (Phosphorus, Iodine , Potassium, iron).

The nutrients in the grass also become less accessible to cattle as grasses become harder to digest as they mature. As a result of this decline in pasture quality and digestibility 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. In addition, reproductive performance becomes impaired because of excessive loss of weight. As a general rule animals can lose up to 18% of their peak body weight without affecting the reproductive processes. Beyond this point fertility becomes severely affected ((MAWRD, 1996).). Further, local farmers fetch low returns as prices for cattle fall extremely low and yet oxen are too weak at the onset of the wet season when they are needed for ploughing in preparation for the production of crops. Towards the end of the dry season or beginning of the rainy season, cattle especially oxen are needed for land preparation yet this is the time when they are in their worst or poorest body condition.

Natural alternative sources of protein and mineral supplements are necessary to counteract excessive animal weight loss during the dry season (FAO, 2004) this is very important so that animals can easily regain their weight and condition fast enough with the onset of rainy season through compensatory growth. Natural sources are particularly preferred because commercial feeds are expensive and unaffordable by the majority of communal farmers. Natural browse plants and shrubs represent an enormous potential source for cattle in Sibbinda constituency, and these feed resources are generally ignored in feeding systems for

cattle, mainly because of the inadequate knowledge of various aspects of their potential nutritive value. There is not much information from structured scientific study looking at the indigenous knowledge systems in the Sibbinda constituency. Therefore, screening of potential browse plants and plant parts and analysis of their nutritive value is the first step towards addressing this problem. This is why this study was necessary.

### 1.3 General objectives

To identify through indigenous knowledge and direct observation and animal response trial the main browsable parts and plant species) and to determine the nutritive value of potential browse plants as natural supplementary feeds for cattle during the dry season to improve the live weight in Sibbinda constituency of Zambezi region.

### 1.4 Objectives of the study

1.4.1 To identify and establish the common and botanical names of potential browse plants potentially usable as dry season supplementary feeding for cattle in Sibbinda constituency.

1.4.2 To determine and compare the nutritive value of leaves, pods and twigs of selected potential browse species in Sibbinda constituency.

1.4.3 To determine the palatability of the best five browse species

### 1.5 Null Hypotheses of the study

1.5.3 There are potential browsable species for supplementary feeding of cattle in Sibbinda constituency. Ha

There are differences in nutritive value among browsable plants in Sibbinda constituency. Ha

1.5.2 There are no differences in palatability of browse species in Sibbinda. Ho

### 1.6 Significance of the study

Knowledge of how the chemical and nutritive value of browse plants and plant parts that are utilized by cattle during dry season is indispensable among communal farmers in Zambezi region. The result of the study will enable farmers to make informed decisions and make

necessary preparations for the dry season and improve live weight of cattle. And upon realising the value of these browse plants as animal feeds, farmers will protect and conserve these plants in an eco-friendly way. For producers in the Northern Communal Area (NCA) to sell their cattle through the formal market (MeatCo), it is a prerequisite that their cattle are kept in quarantine camps to be inspected for any diseases for at least 21 days before entering the South African market. A problem associated with this is that the transaction costs involved in the marketing of cattle are high in the formal market, because these cattle often lose weight and grade in the camps due to insufficient feed especially in the dry season resulting in lower prices (Doss, McPeak & Barrett, 2005; FAO & NEPAD, 2005; Kirsten, 2002; NASSP, 2005).The meat producing companies will use the findings to educate farmers to improve feeding practices and the Ministry of Agriculture Water and Forestry (MAWF) and Ministry of Environment and Tourism (MET) will use the outcome of the research to improved beef production in communal areas in a sustainable way.

### 1.7 Limitation of the study

The study was prone to a number of limitations. The study was limited to one academic year that might not be enough to gather and analyse all the data that is season and year dependent. The study was conducted within the boundaries of the Zambezi region. This impacted on the possible generalizability of results to Namibia since other regions present different climatic conditions in terms of annual rainfall, dry spells and other factors such as vegetation and animal feeding practices. Further, the laboratory analysis tests were analysed in Windhoek as no laboratory that met the demands of the tests to be performed is available in the Zambezi region.

## CHAPTER 2.

## Literature review and conceptual framework

### 2.1 Introduction

Browse is basically referred to as the portion or amount of woody plants available for animal consumption.

Browse species have considerable potential in mixed crop livestock production systems, to supplement low quality feeds, fix atmospheric nitrogen, provide fuel and shelter and to help in soil and water conservation. Moreover, the ability of most browse species to remain green for a longer period is attributed to deep root systems, which enable them to extract water and nutrients from deep in the soil profile and this contributes to theincreased CP content of the foliage. The term 'grazing' describes all the processes (browsing, foraging, herbivory etc) by which animals on pastures or in the rangeland consume rangeland plants in order to acquire energy and nutrients to be used for growth, milk, wool production and so on (El Hassan, 2000). Grazing is an agricultural process in that grazers produce food and various products for human consumption.

Browse plants constitute a vital component in livestock productivity in the arid and semi-arid zones. About 52% of cattle, 57% of the sheep, 65% of goats and 100% of the camels are in tropical Africa and they depend heavily on browse species to meet their dietary requirements (FAO, 2006). They supply goats and camels with the bulk of their nutritive requirements and complement the diet of cattle and sheep with protein, vitamins and minerals.

Livestock rearing is an integral part of the farming system. Cattle, donkey, sheep, goats, pigs and various kinds of poultry are kept. In the cropping season the cattle graze the natural grasses and after harvest they graze the crop residues supplemented by browse plants. Household waste and grains form additional feed for poultry. Studies have been carried out by Asante et al., (2002), Baatuuwie (2005) and several others on browse identification, farmers' preference and pre-treatment methods on seeds of browse plants. However there

exist very limited information regarding the harvesting and marketing of browse plants in Africa.

Browse plants, beside grasses, constitute one of the cheapest sources of feed for ruminants. Browse plants provide vitamins and frequently mineral elements, which are mostly lacking in grassland pasture. Their year round evergreen presentation and nutritional abundance provides for year round provision of fodder (Opara, 1996; Oji and Isilebo, 2000). It also enables standing feed reserve to be built so that herds can survive critical periods of shortfall, or even prolonged periods of drought, without remarkable losses (Odoh and Adamu-Noma, 2000). Deforestation, urbanization and bush burning are some of the major factors responsible for dwindling proceeds of browse feed resource for ruminant livestock. Conservatory methods however, would ensure that locally adapted and wellestablished species do not become extinct

**2.2 Nutritive value of forages**

Nutritive value describes the forage's capacity to meet the animal's nutritional needs. A good nutritive value description of forages should include measures of voluntary intake, nutrient or antinutrient content, digestibility and metabolisability of the nutrients.

Nutritive value is a function of the feed intake (FI) and the efficiency of extraction of nutrients from the feed during digestion (digestibility). Feeds of high nutritive value promote high levels of production (liveweight gain). Feed intake in ruminants consuming fibrous forages is primarily determined by the level of rumen fill, which in turn, is directly related to the rate of digestion and passage of fibrous particles from the rumen. Voluntary consumption of feed may also be modified by animal preference, some feeds being eaten in smaller or larger amounts than predicted by digestibility (D) (Ahn, *et al.* 1990) ). The acceptance or edibility (palatability) of a feed has been related to both physical characteristics (hairiness

and bulk density) and the presence of compounds which may affect taste and appetite (volatile oils, tannins and soluble carbohydrates).

The productivity of ruminants is closely associated with the capacity of a feed to promote effective microbial fermentation in the rumen and to supply the quantities and balances of nutrients required by the animal tissues for different productive states.

Feed composition is determination of the chemical constituents making up a feedstuff. It is basically profiling the nutrient composition and density of the feed material. It is normally measured through the proximate System (AOAC, 1990). The importance of proximate analysis parameters are dry matter (DM), crude fat/ether extracts (EE), crude fibre (CF), crude protein (CP), and nitrogen free extracts (NFE). Feed evaluation determines the potential usefulness of the feed to livestock. The important feed evaluation parameters are total digestible nutrients (TDN), digestible energy (DE), metabolisable energy (ME), voluntary feed intake (VFI), palatability and digestibility.

Browses constitute an abundant biomass in farmlands, bush fallows and forests in the humid tropical environment of Africa.

They are commonly utilized in the wild by small-holder livestock farmers for feeding small ruminants (Uwechue1990; Okoli et al 2002). The potential of leaf meals from these tropical trees and shrubs to yield relatively higher levels of crude protein and minerals and lower crude fiber levels than tropical grasses has also been recognized.

### 2.2.1 The factors affecting the nutritive value of forages include:

**Forage species**

A plant may have satisfactory dry amounts of inorganic and organic nutrients as forage for livestock but is of little value if it lacks palatability. Furthermore, the palatability and abundance of the various species determine the botanical composition of the grazing animal's diet.

**Stage of maturity**

In any pasture, not every plant will have the same nutritive value because different plant characteristics directly or indirectly affect forage quality.

Weather conditions and forage maturity are the primary factors affecting quality of a stand. Maturity, or stage of growth, is the principal factor responsible for declining forage nutritive value. As the plant advances in growth beyond the first couple of weeks (where protein and digestibility are highest), stem growth advances, as well as deposition of fibrous components at the plant cell level.

With advancing maturity, one of the main chemicals deposited internally in the plant cell walls is lignin. Lignin, a component of fiber, is essentially indigestible, accumulates mostly at plant maturity, and acts as a barrier to fiber degradation by rumen microbes. The microbial population in the rumen leads to degrading of the forage fiber, thereby making it unavailable for the animal. If the forage is too mature, fiber is more prevalent in the forage, and digestibility of the forage declines; crude protein (CP) also declines in the forage tissue. This decline is more pronounced and sudden in warm-season perennial grasses — especially in plant tissue older than 35–40 days

The stage of growth seems to be the most important factor affecting the chemical composition and digestibility of range forage In general all forages are highly succulent in early growth, which markedly enhances their palatability. Most plants decline in nutrient composition with advanced maturity Tan et al (2003).Thus, grasses and forbs are referred to as “watered concentrates” while in the early stages of growth. Striking nutritive differences exist between forage classes (browse, grasses and forbs) at maturity. Browse species are less affected by summer drought periods than are forbs and grasses because of their deeper root

systems. Protein content of browse tends to decrease as the season advances except in certain species which show an increase in protein during the moist fall period.

**Climate**

Climatic factors such as temperature humidity, precipitation, light intensity and altitude may dominate control of the nutritive value of plants. Although plants are dependent upon the soil for their mineral nutrients, climatic factors affect respiration, assimilation, photosynthesis and metabolism to the extent that the mineral and organic matter content of plants may be strongly modified by climatic factors even though grown on the same soil. Precipitation may have direct and indirect influences upon the quality of forage plants. Rainfall, in general, tends to increase nitrogen; phosphorus and ether extract (the soluble fat constituent). However when water is available, the productivity may be influenced or limited by other factors such as soil and air temperature, herbivory, microflora activity and soil nutrient availability

**Soil fertility**

The type of soil may influence the composition of the pasture especially its mineral content. Plants normally react to mineral deficiency in the soil either by limiting their growth or by reducing the concentration of the particular minerals in their tissues, or more usually by both. The acidity of the soil is air important factor which can influence the uptake of many trace elements by plants. Liberal dressing of fertilizers can markedly affect the minerals content of plants and application N-fertilizers is also known to increase leaf area and rate of photosynthesis. As a consequence, the CP content of subsequently the amide and contents are increased. Application of N-fertilizer also depress the water soluble carbohydrates content of temperate grasses which may have an adverse effect on fermentation if the crop is used preserved as silage. Fertilizers may also affect indirectly the nutritive value of a sward by

altering the botanical composition. For example, legume do not thrive on a lime deficient soil, while heavy dressing of N encourage growth of grasses and depress legumes growth.

The physical and chemical properties of soils exert almost unlimited influence upon the nutrient content of plants. Physical properties of soil such as texture and porosity affect the nutritive quality of forage more or less indirectly. Poorly aerated soils greatly limit or decrease the absorption of essential elements, especially phosphorus. Soils rich in biotic life show enhanced aeration and fertility. Nitrogen (N), phosphorus (P) and potassium (K) are the important macronutrients in the soil (CPHA, 2002). Nitrogen is commonly the most important deficient nutrient in forage crops. Monitoring nitrogen in the soil is the most important factor for growing quality forage (Tisdale, 1993). When an adequate supply of plant availability nitrogen is available there will be higher photosynthesis activity, vigorous vegetative and a dark green plant color (PHA, 2002).

**Grazing management**

Grazing management means controlling grazing animals on pasture. The two most important tools for influencing the level of animal output under grazing are: concentration of animals (stocking rate) and system of grazing management.

The closeness to which a pasture is grazed is defined as grazing pressure. Grazing pressure is affected by both the stocking rate (animals per acre) and the available forage (pounds of forage per acre). Grazing pressure affects not only animal performance but also the plant species in a pasture. low animal intake and low gain rates. The biggest challenge faced in the pasture system is reliably estimating the carrying capacity of the land. If land is to be utilized for pasture, its use during the year must be maximized to provide the best compromise between yield of animal growth and forage nutrient yield (Chester-Jones, 1996)

**Tannings**

The tannins are a group of plant secondary compounds which have been known and used by Man forcenturies. Their name comes from the French *tan* meaning the bark of the holm oak and other trees used in tanning.From a chemical point of view it is difficult to define tannins since the term encompasses some very diverse oligomers and polymers (Harborne, 1999; Schofield *et al.,* 2001). It might be said that the tannins are a heterogeneous group of high molecular weight phenolic compounds with the capacity to form reversible and irreversible complexes with proteins (mainly),polysaccharides (cellulose, hemicellulose, pectin, etc.), alkaloids, nucleic acids and minerals, etc. (McLeod, 1974; Mole and Waterman, 1987; Mangan, 1988; Mueller-Harvey and McAllan, 1992; Van Soest, 1994; Giner-Chavez, 1996; Schofield *et al*., 2001).The tannins have traditionally been divided into two groups: the condensed and the hydrolysable tannins.Hydrolysable tannins (HT) are made up of a carbohydrate core whose hydroxyl groups are esterified with phenolic acids (mainly gallic and hexahydroxydiphenic acid). The condensed tannins (CT), or proanthocyanidins, are non-branched polymers of flavonoids units (flavan-3-ol, flavan-3,4-diol), and usually have a higher molecular weight than the HT (1000-20000 Da compared to 500-3000 Da) (McLeod, 1974; Mueller-Harvey and McAllan, 1992; Mueller-Harvey, 1999

Some tree legumes contain anti-nutritive factors which adversely affect nutritive value. For this reason, depending on the species, tree legume foliage may be of lower nutritive value as a sole feed than as a supplement to other feeds. The significance of secondary plant compounds becomes more evident when tree foliage is the only feed consumed.Tannins may therefore have a beneficial effect (increasing bypass protein or decreasing ammonia loss) or a detrimental effect (depressing palatability, decreasing rumen ammonia, decreasing post-ruminal protein absorption) on protein availability (Borens and Poppi (1990). It is clear that the interpretation of the nutritional value of protein in forage trees requires information on the

nature and action of tannins. The proteins in the leaves of species which do not have tannins will be rapidly degraded in the rumen, providing high levels of rumen ammonia, much of which will ultimately be wasted by excretion as urinary urea. Such feeds provide N in a similar way to urea. Species which contain some tannins will therefore provide both degradable and undegraded rumen N and will be more effective sources of supplemental N for ruminants. Nevertheless, the significance of tannins in tree legume forage is poorly understood, with low concentrations being beneficial and high concentrations detrimental. It is also likely that not all tannins act similarly; this area requires further study

### 2.2.3 Characteristics of a plant species that determine its potential nutritive value are related to its:

**Morphology**

Under natural conditions, plants frequently encounter combinations of stress factors (Bazzaz, 1996; Sultan et al., 1998). Consequently, the individual ability to tolerate multiple stresses through morphological adjustments is a major feature that determines species survival and colonization, and hence the ecological breadth of the species (Chapin et al., 1987; Bazzaz, 1996; Sultan et al., 1998).

However, plants frequently experience resource and mechanical stresses simultaneously under natural conditions. In such conditions, plant growth is altered in a complex interactive manner (Idestam-Almquist and Kautsky, 1995; Power, 1996; Henry and Thomas, 2002) that cannot be simply predicted from the responses to each stress factor when considered independently, (Sack,2004) and focus on the optimization of resource acquisition and allocation.

**Physiology**

Plants produce organic matter from mineral elements absorbed from the soil and atmosphere. Thus, the essential elements are fundamentally important for plant physiology. Plants require 17 essential elements for completion of their life cycle, namely C, H, O, Ca, K, Mg, N, S, P, Cl, B, Cu, Fe, Mn, Mo, Ni and Zn. Deprivation of even one of these essential elements causes physiological disorders, e.g. cell death under B deprivation (Koshiba et al. 2009). Elements that stimulate growth and may be essential to particular species are defined as beneficial elements. The five most investigated beneficial elements are Al, Co, Na, Se and Si (Pilon-Smits et al. 2009).

**Biochemistry**

It is widely purported that ecosystem function depends on biological diversity. Nonetheless, the issue is controversial (Kaiser, 2000), in part because little is known about the biochemical links associated with plant diversity. While we have much to learn about biochemical interactions among plants, and about how herbivores learn to mix their diets to optimize intake of biochemicals, we submit that biochemical diversity increases the potential for resiliency, adaptability, and productivity of ecosystems by increasing options for plants, herbivores, and people. Furthermore, people interested in managing ecosystems can use understanding of biochemical interactions among plants and herbivores to enhance and maintain the biodiversity of Landscapes (John.A.Bissonette, 2008). The kinds and amounts of nutrients and toxins in a plant or its neighbours determine the effectiveness of a toxin and influence the probability of a plant being eaten (Provenza et al., 2002). All plants contain some levels of toxins so complete avoidance is not feasible. Rather, herbivores must regulate intake of toxins (Foley et al., 1999). Intake of toxic plants depends on the kinds and concentrations of nutrients and toxins; some interactions increase intake, others do not (Burritt and Provenza, 2000; Villalba et al., 2003)

**Stage of maturity**

Multiplicity of factors affects the rate of change in nutrient composition with advancing plant development and maturity stages. These factors may include any one or a combination of the following: plant type, climate, season, weather, soil type and fertility, soil moisture, leaf stem ratio, physiological and morphological characteristics and others, and may vary with annuals vs. perennials, grasses vs. legumes,

Declining in nutrient level in grass through stage development results in declining in utilization. This decline occurs more sharply One study showed that in some grasses the digestibility at early leaf was 65.2%, was still 64.7% at prebloom, and suddenly fell to 56.6% at early bloom within a very few days (Wallace et al. 1973)

**Environment**

Plants are often thought of as passive in relation to the environment. However this is not always valid assumption; for there are many plants that clearly manipulate their environment in a fashion that tends to makes certain nutrients more readily available. For example, iron is a limiting nutrient in many agricultural areas, but it comprises about 3% of the average soil which, if available, would be far in excess of the needs of the average plant. Some plants actively excrete protons, and the resulting decrease in pH increases the solubility of iron in their environment.

The first step for determining the nutritive value of feedstuff for cattle is to analyse the chemical composition of different species of plants preferred by cattle, and then to measure their digestibility and palatability. The chemical composition of many foods has been measured from different ecosystems in the Arab region of Asia and Africa (Wardeh et al., 1990). In Iran, Javan (2001) reported the digestibility of some arid rangeland plants using bovine rumen liqure. Towhidi (2007) reported the nutritive value of 11 plant species from the province of Yazd and also, Yousef Elahi et al. (2012a, b) reported nutritional quality of some

halophytes species from Sistan area, Iran, but in general little information is known about the nutritive value of range herbage consumed by cattle in the arid and semi-arid zones of Iran.

The nutrient value of range forage is dependent on botanical composition.

Botanical and chemical composition and season of growth affect the digestibility of pasture, and the nature and quantities of the products of digestion. Generally, legumes have higher protein content than grasses and this declines only slowly with maturity (Norton, 1982). Corbett (1987) believed that desirable forage is green, leafy, and leguminous.

The components of pasture preferred by animals are shown in figure 1.

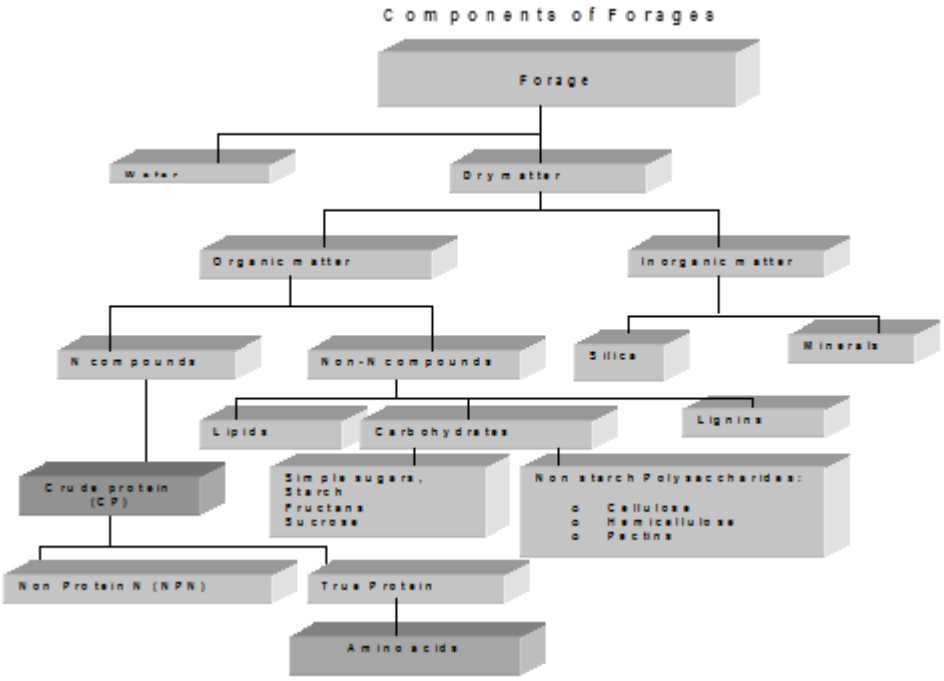


Fig 1: Components of Forage

### 2.4 The role of ligneous fodder resources for ruminant husbandry in Africa

In the Sahelian and Sudanian zone of West Africa, primary fodder resources for ruminants are natural forages such grasses and dicotyledonous herbaceous species, ligneous plants and crop residues (Teferedegne, 2000). A ligneous fodder plant, so-called “browse”, comprises the tender shoots, twigs and leaves of shrubs and trees, and their fruits and pods (Devendra,

1996). Browse plants provide valuable fodder that, particularly in the dry season, supplements the senescent herbaceous vegetation and cereal residues of poor digestibility and low nutritive value.

Numerous studies have addressed the value of browse for livestock nutrition, such as an increased metabolizable energy intake, nitrogen intake and feed use efficiency, and thus an improved reproductive and productive performance of the animals (Le Houerou, 1980a; Fall Touré et al., 1998; Abdulrazak et al., 2000; Sangaré et al., 2003; Bwire et al., 2004; Yayneshet et al., 2009). Browse availability is especially important for grazing livestock systems, where it enables survival of sheep, goats, cattle and camels during dry periods and drought years (Le Houerou, 1980b; Thomas and Sumberg, 1995; Devendra, 1996), and herders generally have a good knowledge on the occurrence, palatability and availability of browse (Bellefontaine et al., 2002; Gautier et al., 2005). Apart from direct grazing of browse plants and their organs, different techniques are practiced by herders to make browse material available to livestock. Pruning, which consists in "eliminating dead or small branches and the suckers that tend to weaken the tree", is often practiced by herders (Teferedegne, 2000). This technique aims to obtain a maximum amount of forage and also has a positive effect on tree growth and leaf production if properly practiced. Leaves and pods are also harvested by agro-pastoralists and serve as feed supplement for sedentary animals during the dry season (Sanon, 2005).

## 2.5. Anticipated climate change in Africa

### 2.5.1 Consequences for farming systems in semi-arid and sub-humid zones

Climate projections for Southern Africa are consistent when it comes to predicting and forecasting temperature changes, but projections of future rainfall patterns and overall amounts are contrasting. According to IPCC (2007), the average rise in temperature between 1980/99 and 2008/99 is expected to be between 3°C and 4°C for the whole African continent with the highest increase in Mozambique (+4°C). According to the vulnerability and adaptation analyses by MECV (2007), temperature projections based on the climate model of the Meteorological Research Institute (MRI) of the Japanese Meteorological Agency (JMA) indicated that in Zambia average daily temperatures will increase by about 0.8°C in 2025 and 1.7°C in 2050 as compared to year 1990, whereby the increase may be doubled due to seasonal variation. At the same time, the average annual rainfall will be reduced by 3.4% in 2025 and by 7.3% in 2050, with very strong inter-annual and seasonal variability. Local farmers have also observed an increase in maximum daily temperatures and a decrease in rainfall over the last decade in the Sahelian region (Metz et al., 2009).

Although there is still a fair amount of uncertainty in rainfall-related climate projections for Southern Africa (Brook, 2006; OCDE/SWAC, 2009), changes will occur and increasing climate variability will have negative impacts on cereal production, land use, water resources and food security (Mendelsohn, 2009). As far as the regional grazing-based livestock systems are concerned, the anticipated changes will very likely lead to a decreasing animal productivity and will threaten the provision of a wide range of livestock products (MRA, 2005; Nardone et al., 2010) due to an expected drastic reduction of pasture biomass production and of the possibilities for watering the major livestock species, namely cattle, sheep and goats (Seo and Mendelsohn, 2006). The grazing and rainfed mixed systems will be threatened most by the negative effects of climatic change (Nardone et al., 2010; Crane et al.,

2011); nevertheless the integrated crop-livestock systems are presumably more resilient than the specialised pastoralist systems (Seo, 2010). In order to mitigate or reduce the increased vulnerability of their production systems and thus their livelihoods, crop and livestock farmers in the region respond to climate change and variability by various adaptation strategies (Nyong et al., 2007). Studies reported an adoption of a wide range of small-scale adaptation and coping strategies by local farmers to secure their farming activities and incomes (Barbier et al., 2010; Ouedraogo et al., 2010, Metz et al., 2009, 2011). At the national level, most of the Sahelian and Sudanian countries in West Africa have adopted national programmes to mitigate the negative impacts of climate change (Kandji et al., 2006). How effective these are in reaching the local crop and livestock farmers and sustaining their livelihoods remains to be investigated.

**2.6 System vulnerability and adaptive capacity**

There have been many attempts to define vulnerability in relation to climate change (Adger et al., 2005; Brooks et al., 2005; Barry and Wandel, 2006; Traerup, 2010) and each definition depends on the purpose of the study. According to the IPCC (2007), vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character,

Magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptation capacity (IPCC, 2001). Vulnerability has also been defined as"the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects" (Adger et al., 2007). Adaptive capacity is the ability of a system to adjust to climate change.

## 2.7 Communal Farmers' coping measures and adaptation strategies

In the literature on adaptation to climate change, the term 'coping' is sometimes used as a synonym for adaptation (Fankhauser et al., 1999). But the two concepts are differently used in many cases. Dinar et al. (2008) defined coping strategies as those that have evolved over time through people's long experience in dealing with the known and understood natural variation that they expect in seasons, combined with their specific responses to the season as it unfolds. The same author defined adaptation strategies as long term strategies that are needed for people to respond to a new set of evolving biophysical, social and economic

Conditions that they have not experienced before. This definition of adaptation is consistent with IPCC (2007) that defined adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, in order to moderate harm or exploit beneficial opportunities. Adaptation can be anticipatory (i.e. proactive) or reactive (Frankhauser et al., 1999; IPCC, 2007). Anticipatory adaptation takes place before impacts of

Climate change has been actually observed, whereas reactive adaptation occurs after the impacts have been observed. Both anticipatory and reactive adaptations may further be differentiated as either public or private. While public adaptation is normally initiated, implemented or facilitated by governmental institutions, the private one is initiated and implemented by individuals, households, or communities.

As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers. Browses have multiple roles in farming systems such as feed, fire wood and as human and veterinary medicines (Luseba and Van der Merwe 2006). These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons and dry periods. They have deep root systems enabling the extraction of water and nutrients from deep in the soil profile (Teferi et al 2008). Most browse plants have high crude protein content, ranging from 10 to more than 25% on a dry

matter basis (Moleele 1998). This reliable protein resource can be used to develop a sustainable feeding system and increase livestock productivity.

Practices and knowledge of ethnobotany vary with socioeconomic level, geographical origin, age, gender, ethnicity, level of education and profession (Pfeifer and Butz 2005). Allem (2000) defined ethnobotany as "the biological, economic, cultural inter-relationship studies between people and plants in the environment which they exist". It is an integral part of indigenous/local knowledge of a particular society (Osawaru and Danin-Ogbe 2010).

Different communities have their own knowledge about plants and their uses. Luseba and Van der Merwe (2006) referred to "ethny specific" characteristics of this local knowledge. Farmers have an impressive knowledge of browsed species. Involving farmers in the process of data collection is important because as potential users of new technologies to be developed, their knowledge and preferences are critical (Haugerud and Collinson 1990). However, some of the knowledge is liable to be distorted or lost completely if transfer is not done continuously.

The present study was conducted to describe the knowledge and utilisation of trees and shrubs as feed for livestock in the Bushbuckridge area and to document the results in order to prevent loss of information during oral transfer from one generation to another.

During the dry season, ruminant diets are limited by shortages in amount and quality of available forage (Shelton, 2004), crop residues or by products (Babayemi et al., 2004a) which result in reduced livestock productivity in the tropical countries (Odenyo et al., 1997). Tree fodders are important in providing nutrient to grazing ruminants in arid and semi-arid environments, where inadequate feeds are a major constraint to livestock production (Aganga and Tshwenyane, 2003). Tree fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity (Shelton, 2004). Evidence from the Intergovernmental Panel on Climate Change (IPCC, 2007) is now

overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected.

The International Fund for Agricultural Development (IFAD) acknowledges climate change as one of the factors affecting rural poverty and as one of the challenges it needs to address.

While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. Rural poor communities rely greatly for their survival on agriculture and livestock keeping that are amongst the most climate-sensitive economic sectors.

The IPCC predicts that by 2100 the increase in global average surface temperature may be between 1.8° C and 4.0° C. With increases of 1.5° C to 2.5° C, approximately 20 to 30 percent of plant and animal species are expected to be at risk of extinction (FAO, 2007b) with severe consequences for food security in developing countries. The possible effects of climate change on food production are not limited to crops and agricultural production. Climate change will have far-reaching consequences for dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity. Heat distress suffered by animals will reduce the rate of animal feed intake and result in poor growth performance (Rowlinson, 2008). Lack of water and increased frequency of drought in certain countries will lead to a loss of resources. Consequently, as exemplified by many African countries, existing food insecurity and conflict over scarce resources will be exacerbated.6 The following sections provide an overview of the effects of climate change on both livestock and fisheries.

**2.8 The effects of climate change on livestock**

In pastoral and agropastoral systems, livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that

are affecting livestock production systems, such as rapid population and economic growth, rising demand for food (including livestock) and products,7 conflict over scarce resources (land tenure, water, biofuels, etc). For rural communities, losing livestock assets could trigger a collapse into chronic poverty and have a lasting effect on livelihoods.

The direct effects of climate change will include, for example, higher temperatures and changing rainfall patterns, which could translate into the increased spread of existing vector-borne diseases and macroparasites, accompanied by the emergence and circulation of new diseases. In some areas, climate change could also generate new transmission models.

Responses to climate change include (i) adaptation,2 to reduce the vulnerability of people and ecosystems to climatic changes, and (ii) mitigation,3 to reduce the magnitude of climate change impact in the long term. However, neither adaptation nor mitigation alone can offset all climate change impacts. To respond to this threat it will be necessary to focus both on mitigation, to reduce the level of emission of gases contributing to global warming,and on adaptation, to support local communities in dealing with the impacts.

**Impacts**

**Water:**

Water scarcity is increasing at an accelerated pace and affects between 1 and 2 billion people. Climate change will have a substantial effect on global water availability in the future. Not only will this affect livestock drinking water sources, but it will also have a bearing on livestock feed production systems and pasture yield.

**Feeds:**

As climate changes and becomes more variable, niches for different species alter.

This may modify animal diets and compromise the ability of smallholders to manage feed deficits.

**Changes in the primary productivity of crops, forage and rangeland**

Effects will depend significantly on location, system and species. In C49 species, a rise I temperature to 30-35° C may increase the productivity of crops, fodder and pastures.

In C310 plants, rising temperature has a similar effect, but increases in CO2 levels will have a positive impact on the productivity of these crops.

For food-feed crops, harvest indexes will change, as will the availability of energy that can be metabolized for dry season feeding. In semi-arid rangelands where the growing season is likely to contract, productivity is expected to decrease.

**Changes in species composition**

As temperature and CO2 levels change, optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes. For example, higher CO2 levels will affect the proportion of browse species. They are expected to expand as a result of increased growth and competition between each other. Legume species will also benefit from CO2 increases and in tropical grasslands the mix between legumes and grasses could be altered.

**Quality of plant material**

Rising temperatures increase lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species. The resultant reduction in livestock production may have an effect on the food security and incomes of smallholders. Interactions between primary productivity and quality of grasslands will require modifications in the management of grazing systems to attain production objectives.

**2.9 Biodiversity (genetics and breeding):**

In some places there will be acceleration in the loss of the genetic and cultural diversity already occurring in agriculture as a result of globalization. This loss will also be evident in crops and domestic animals. A 2.5° C rise in global temperature would determine major

losses: between 20 and 30 per cent of all plant and animal species assessed could face a high risk of extinction. Ecosystems and species display a wide range of vulnerabilities to climate change, depending on the imminence of exposure to ecosystem-specific critical thresholds, but assessments of the effects of CO2 fertilization and other processes are inconclusive.

Local and rare breeds could be lost as a result of the impact of climate change and disease epidemics. Biodiversity loss has global health implications and many of the anticipated health risks driven by climate change will be attributable to a loss of genetic diversity.

**Livestock (and human)health:**

Vector-borne diseases could be affected by: (i) the expansion of vector populations into cooler areas (in higher altitude areas: malaria and livestock tick-borne diseases) or into more temperate zones (such as bluetongue disease in northern Europe); and (ii) changes in rainfall pattern during wetter years, which could also lead to expanding vector populations and large-scale outbreaks of disease (e.g. Rift Valley fever virus in East Africa).Temperature and humidity variations could have a significant effect on helminth infections.Trypanotolerance, an adaptive trait which has developed over the course of millennia in sub-humid zones of West Africa, could be lost, thus leading to a greater risk of disease in the future.Changes in crop and livestock practices could produce effects on the distribution and impact of malaria in many systems, and schistosomiasis and lymphatic filariasis in irrigated systems.

**Heat-related mortality and morbidity could increase.**

For example, in parts of East Africa, maize is likely to be substituted with crops more suited to drier environments (sorghum, millet); in marginal arid southern Africa, systems could convert from mixed-crop livestock to rangelands-based systems.C4 plants possess biochemical and anatomical mechanisms to raise the intercellular carbon dioxide concentration at the site of fixation; this reduces, and sometimes eliminates, carbon losses through photorespiration. C4 plants inhabit hot, dry environments and have a very high rate

of water-use efficiency, which means that there can be up to twice as much photosynthesis per gram of water as there is in C3 plants. However, C4 metabolism is inefficient in shady or cool environments. Less than 1 per cent of the earth's plant species can be classified as C4. 10 C3 plants, which account for more than 95 per cent of earth's plant species, use rubisco to make a three-carbon compound as the first stable product of carbon fixation. C3 plants flourish in cool, wet and cloudy climates, where light levels may be low, because the metabolic pathway is more energy efficient and, if water is plentiful, the stomata can stay open and let in more carbon dioxide. Carbon losses through photorespiration are high in C3 plants.

**2.8 Importance of fodders**

Tree fodders are important source of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feeds. Tree fodders form part of the complex interactions between plants, animals and crops (Aganga and Tshwenyane, 2003). They help to balance a plant-animals ecosystem and from which there is a sustainable source of feeds (Devendra, 1994).The potential of forage from fodder trees and shrubs in herbivore nutrition has been investigated in many studies (Topps, 1992; Degen et al, 1998; Ramirez, 1998). The value of these plants in animal nutrition is associated with features such as abundance, accessibility, protein content and quality in terms of available energy and vitamins (Kibri et al.1994; Ramirez, 1998). Browsable forage is claimed to have a great potential as a protein supplement compared to the graminaceous fodder (grasses) and crop residues containing low protein and fermentable energy levels (EI Hassan et al, 2000).These browsable forages are important for animal production owing to their potential and nutritive value. Their deep root systems take up minerals and access ground water during period of water scarcity or when growing in poor top soils (Topps, 1992).

There is also considerable evidence which shows that both the rural poor and the landless receive a higher proportion of their income from livestock than do the better to do.

Freeman, et al,(2008) report that livestock is crucial to the livelihoods of many households in Southern Africa, although the role of livestock in terms of food security has not been either fully understood or exploited.

In Zimbabwe, goats are particularly important to the poor, those living in the drier areas, and women farmers. High level of kid mortality and very low growth rates during dry season constraint goat productivity.

The prospects for wide adoption of P. Juliflorapod feeding appear good. Women who participated in a pod collection trial in 1999 continued to collect pods when they were no longer involved in the project. The only cost is labour, but the pods are ready for collection at a time of year when people are comparatively less busy.

Pods from Acacia species and other trees are relatively high in protein (11 to 20%) and are either browsed by livestock or eaten when they fall to the ground. The value of pods is recognised by farmers, but there is scant advice available on which species are best and on how much and when to feed. Ways of alleviating the harmful effects of the pods' tannin content and benefiting from their anti-helminthic properties also need to be considered.

## CHAPTER 3

## 3. Methodology

### 3.1. Study site

The study was carried in Sibbinda constituency situated 40 to 60km south- east and west of Katima Mulilo town between the Linyanti road and Trans-Zambezi high way.

Rainfall ranges between 500-700 mm. The rainfall season extends from October/November to April. Less than 1% of total precipitation is recorded in the winter period of June to September (MAWRD, 1996). Temperature naturally varies with the seasons, and ranges from a maximum average of over 10ºC in winter, which rises to 36ºC or above in summer. The soils that support the woodlands are dominated by unconsolidated aeolian material, generally referred to as Kalahari Sand (De Pauw and Coetzee, 1999).

The constituency is traversed by perennial rivers such as the Linyanti and Chobe as well as Lake Liambezi that result in unconsolidated fluvial sands. The soils are shallower than the dunes, have a heavier texture and are generally considered more productive than the dunes. The different soil types give rise to noticeable varried species composition. Trees such as *Colosphosperm mopane, Guibourtia coleosperma, Burkea Africana, Terminalia sericea, Ziziphus mucronata* and *Dichrostachys cinerea* as well as many other various species of *Acacia* are found. This differentiation of vegetation may be attributed to differences in soil moisture holding capacity (Freeman et al, 2008).

Sibbinda constituency consists of approximately 10,200 people (Census, 2011) of which 10 % of this population was selected to be the sample to the study.

3.2 **Research design.**

The research design to this study was explorative mixed design incorporating both qualitative and quantitative research techniques. Mixed methods research design requires the collection and analysis of qualitative and quantitative data in a single study, extending the information

with more complementary, meaningful interpretation (Jick, 1979). "Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purpose of breadth and depth of understanding and corroboration" (Johnson et al., 2007).

From the qualitative angle, a structured interview questions and questionnaires were prepared and administered to interview communal farmers, key informants purposively sampled from the Ministry of Agriculture, Water and Forest (MAWF) and Non Government Organisations (NGOs) .The questionnaires were used as research tools to gain indigenous knowledge on (1) the identification of different browsable trees and shrubs species, (2) season of availability and (3) trends in availability and how they are liked by their cattle. Communal farmers were asked for the tree and shrub names in their local language (lozi) and the samples were collected and preserved for subsequent botanical identification. Initially all the available forage species were identified with local names prior to entering them into the questionnaire. The scope and breadth of the research was therefore, to begin with tapping into indigenous knowledge of the community and then validating this knowledge through chemical analysis and lastly determining the potential of the browse species through feed evaluation techniques. Indigenous knowledge uses empirical evidence (i.e. learned experience over time): chemical analysis determination of (dry matter, ash, ether extract, crude fibre, crude protein and nitrogen free extracts) characterises the nutritional chemical components (i.e. nutrients): and feed evaluation (digestible energy, metabolisable energy, total digestible nutrients and palatability) quantifies the actual potential usefulness of the feedstuff to the animal.

### 3.3 Population of the study

For the administration of questionnaires the target population to this study consisted of 1020 households in two villages. For browse species identification and characterisation all browsable trees within the boundaries of Sibbinda constituency constituted the target population.

### 3.4 The sample

For indepth focus group discussions, the sample of respondents was 240 households in the two villages and sampling was done randomly to remove bias. A Purposeful Sampling technique used to determine the focus groups in the study area. Ten groups (sub-courts) were identified, each comprising of 120 respondents per village.

From all the browse species (sampling leaves, pods and seeds of the most preferred) the best five browsable feedstuffs ranked by the community were sampled for chemical analysis (proximate analysis analysing for dry matter (DM), ash, crude fibre (CF), crude protein (CP), ether extract (EE) and nitrogen free extracts (NFE)) and for feed evaluation (i.e. Digestible energy, Metabolisable energy, digestibility and palatability).

The five best browse species' samples were established by first surveying the area in order to establish the structure of the vegetation.

### 3.5 Research instrument

For plant identification indigenous knowledge of browsable plants, in depth focus group interviews, raw data field notes and questionnaires were used as research instruments.

### 3.6 A survey to obtain indigenous knowledge on browse plants

Gathering indigenous knowledge and data on browse species through focus group discussions, structured questionnaire and interviewing key informants. This allowed the researcher to rank the best 5 browse species for further study.

#### 3.6.1 Interviews

In determining the browse species in Sibbinda constituency the researcher gathered indigenous knowledge through a questionnaire (in Appendix 1), and had to obtain a sample of 10% from the target population. In the sampling technique only those whom were thought to contribute reliable information like the extension staff were used as key informants.

An attendance of all members was welcome though questions were directed specifically to the homogenous group whom were chosen. The questionnaire used during these focus group discussions is in *appendix 1*

#### 3.6.2 Identification of all browse plant species

For the identification of all browsable plants using local names in Sibbinda constituency, the researcher established focus group discussions, with residents of Sibbinda constituency. The focus group comprised of twelve members each time from each of the two selected villages in Sibbinda constituency, see Figure 1 below and A*ppendix 5 and 6*.

**Fig 2:** *The researcher having an interview with the communal farmers.*

### 3.6.3 Selection of sample

The researcher first surveyed the study area to establish the vegetation structure of the area and divided the area into 5 strata of 100 m x 100m. Three belt transect of 50 m x 20 in each stratum were used to collect leaves and pods from common browsable plants that were ranked by the community as the most preferred by their animals. These were namely *Acacia erioloba, Colosphosperm mopane, terminally sericea, Bahia massaiesnsis and Dichrostachys cinerea,* were randomly harvested in sufficient quantities from all sides of each plant and sun-dried and stored in polythene bags to await chemical analyses and evaluation. More material of the browseable material was used for palatability feeding trials.

## 3.7 Experiments

### 3.7.1 Experiment 1:- Chemical analyses of the best five browse species

Leaves of browsable trees and shrubs, and pods, were harvested in sufficient quantities for laboratory studies and were sun-dried on the day of collection to reduce moisture content to about 30% so that the material would not easily become mouldy. Hay was harvested in the same area as the sampled browse materials.

Hay was used as a control in this study because it is the basal diet that the animals eat and when they browse they will be trying to supplement nutrients that are deficient in the basal diet.

The harvested material of each species was mixed thoroughly. After sun-drying, the material was oven-dried at temperature of 60°C over night and then ground through a 2 mm mesh sieve. The samples were stored in polythene bags pending chemical analyses. Dry matter (DM), ash, crude protein (CP), fat (ether extract), crude fibre (CF) and nitrogen free extracts (NFE) were determined by proximate analysis (AOAC, 1990). In the laboratory all chemical analyses were carried out in duplicate on each of the two replicate samples of each browse material such that the value for each replicate was an average of the duplicate analyses. In cases were duplicate results of the same sample differed by 10%, a re-run was done. This is according to (AOAC, 1990) guidelines of quality control in chemical analyses. Dry matter (DM) was determined by drying the samples at 105°C overnight and ash by igniting the samples in a muffle furnace at 550°C for 8 hours. Nitrogen (N) content was measured by the Kjeldahl method (AOAC, 1990). Crude protein was calculated as N%×6.25. Crude Fibre was determined using the acid and alkali digestion method (AOAC, 1990).

**Experiment 2: Feed evaluation**

The digestible, metabolisable energy were calculated for grazing cattle using (AOAC, 1990) regression equations. TDN is a number that indicates the amount of energy provided to cattle from feed. TDN can be expressed as either a percentage of the ration. Total digestible nutrients was calculated as **TDN**= (digestible crude protein) + (digestible crude fiber) + (digestible nitrogen-free extract) + (digestible crude fat x 2.25).

**Experiment 3: The palatability trial**

Thirty six (36) steers were divided into eight (9) groups with two replications such that each group was given one of the 8 browse material (plus hay) and control group only hay for 45 minutes over a 7 day period after going through an adaptation period of 7 days. All steers were between 24 and 30 months old and from the same village and grazing area. The animals were offered the browse materials for 45 minutes at 8AM in the morning before they are let loose into the rangelands for grazing and browsing.

The palatability trial was done during the dry period from mid August to early September when the animals were used to browsing due to limited grazing. The amount of feed offered and the amount remaining after 45 minutes was used to calculate what had been consumed and this was used as an indicator of palatability. The adaptation period was short 7 days because the animals were already browsing and that harvesting enough material was a challenge due to the drought of 2012/2013 season.

### 3.8 Data Analysis

#### 3.8.1. Qualitative data

Qualitative data were mainly analysed, interpreted and presented through the use of descriptive statistics and graphs in order to contextualize and interpret quantitative results

#### 3.8.2 .Quantitative data

IBM SPSS (version 21) Statistical Package was used to compare the nutritive values among browsed plants and the control (hay) using T- test. Significance between the means was identified using Kruskal-Wallis Test (Pearse and Hartley 1966). Mean were considered significance difference at $P<0.05$. Standard errors of means were calculated from the residual mean square.

### 3.9 Research Ethics

This research therefore was conducted in a transparent manner with the inclusion of the community members particularly leaders of the communities in which the data was collected. The researcher sought authorization to conduct research from the Ministry of Agriculture, Water and Forestry, Ministry of Environment and Tourism and obtained ethical clearance from the University of Namibia. Informed consent was obtained from every respondent before participating in interviews and such participant's rights was explained before any interviews. No confidential personal details were taken from any person for the purpose of this study. All data was combined to form part of a whole body of information generated for this research. All materials used, citations and references were acknowledged and accurately documented using applicable bibliographical approaches and guidelines.

Animals used in the palatability trial were confined for 45 minutes only every morning before going to graze and browse to avoid stressing them.

## CHAPTER 4. RESULTS

### 4.0 Evaluation of Indigenous knowledge on browse in Sibbinda Constituency

Table 4.0 shows all the important browse species identified and ranked by the farmers as important alternative feed resources for cattle during the dry season. *Acacia eriobola*, *Dichrostachys Cineria* were the most popular and the least were *Boscia Albitrunca* and *Strychnos cocculoide.* The farmers observed that cattle eat selectively the leaves, pods and seed and sometimes twigs. This feeding behaviour was explained by the farmers to be because of the animals' inherent ability to choose nutritious parts of the browse plant.

**Table 4.0 Browseable materials identified by the communal farmers**

| | **Botanical Name** | **Responses (in numbers)** | **Responses (%)** |
|---|---|---|---|
| 1 | *Acacia Erioloba* | **195** | **19.1** |
| 2 | *Dichrostachys Cineria* | **162** | **15.9** |
| 3 | *Baphia massaiensis* | **146** | **14.3** |
| 4 | *Colophospermum mopane* | **131** | **12.8** |
| 5 | *Guibourtia coleosperma* | **112** | **11.0** |
| 6 | *Terminalia sericea* | **85** | **8.3** |
| 7 | *Berchemia Discolor* | **75** | **7.4** |
| 8 | *Combretim collinum* | **57** | **5.6** |
| 9 | *Swartzia madagascariensis* | **33** | **3.2** |
| 10 | *Boscia Albitrunca* | **18** | **1.8** |
| 11 | *Strychnos cocculoides* | **6** | **0.6** |

Table 4.1 shows the moisture content of the browse materials compared to the control (hay). Moisture content in all browseable species was predominantly higher as compared to that of the control (hay). Hay had a mean moisture content of 2.99g/100g. The moisture content is significantly different from the control ($P<0.05$). *Colophospermum mopane* and *Baphia massaiensis* had the highest moisture content ($P<0.05$) of 10.33g/100g and 11.66 g/100g respectively).

| **BROWSE SPECIES** | **Moisture g/100g** |
|---|---|
| *Acacia erioloba leaves* | 5.80 |
| *Acacia erioloba pods* | 6.95 |
| *Acacia erioloba seeds* | 7.45 |
| *Dichrostachys cinerea leaves* | 5.55 |
| *Dichrostachys cinerea pods* | 7.85 |
| *Colophospermum mopane* | 10.34 |
| *Baphia massaiensis* | 11.66 |
| *Guibourtia coleosperma* | 5.83 |
| Control (Hay) | 2.99 |
| **Standard deviation** | **2.23** |
| **Standard error** | **0.79** |

**Table 4.1 Comparison of moisture content of browse feedstuffs in g/100g**

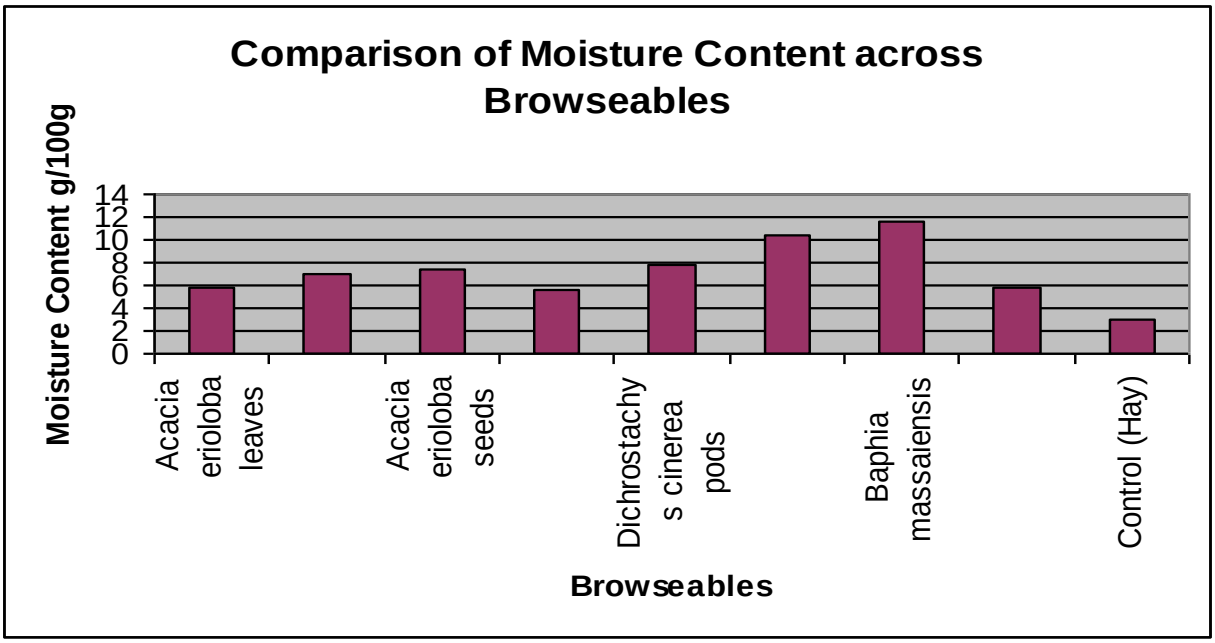


**Fig 3**: Shows the moisture content of the browseables compared to the control (hay)

### 4.2 Comparisons of the ash content of browseables

**Table 4.2 Comparison of ash content of browse feedstuffs in g/100g**

Table 4.2 below shows that ash content (on a dry matter basis) was significantly different ($P=0.013$) among the browse feedstuffs. There were significant differences to the control (hay) ($P<0.05$) except for *Acacia erioloba leaves. Dichrostachys cinerea* leaves had the highest ash content of 14.48 g/100g.

**Table 4.2 Ash content of the browse materials**

| BROWSE SPECIES | Ash |
|---|---|
| *Acacia erioloba leaves* | 7.94 |
| *Acacia erioloba pods* | 4.06 |
| *Acacia erioloba seeds* | 4.73 |
| *Dichrostachys cinerea leaves* | 14.48 |
| *Dichrostachys cinerea pods* | 6.32 |
| *Colophospermum mopane* | 7.34 |
| *Baphia massaiensis* | 4.62 |
| *Guibourtia coleosperma* | 6.27 |
| Control (Hay) | 8.94 |
| **Standard deviation** | **3.63** |
| **Standard error** | **1.24** |

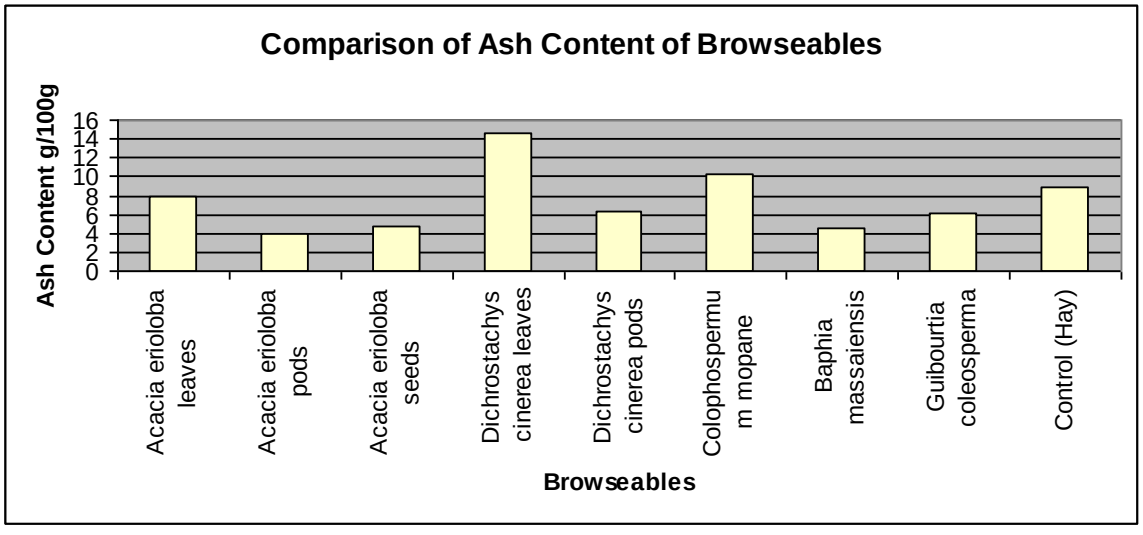


**Fig 4**: *Shows the ash content of the browse materials compared to the control (hay)*

### 4.3 Fat content (ether extract) of browse materials

The fat content of the browseable materials are shown below (on a dry matter basis) in Table 4.3. Table 4.3 shows that *Acacia erioloba leave, Acacia erioloba seeds Colophospermum mopane* has the highest (P<0.05) ether extract of 5.76 g/100g, 3.24 g/100g and 5.32 g/100g respectively.

| **BROWSE SPECIES** | **Fats & oils g/100g** |
|---|---|
| *Acacia erioloba leaves* | 5.76 |
| *Acacia erioloba pods* | 0.63 |
| *Acacia erioloba seeds* | 3.24 |
| *Dichrostachys cinerea leaves* | 1.925 |
| *Dichrostachys cinerea pods* | 0.8 |
| *Colophospermum mopane* | 5.32 |
| *Baphia massaiensis* | 2.82 |
| *Guibourtia coleosperma* | 2.36 |
| Control (Hay) | 1.25 |
| **Standard deviation** | **1.89** |
| **Standard error** | **0.68** |

**Table 4.3:** Fat content of the browse material

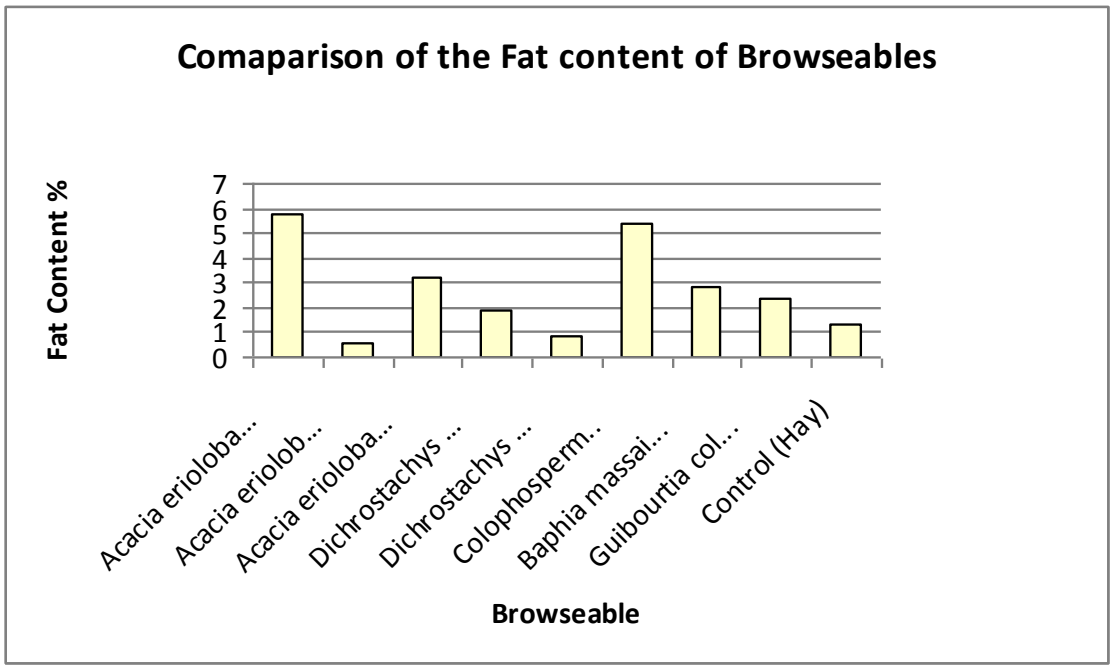


**Fig 5: Shows the Fat content of the browse materials**

### 4.4 Crude Fibre Content of the Browseables

Fig 4.4 shows the contents of crude fibre (on a dry matter basis) of the five browseable species and their different parts. *Acacia erioloba* were found to be more abundant ($P<0.05$) in crude fibre especially the leaves and the pods, as noted by both replications i.e. *Acacia erioloba pods* had a content of *36.23 g/100g*, 36.24 g/100g in rep 1 and rep 2 respectively. It was found that pods from all the browseables had higher fibre content ($P<0.05$) as they had the least mean of 26.435 (*Dichrostachys cinerea pods).* Most browseable contained less crude fibre in comparison to the control (hay) which had 34.72 g/100g mean crude content fibre as shown in graph 4 below.

Table 4.4 shows that's the pods were very high in crude fibre content. *Acacia erioloba* pods has crude fibre content that is not significantly different ($P>0.05$) from the control (the hay).

| BROWSE SPECIES | Crude fiber g/100g |
|---|---|
| *Acacia erioloba leaves* | 27.33 |
| *Acacia erioloba pods* | 36.23 |
| *Acacia erioloba seeds* | 14.24 |
| *Dichrostachys cinerea leaves* | 18.50 |
| *Dichrostachys cinerea pods* | 26.43 |
| *Colophospermum mopane* | 19.29 |
| *Baphia massaiensis* | 28.05 |
| *Guibourtia coleosperma* | 24.23 |
| Control (Hay) | 34.72 |
| **Standard deviation** | **6.87** |
| **Standard error** | **2.43** |

Table 4 Comparison of crude fibre content of browseables in g/100g

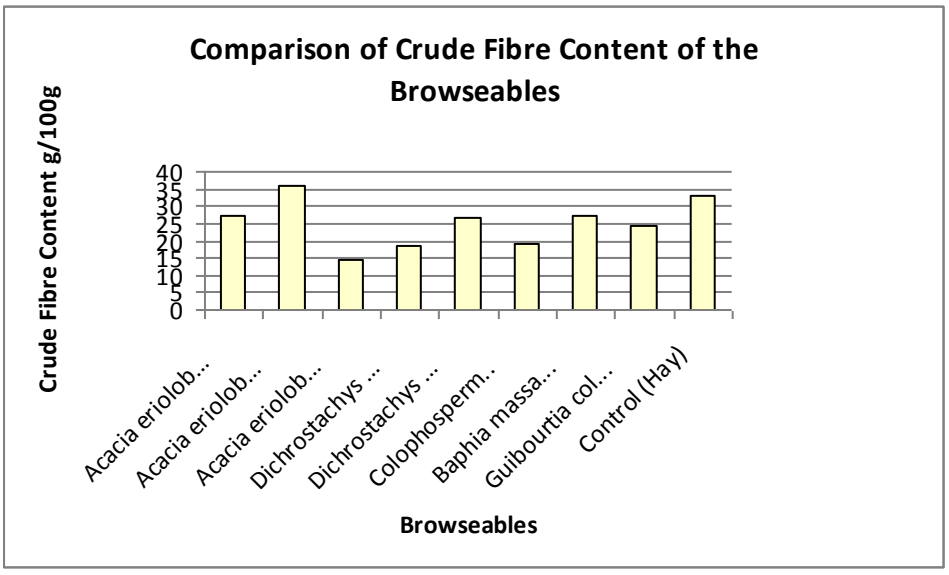


**Fig 6**: Crude Fibre content of the browse materials compared to the hay

### 4.5 Crude protein content of the browseables

The mean abundance for crude protein is higher in *Acacia erioloba seeds* (27.63 g/100g) than in *Dichrostachys cinerea* pods (16.64 g/100g) ($P<0.05$) and *Acacia erioloba pods* had the least crude protein content of 9.47g/100 though significantly higher ($P<0.05$) than the control (hay). The results are shown pictorially in Figure 4.5.

| **BROWSE SPECIES** | **Crude Protein g/100g** |
|---|---|
| *Acacia erioloba leaves* | 12.34 |
| *Acacia erioloba pods* | 9.47 |
| *Acacia erioloba sedes* | 27.63 |
| *Dichrostachys cinerea leaves* | 14.66 |
| *Dichrostachys cinerea pods* | 16.64 |
| *Colophospermum mopane* | 10.19 |
| *Baphia massaiensis* | 16.18 |
| *Guibourtia coleosperma* | 13.49 |
| Control (Hay) | 3.33 |
| **Standard deviation** | **5.69** |
| **Standard error** | **2.01** |

Table 4.5 Comparison of crude protein content of browse feedstuffs in g/100g

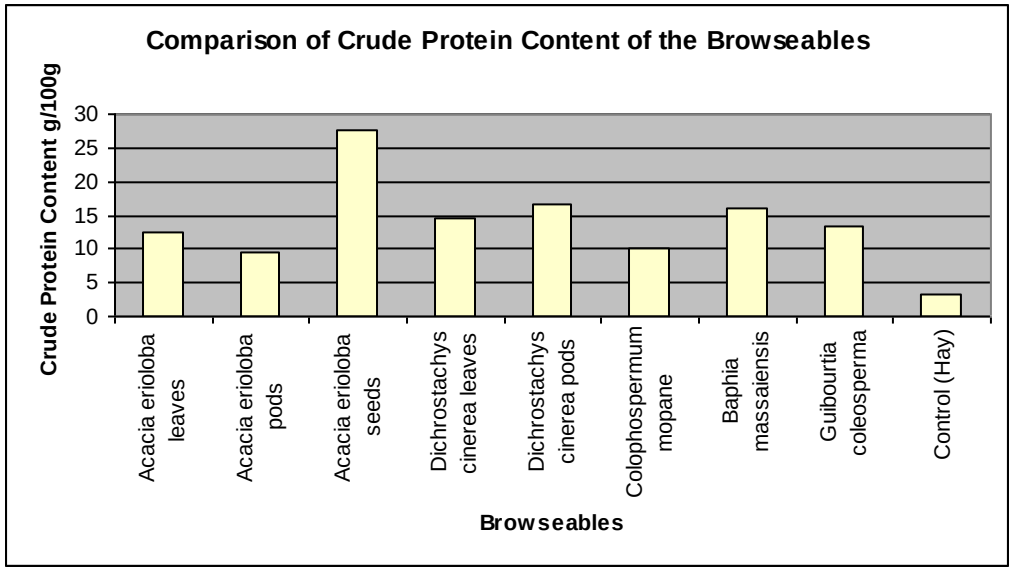


**Fig 7**: Shows the crude protein content of the browse materials

### 4.6 Total digestible nutrients

The control *(hay)* had less Total Digestible Nutrients (TDN) compared to other browseable feedstuffs ($P<0.05$). Hay had a mean Total Digestible nutrient of 40.78 % as compared to *Acacia erioloba* pods with a mean content of 53.06 %. *Acacia erioloba* seeds had a very high TDN of 72.34 % which was significantly higher ($P<0.05$) than the control and all the other browseable materials.

| BROWSE SPECIES | Total Digestible Nutrient % |
|---|---|
| *Acacia erioloba leaves* | 63.38 |
| *Acacia erioloba pods* | 53.06 |
| *Acacia erioloba seeds* | 72.34 |
| *Dichrostachys cinerea leaves* | 55.17 |
| *Dichrostachys cinerea pods* | 58.39 |
| *Colophospermum mopane* | 61.07 |
| *Baphia massaiensis* | 55.3 |
| *Guibourtia coleosperma* | 57.18 |
| Control (Hay) | 40.78 |
| **Standard deviation** | **6.19** |
| **Standard error** | **2.20** |

**Table 4.6 Comparison of Total Digestible nutrients content of browse feedstuffs in percentage**

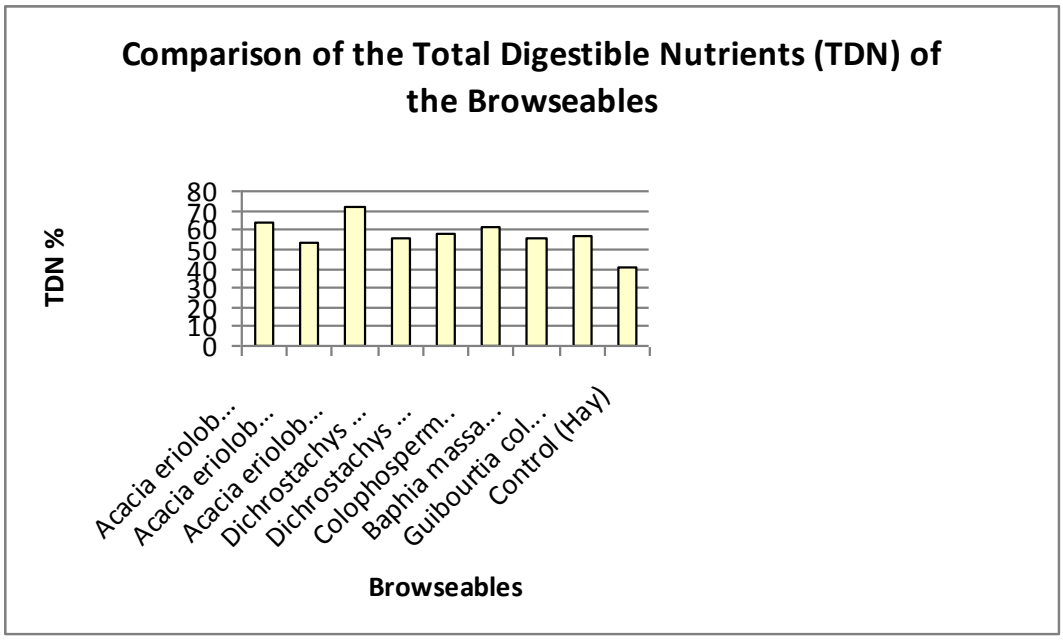


**Fig 4.6**: Shows the Total Digestible Nutrients (TDN) content of browseable

### 4.7 Digestible Energy Content of the browseables

All the browseable species in this study had more digestible energy content ($P<0.05$) as compared to the control (hay) which had 9.00 M/Kg. *Acacia erioloba* pods had the least mean digestible energy content of 10.23 MJ/kg but still significantly higher than that of hay ($P<0.05$). The browseable species had energy levels higher than the maintenance energy requirements (10 MJ/kg) of grazing cattle.

**Table 4.7:** Digestible energy for browse species of control

| BROWSE SPECIES | Digestible Energy MJ/KG |
|---|---|
| *Acacia erioloba leaves* | 12.29 |
| *Acacia erioloba pods* | 10.23 |
| *Acacia erioloba seeds* | 13.11 |
| *Dichrostachys cinerea leaves* | 10.34 |
| *Dichrostachys cinerea pods* | 11.42 |
| *Colophospermum mopane* | 11.12 |

| | |
|---|---|
| *Baphia massaiensis* | 10.09 |
| *Guibourtia coleosperma* | 10.65 |
| Control (Hay) | 9.15 |
| **Standard deviation** | **1.09** |
| **Standard error** | **0.38** |

Fig 4, 7 shows the Digestible Energy content of the browseable materials

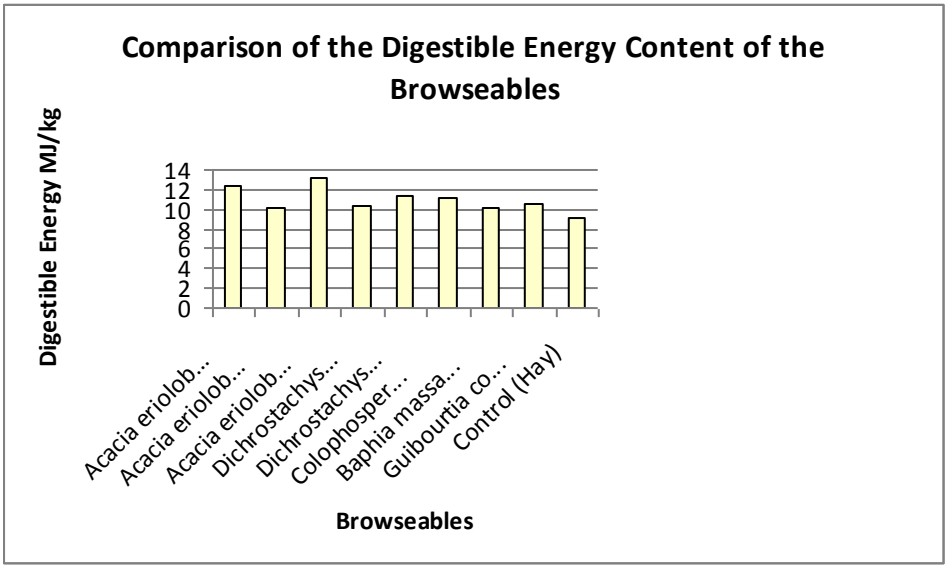


Fig 9: Digestible Energy content of the browseable materials

**4. 8 Metabolisable Energy MJ/kg**

Table 4.8 below shows that browseable species in this study contains high amounts of metabolisable energy and they is less difference in the contents of metabolisable energy in all the plant parts i.e. the highest mean metabolisable energy is 12.43 MJ/kg in *Acacia erioloba seeds* and the lowest being 8.13 MJ/kg in *Baphia massaiensis. The ME of Acacia erioloba pods, Dichrostachys cinerea leaves Dichrostachys cinerea leaves* did not differ significantly (P>0.05) to that of the control (hay)

**Table 4.8 Comparison of Metabolisable Energy content for ruminants of browse feedstuffs in MJ/kg**

| BROWSE SPECIES | Metabolisable energy MJ/kg |
|---|---|
| *Acacia erioloba leaves* | 10.24 |
| *Acacia erioloba pods* | 8.2 |
| *Acacia erioloba seeds* | 12.43 |
| *Dichrostachys cinerea leaves* | 8.06 |
| *Dichrostachys cinerea pods* | 9.17 |
| *Colophospermum mopane* | 10.18 |
| *Dichrostachys cinerea leaves* | 8.13 |
| *Guibourtia coleosperma* | 9.15 |
| Control (Hay) | 8.11 |
| **Standard deviation** | **1.50** |
| **Standard error** | **0.52** |

These results are shown in graph form in Figure 4.8 below.

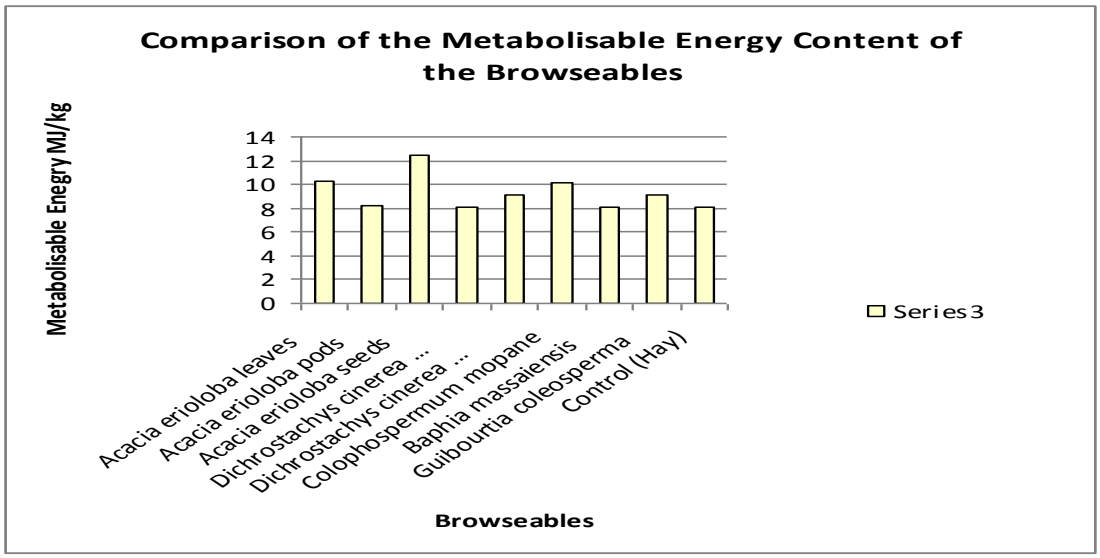


**Fig 10**: *Shows the L.S Means for Metabolisable Energy content*

### 4.9. Palatability of the browseables

Table 4.9, below shows the results of the palatability test on a dry matter basis. Palatability varied marginally between and among most browseable materials but all were significantly ($P<0.05$) higher than that of hay. *Dichrostachys cinerea* pods has the highest palatability which was significantly different from the rest and the control ($P<0.05$)

**Table 4.9 Comparison of Palatability of browse feedstuffs in kg within 45 minutes of feeding time**

| BROWSE SPECIES | Palatability kg/45 minutes |
|---|---|
| *Acacia erioloba leaves* | 1.27 |
| *Acacia erioloba pods* | 1.29 |
| *Acacia erioloba seeds* | 2.35 |
| *Dichrostachys cinerea leaves* | 1.34 |
| *Dichrostachys cinerea pods* | 6.94 |
| *Colophospermum mopane* | 2.48 |
| *Baphia massaiensis* | 1.28 |
| *Guibourtia coleosperma* | 1.32 |
| Control (Hay) | 0.99 |
| **Standard deviation** | **1.95** |
| **Standard error** | **0.69** |

The palatability trial results are also shown below in graph form in Figure 4.9.

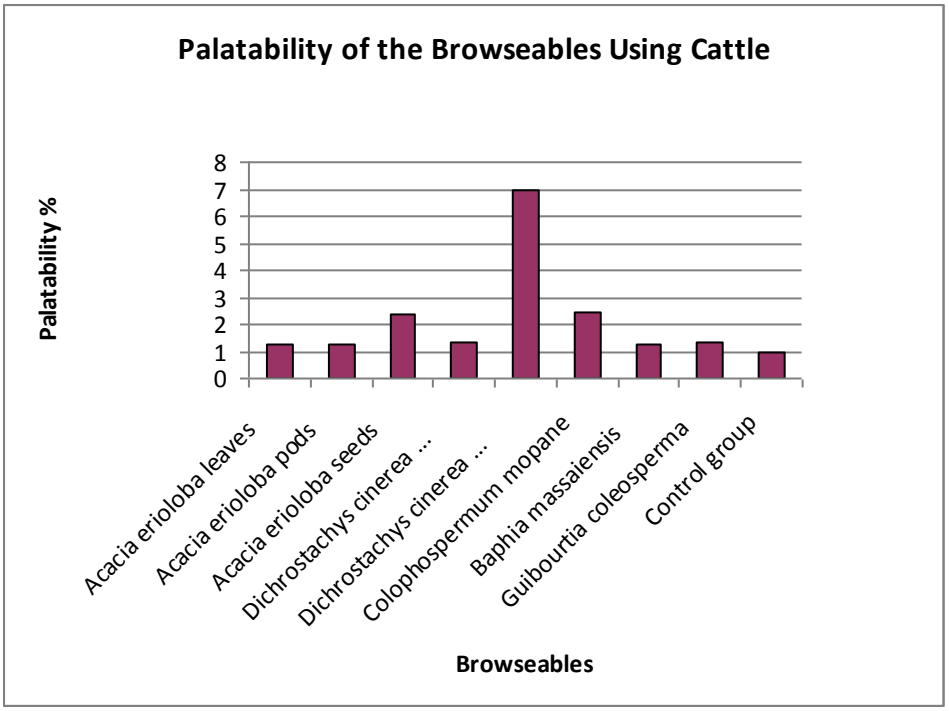


**Fig 11:** *Palatability for different of hay.*

# CHAPTER 5

# DISCUSSION

As the interview process was not biased, the results from the questionnaires were used to aggregate the responses so as to rank qualitatively the ones found the most useful by the farmers themselves from their own indigenous knowledge. The determination of browse plant species was mostly based on the information from the communal farmers, whom were mostly concentrating on commonality, multipurpose and palatability by cattle.

Zambezi region has a well –defined short rainy season and a prolonged dry season, which last for at least eight months of the year. It is during the dry season and drought period that browses are very important in livestock nutrition. In this study it was found that they are a variety of browsables in the study area. The parts consumed were leaves, pods and twigs and all these constituted the browse.

*Dichrostachys cinerea* and *Acacia Erioloba* has relatively high protein content (9-19 % DM) and may be an alternative source of crude protein in cattle fattening meals (Feedipedia, 2011; Choongo et al., 2008). Its nutritive value varies widely between seasons and depends on temperature and rainfall. For example, in Botswana, DM content might be only 43 % in the wet season (March to May) and increases up to 74 % in the dry season (July to September) (Aganga et al., 2005). It is against such background that indigenous knowledge ranked these species the highest.

## 5.1 Palatability

There appears to be no reliable single index for determining palatability in trees and shrubs, and no absolute scale by which it may be measured. Palatability is usually assessed subjectively by observation of animal behavior. The results obtained in this study are indicative and forms a basis for doing more palatability tests. This is because of the drought; nutritional stress was a big factor. During droughts animals tend to eat anything green and

this trial will have revealed the correct situation if it had been done under a normal rainy season. The experiment was done within one village at selected households and this presented management challenges as opposed to a situation if it had been done on a research station.

### 5.1.2 Measuring Palatability

Local variations in forage preferences are important; a combination of methods or obtaining food habit data appears the most useful, since any given method in use has limitations. Among the methods used in assessing palatability are: visual assessment and time spent on grazing. Using the visual assessment technique the study found that cattle spent most of their feeding on browsable was mainly on the pods of the browsables as compared to the other parts like leaves, twigs. This means if a commercial feed meal is to be developed using these browse species the parts preferred are the pods.

The palatability study complimented direct observation of cattle grazing. Cattle follow ups in the rangelands were conducted for a duration of a month in which the researcher obtained that livestock (Cattle) preferred pods to other parts of browsable plants, and therefore had a conclusive judgemental that pods are more palatable than other parts.

## 5.2 Ash and Moisture content of browse plants

*Dichrostachys cinerea* 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 (Aganga 2000). According to the chemical analysis moisture was determined when the sample were dried to a constant weight at $105^0$C. *Baphia massaiensis* had a lot of moisture compared to other species as it had 11.6 g/100g of moisture, the lowest specie interms of moisture content was Acacia erioloba leaves and Guibourtia coleosperma which had 5.8 g/100. Because of their high moisture content *Colophospermum mopane* and *Baphia massaiensis* can be useful feed resources that supply metabolic water to the animals during

the dry season. Similar work was reported by Grutteridge and Shelton (2001). The rate and extent of moisture removal depends on the size and shape of the sample, and how finely it is ground. The greater the surface area of material exposed to the environment, the faster the rate of moisture removal. Which corresponds with this study as all broad leaf species lost a lot of moisture. It is therefore a leant lesson that in the drought / dry season cattle should be fed on species with narrow leaves like *Baphia massaiensis* as it will be having more moisture.

**5.3 Protein content of browse plants**

Protein is considered the most important nutrient component. However, 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. 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 shrubs contain higher percentages of crude protein than leaves or other parts. In a similar study the tips of the pods contain higher protein levels than other sections (Aldous, 1945).

It is assumed that a considerable part of nitrogen might be lost during leaf fall. This situation does occur in the evergreen fodder shrubs. Since crude protein content is significantly correlated to digestible protein content, determination of the crude protein level of a plant can give a reasonably reliable indication of feed value (Sullivan, 1962). A slight deficiency in its intake adversely affects reproduction, lactation, and growth, while a serious deficiency results in the failure of the animal body to maintain itself.

The crude protein content of *Acacia erioloba* seeds were the highest in the study which was in the range of 27. 2 g/100g *Acacia erioloba* pods recorded the lowest crude protein as it contains 9.4g/100g. These results are similar to those obtained by Barry, (1986) Chemical

analysis of the tree parts eaten by the animals showed high CP and low to medium NDF contents. In the two species, *A. Erioloba and D. cinerea* in which leaves were analysed at different stages, CF content increased and CP content decreased with maturity. *Acacia* seeds and *D. cinerea,* leaves had a higher CP and lower NDF content than pod. According to Sharma et al., (1998), corroborated by the work of Aganga et al., (2000) the high protein content of *Dichrostachys cinerea*, *Acacia* browse may alleviate problems of protein shortage during the dry season when it is fed to cattle as a supplement for low quality forages

**5.4 Crude fibre content of selected browse plants**

Crude fiber is a traditional measure of fiber content in feeds. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) are more useful measures of feeding value, and should be used to evaluate forages and formulate rations. In this study due to limited laboratory capacity this was not done.

Since *Acacia erioloba* pods and *Dichrostachys cinerea* pods are very high in crude fibre content, they can be useful for bulk during the dry season for ruminants especially if they are fed to the animals with other low fibre but high protein browse.

The nutritive value of forages for livestock feeding depends on the balance between the nutritive components of the plants, the digestibility of such nutrients, the metabolism of absorbed nutrients and the quantity of nutrients ingested by the animal (Seoane *et al*., 1981). In order to decrease the cost and time involved in *vivo* forage evaluation, laboratory procedures have been developed. According to Van Soest (1983) chemical and physical analyses contribute to the determination of the nutritive value and have been suggested as alternative ways to determine quality of feedstuffs with regards to CF content which is assumed to be very high in most browsable apart from the acacia. In the study it was

determined that Acacia pods contains a lot of *Crude fiber* as compared to other browsables (i.e. *Acacia erioloba* pods had 36 g/100g which is too high as it is advisable for livestock to consume less fiber like acacia erioloba seeds

### 5.5 Crude fat (Ether extract) of browse species

Fats supply 2.25 times more energy that carbohydrates (McDonald, 2010) so due to their high fats and oil content *Acacia erioloba leave, Acacia erioloba seeds Colophospermum mopane* are 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. The term crude fat (ether extract) includes a wide variety of substances which are not digestible to any extent, and may even inhibit rumen function (Nagy *et al.*, 1964), such as terpenes, resins, and essential oils. The high ether extract values obtained from laboratory analysis can give a misleading nutritional result (Dietz *et al.*, 1962). The true lipids include simple, compound (phospho-lipides), and derived lipids (saturated and unsaturated fatty acid), and true fats and oils, most of which are digestible in varying degrees by ruminants.

From a nutritional point of view, fats are highly important reserve foods in shrubs because they contain almost twice as 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 midsummer, then increase in fall and winter (Dietz *et al.*, 1962). Ruminants are not dependent upon fat in shrubs since fat is synthesized in the rumen from carbohydrates and proteins. However, range animals seem to benefit from grazing on shrubs such as *Eurotia lanata*, which contain good fat levels (Dietz *et al.*, 1962).

## 5.6 Total Digestible Nutrients (TDN) and Digestible Energy (DE) of browse plant species

Total Digestible Nutrients (TDN): is defined as sum of the digestible fiber, protein, lipid, and carbohydrate components of a feedstuff or diet. TDN is directly related to digestible energy and is often calculated based on ADF. TDN is useful for beef cow rations that are primarily forage. When moderate to high concentrations of concentrate are fed, net energy should be used to formulate diets and predict animal performance. TDN values tend to under predict the feeding value of concentrate relative to forage i.e. all seeds from plants have high TDN. In the study the *Acacia erioloba* had the highest TDN which was 72g/100g as digestible nutrients. This implies that if cattle are fed on seeds in the dry season they will have a lot of energy as most feed will be digested.

In the Sibbinda community, locals have extensive knowledge of their rangelands with emphasis on the browsables and grasses. According to Oba and Kotile (2001) Communal communities usually have a detailed knowledge of their grazing lands, acquired through extensive observation and continuous herding practice. Turner et al. (2000) concluded that traditional knowledge of indigenous people was fundamentally important in the management of local resources. Other studies (e.g Fernandez-Gimenez 2000; Ayana and Fekadu 2003:Amaha 2006; Ayana and Oba 2008: also showed that documenting indigenous knowledge of rangeland resources can provide useful information for the development , sustainable utilisation and conservation of natural resources. Additionally community based knowledge may provide now insights for improving existing scientific knowledge and a bases for designing appropriate research and development policies. In most parts of Ethiopia, Namibia included the indigenous knowledge of pastoralists is not adequately documented (Gemedo 2004: Amaha 2006).Therefore More research is needed because traditional

knowledge of indigenous people is fundamentally important in the management of local resources.

# CHAPTER 6

## 6.1 CONCLUSIONS

The results of this study show that browsable trees are highly nutritious and contribute substantially to the diet of livestock during the dry season especially in the communal areas compared to the basal feed, hay. Further this study has provided information on the value of a number of plant species adapted to arid environments for use as cattle feed.This information may prove useful for herders, farmers and ruminant's nutritionists in feeding strategies for cattle in the dry season. There were no consistent patterns between the chemical compositions with gas production of studied plants. It is suggested to evaluate of ant nutrients such as tannins and sapon in in these species. Most of the browsable plants in the study population were palatable. All the five browsable species analysed in the process of this study contained relative high digestible energy and metabolisable energy which is very essential in the production of livestock.

There were significant variations in chemical composition of browsable species studied in this experiment. There is no single best browsable tree as they differ in chemical composition, hence complement each other to provide the necessary nutrients to the livestock.

The demonstrable benefit of browse plants are improved performance of animals and reduced costs of feeding, these advantages justify the more intensive and wider utilisation of fodder trees and shrubs in appropriate feeding systems and represent an important strategy for increasing the current level of contribution from ruminants. This study indicated that a large reserve of plant species in the local flora are available that could be potentially used for livestock feeding.These feeds, if fully exploited, could assist in increasing the level of production and productivity of the livestock resources in the region. However, these feeds,

apart from chemical composition, need to be characterized further in terms of palatability, digestibility, feed intake, animal response trials and anti-nutritional factor studies, in order to beable to enhance their utilization in future.

The multiple use of the local tree and shrub species in different farming systems has led to negative and positive effects. The negative one is related to wiping out, for example, of the species that are more palatable to grazing and browsing ungulates. As a result many areas are bare and are susceptible to wind and water erosion. The positive effect involves exploiting of this knowledge from users (farmers) and incorporating it in research and development systems for the benefit of the present and future generations. It is therefore important for all parties (research-extension-farmers) to work collectively for the purpose of building a sustainable livestock production system through efficient utilization of multipurpose trees and shrubs.

## 6.2 RECOMMENDATIONS

Efforts by the Ministry of Environment and Tourism in planting more indigenous trees should be supported as they constitute a valuable supplement for cattle in the dry season. Farmers in the villages should be co-opted in these tree planting activities. More research is needed on the palatability of these browsable tree species and on technologies that can be used to pellet the browse for use in dry months. The ministry of Agriculture water and Forest should promote the use of these browsable plants and plant parts as cattle feed supplements during dry seasons. Farmers should be educated on the benefits of agro forestry to encourage private planting of multi-purpose tree species. This will make their indigenous knowledge more useful so that they can better manage their animals during the dry season and in time of droughts. A participatory approach can be used to identify' farmer's preferred species for forest or private plantation.

There is need to identify a few promising fodder tree species and establish their silivicultural practices, propagation techniques, and looping techniques and measure the chemical composition including anti-nutritional factors and feeding value.

On-farm tree growing to facilitate sustainable livestock should be encouraged and supported nationally. Such on-farm planting should involve indigenous trees for shade and research into their ability to reduce erosion.

Such research could be carried out in all regions after farmers' preferences for tree density and fodder needs have been investigated.

Investigation of the harvesting time for the pods of *acacia eriobola*. is needed so that seed are both retained in pods and are immature at harvest to ensure that the protein content is maintained at a high level and that self-seeding on-farm or the range is avoided.

Comparative studies of the crude protein contents of the leaves and pods of all four species are needed. Such studies should be followed by feed trials comparing the growth of animals fed on pods with those fed on leaves.

The results of such studies will form the basis for the respective roles of leaves and pods in feeding strategies.

## REFERENCE


Abdulrazak. S.A, Fujihara. T, Ondiek J.K, Ørskov. E.R. (2000). Nutritive evaluation of some

Abule, E., Snyman, H.A., Smit, G.N., (2005a). Comparisons of pastoralists perceptions about rangeland resource utilization in the Middle Awash Valley of Ethiopia. Journal of Environmental Management 75, 21–35.

Abule, E., Snyman, H.A., Smit, G.N., (2005b). The influence of woody plants and livestock grazing on grass species composition, yield and soil nutrients in the Middle Awash Valley of Ethiopia. Journal of Arid Environments 60, 343–358.

Ahn, J.H. (1990) Quality assessment of tropical browse legumes: tannin content and nitrogen degradability. PhD thesis, The University of Queensland.

Al, V. S. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch

AOAC.( 1990). Association of Official Analytical Chemists. Official methods of analysis. Washington, D.C. 2044 pp.

Asante, W.J., Oppong, S.K. and Sam, O. (2002). Survey of Browse Plants in Peri-urban

Baatuuwie, N.B. (2005). The effects of pre-treatment on seeds of some indigenous browse

Babayemi, O.J., D. Demeyer and V. Fievez, 2004b. *In vitro* fermentation of tropical browse seeds in relation to. Nutrition of grazing ruminants in Feed Sci., 13 Suppl. 1: 31-34.

Bazzaz F.A. (1996). Plants in changing environments: linking physiological, population and community ecology. Cambridge: Cambridge University Press.

Borens, F.M.P. and Poppi, D.P. (1990) The nutritive value for ruminants of Tagasaste (*Chamaecytisus palmensis*), a leguminous tree. *Animal Feed Science and Technology* 28, 27

Burrit , E. A., & Provenza, F. D. (2000). Roles of toxin in intake of variety diet by sheep. Journal of chemistry Ecology, 26, 1991-2005.

Chester-Jones, H, H. Rebhan and D. M. Ziegler. (1996). High energy no-roughage programs for feedlot Holstein steers: an assessment of performance and economic efficiencies. *J. Anim. Sci.* 74 (Supp. 1): 43 Abstract.

Choongo, K., Siulapwa, N. J., Mwaanga, E., Muzandu, K., & Siyumbi, D. (2008). Effects of

Corbett L.K., Newsome A.E. (1987). The feeding ecology of the dingo. III. Dietary relationships with widely fluctuating prey populations in arid Australia: a hypothesis of alternation of predation. *Oecologia* 74: 215-227.

CPHA. (2002). Western Fertilizer Handbook. 9th Edition. Interstate Publisher, Inc. Danville,

Dendra. C. (1996). Opportunities for increasing the economic contribution of small ruminants in Asia. Canberra, Australia.

De Pauw. E. & Coetzee. M.E. (1999). Production of an Agro-Ecological Zones Map of Namibia (first approximation), Part 2: Results. Agricola 10:8-68

Dichrostachys cinerea supplementation on weight gain and rumen protozoa in cattle. Livest. Res. Rural Dev, 20(5), 73.

Dicko, M. S., & Sangare, M. (1981). Les aliments du bétail vendus sur le marché de Nino. Rapport interne.

Doss, C.; McPeak, J. & Barrett, C.B. (2005). Perceptions of risk within pastoralist households in Northern Kenya and Southern Ethiopia. New Haven: Yale University.

El Hassan, S. M., Lahlou-Kassi, A., Newbold, C. J., & Wallace, R. J. (2000). Chemical composition and degradation characteristics of foliage of some African multipurpose trees. Laboratory of Animal Science, Faculty of Life and Environmental Science.Ethiopia. Animal Feed Science and Technology, 148: 12-33.

FAO & NEPAD (2005) (Food and Agriculture Organization & New Partnership for Africa's Development). Government of the Republic of Namibia: Livestock Improvement. Midrand: NEPAD.

FAO (2004). Protein sources for the animal feed industry. Proceedings: Expert Consultation and Workshop Bangkok, Thailand.

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

FAO, 2008a. Livestock, a major threat to environment. Rome, Italy. Available at http://web.archive.org/web/20080328062709/http%3A//www.fao.org/newsroom/en/news/2006/1000448/index.

Foley, W.J., Iason, G.R., McArthur, C. (1999). Role of plant secondary metabolites in the nutritional ecology of mammalian herbivores: Symposium on the Nutrition of Herbivores, Nutritional Ecology of Herbivores, American Society of Animal Science, IL,pp. 130–209.

Giner-Chávez B.I., (1996). Condensed tannins in tropical forages. Doctoral Thesis. Cornell University. Ithaca, NY, USA.

Grutteridge, R. C., & Shelton , H. M. (2001). Forage tree legume as in Tropical Agriculture.

Hansen, R. P., & Czochanska., Z. (1974). Composition of the lipids of lupin seeds. Agric, 25, 409-415.

Harborne J.B., (1999). An overview of antinutritional factors in higher plants. In: Secondary plants products. Antinutritional and beneficial actions in animal feeding.NottinghamUniv Press, UK, pp. 7-16.

Henry .H, Thomas S.C. (2002). Interactive effects of lateral shade and wind on stem, allometry, biomass allocation, and mechanical stability in Abutilon theophrasti (Malvaceae) American Journal of Botany.;89:1609–1615.

Hill, G. D., & Tamminga. , S. (1998). The effects of antinutritional factors in legume seed and rapeseed on ruminant nutrition. 157-172.

Idestam-Almquist J, Kautsky L. (1995).Plastic responses in morphology of Potamogeton pectinatus L. to sediment and above-sediment conditions at two sites in the northern Baltic proper. Aquatic Botany. 52:205–216. Illinois. 356 p. International Institute for Agricultural Development. (n.d.). 125.

IPCC.(2007). "5.2 Key vulnerabilities, impacts and risks – long-term perspectives". In Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.). Synthesis Report. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Print version: IPCC, Geneva, Switzerland. This version: IPCC website. Retrieved 2011-06-01.

John Bessonette , A. (2008). Evaluation of the use and effectiveness of wild life crossing. National coperative highway reserve programm.

Kaitho, J. R. (1997). Nutritive value of browses as protein supplement(s) to poor quality roughages. PhD thesis. Wageningen Agricultural University. 189 pp.

Kirsten, J.F. (2002). Livestock marketing in the Northern Communal Areas of Namibia (livestock producer marketing strategies and informal trade in live animals, meat, hides and skin). Windhoek: NOLIDEP.

Koshiba, T. , Kobayashi, M. and Matoh , T. (2009). Boron nutrition of tobacco BY-2 cells. V. Oxidative damage is the major cause of cell death induced by boron deprivation. Plant Cell Physiol. 50: 26 – 36.

Koshiba. (2009). Boron nutrition of Tobbacco by two cells.v.oxidative damage. is the major cause of cell death induced by boron deprivation plant cell phiysiology . 26-37.

Kumasi. Journal of the Ghana Science Association. Vol. 4 No. 1. Pp.49-50.

Le Houérou. H.N. (1980b). The role of browse in the Sahelian and Sudanian zones. In: Le Houérou, H.N. (ed.) Browse in Africa, and Chapter 6. ILCA, Addis Abeba, Ethiopia.

LEAD. (1999). Livestock, Environment and Development Initiative. Livestock and Environment Toolbox. From <http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Tech 23Prunin.htm#EIA> (accessed 14 May 2012).

Luseba and Van Der Merwe (2006). Use of ethnoveterinary medicinal plants in cattle by Setswanaspeaking people in the Madikwe area of the North West Province of South Africa. *Journal of South African Veterinary Association,* 72:189–196.

MAWRD (2002). Socio-economic survey of southern communal areas. 1-98. Windhoek, Namibia.

MAWRD.(1996). Namibia agriculture research plan. Ministry of Agriculture, Water and Rural Development, Windhoek.

McLeod, D.B. (1988). Affective issues in mathematical problem solving: Some theoretical considerations. Journal for Research in Mathematics Education, 19, 134-141.

McLEOD M.N., (1974). Plant tannins - Their role in forage quality. Nutr Abst Rev 44, 803-812.

Mertz, O., C. Mbow, J. Østergaard Nielsen, A. Maiga, D. Diallo, A. Reenberg, A. Diouf, B. Barbier, I. Bouzou Moussa, M. Zorom, I. Ouattara, and D. Dabi. (2010). Climate factors play a limited role for past adaptation strategies in West Africa. *Ecology and Society*

Mole S., Waterman P.G.,( 1987). Tannic acid and proteolytic enzymes: enzyme inhibition or substrate deprivation? Phytochemistry 26, 99-102.

Mole, S. And Waterman, P.G. 1987. A critical analysis of techniques for measuring tannins in ecological studies. 1. Techniques for chemically defining tannins. Oecologia 72, 137–143.

Morgan D.L. (1988) *Focus groups as qualitative research*. London: Sage.

Morton (2007).The impact of climate change on smallholder and subsistence agriculture Pennsylvania State University, University Park, PA. www.pnas.org/cgi/doi.10.1073/pnas.0701855104.

Mueller-Harvey I., Mcallan A.B.,( 1992.) Tannins. Their biochemistry and nutritional properties. In: Advances in plant cell biochemistry and biotechnology, Vol. 1 (Morrison I.M., ed.). JAI Press Ltd., London (UK), pp. 151-217

Nardone A, Godi M, Artuso A, Schieppati M. (2010). Balance rehabilitation by moving platform and exercises in patients with neuropathy or vestibular deficit. *Archives of Physical Medicine and Rehabilitation 91*(12):1869-77.

NASSP (2005) (National Agricultural Support Services Programme)... Onyuulaye Auction final

Norton, B. W. (1982). Differences between species in forage quality. Common wealth Agricultural Bureaux.

Odoh, S.O. and H. Adamu-Noma,( 2000). A survey of browse species in Benue North Agricultural Zone.

Oji U I and Isilebo J O. (2000) Nutrient characterization of selected browse plants of the humid tropics. In Proc. 27th Annual NSAP conference, 18th - 21st March 2000, Umudike, Nigeria. Pp.54-56.

Okoli I C, Ebere C S, Uchegbu M C, Udah C A and Ibeawuchi I I (2002**)** Survey of the diversity of plants utilized for small ruminant feeding in Southeastern Nigeria. Agriculture Ecosystem and Environment

Onwuegbuzie.A. J, Turner, L. A. (2007). Toward a definition of mixed methods research. Journal of Mixed Methods Research, 1(2), 112–133. Cornell University.

Opara, C.C., (1996). The use of *Alchonea cordifolia* leaf meal as feed ingredient in poultry diet. M.Sc Thesis, Federal University of Technology, Owerri.Unpublished.

Oppong. (2001). Small ruminant feed systems: perceptions and practices in the transitional zone of Ghana. Journal of Ethnobiology and Ethnomedicine.

Palgrave, K. C. (1983). Trees of Southern Africa.2nd edition.

Paterson, R. T., Karanja, G. M., Roothaert, R. L., Nyaata, O. Z., & Kariuki, I. W. (1998). A review of tree fodder production and utilization within smallholder agroforestry systems in Kenya. Agroforestry Systems, 41, 181-199.

Pilon-Smits, Quinn, C.F, Tapken .W, Malagoli, M. and Schiavon, M. (2009). Physiological functions of benefi cial elements. Curr. Opin. Plant Biol.12: 267 – 274.

PHA .(2002), *Plant Health Australia (Plant Industries) Funding Act 2002*

Power P. (1996) Effects of current velocity and substrate composition on growth of Texas wildrice (Zizania Texan) Aquatic Botany. 55:199–204.

Provenza, F.D, Burritt, E.A, Perevolotsky, A., Silanikove, N. (2000). Self-regulation of intake of polyethylene glycol by sheep fed diets varying in tannin concentrations. J. Anim. Sci. 78, 1206–1212

Provenza, F.D., Villalba, J.J, Bryant, J.P, (2002). Polyethylene glycol influences selection of foraging location by sheep consuming quebracho tannin. J. Anim. Sci. 80, 1846–1851

Rethman, N. F., & Kotze, G. D. (1986). Veld condition in the South-Eastern Transvaal and its effect on grazing capacity. Journal of the Grassland Society of Southern Africa, 3(4), 134-140.

Reynolds , V., & Nautiyal , B. P. (1987). Grazing and fodder collection in Garhwal, N. India. International Journal of Environmental Studies.

Roshetko , J. (1994). Agroforestry for the Pacific Technologies Published by the Agroforestry Information Service (AIS) of the Nitrogen Fixing Tree Association (NFTA).

Sack L. (2004) Responses of temperate woody seedlings to shade and drought: do trade-offs limit potential niche differentiation? Oikos; 107:110–127.

Sangaré, M, Fernandez-Rivera.S, Hiernaux, P, Pandey, V.S, (2003). The effect of supplementation with fresh browse of Ziziphus mauritiana or Combretum aculeatum on feed intake, nitrogen utilization and growth of grazing range sheep. Tropical Animal Health and Production, 35: 465-476.

Sanon , H. O. (2007). The importance of some Sahelian browses species as feed for goats. Doctoral dissertation.

Sanon, H.O, Kabore-Zoungrana.C.Y, Ledin,I.(2007). Edible biomass production from some important browse species in the Sahelian zone of West Africa. Journal of Arid Environments 71: 376-392.

Sansoucy, R. (1994). Livestock – a driving force for food security and sustainable development. FAO Working Paper. FAO: Rome, Italy.

Schofield P., Mbugua D.M., Pell A.N., (2001). Analysisof condensed tannins: a review. Anim Feed Sci Tech

Service, G. S. (2000). Summary of the 2000 Population Census Report. Accra; Ghana: Ghana Statistical Service .

Sibanda, H. M., Ndlovu, L. R., Sibanda, L. M., & Hove, E. (1995). Nutritive value of pods of indigenous browsable tree species in a semiarid area of Zimbabwe. Ann. Zootech, 44

Species on germination in Northern Ghana. Unpublished. B.Sc. Thesis, Department of RNR,

Sultan S.E.(1998). Physiological response to complex environments in annual Polygonum species of contrasting ecological breadth. Oecologia.; 115:564–578.

Tan, J. L., Tien, J. & Chen, C. S. (2002) Langmuir 18, 519–523.

Teferedegne. T. (2000) New perspectives on the use of tropical plants to improve ruminant nutrition. Proceedings of the Nutrition Society, 59: 209-214.

Teferi , N. (2008). Browse in Africa. Addis Ababa, Ethiopia: International Livestock Centre for Africa (ILCA).

Terefi A, Solomon M and Lisanework, N. (2008). Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. Livestock Research for Rural Development, 20.

Thomas. D, Sumberg. J.E. (1995). A review of the evaluation and use of tropical forage legumes in sub-Saharan Africa. Agriculture, Ecosystems and Environment, 54: 151-163.

Tisdale, S. L., Nelson, W. L., Beaton, J. D, and J. L. Havlin. (1993). Soil Fertility and Fertilizers.Macmillan Publishing Cmpy. New York

Tompkins, E. L. and W. N. Adger. 2004. Does adaptive management of natural resources enhance resilience to climate change? Ecology and Society **9**(2): 10. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art10/

Touré, Y. T., Petrarca, V., Traoré, S. F., Coulibaly, A., Maiga, H. M., Sankaré, O., Sow, M., Di Deco, M. A. And Coluzzi, M. (1994). Ecological Genetic Studies In The Chromosomal Form Mopti Of Anopheles Gambiae S.Str. In Mali, West Africa. Genetica 94, 213-223

Towhidi A. (2007). Nutritive value of some herbage for dromedary Camel in Iran. Pakistan J. biological sciences, 10(1):167-170 UDS, Tamale Ghana.P.4.

UwechueN P (1990) The effect of level of fertilizer application and stage of maturity on the yield and chemical composition of threes tropical grasses in Western Nigeria. MSc. Thesis, University of Ibadan, Ibadan Nigeria

Van Soest P.J. (ed.), (1994.) Nutritional ecology of the ruminant, 2nd ed. Cornell Univ Press. Ithaca, NY, USA. 476 p.

Villalba, J.J, Provenza, F.D. Dong, G. (2003). Implications of plant chemistry and herbivore learning for diet mixing and plant biochemical diversity. Oikos, submitted for publication.

Wallace, M.H, Chappell G.L, M, Ely, D.G. DeWeese, W.P. Nishimuta, J.F. (1973). *Nutrient utilization by lambs ted three grass hays harvested at three maturity stages*. J. Anim. Sci. 37:298.

Wardeh. M.F, M. Dawa.M, Soghmari .M.M.O and. Mastafa A.l. (1990). *The nutritive value of preferred plant species by camels (Came/us dromedarius).* In Proc. Int. Conf. Camel Production and Improvement 10-13 December, Tobruk, Libya.

Yayneshet, T, Eik, L.O, Moe. S.R.( 2009). *Seasonal variations in the chemical composition and dry matter degradability of exclosure forages in the semi-arid region of northern*

Yousef E M, Mirzaee HR, Peyravi M, Tavakoli H. (2012b). *Study of chemical composition and dry matter degradability of Tamarix aphylla and Tamarix hispida in Sistan region*. Proceedings of 5th National Conference on Range and Range Management of Iran. Boroujerd, Iran.

**APPENDENCIES**

**1. Questionnaire**

**Personal Details of Respondents**

1. GENDER M ☐ F ☐
2. AGE 2.1 20-40 ☐
   2.2 40- 60 ☐
   2.3 60-80 ☐
   2.4 80-100 ☐
   2.5 Other ☐
3. **What number of cattle do you have?**
   3.1. 10-20, ☐
   3.2 20-40, ☐
   3.3 40-60, ☐
   3.4 60-80 , ☐
   3.5 80-100, ☐
   3.6 100 and above ☐
4. **What breed of cattle do you have?**
   4.1. Sanga, ☐ 4.2Brahman, ☐ 4.3Mixture ☐ 4.4 others? ☐
5. **If it is a mixture what is the main breed in your kraal?**
   .....
6. **Do the cattle stay out night and day or do they come in at evening?**
   Yes ☐ OR No ☐
7. Roughly how many months in a year do your cattle spend more time on grazing than on browsing : 2 ☐ 3 ☐ 4---6 ☐

8. Which months are those? J, F, M, A, M, J, J, A, S, P, O, N, D,

   ***Write the month hear*** ☐

9. **What will be the body condition of cattle?**

☐ ☐ ☐ ☐ ☐

10. **In which Seasons are cattle's body conditions better?**

    Summer ☐ Autamn ☐ Winter ☐

11. Which shrubs and trees are browsed?

NAME OF THE AREA.....

| **No** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **8** | |
| **9** | |
| **10** | |
| **11** | |
| **12** | |
| **13** | |
| **14** | |
| **15** | |
| **16** | |
| **17** | |
| **18** | |
| **19** | |
| **20** | |

12. **Do they have a preference for specific shrubs/trees?**

    Y ☐ or N ☐

    **If yes/no explain**

    .....

    .....

    .....

13. **If yes which are those shrubs/trees**

    .....

14. **Which shrubs or trees are browsed at the beginning, middle and end**

    .....

15. **Which are the common ones?**

    .....

16. **In what weather conditions do you see the cattle browsing bushes / trees?**

    .....

    .....

17. **What will be the grass quality / quantity during the periods by which cattle like browsing mostly**

    .....

    .....

18. **Do cattle browse bushes/ trees more at certain ages or stages?(more than one answer can be selected)**

    .....

    .....

19. **What difficulties do you think cattle encounter in accessing the browse?**

    .....

    .....

**APPENDIX 2**

## ANALYTICAL METHODOLOGIES (AOAC 1990) USED

### Type of Sample(s)

Animal feedstuffs

### Samples Received

Eight sample(s) received on the 15/08/2013

### Test(s) Required

Moisture, crude fats & oils, crude nitrogen (protein calculated), crude fiber, ash, total digestible nutrients, digestible energy, metabolisable energy,

### Test Method(s) used

Determination of moisture and other volatile matter content

In house method based on 73/47/EEC, Part 1

Dried to constant weight at ±100°C

Reporting: weight %

Determination of crude fats and oils, extractable

In house method based on 98/64/EEC, Part B

Extraction: petroleum ether (bp. 40-60°C)/4h

Reporting: weight %

Determination of nitrogen content and calculation of protein content

In house method based on 93/28/EEC

Digestion: concentrated sulphuric acid and Kjehltabs: 3.5g $K_2SO_4$/0.4g$CuSO_4$

Distillation followed by titration with hydrochloric acid

Protein content calculated from nitrogen content; nitrogen factor = 6.25

Reporting: weight %

Determination of crude fibre content

Ref. FOSS Application Note, based on Weende method

Treatment: boiling sulphuric acid and sodium hydroxide

Gravimetrically

Reporting: weight %

Determination of crude ash

In house method based on 71/250/EEC, Point 5

Dry decomposition at 550°C

Gravimetric

Reporting: weight %

Total digestible nutrients, digestible energy and metabolisable energy

Calculate

**Remark:**
**Estimates of energy availability**

Available energy and digestibility is estimated from chemical composition. Most energy values are predicted from fibre analyses, because fiber is negatively related to the animal's ability to digest and use nutrients in the feed.

**TDN calculated for dry roughage**

Digestible energy (DE) calculated from TDN for cattle and sheep (Crampton *et al*., 1957; Swift, 1957)

Metabolisable energy (ME) calculated from DE for cattle and sheep (Moe and Tyrrell, 1976)

S. Rügheimer

Laboratory Manager

**APPENDIX 3**

**Names of Browsable trees obtained from the interview**

| | **Local Name** | **Common Name** | **Botanical Name** | **Edible Parts** | **Other Uses** |
|---|---|---|---|---|---|
| 1 | Muhononо | Silver Terminalia | *Terminalia sericea* | Leaves | Building, Jaundance Diarrhea |
| 2 | Mupani | Mopane | *Colophospermum mopane* | Leaves Pods | Buiding Firewood Densetry |
| 3 | Muzauli | Large False Mopane | *Guibourtia coloosperma* | Leaves | Fruits as food Veneal Diseases |
| 4 | Muselesele | Sickle Bush | *Dichrostachys Cinerea* | Pods Leaves | Densentry Facilitate parturition |
| 5 | Muhoto | Camel Thorn | *Aacacia erioloba* | Pods Leaves | Cough Repels snakes (roots) |
| 6 | Isunde | Sand Camwood | *Baphiamassaiensis* | Leaves | Boosts Libido |
| 7 | Mutobo | Bush Willow | *Combretim collinum* | Leaves | Snake bites |
| 8 | Mushakashela | Snakebean | *Swartzia madagascariensis* | Pods Leaves | |
| 9 | Munzinzila | Bird Plum | *Berchemia Discolor* | Dry leaves | Service food Dying of crafts |
| 10 | Muhuluhulu | Monkey Orange | *Strychnos cocculoides* | Leaves | Parturition |
| 11 | Katema Bakulu | Shepard's tree | *Boscia Albitrunca* | Leaves | Boosts Libido |

# APPENDIX 4

## Statistical Data Analysis Results of Palatability test

**T-Test**

**Notes**

| | | |
|---|---|---|
| Output Created | | 29-NOV-2013 13:42:06 |
| Comments | | |
| Input | Data | D:\palatability.sav |
| | Active Dataset | DataSet2 |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 8 |
| Missing Value Handling | Definition of Missing | User defined missing values are treated as missing. |
| | Cases Used | Statistics for each analysis are based on the cases with no missing or out-of-range data for any variable in the analysis. |
| Syntax | | T-TEST PAIRS=PALATABILITYkg45minutesperiod WITH after (PAIRED) /CRITERIA=CI(.9500) /MISSING=ANALYSIS. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.04 |

[DataSet2] D:\palatability.sav

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | PALATABILITY kg/45minutes period | 2.2888 | 8 | 1.84591 | .65263 |
| | after | 2.2725 | 8 | 2.05814 | .72766 |

**Paired Samples Correlations**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | PALATABILITY kg/45minutes period & after | 8 | .994 | .000 |

**Paired Samples Test**

| | | Paired Differences | | | |
|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference |
| | | | | | Lower |
| Pair 1 | PALATABILITY kg/45minutes period - after | .01625 | .30114 | .10647 | -.23551 |

**Paired Samples Test**

| | | Paired Differences | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|
| | | 95% Confidence Interval of the Difference | | | |
| | | Upper | | | |
| Pair 1 | PALATABILITY kg/45minutes period - after | .26801 | .153 | 7 | .883 |

**T-Test**

**Notes**

| | | |
|---|---|---|
| Output Created | | 29-NOV-2013 14:07:59 |
| Comments | | |
| Input | Data | D:\chemical analysis.sav |
| | Active Dataset | DataSet3 |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 8 |
| Missing Value Handling | Definition of Missing | User defined missing values are treated as missing. |
| | Cases Used | Statistics for each analysis are based on the cases with no missing or out-of-range data for any variable in the analysis. |

| | | |
|---|---|---|
| Syntax | | T-TEST PAIRS=Fatsoils Ash Crudefiber CrudeProtein Totaldigestiblenutrient DigestibleenergyMJKG MetabolisableenergyMJkg Moistureg100g WITH Fatsoils_A Ash_A Crudefiber_A CrudeProtein_A Totaldigestiblenutrient_A DigestibleenergyMJKG_A MetabolisableenergyMJkg_A Moistureg100g_A (PAIRED)<br>/CRITERIA=CI(.9500)<br>/MISSING=ANALYSIS. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.01 |

[DataSet3] D:\chemical analysis.sav

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Fats & oils | 2.86 | 8 | 1.890 | .668 |
| | Fats & oils | 2.86 | 8 | 1.884 | .666 |
| Pair 2 | Ash | 7.35 | 8 | 3.575 | 1.264 |
| | Ash | 6.58 | 8 | 3.400 | 1.202 |
| Pair 3 | Crude fiber | 24.18 | 8 | 6.808 | 2.407 |
| | Crude fiber | 24.39 | 8 | 6.935 | 2.452 |
| Pair 4 | Crude Protein | 15.04 | 8 | 5.590 | 1.976 |
| | Crude Protein | 15.10 | 8 | 5.795 | 2.049 |
| Pair 5 | Total digestible nutrient % | 59.54 | 8 | 6.151 | 2.175 |
| | Total digestible nutrient % | 59.43 | 8 | 6.221 | 2.199 |
| Pair 6 | Digestible energyMJ/KG | 11.17 | 8 | 1.037 | .367 |
| | Digestible energyMJ/KG | 11.14 | 8 | 1.138 | .402 |
| Pair 7 | Metabolisable energy MJ/kg | 9.41 | 8 | 1.500 | .530 |
| | Metabolisable energy MJ/kg | 9.47 | 8 | 1.469 | .519 |
| Pair 8 | Moisture g/100g | 7.67 | 8 | 2.234 | .790 |
| | Moisture g/100g | 135.89 | 8 | 363.705 | 128.589 |

**Paired Samples Correlations**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Fats & oils & Fats & oils | 8 | 1.000 | .000 |
| Pair 2 | Ash & Ash | 8 | .819 | .013 |

| | | | | |
|---|---|---|---|---|
| Pair 3 | Crude fiber & Crude fiber | 8 | .998 | .000 |
| Pair 4 | Crude Protein & Crude Protein | 8 | .999 | .000 |
| Pair 5 | Total digestible nutrient % & Total digestible nutrient % | 8 | .993 | .000 |
| Pair 6 | Digestible energyMJ/KG & Digestible energyMJ/KG | 8 | .953 | .000 |
| Pair 7 | Metabolisable energy MJ/kg & Metabolisable energy MJ/kg | 8 | .999 | .000 |
| Pair 8 | Moisture g/100g & Moisture g/100g | 8 | .483 | .225 |

| | | Paired Differences | | | |
|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference |
| | | | | | Lower |
| Pair 1 | Fats & oils - Fats & oils | .001 | .037 | .013 | -.030 |
| Pair 2 | Ash - Ash | .773 | 2.104 | .744 | -.986 |
| Pair 3 | Crude fiber - Crude fiber | -.210 | .433 | .153 | -.572 |
| Pair 4 | Crude Protein - Crude Protein | -.061 | .315 | .111 | -.325 |
| Pair 5 | Total digestible nutrient % - Total digestible nutrient % | .103 | .733 | .259 | -.510 |
| Pair 6 | Digestible energyMJ/KG - Digestible energyMJ/KG | .034 | .348 | .123 | -.257 |
| Pair 7 | Metabolisable energy MJ/kg - Metabolisable energy MJ/kg | -.063 | .062 | .022 | -.115 |
| Pair 8 | Moisture g/100g - Moisture g/100g | -128.223 | 362.632 | 128.210 | -431.390 |

| | | Paired Differences | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|
| | | 95% Confidence Interval of the Difference | | | |
| | | Upper | | | |
| Pair 1 | Fats & oils - Fats & oils | .032 | .086 | 7 | .934 |
| Pair 2 | Ash - Ash | 2.531 | 1.039 | 7 | .334 |
| Pair 3 | Crude fiber - Crude fiber | .152 | -1.371 | 7 | .213 |
| Pair 4 | Crude Protein - Crude Protein | .202 | -.550 | 7 | .600 |

| | | | | | |
|---|---|---|---|---|---|
| Pair 5 | Total digestible nutrient % - Total digestible nutrient % | .715 | .396 | 7 | .704 |
| Pair 6 | Digestible energyMJ/KG - Digestible energyMJ/KG | .324 | .275 | 7 | .792 |
| Pair 7 | Metabolisable energy MJ/kg - Metabolisable energy MJ/kg | -.010 | -2.839 | 7 | .025 |
| Pair 8 | Moisture g/100g - Moisture g/100g | 174.945 | -1.000 | 7 | .351 |

*Nonparametric Tests: Independent Samples.

```
NPTESTS

  /INDEPENDENT TEST (Fatsoils Fatsoils_A Ash Ash_A Crudefiber Crudefiber_A CrudeProtein CrudeProtein_A Totaldigestiblenutrient
Totaldigestiblenutrient_A DigestibleenergyMJKG DigestibleenergyMJKG_A MetabolisableenergyMJkg MetabolisableenergyMJkg_A)
GROUP (browserspecies)

  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE

  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

**Nonparametric Tests**

**Notes**

| | | |
|---|---|---|
| Output Created | | 29-NOV-2013 14:14:00 |
| Comments | | |
| Input | Data | D:\chemical analysis.sav |
| | Active Dataset | DataSet3 |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 8 |
| Syntax | | NPTESTS<br>/INDEPENDENT TEST (Fatsoils Fatsoils_A Ash Ash_A Crudefiber Crudefiber_A CrudeProtein CrudeProtein_A Totaldigestiblenutrient Totaldigestiblenutrient_A DigestibleenergyMJKG DigestibleenergyMJKG_A MetabolisableenergyMJkg MetabolisableenergyMJkg_A) GROUP (browserspecies)<br>/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE<br>/CRITERIA ALPHA=0.05 CILEVEL=95. |
| Resources | Processor Time | 00:00:00.25 |
| | Elapsed Time | 00:00:00.72 |

[DataSet3] D:\chemical analysis.sav

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Fats & oils is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 2 | The distribution of Fats & oils is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 3 | The distribution of Ash is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 4 | The distribution of Ash is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 5 | The distribution of Crude fiber is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 6 | The distribution of Crude fiber is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 7 | The distribution of Crude Protein is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 8 | The distribution of Crude Protein is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 9 | The distribution of Total digestible nutrient % is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 10 | The distribution of Total digestible nutrient % is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 11 | The distribution of Digestible energyMJ/KG is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 12 | The distribution of Digestible energyMJ/KG is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 13 | The distribution of Metabolisable energy MJ/kg is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |
| 14 | The distribution of Metabolisable energy MJ/kg is the same across categories of browserspecies. | Independent-Samples Kruskal-Wallis Test | .429 | Retain the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

DATASET ACTIVATE DataSet3.

SAVE OUTFILE='D:\chemical analysis.sav'

/COMPRESSED.

NPAR TESTS

/K-W=Moistureg100g Moistureg100g_A Fatsoils Fatsoils_A Ash Ash_A Crudefiber Crudefiber_A CrudeProtein CrudeProtein_A Totaldigestiblenutrient Totaldigestiblenutrient_A DigestibleenergyMJKG DigestibleenergyMJKG_A MetabolisableenergyMJkg MetabolisableenergyMJkg_A BY browserspecies(1 8)

/MISSING ANALYSIS.

**NPar Tests**

**Notes**

| | | |
|---|---|---|
| Output Created | | 29-NOV-2013 14:19:42 |
| Comments | | |
| Input | Data | D:\chemical analysis.sav |
| | Active Dataset | DataSet3 |

| | | |
|---|---|---|
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 8 |
| Missing Value Handling | Definition of Missing | User-defined missing values are treated as missing. |
| | Cases Used | Statistics for each test are based on all cases with valid data for the variable(s) used in that test. |
| Syntax | | NPAR TESTS<br>/K-W=Moistureg100g Moistureg100g_A Fatsoils Fatsoils_A Ash Ash_A Crudefiber Crudefiber_A CrudeProtein CrudeProtein_A Totaldigestiblenutrient Totaldigestiblenutrient_A DigestibleenergyMJKG DigestibleenergyMJKG_A MetabolisableenergyMJkg MetabolisableenergyMJkg_A BY browserspecies(1 8)<br>/MISSING ANALYSIS. |
| Resources | Processor Time | 00:00:00.02 |
| | Elapsed Time | 00:00:00.01 |
| | Number of Cases Allowed[a] | 35746 |

a. Based on availability of workspace memory.

[DataSet3] D:\chemical analysis.sav

**Kruskal-Wallis Test**

**Ranks**

| | browserspecies | N | Mean Rank |
|---|---|---|---|
| Moisture g/100g | acacia erioloba leaves | 1 | 2.00 |
| | acacia eriloba pods | 1 | 4.00 |
| | acacia erioloba seeds | 1 | 5.00 |
| | dichrostachys cinerea leaves | 1 | 1.00 |
| | dichrostachys cinerea pods | 1 | 6.00 |
| | colophospermum mopane | 1 | 7.00 |
| | baphia massaiensis | 1 | 8.00 |
| | guibourtia coleosperma | 1 | 3.00 |
| | Total | 8 | |

| | | | |
|---|---|---|---|
| | acacia erioloba leaves | 1 | 2.00 |
| | acacia eriloba pods | 1 | 4.00 |
| | acacia erioloba seeds | 1 | 5.00 |
| | dichrostachys cinerea leaves | 1 | 1.00 |
| Moisture g/100g | dichrostachys cinerea pods | 1 | 6.00 |
| | colophospermum mopane | 1 | 8.00 |
| | baphia massaiensis | 1 | 7.00 |
| | guibourtia coleosperma | 1 | 3.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 8.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 6.00 |
| | dichrostachys cinerea leaves | 1 | 3.00 |
| Fats & oils | dichrostachys cinerea pods | 1 | 2.00 |
| | colophospermum mopane | 1 | 7.00 |
| | baphia massaiensis | 1 | 5.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 8.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 6.00 |
| | dichrostachys cinerea leaves | 1 | 3.00 |
| Fats & oils | dichrostachys cinerea pods | 1 | 2.00 |
| | colophospermum mopane | 1 | 7.00 |
| | baphia massaiensis | 1 | 5.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 6.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 3.00 |
| | dichrostachys cinerea leaves | 1 | 8.00 |
| Ash | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 7.00 |
| | baphia massaiensis | 1 | 2.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |

| | | | |
|---|---|---|---|
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 4.00 |
| | dichrostachys cinerea leaves | 1 | 8.00 |
| Ash | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 2.00 |
| | baphia massaiensis | 1 | 3.00 |
| | guibourtia coleosperma | 1 | 6.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 6.00 |
| | acacia eriloba pods | 1 | 8.00 |
| | acacia erioloba seeds | 1 | 1.00 |
| | dichrostachys cinerea leaves | 1 | 2.00 |
| Crude fiber | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 3.00 |
| | baphia massaiensis | 1 | 7.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 6.00 |
| | acacia eriloba pods | 1 | 8.00 |
| | acacia erioloba seeds | 1 | 1.00 |
| | dichrostachys cinerea leaves | 1 | 2.00 |
| Crude fiber | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 3.00 |
| | baphia massaiensis | 1 | 7.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 3.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 5.00 |
| Crude Protein | dichrostachys cinerea pods | 1 | 7.00 |
| | colophospermum mopane | 1 | 2.00 |
| | baphia massaiensis | 1 | 6.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |

| | | | |
|---|---|---|---|
| | acacia erioloba leaves | 1 | 3.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 5.00 |
| Crude Protein | dichrostachys cinerea pods | 1 | 7.00 |
| | colophospermum mopane | 1 | 2.00 |
| | baphia massaiensis | 1 | 6.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 2.00 |
| Total digestible nutrient % | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 6.00 |
| | baphia massaiensis | 1 | 3.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 1.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 2.00 |
| Total digestible nutrient % | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 6.00 |
| | baphia massaiensis | 1 | 3.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 3.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 2.00 |
| Digestible energyMJ/KG | dichrostachys cinerea pods | 1 | 6.00 |
| | colophospermum mopane | 1 | 5.00 |
| | baphia massaiensis | 1 | 1.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |

| | | | |
|---|---|---|---|
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 2.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 4.00 |
| Digestible energyMJ/KG | dichrostachys cinerea pods | 1 | 6.00 |
| | colophospermum mopane | 1 | 5.00 |
| | baphia massaiensis | 1 | 1.00 |
| | guibourtia coleosperma | 1 | 3.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 7.00 |
| | acacia eriloba pods | 1 | 3.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 1.00 |
| Metabolisable energy MJ/kg | dichrostachys cinerea pods | 1 | 4.00 |
| | colophospermum mopane | 1 | 6.00 |
| | baphia massaiensis | 1 | 2.00 |
| | guibourtia coleosperma | 1 | 5.00 |
| | Total | 8 | |
| | acacia erioloba leaves | 1 | 6.50 |
| | acacia eriloba pods | 1 | 3.00 |
| | acacia erioloba seeds | 1 | 8.00 |
| | dichrostachys cinerea leaves | 1 | 1.00 |
| Metabolisable energy MJ/kg | dichrostachys cinerea pods | 1 | 5.00 |
| | colophospermum mopane | 1 | 6.50 |
| | baphia massaiensis | 1 | 2.00 |
| | guibourtia coleosperma | 1 | 4.00 |
| | Total | 8 | |

**Test Statistics[a,b]**

| | Moisture g/100g | Moisture g/100g | Fats & oils | Fats & oils | Ash | Ash |
|---|---|---|---|---|---|---|
| Chi-Square | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 |
| df | 7 | 7 | 7 | 7 | 7 | 7 |
| Asymp. Sig. | .429 | .429 | .429 | .429 | .429 | .429 |

**Test Statistics[a,b]**

| | Crude fiber | Crude fiber | Crude Protein | Crude Protein | Total digestible nutrient % |
|---|---|---|---|---|---|
| Chi-Square | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 |
| df | 7 | 7 | 7 | 7 | 7 |
| Asymp. Sig. | .429 | .429 | .429 | .429 | .429 |

**Test Statistics[a,b]**

| | Total digestible nutrient % | Digestible energyMJ/KG | Digestible energyMJ/KG | Metabolisable energy MJ/kg | Metabolisable energy MJ/kg |
|---|---|---|---|---|---|
| Chi-Square | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 |
| df | 7 | 7 | 7 | 7 | 7 |
| Asymp. Sig. | .429 | .429 | .429 | .429 | .429 |

a. Kruskal Wallis Test

b. Grouping Variable: browserspecies

**APPENDIX 5**

**Names of Browsable trees obtained from the interview**

| | **Local Name** | **Common Name** | **Botanical Name** | **Edible Parts** | **Other Uses** |
|---|---|---|---|---|---|
| 1 | Muhononо | Silver Terminalia | Terminalia sericea | Leaves | Building, Jaundance Diarrhea |
| 2 | Mupani | Mopane | Colophospermum mopane | Leaves Pods | Buiding Firewood Densetry |
| 3 | Muzauli | Large False Mopane | Guibourtia coloosperma | Leaves | Fruits as food Veneal Diseases |
| 4 | Muselesele | Sickle Bush | Dichrostachys Cinerea | Pods Leaves | Densentry Facilitate parturition |
| 5 | Muhoto | Camel Thorn | Aacacia erioloba | Pods Leaves | Cough Repels snakes (roots) |
| 6 | Isunde | Sand Camwood | Baphiamassaiensis | Leaves | Boosts Libido |
| 7 | Mutobo | Bush Willow | Combretim collinum | Leaves | Snake bites |
| 8 | Mushakashela | Snakebean | Swartzia madagascariensis | Pods Leaves | |
| 9 | Munzinzila | Bird Plum | Berchemia Discolor | Dry leaves | Service food Dying of crafts |
| 10 | Muhuluhulu | Monkey Orange | Strychnos cocculoides | Leaves | Parturition |
| 11 | Katema Bakulu | Shepard's tree | Boscia Albitrunca | Leaves | Boosts Libido |