# EFFECT OF SHREDDED *COLOPHOSPERMUM MOPANE* WOOD INCLUSION AS ROUGHAGE ON PERFORMANCE OF FATTENING NGUNI HEIFERS

BY

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## DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture (Animal production) has not previously been submitted by me for a degree at this or any other university, that it is my own work in design and execution, and that all materials contained therein has been acknowledged.

Signature……………………… Date…………………………...

**Kgasago N**

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## DEDICATION

This study is dedicated to my lovely mother Maria MmadikgaleKgasago, my brothers Richard MajeKgasago and Morongoa Martin Kgasago and other family members for their support in educating me.

**ABSTRACT**

A study was conducted to determine the effect of shredded *Colophospermum* (*C.*) *mopane* wood inclusion as roughage on performance of fattening Nguni heifers weighing 200 ± 5kg. The four diets used were isocaloric and isonitrogenous but with different shredded *C. mopane* wood inclusion levels of 5 ($F_{95}M_5$), 8.5 ($F_{91.5}M_{8.5}$), 10 ($F_{90}M_{10}$) and 15 ($F_{85}M_{15}$) %. The heifers were randomly allocated to the treatments in a completely randomized design. A quadratic equation was used to determine the shredded *C. mopane* inclusion levels for optimal productivity of the heifers. Shredded *C. mopane* wood inclusion level had effect ($P<0.05$) on intake and feed conversion ratio (FCR). Diet DM, OM, CP, NDF and ADF intakes per metabolic weight and FCR of Nguni heifers were optimized at different shredded *C. mopane* wood inclusion levels of 11.0, 13.7, 8.0, 15.0, 14.0, 14.0 and 15%, respectively. However, shredded *C. mopane* wood inclusion level did not affect ($P>0.05$) diet *in vitro* digestibility, carcass weight, dressing percentage, meat pH, meat shear force values and meat colour intensities except for red colour intensity of rump steak. It was, thus, concluded that shredded *C. mopane* wood can be used as roughage without adversely affecting diet intake, FCR, and live weight of Nguni heifers. However, diet intake and FCR were optimized at different *C. mopane* wood inclusion levels.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Beef cattle are raised for red meat supply (4-H beef project, 1998). Beef cattle play important roles as sources of animal protein, manure and cash sales (Madziga*et al.,* 2013; Dovie *et al.,* 2006). Thus, beef cattle are nutritionally and economically important in South Africa. However, productivity of beef cattle in South Africa is low (RMRD SA, 2011). Higher prices, scarcity and poor nutrition of feeds are major causes of low beef production during the dry season in most rural areas of South Africa (Van Pletzen, 2009). During the dry season, rural farmers supplement their animals with concentrates to alleviate the problems of poor nutrition. Concentrates have to be balanced with roughages for optimal feed digestibility and healthy rumen functioning (Galyean and Abney, 2006). However, there is of roughage shortage, particularly during the dry season (Musemwa*et al*., 2008). Studies have shown that the use of wood tree as a roughage source can improve production of beef cattle in feedlots (Baker and Millett, 1975; El-Sabban*et al*., 1971). The northern and western parts of Limpopo province are covered with *Colophospermummopane (C. mopane)* trees (Makhado*et al.,* 2009) and can provide an ideal local roughage source for cattle. However, the effect of shredded *Colophospermummopane* wood supplementation as roughage on performance of fattening Nguni cattle had not been determined. Therefore, this study determined the supplementation levels of shredded *C. mopane* wood for optimal productivity of fattening Nguni heifers.

## 1.2 Problem statement

There is scarcity of roughage for fattening cattle during the dry season. If available, such feed is expensive (Hales *et al*., 2014). Fattening diets are supplemented with roughages for optimal digestion in the reticulo-rumen of cattle (Owens *et al*., 1998). Low levels of roughage in such diets result in poor growth of the animals. Information on the effect of shredded *Colophospermummopane* wood inclusion as roughage on the performance of fattening Nguni cattle is not available. Such information would be useful to Nguni beef cattle farmers in South Africa.

## 1.3 Motivation of the study

This study generated information on the effect of shredded *Colophospermummopane* wood supplementation levels for optimal feed intake,digestibility, growth rate, mortality and carcass characteristics of fattening Nguni heifers. The information obtained from this study will help the farmers to formulate fattening diets for optimal productivity of fattening Nguni cattle. Improving productivity of Nguni cattle will improve the nutrition and economic status of Nguni cattle producers and consumers.

## 1.4 Aim and objectives

The aim of the study was to determine shredded *C. mopane* wood inclusion levels for optimal productivity of fattening yearling Nguni heifers

The objectives of this study were to determine:

i. the effect of supplementing fattening diets with shredded *C. mopane* wood as a dietary roughage on intake, digestibility, growth, feed conversion ratio, mortality and carcass characteristics of yearling Nguni heifers.
ii. shredded*Colophospermummopane* wood inclusion levels for optimal productivity of fattening yearling Nguni heifers.

## 1.5 Hypotheses

i. Shredded *C. mopane* wood inclusion into diets has no effect on intake, digestibility, growth, feed conversion ratio, mortality and carcass characteristics of yearling Nguni heifers.
ii. There are no shredded *C. mopane* inclusion levels for optimal productivity of fattening yearling Nguni heifers.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Interest in roughage alternates for beef has grown in recent years. This is because of shortage or high cost of traditional roughage sources in certain areas, more especially during dry seasons (Musemwa*et al.,* 2008). Although research indicates reducing roughage level in feedlot diets can improve feed efficiency and reduce cost of gains, it cannot be completely removed from feedlot diets without negative effects on health and performance of the animals. Feedlot animals are fed high energy grain rations that are increasingly being supplied by manufacturers of complete or mixed feed (Feuz and Russel, 2014).It is, therefore, important to include roughages in the rations to provide tactile stimulation of rumen walls and to promote cud-chewing, which in turn increases salivation and supply of buffer for maintenance of ideal rumen pH (Barker and Millet, 1975). A wide variety of roughage sources are available to farmers, for example hay, straw, maize bran, etc. on farms producing crops (Quinn *et al*., 2011; Galyean and Defoor. 2003). These roughages contain high amounts of cellulose and hemicelluloses which can be digested by ruminant animals (Moreira *et al.,* 2013; Radunz, 2012). Tree woods also contain high amounts of cellulose and hemicellulose. These can also be digested by ruminant animals (Earth, 2014)

## 2.2 *Colophospermummopane* tree

*Colophospermum (C.) mopane*is a tree that survives mostly in low lying regions of southern Africa (Werger and Coetzee, 1978). Mapaure (1994) reported that in South Africa the area covered by *C. mopane* is estimated to be about 555 000km$^2$ and that the tree dominates most of Limpopo and Mpumalanga provinces *Colophospermummopane* adapts well to areas with altitudes ranging between 300 and 1000 meters above sea level (Makhado*et al*., 2009). The tree does well in regions with low and moderate summer rainfall ranging between 400 and 1000 mm per year (Van Voorthuizen, 1976). During the dry season, livestock browse *C. mopane*leaves (Macala*et al*., 1990). A study conducted by Makhado*et al*. (2009) found that *C. mopane* is mainly used for firewood, fence poles, building kraals, production of wooden handcrafts and charcoal. However, the use of *C. mopane* as a roughage source for cattle can reduce the problem of roughage shortage in South Africa.

### 2.3 *Colophospermummopane* wood composition

*Colophospermummopane*is composed of cellulose, hemicellulose and lignin as major cell wall constituent polymers with slight amounts of minor components of inorganic substances (Hosoya*et al.,* 2007). During the growth, cellulose micro-fibrils give the cell wall tensile strength while lignin gives the stem rigidity (Tullus*et al.,* 2010). Although the microstructure of plant cell walls varies in different types of plants, cellulose fibres reinforce a matrix of hemicellulose and either pectin or lignin (Gibson, 2012). Older and woodier plants have high levels of lignin, cellulose and hemicellulose (Rowell, 2012).Lignin and cellulose composition of wood differs with wood species (Table 2.1). The carbohydrate portion of the wood comprises of cellulose and hemicelluloses. Cellulose is a polymer composed of glucose chains and consists of carbon, hydrogen, and oxygen in the form of starches, proteins and sugars. Cellulose content ranges from 40 to 50% of the dry wood weight. Hemicelluloses consist of pentose sugar carbohydrates, mainly xylose (Pettersen, 1984). These celluloses and hemicelluloses can be digested by ruminant animals.Ruminants can utilise cellulosic materials as food because of a valuable symbiotic relationship with microorganisms present in the rumen section of their digestive tract(Lynd *et al.,* 2002).The symbiotic arrangement consists of the animal's rumen, a chamber preceding its true stomach, and the ability of the rumen to culture cellulolytic micro-organisms. In many ways, the animal's physiology and anatomy provide ideal fermentation conditions for the micro-organisms, which in turn provide the animal with nutrients by enzymatically breaking down cellulose and hemicelluloses.

The energy yielding products which the animal absorbs into its bloodstream from this anaerobic fermentation are primarily acetic, butyric and propionic acids (Cheeke and Dierenfeld, 2010). The digestion of celluloses and hemicelluloses is impeded by lignin which interferes with gut microbes that have necessary enzymes to digest cellulose and hemicellulose because it both acts as a physical barrier to digestion and contains chemical bonds that cannot be broken down by normal microbial flora (Earth, 2014;Beckman, 1915). Lignin is described as a polymer formed from monoligonols derived from the phenylpropanoid pathways in vascular plants. Lignification in woody plants controls the amount of fibre that can be digested and therefore, has a direct impact on the digestible energy (DE) value of the feed (Jung and Buxtono, 1994). Undigested feed portion passes slowly through the digestive tract and contributes to the fill effect of the diet. The greater the concentration of indigestible fibre in the diet, the lesser the dry matter an animal will consume. Therefore, lignification impacts on feed nutritive value by both decreasing DE value and limiting dry matter intake (Moore and Jung, 2001; Moore *et al.,* 1993).

**Table 2.1** Chemical composition of some wood species (%)

| Constituent | Scots Pine (*Pinus sylvestris*) | Spruce (*Picea glauca*) | Eucalyptus (*Eucalyptus camaldulensis*) | Silver birch (*Betula verrucosa*) |
|---|---|---|---|---|
| Cellulose | 40.0 | 39.5 | 45.0 | 41.0 |
| Hemicellulose | | | | |
| Glucomannan | 16.0 | 17.2 | 3.1 | 2.3 |
| Glucuronoxylan | 8.9 | 10.4 | 14.1 | 27.5 |
| Other polysaccharides | 3.6 | 3.0 | 2.0 | 2.6 |
| Lignin | 27.7 | 27.5 | 31.3 | 22.0 |
| Total extractives | 3.5 | 2.1 | 2.8 | 3.0 |

Source: Institute of Paper Science and Technology (2014)

### 2.4 Cellulose and hemicellulose degradation in the reticulo-rumen

Celluloses are degraded anaerobically in the gastro-intestinal tracts of the ruminant animals. Ruminants rely on rumen microbes to ferment cellulose and hemicellulose. The rumen acts as a fermentation chamber in which plant materials are retained long enough to be degraded by microbes. During the process of degradation, plant material mixed with saliva containing bicarbonate enter the rumen and are mechanically ground into smaller particles through the rotary motion of the rumen. Digestion of carbohydrates by microbial enzymes takes place here (McDonald *et al.,* 2010). The food is then passed into the reticulum where it forms clumps or cuds which will be regurgitated when the animal is resting. The chewed cud is passed into omasum and then to the abomasum, an acidic organ that is more like a true stomach in monogastric animals. Host chemical digestive processes begin in the abomasum and continue in the small intestines and large intestines (McDonald, 2010; Leschine, 1995).

Degradation and digestion of plant celluloses, hemicellulose and other peptides occurs mainly in the rumen. Enzymes that catalyze the hydrolysis of glycosidic bonds and degrade polysaccharides into smaller structural substrates are known as glycosidases or glycoside hydrolases (Bernaliere*t al*., 1992). Cellulases are glycoside hydrolases with the primary role of cleaving the cellulose chains into shorter cellodextrines with two to six units. They are further divided into endoglucanases and exoglucanases. These endoglucanases attack the internal glucosidic bonds in the amorphous regions of the cellulose chains and increase the number of loose ends which represent the substrates for exogucanases. The latter are, generally, possessive enzymes that bind to the substrate and then progress to the end (Zorec, 2014).

Bacteria are generally believed to provide most of the cellulytic activity in the rumen but rumen fungi and to a lesser extent rumen protozoa may make a significant contribution. Based on determinations of relative numbers in the rumen and ability to degrade purified and intact forage cellulose,principal cellulytic bacteria species appear to be fybrolytic bacteria, *Fibroctersuccinogenes, Ruminococcusflavefaciens* and *Ruminococcusalbus* (Forsberg and Cheng, 1992). The Different population of bacteria will dominate the rumen fermentation depending on the type of diet being fed. Cattle fed diets solely of forage with high fibre will have microbes that are high in fibrolytic bacteria. Simplistically, the fermentation of cellulose and hemicellulose results in the production of volatile fatty acids that are used by an animal for energy (Kung Jr., 2014). *Ruminococcusbacteria* break down the plant fibre into monosaccharides which can then be further broken down through glycolysis. This symbiotic relationship enables ruminants to digest fibre without having to encode for more of their own enzymes to do this job (Mackie, 2002)

The rumen is responsible for the digestion of 60 to 90% of the cellulose and hemicellulose in the gastrointestinal tract, depending on the lignification of the forage(Moreira *et al*., 2013). The cellulose and hemicellulose fermentation leads to the production of volatile fatty acids (VFA), which are absorbed, metabolized and utilized by the animal (Sofos, 2005).

**2.5 Microbial and animal limitations to fibre digestion**

Animal and feeding systems can have a significant effect on the digestion of fibre. Notably, intake, dietary interactions, feed composition, rumen pH and feed additives will, to some degree, influence fibre digestion and hencemicrobial growth. Among rumen microbes, bacteria are of significant importance in the biological degradation of plant fibre due to their large biomass and high activity (Koike and Kobayashi, 2009).

The quantity and size of fibre particles in the diets of a ruminant are significant to maintain optimal rumen function. Long fibres in the rumen form the rumen “surface-covering”. The “surface-covering” is where fibrous materials are entangled because they are too long to pass to the lower gut. Fibre from the mat is regurgitated and chewed producing large amounts of saliva that naturally buffer the rumen. When large feed particles are chewed, the surface area for rumen microbes to attach and then digest the feed is increased. In order for a feed particle to pass out of the rumen and into the lower gut, it must attain a size of about 1mm (van Soest, 1996). Passage of particles from the rumen is important because without digestion and passage, food would fill the rumen and depress intake (Chiba, 2014). There must, also, be a balance between retention time in the rumen for microbial digestion and passage. For example, grinding fibre to extremely small particles may assist in passage from the rumen but ruminal digestion of thosefibre particles may actually be decreased if they pass too quickly. The normal process of particle size reduction in the rumen leads to increased surface area for microbial attachment and digestion (Buxton and Readfearn, 1997). As intake increases, the digesta flowing from the rumen will contain particles at earlier stages of digestion and this will resultinto a lower dry matter digestibility (McDonald*et al*., 2010). Similarly, high level of intake may depress the ruminal fibre digestion, resulting in lower gross energy intake (Allen and Mertens, 1998; Varga and Kolver, 1997).

The pH of the rumen has profound effects on the growth of rumen microbes and the digestion that takes place in this organ(Russell and Dombrowski, 1980). A pH of 7 is considered neutral, where the amount of acid and base are equal. When pH falls below 7, the medium is considered to be acidic in nature. The lower the pH falls below 7, the more acidic it is. A number of different factors can affect ruminalpH. Lack of sufficient fibre or fibre that is chopped too finely reduces chewing times and, thus, reduces saliva production causing a decrease in ruminal pH (Saunders, 2015). Kung Jr (2014) observed that cattle fed a diet with long fibre particles chew for more than 10 hours and ruminate for about 6 hours. The ratio of forage to concentrate in the diet of ruminants also affects ruminal pH (Na *et al.,* 2013). As concentrates increase in the diet, total acid production in the rumen increases, causing a decrease in pH. In contrast, feeding buffers, especially in corn silage-based diets, can increase ruminalpH. The type of concentrate can also affect ruminal pH as the starch in barley is more readily fermented to acids in the rumen than the starch from corn (Nikkhah, 2012). Besides requiring protein and energy for growth, fibrolytic bacteria in the rumen grow best when the pH of the rumen is between 6.2 and 6.8. If rumen pH falls below 6.0-6.2, fibre digestion in the rumen begins to decline. As rumen pH decreases, fibrolytic bacteria in the rumen become less active and fibre digestion is decreased. When ruminal pH falls below 5.8, the rumen is mildly acidic and fibre digestion in the rumen ceases completely. When ruminal pH drops below 5.2, animals can suffer from digestive disorder and acidosis (Cheng *et al.,* 1998; Owens *et al*., 1998)

## 2.6 Roughage requirements of beef cattle

Dietary fibre is the undigestible portion of food derived from plants and it is divided into neutral detergent fibre (NDF) and acid detergent fibre (ADF). Neutral detergent fibre (NDF) is commonly noted on forage test results and it refers to fibre that is soluble in neutral detergent and includes cellulose, hemicellulose and lignin. Neutral detergent fibre (NDF) represents all plant cell wall material, is only partly digestible by animals and is negatively correlated with dry matter intake. As NDF increases in the diet, dry matter intake also decreases (Arelovich*et al*., 2008). Acid detergent fibre (ADF) is the portion of fibre that is insoluble in acid detergent and is negatively correlated with intake and digestibility (figure 2.1). This is due to the combination effect of physiological changes in plant cell wall which are more difficult for rumen bacteria to attach to and to digest (Hoffman *et al.,* 2003). Acid detergent fibre (ADF) is composed of highly indigestible plant material, generally only the lignified or otherwise indigestible portions of pant cell walls. Generally, as ADF increases forages or feeds become less digestible (Parish and Rhinechart, 2008). Determining the NDF and ADF contents of the diet helps to clearly articulate the relationship between the fibre content of the diet and dry matter intake, digestibility, feed conversion ratio and also growth of an animal (Riaz*et al.,* 2014)

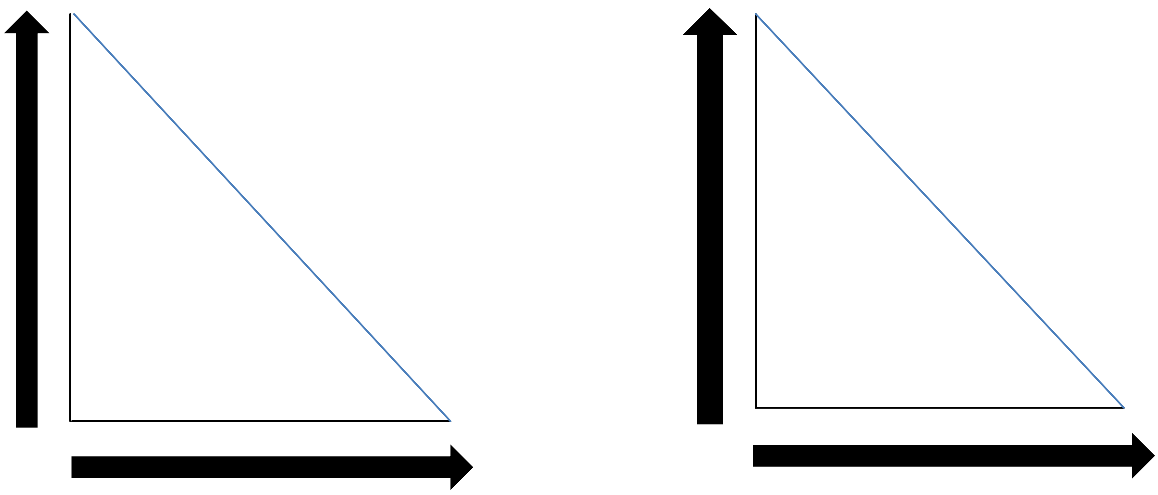

**Figure 2.1** Relationships between neutral detergent fibre (NDF) and dry matter intake, and between acid detergent fibre and digestibility (Parish and Rhinehart, 2008)

The transition from forage to fattening diets by cattle generally involves several feed formulations of varying proportions of roughages and concentrates. This gradual adaptation to fattening diets minimises the occurrence of acidosis and other metabolic disorders (Brown *et al*., 2006; Bevans *et al.,* 2005). It is generally necessary to include some long, shredded or chopped roughage in formulated rations because of its physiological effects including increase in saliva secretion and rumen motility. These effects promote stability in rumen function and a balance in the absorbed nutrients that is appropriate for normal metabolic processes (Freer *et al.,* 2007). At one time it was considered necessary that fattening rations for ruminants should contain at least 30% of roughage. Attempts were made to decrease or completely remove the roughage portion of the diet. This resulted in low energy intake, affecting weight gain and feed conversion ratio (Wise *et al.,* 1968). Cattle receiving a full feed of grain and less than the minimum requirements for roughage are subject to bloat, acidosis and other digestive disorders (NRC, 2001). Absence or low roughage levels in feedlot diets results in poor dry matter intake, poor average daily gain and low feed conversion ratios (Traxler*et al*., 1995). Similarly, higher dietary fibre proportions decrease daily gain (Benton *et al*., 2007). Gill *et al*. (1981) reported that very high roughage components affect feedlot cattle by decreasing growth rate. However, Levya*et al*. (1997) reported that very low dietary roughage components result in higher live weight gains and carcass weights of beef cattle steers. The roughage inclusionlevels for fattening diets depend on the source and particle size (McDonald *et al*., 2010). Thus, data on supplementation levels for optimal productivity are not conclusive.

### 2.7 Wood as a roughage source for fattening beef cattle

Residues from hardwood and soft wood give out good results when they are used in ruminant diets as alternative sources of roughage (Baker and Millett, 1975). Wood residue may serve as a source of digestible energy and as a roughage substitute in ruminant rations (Keith and Daniels, 1976). Wood and bark of small particle size from hardwoods could be used as a roughage substitute in high grain rations for cattle. However, since the digestibility of untreated wood is poor, this type of roughage can contribute little to the dietary energy needs of ruminants. Therefore, animals fed with wood–containing rations tend to compensate for the lower digestibility by eating more (Glanc and Mandell, 2013). For beef cattle, depending on other ration ingredients, concentrations of 5-15% screened sawdust appear practical (Barker *et al*., 1975).Both *invivo* and *invitro* rumen tests indicate low digestibility for wood. Bark, generally has a higher digestibility than wood, but differences among species are larger. Barker *et al*. (1975) investigated several wood species and found the highest digestibility values of 33 and 50% for bark and wood, respectively (Table 2.2).

**Table 2.2***In vitro* digestibility of different wood species

| | *Invitro* digestibility of DM (%) | |
|---|---|---|
| Species | wood | Bark |
| *Acer saccharum* | 7 | 14 |
| *Betulaalleghaniensis* | 6 | 16 |
| *Fraxinusnigra* | 17 | 45 |
| *Populustremuloides* | 33 | 50 |
| *Tiliaamericana* | 5 | 25 |
| *Ulmusamericana* | 8 | 27 |
| *Larixaccidentalis* | 3 | 7 |

Source: Barker *et al*. (1975)

Anthony (1968) compared Bermuda grass hay and oak sawdust for fattening yearling steers and reported that inclusion of 10% oak sawdust produced equal daily gains of cattle with equal efficiency to 10% mixture of Bermuda grass hay. Further, no harmful effects resulting from the feeding of hardwood waste were found.In addition, Ammerman and Block (1964) observed that the wood is not as good, nutritionally, as grass but the wood appears to serve as a roughage source in finishing diets. Sherrod *et al.* (1973)evaluated hardwood and softwood shavings and compared them with cotton seed hulls in 10% roughage fattening rations. The authors observed that animal gains and feed intakes with both types of shavings were not different to cotton seed hull, although feed conversion ratio was less efficient for those on wood shavings. There was no significant difference in the carcass characteristics for all comparisons of roughage treatments.Marion *et al*. (1972) used a ground Mesquite wood as roughage in rations for yearling steers and reported that the steers fed the Mesquite meal had an average daily gain of 0.99 kg, compared with 1.03 kg for those on the cottonseed hull ration. The dressing percentage of animals fed a Mesquite ration was lower than for those fed cottonseed hulls. Carcass grades for animals on Mesquite and cottonseed hulls were the same. Shelford (1966) used alder sawdust as roughage in beef cattle rations and observed that the inclusion of the sawdust had no significant effect on live weight gain. However, the animals that received a diet with sawdust had higher gain than the group that received a diet without sawdust. Similarly, El-Sabban*et al.* (1971) evaluated oak sawdust as a roughage substitute in beef cattle finishing rations and reported that sawdust could be successfully used up to a level of 15% of the ration. Thus, the results of the use of wood as roughage for ruminant animals are not conclusive and extensive.

## 2.8 Conclusion

Studies on the inclusion of wood shavings in the diets for fattening cattle are not conclusive and extensive. No study was found on the effect of shredded *Colophospermummopane* wood inclusion as roughage on the performance of fattening Nguni cattle. Thus, there was need to determine theinclusion levels of shredded*Colophospermummopane*wood for optimal productivity of fattening Nguni steers.

# CHAPTER 3

# MATERIALS AND METHODS

### 3.1 Study site

The study was conducted at the University of Limpopo Experimental Farm, Limpopo Province, South Africa. The farm is located about 10 km north-west of the University of Limpopo, Turfloop campus. The University of Limpopo lies at latitude 27.55ºS and longitude 24.77ºE. The ambient temperatures around the study area range between 20 and 36ºC during summer and between 05 and 25ºC during winter. The mean annual rainfall ranges between 446.8 and 468.4mm (Shiringani, 2007).

### 3.2 Acquisition of materials for the experiment

All the required materials including chemicals, medicines, a growth promoter and vaccines were purchased from NTK Company in Polokwane before the commencing of the experiment. The diets were formulated by me, and produced by Gaza Beef Feedlot (Pty) Ltd, Gravelotte, South Africa.

### 3.3 Experimental procedures, dietary treatments and design

An experiment was conducted on twelve yearling Nguni heifers weighing 200 ± 5kg.The heifers were used instead of steers because steers were not available. The experiment lasted for 120 days. The experimental animals were randomly allocated to four treatments having *C. mopane*inclusion levels of 5, 8.5, 10 and 15% (Table 3.01). Each treatment had three replicates, with one heifer per replicate.

Before the start of the experiment, all the animals were processed as follows:

i. Weighed.
ii. Injected with 10ml of vitamin B complex and 10ml of vitamin E supplied by Afrivet (Pty),Ltd, South Africa for appetite and prevention of the oxidation of polyunsaturated fatty acids. These vitamins function as primary constituents of subcellular membranes and precursors of prostaglandins (Wang and Quinn, 2000)

iii. Vaccinated against clostridia, bacterial and viral diseases. Animals were injected with 2ml of Swavet, manufactured by MSD Animal Health, Intervet, South Africa. This is for active immunisation against anthrax, botulism and black quarter. The animals were also injected with 5ml of Multiclos vaccine (manufactured by MSD) for immunisation against *Clostridium perfringens*type A,B and C.

iv. Implanted with a growth promoter (Ralgro,manufactured by MSD Animal Health,Intervet,South Africa).

v. Treated against internal (Ecomectin 1% by Eco Animal Health, South Africa) and external (Deadline "deep" by MSD Animal Health, South Africa) parasites.

vi. Horns were clipped to prevent the animals from bruising each other.

The heifers were housed in individual pens and had access to clean water and food *ad libitum.* Automated cup drinkers were installed in each pen to avoid water spillage and contamination. All the drinkers and feeders were cleaned daily at 07.00 hours.

**Table 3.1** Dietary treatments for the study

| Diet code | Diet description |
|---|---|
| $F_{95}M_5$ | A mixture of 95% fattening diet (having 15% CP and based on maize bran, poultry manure, high protein concentrate and feed additives) and 5% shredded *Colophospermummopane* wood roughage |
| $F_{91.5}M_{8.5}$ | A mixture of 91.5% fattening diet (having 15% CP and based on maize bran, poultry manure, high protein concentrate and feed additives) and 8.5% shredded *Colophospermummopane* wood roughage |
| $F_{90}M_{10}$ | A mixture of 90% fattening diet (having 15% CP and based on maize bran, poultry manure, high protein concentrate and feed additives) and 10% shredded *Colophospermummopane* wood roughage |
| $F_{85}M_{15}$ | A mixture of 85% fattening diet (having 15% CP and based on maize bran, poultry manure, high protein concentrate and feed additives) and 15% shredded *Colophospermummopane* wood roughage |

**Table 3.2** Diet ingredient composition for the experiment

| Ingredient (%) | Diet | | | |
|---|---|---|---|---|
| | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ |
| *Colophospemummopane* | 5.0 | 8.5 | 10.0 | 15.0 |
| Citrus meal | 10.0 | 10.0 | 10.0 | 9.0 |
| Broiler chicken manure | 22.0 | 20.4 | 21.0 | 20.0 |
| High protein concentrate* | 8.7 | 8.9 | 9.0 | 9.2 |
| Molasses meal | 4.3 | 4.3 | 4.3 | 4.2 |
| Hominy chops | 50 | 47.9 | 45.68 | 42.58 |
| Total | 100 | 100 | 100 | 100 |

* Purchased from SymanVoere, pty, Polokwane.

The diet without C. mopane wood as roughages was not used in the study. This is because 100% concentrates will cause digestive disorders like acidosis and bloat (Owens *et al*., 1998)

**3.4 Data collection**

The live weights of the heifers were recorded at the commencement of the experiment. Thereafter, weekly mean live weights were measured until the termination of the experiment. Weekly feed intakes were taken throughout the experimental period. Daily mean live weights and feed intakes were calculated from the weekly measurements. Daily mean growth rates and feed conversion ratios were calculated (McDonald *et al*., 2010). At the termination of the experiment, all the animals were transported to an approved abattoir (Vencor Limited, South Africa) for slaughter. Prior to slaughter, animals were restricted from feed and water overnight (12 hours). Slaughter was done by stunning the animal with a captive bolt and then severing the jugular vein using a sharp knife. Animals were then hanged upside down to allow smooth blood outflow. Dead animals were stimulated electrically (500v, 12.5Hz for 2 minutes) to prevent muscle contractions (Swanepoel*et al.,* 1990). After the skin removal, all the offals were removed and the warm carcass weight was recorded before cooling. Empty reticulo-rumen weights were also recorded. After cooling for overnight, the cold carcass weights were recorded to determine the cold dressing percentage. Dressing percentage was calculated as the ratio of carcass weight divided by the final live weight and the result multiplied by a 100. Rump steak, sirloin steak and fillet samples were cut for meat analysis (El-Sabban*et al.,* 1971; Swanepoel*et al.,* 1990). Meat pH was measured using a digital pH meter (Crison pH25, CRISON instruments, South Africa). The pH meter was calibrated with pH values of4, 7 and 9 standard solutions before each measurement. The pH measurements and colour were taken from the rump steak, sirloin steak and fillet. Meat colour intensities (lightness = L*, redness = a* and yellow = b*) were measured using a 45/0 BYK-Gardener instrument (BYK-Gardener, GmbH, Germany) on the cut surface of individual steaks (CIE, 1996). Three replicates were taken per sample. Shear force values of rump and sirloin steaks were also measured. Samples were cored using a 2.5mm core diameter parallel to the grain of meat and sheared perpendicular to the fibre direction using a Warner-Bratzler shear force device, Instron Universal Testing Machine (Model 3344, Instron Industrial Products, GC, USA) equipped with a Warner-Bratzler (WB) shear force apparatus (crosshead speed at 400 mm/min, one shear in the centre of each core). The measurements were read in Newtons.

**3.5 Chemical analysis**

Dry matter of feeds, feed refusals and meat samples were determined by drying the sample in the oven for 24 hours at a temperature of 105°C. Neutral and acid detergent fibre contents of feeds were determined according to Van Soest*et al.* (1991). Ash content of feeds was determined by ashing a sample at 600°C in a muffle furnace overnight. Nitrogen contents of feed and meat samples were determined using Kjeldahlmethod (AOAC, 2002). Gross energy values of feeds were determined using a bomb calorimeter (AOAC, 2002).

### 3.6 Data analysis

Data on feed intake, growth rate, *in vitro* digestibility feed conversion ratio, live weight, dressing percentage, meat pH,meat colour and meat shear force values of Nguni heifers were analysed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2012).

$Y = \mu + d + e$

Where Y = feed intake, live weight, growth rate, feed conversion ratio and dressing percentage; d =shredded Colophospermummopane wood inclusion level and e = experimental error

Fisher's least significant difference (LSD) was used to test the significance of difference between treatment means (P<0.05) (SAS, 2012).  Responses in feed intake, feed intake per metabolic weight, feed conversion ratio (FCR) and live weight of Nguni heifers to shredded *Colophospermummopane* wood inclusion level were modelled using the following quadratic equation (SAS, 2012) :

$Y= a+b_1x + b_2x^2$

Where Y=feed intake, live weight, growth rate, feed conversion ratio and dressing percentage; a= intercept; b= coefficients of the quadratic equation; x= shredded *Colophospermummopane* wood inclusion level and $–b_1/2b_2$= x value for optimal response. The quadratic equation was preferred because it gave the best fit.

# CHAPTER 4

# RESULTS

Results of the nutrient composition of the diets used for the experiment are presented in Table 4.1.All the diets had similar (P>0.05) crude protein and energy contents.

**Table 4.1** Nutritional composition of diets (the units are percentages except net energy as MJ/kg DM diet)

| Variable | Treatment | | | | SEM |
|---|---|---|---|---|---|
| | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ | |
| Dry matter | 92.19 | 92.30 | 91.7 | 91.8 | 3.012 |
| Ash | 6.00 | 6.06 | 6.70 | 7.13 | 1.213 |
| Net energy | 16.57 | 16.56 | 16.50 | 16.46 | 1.312 |
| Crude protein | 15.72 | 15.70 | 15.54 | 15.40 | 0.301 |
| Fat | 4.80 | 4.76 | 4.72 | 4.36 | 0.402 |
| ADF | 21.45 | 22.77 | 22.72 | 25.60 | 2.134 |
| NDF | 39.04 | 39.49 | 41.30 | 41.99 | 2.141 |
| ADL | 4.04 | 5.06 | 5.49 | 5.21 | 1.312 |
| Calcium | 1.04 | 0.86 | 0.96 | 0.89 | 0.214 |
| Magnesium | 0.33 | 0.30 | 0.31 | 0.32 | 0.021 |
| Potassium | 1.17 | 1.05 | 1.07 | 1.11 | 0.142 |
| Sodium | 0.37 | 0.35 | 0.34 | 0.36 | 0.031 |

SEM: Standard error of the means

ADF: Acid detergent fibre

NDF: Neutral detergent fibre

ADL: Acid detergent lignin

Results of the effect of shredded *Colophospermummopane* wood inclusion level on intake, live weight, live weight gain and feed conversion ratio of Nguni heifers are presented in Table 4.2. Nguni heifers on diets having 8.5 or 15% shredded *C. mopane* wood inclusion levels had higher (P<0.05) daily DM, OM and CP intakes than those on a diet having 5% shredded *C. mopane* wood inclusion level. However, heifers on diets having 8.5, 10 or 15% shredded *C.mopane* wood inclusion levels had similar (P<0.05) daily DM, OM and CP intakes. Similarly, heifers on diets with 5 or 10% shredded *C.mopane* wood inclusion levels had the same (P>0.05) daily DM, OM and CP intakes. Nguni heifers on a diet having a 15% *C.mopane* wood inclusion level had higher (P<0.05) daily NDF intakes than those on a 5% inclusion level. However, heifers on diets having 8.5, 10 or 15%*C.mopane* wood inclusion levels had similar (P>0.05) daily NDF intakes. Similarly, heifers on diets having 5, 8.5 or 10% *C.mopane* wood inclusion levels had the same (P>0.05) daily NDF intakes. Nguni heifers on diets having 10 or 15% *C.mopane* wood inclusion levels had higher (P<0.05) daily ADF intakes than those on a diet with a 5% inclusion level. However, heifers on diets having 8.5, 10 or 15% *C.mopane* wood inclusion levels had similar (P<0.05) daily ADF intakes. Similarly, heifers on diets having 5 or 8.5% *C.mopane* wood inclusion levels had the same (P>0.05) daily ADF intakes.

Nguni heifers on diets having 8.5 or 15% shredded *Colophospermummopane*wood inclusion levels had higher (P<0.05) daily DM and OM intakes per metabolic weight than those on a diet having a 5% shredded *C.mopane* wood inclusion level (Table 4.2). However, heifers on diets having 8.5, 10 or 15% shredded *C.mopane* wood inclusion levels had similar (P<0.05) daily DM and OM intakes per metabolic weight. Similarly, heifers on diets with 5 or 10% shredded *C.mopane* wood inclusion levels had the same (P>0.05) daily DM and OM intakes per metabolic weight. Nguni heifers on diets having 8.5, 10 or 15% shredded *C.mopane* wood inclusion levels had higher (P<0.05) daily CP, NDF and ADF intakes per metabolic weight than those on a 5% inclusion level. However, heifers on diets having 8.5, 10 or 15% shredded *C.mopane* wood inclusion levels had the same (P>0.05) daily CP, NDF and ADF intakes per metabolic weight.

Nguni heifers on a diet having a 15% shredded *Colophospermummopane*wood inclusion level had better (P<0.05) feed conversion ratio than those on diets having 5 and 8.5% shredded *C.mopane* inclusion levels. Similarly, heifers on diets having 8.5 or

10% shredded *C.mopane* wood inclusion levels had better (P<0.05) feed conversion ratios than those on a 5% inclusion level. However, heifers on diets having 8.5 or 10% *C.mopane* wood inclusion levels had similar(P>0.05) feed conversion ratios. Similarly, heifers on diets having 10 or 15% *C. mopane* wood had the same (P>0.05) feed conversion ratios.

Shredded *Colophospermummopane*wood inclusion level had no effect (P>0.05) on daily live weight gain and final live weight of feedlot Nguni heifers (Table 4.2).

Daily OM,CP and ADF intakes by Nguni heifers were optimized at *Colophospermummopane*wood inclusion levels of 4.95, 13.75 and 12.9%, respectively (Figures 1, 2 and 3, respectively and Table 4.3). Similarly, daily DM, OM, CP, NDF and ADF intakes per metabolic weight were optimised at inclusion levels of 11.0, 13.67, 8.0,15.0 and 14.0%, respectively (Figures 4,5,6,7 and 8, respectively and Table 4.3). Feed conversion ratio of the heifers was optimized at an inclusion level of 14.96% (Figure 9 and Table 4.3).

**Table 4.2** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed intake, feed intake per metabolic weight,feed conversion ratio, initial live weight, final live weight and live weight gainof feedlot Nguni heifers

| Variable | Treatment | | | | SEM |
|---|---|---|---|---|---|
| | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ | |
| Intake (kg/animal/day) | | | | | |
| DM | $6.92^{b}$ | $7.99^{a}$ | $7.40^{ab}$ | $8.07^{a}$ | 0.181 |
| OM | $6.42^{b}$ | $7.46^{a}$ | $6.91^{ab}$ | $7.57^{a}$ | 0.174 |
| CP | $1.05^{b}$ | $1.25^{a}$ | $1.15^{ab}$ | $1.29^{a}$ | 0.034 |
| NDF | $2.70^{b}$ | $2.99^{ab}$ | $3.06^{ab}$ | $3.39^{a}$ | 0.087 |
| ADF | $1.58^{b}$ | $1.71^{ab}$ | $1.89^{a}$ | $1.83^{a}$ | 0.044 |
| Intake (kg/$W^{0.75}$) | | | | | |
| DM | $0.77^{b}$ | $0.99^{a}$ | $0.88^{ab}$ | $0.93^{a}$ | 0.031 |
| OM | $0.71^{b}$ | $0.92^{a}$ | $0.82^{ab}$ | $0.88^{a}$ | 0.029 |
| CP | $0.12^{b}$ | $0.16^{a}$ | $0.14^{a}$ | $0.15^{a}$ | 0.005 |
| NDF | $0.30^{b}$ | $0.37^{a}$ | $0.36^{a}$ | $0.39^{a}$ | 0.012 |
| ADF | $0.17^{b}$ | $0.21^{a}$ | $0.22^{a}$ | $0.21^{a}$ | 0.006 |
| FCR | $9.26^{a}$ | $8.30^{b}$ | $7.35^{bc}$ | $7.11^{c}$ | 0.281 |
| Initial LWT (kg) | 195 | 201 | 191 | 225 | 11.557 |
| Final LWT (kg) | 248 | 269 | 250 | 288 | 20.771 |
| LWT gain (kg/animal/day) | 0.44 | 0.57 | 0.49 | 0.52 | 0.027 |

$^{a,b,c}$ : Means in the row not sharing a common superscript are significantly different ($P<0.05$)

SEM: Standard error of the means; DM: Dry matter; ADF: Acid detergent fibre; OM: Organic matter; LWT: Live weight; CP: Crude protein; FCR: Feed conversion ratio;NDF: Neutral detergent fibre

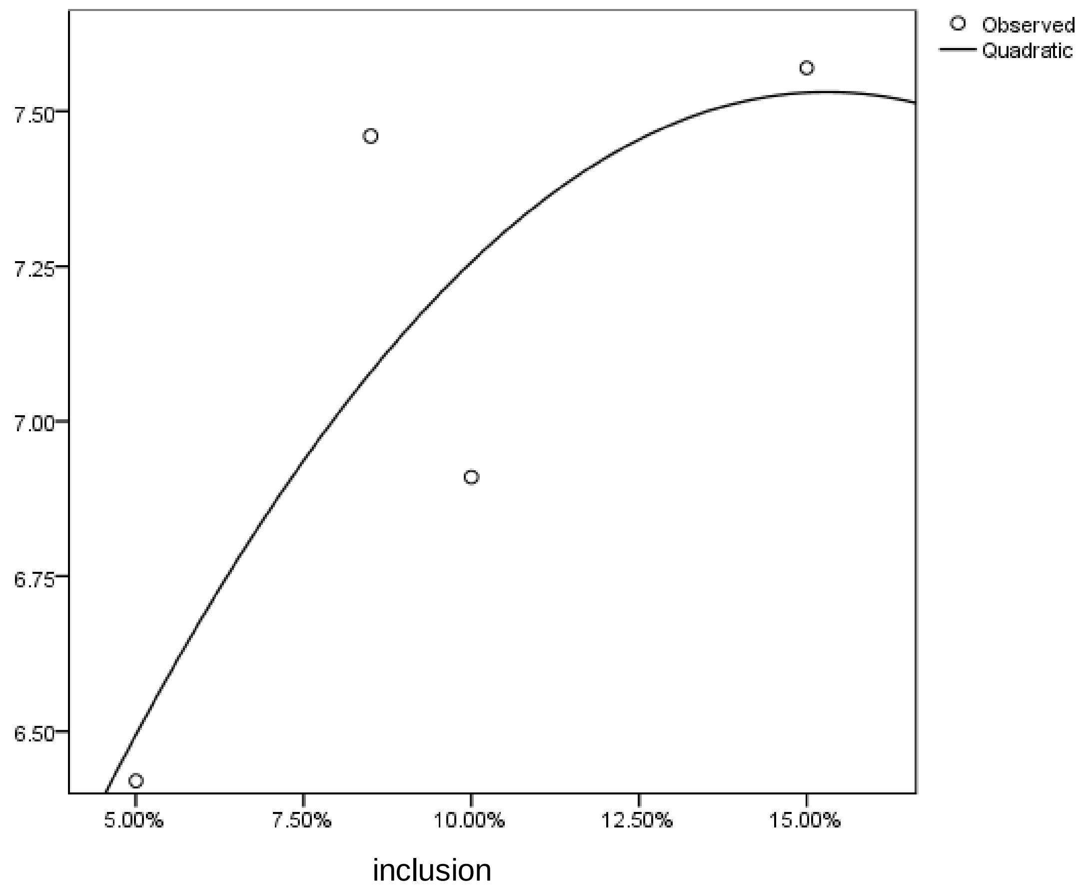


**Figure 4.1** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed OM intake by feedlot Nguni heifers

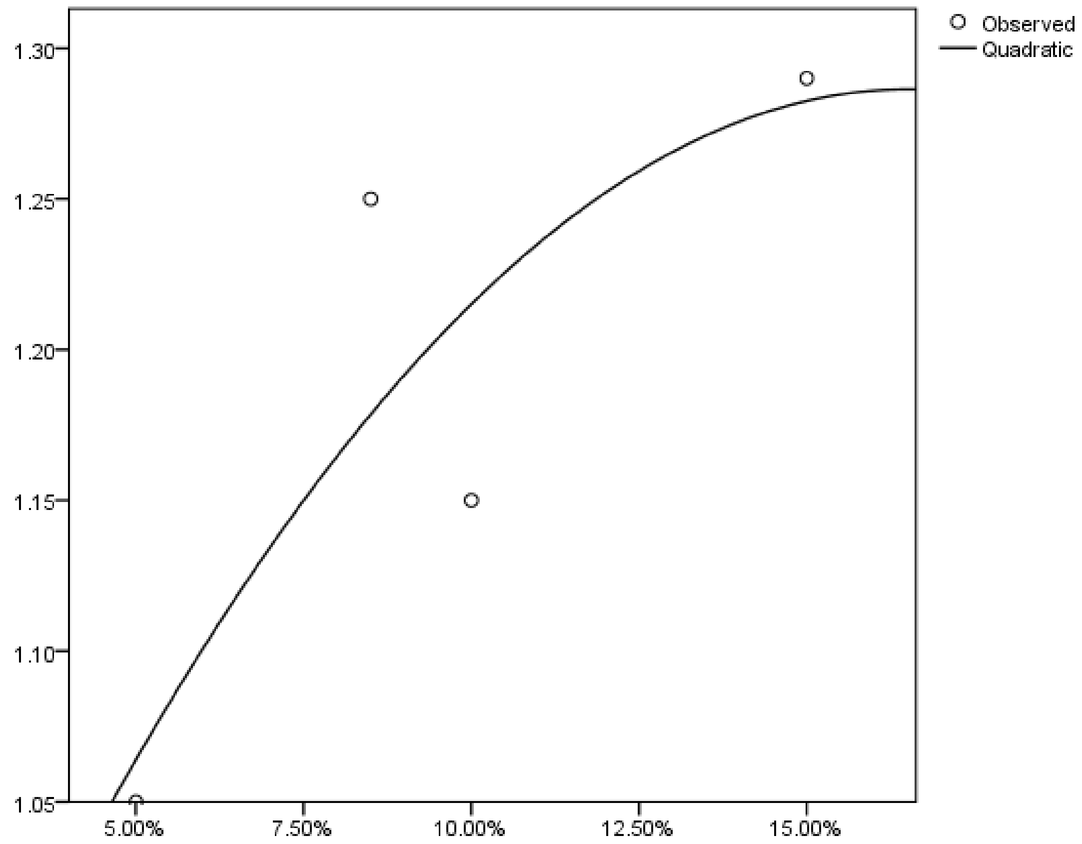


**Figure 4.2** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed CP intake by feedlot Ngunihaifers

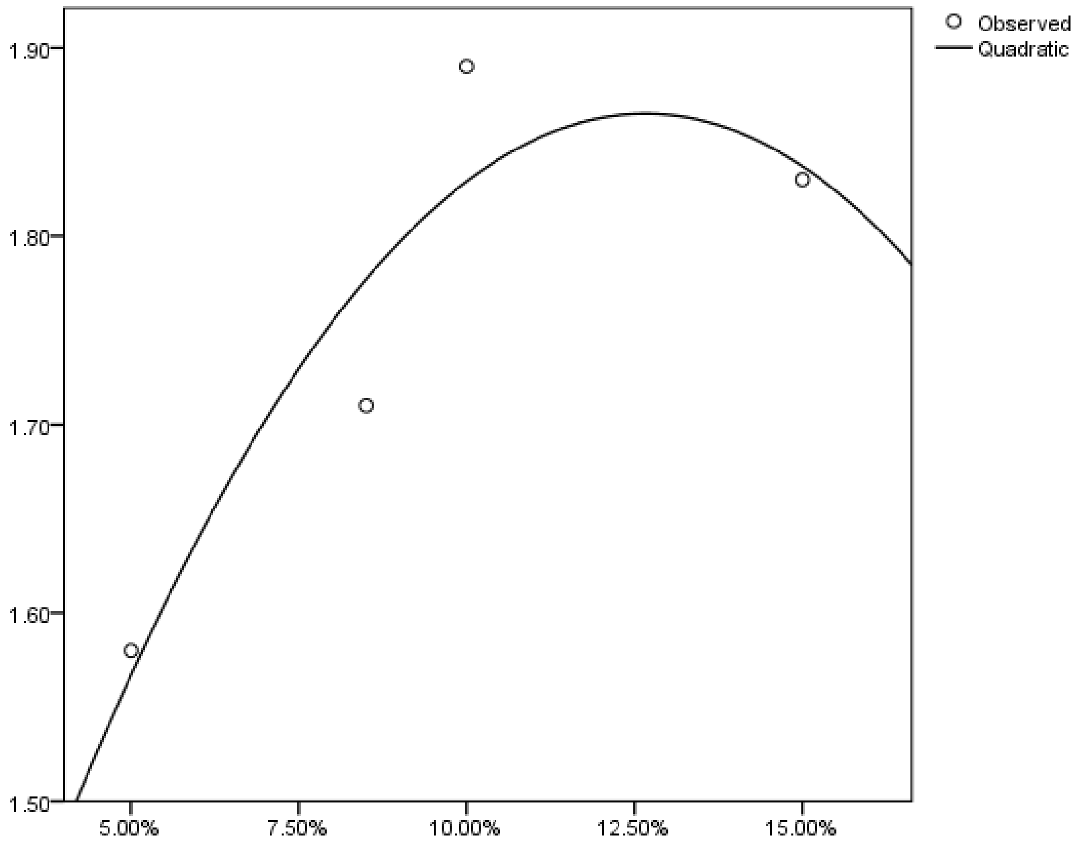


**Figure 4.3** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed ADF intake by feedlot Nguni heifers

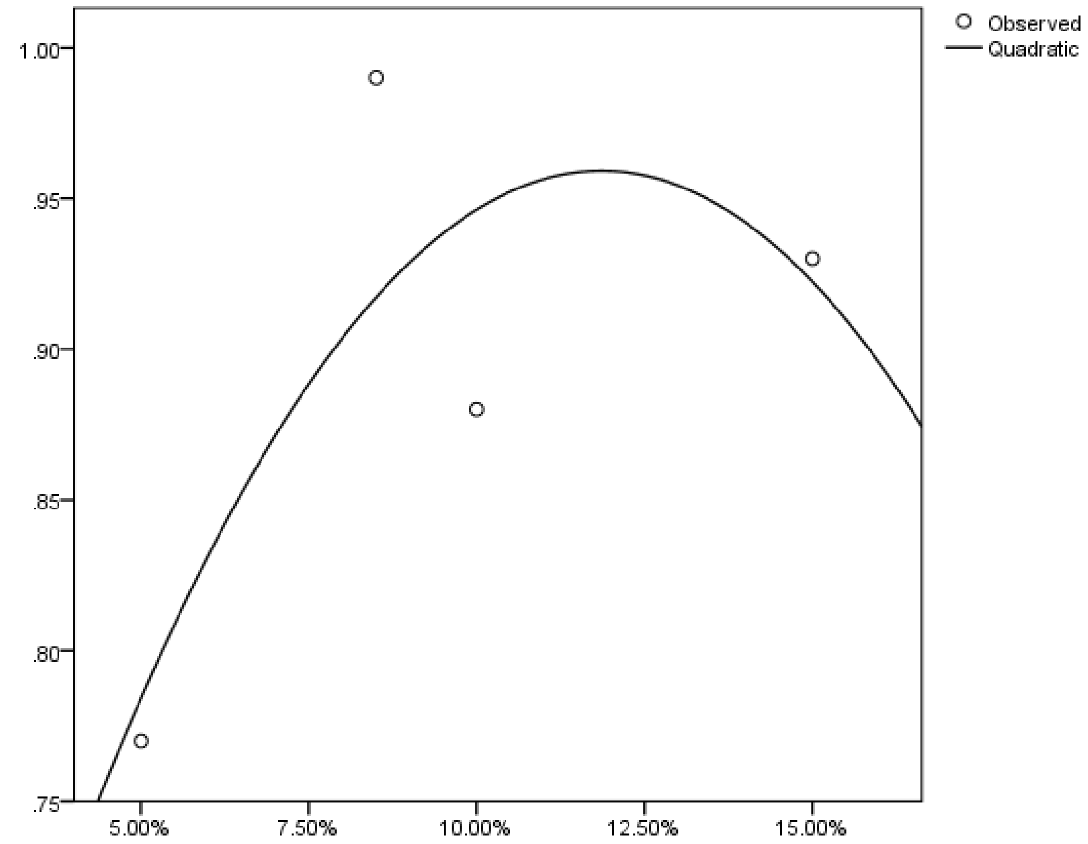


**Figure 4.4** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed DM intake per metabolic weight of feedlot Nguni heifers

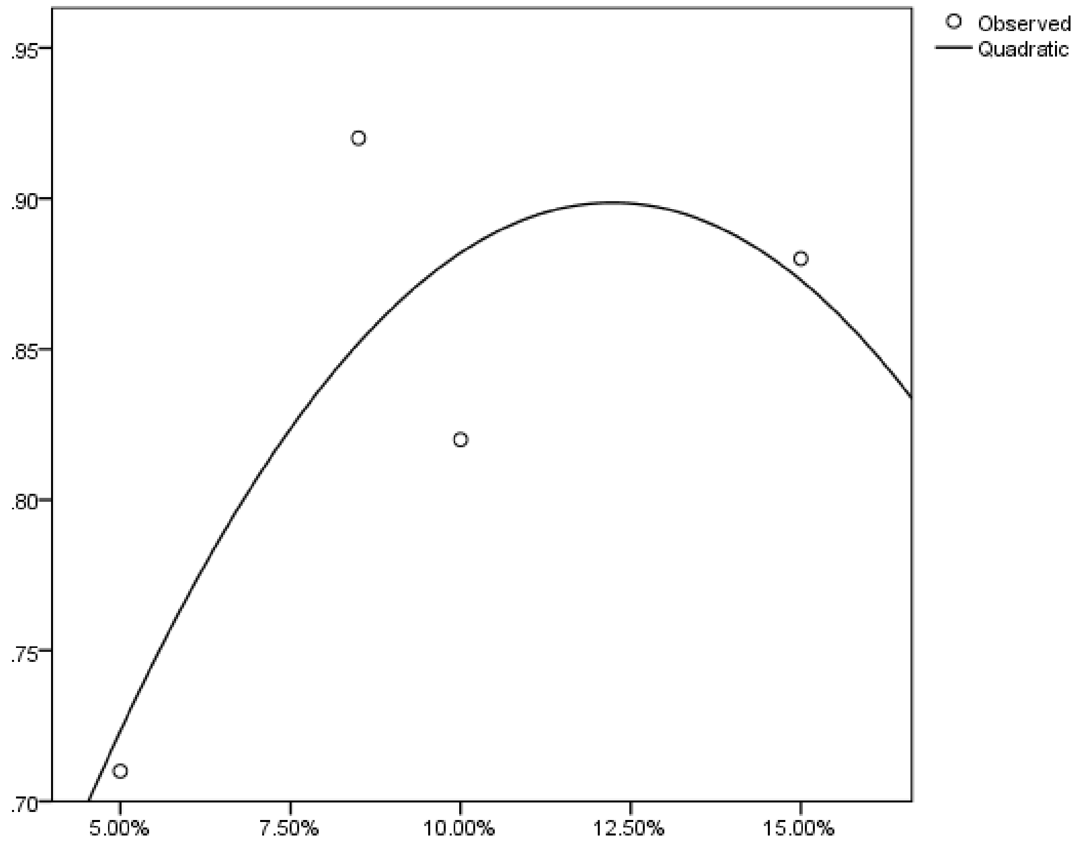


**Figure 4.5** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed OM intake per metabolic weight of feedlot Nguni heifers

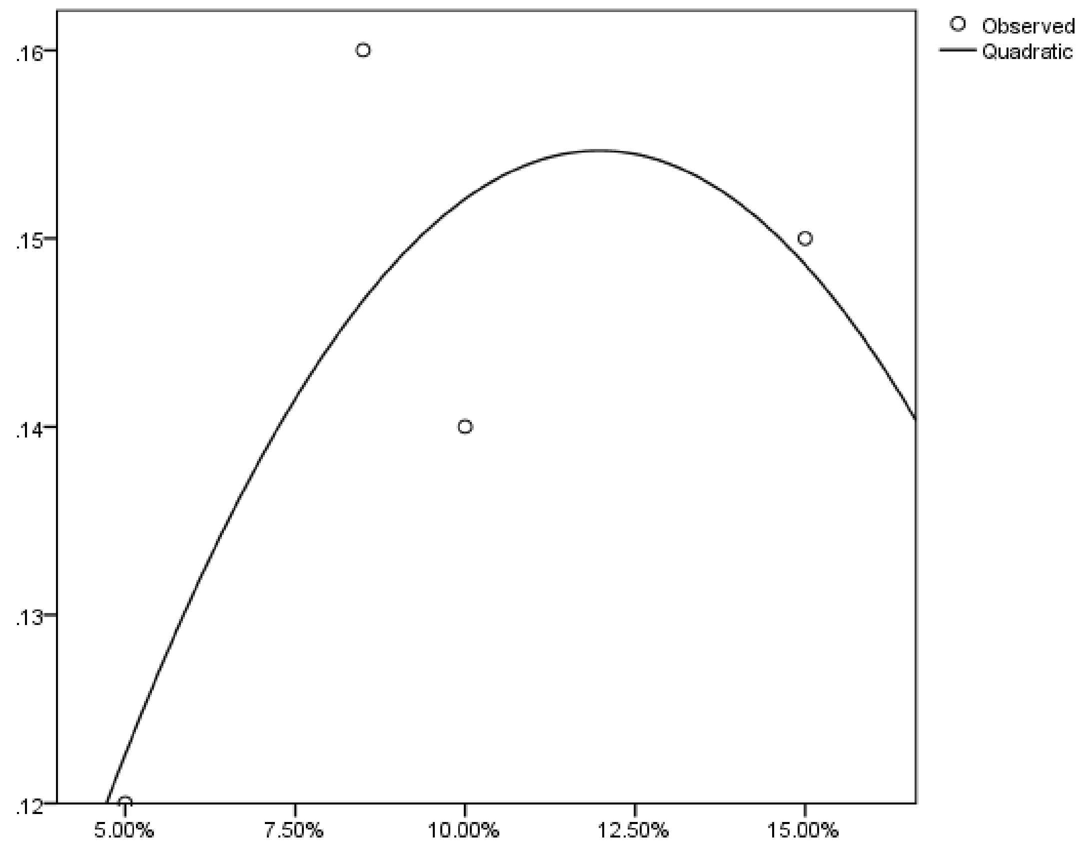


**Figure 4.6** Effect of shredded *Colophospermummopane* wood inclusion as roughage on CP intake per metabolic weight of feedlot Nguni heifers

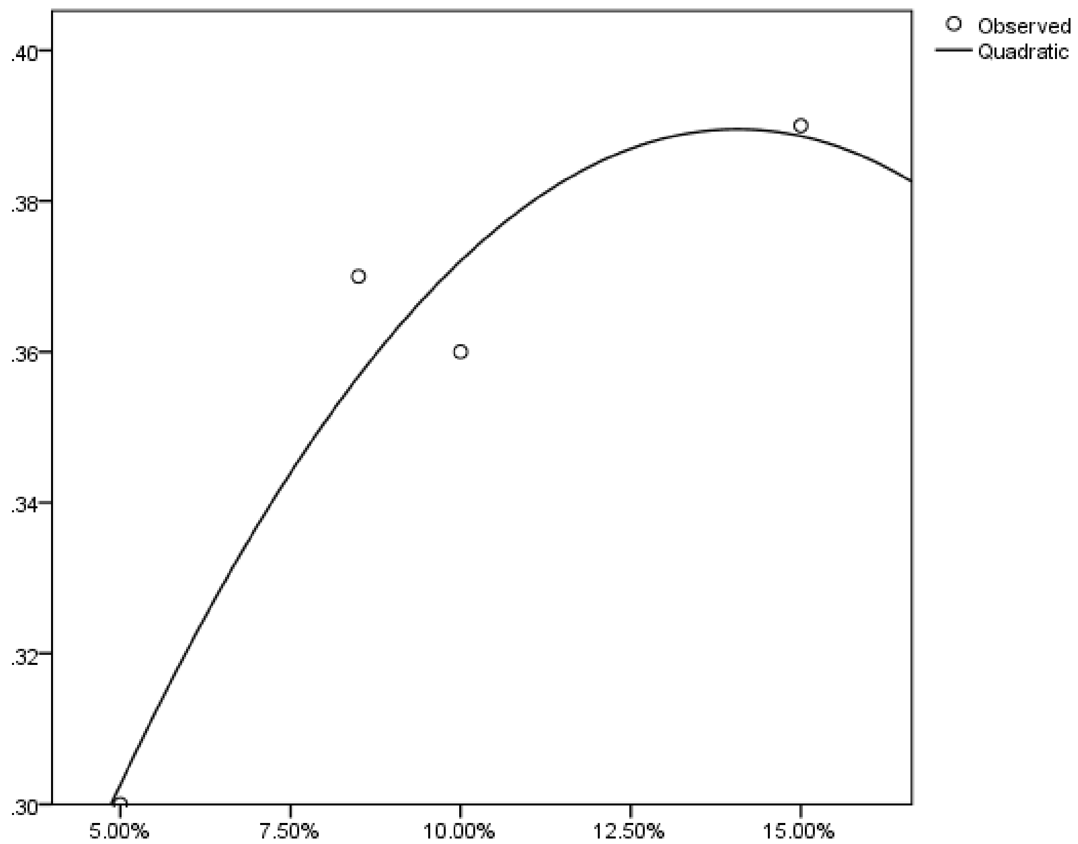


**Figure 4.7** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed NDF intake per metabolic weight of feedlot Nguni heifers

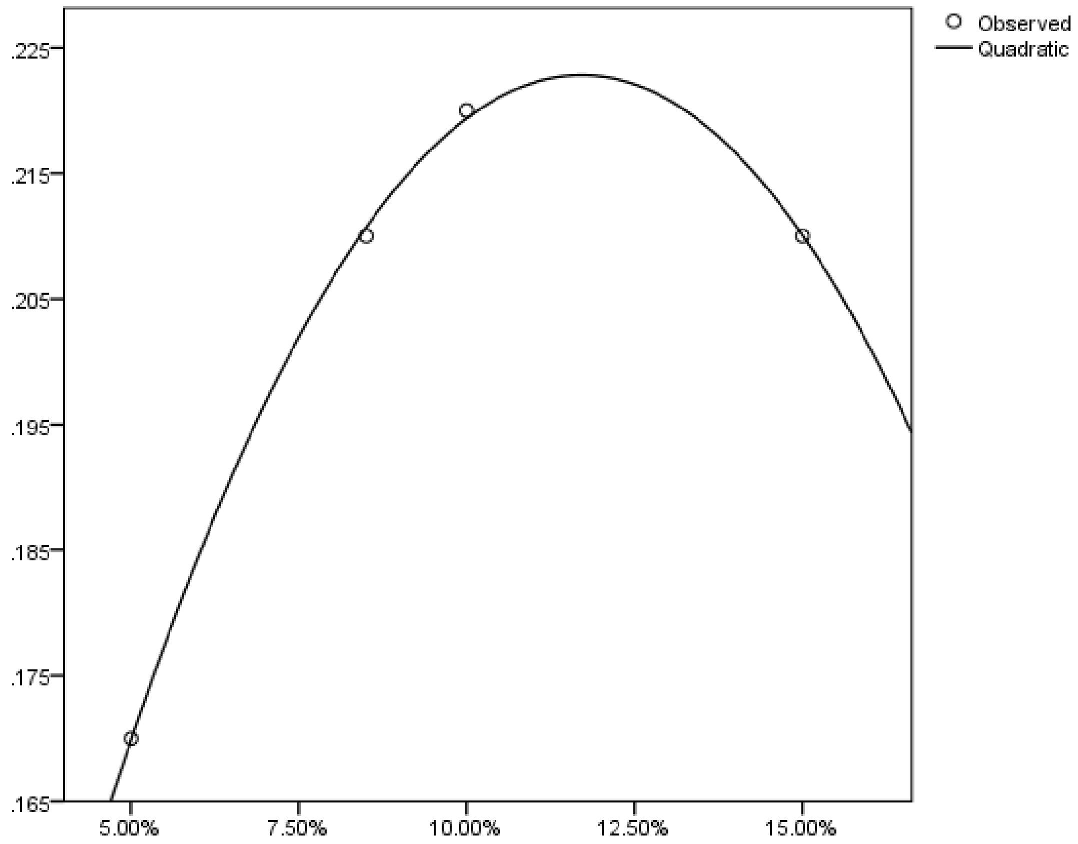


**Figure 4.8** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feed ADF intake per metabolic weight of feedlot Nguni heifers

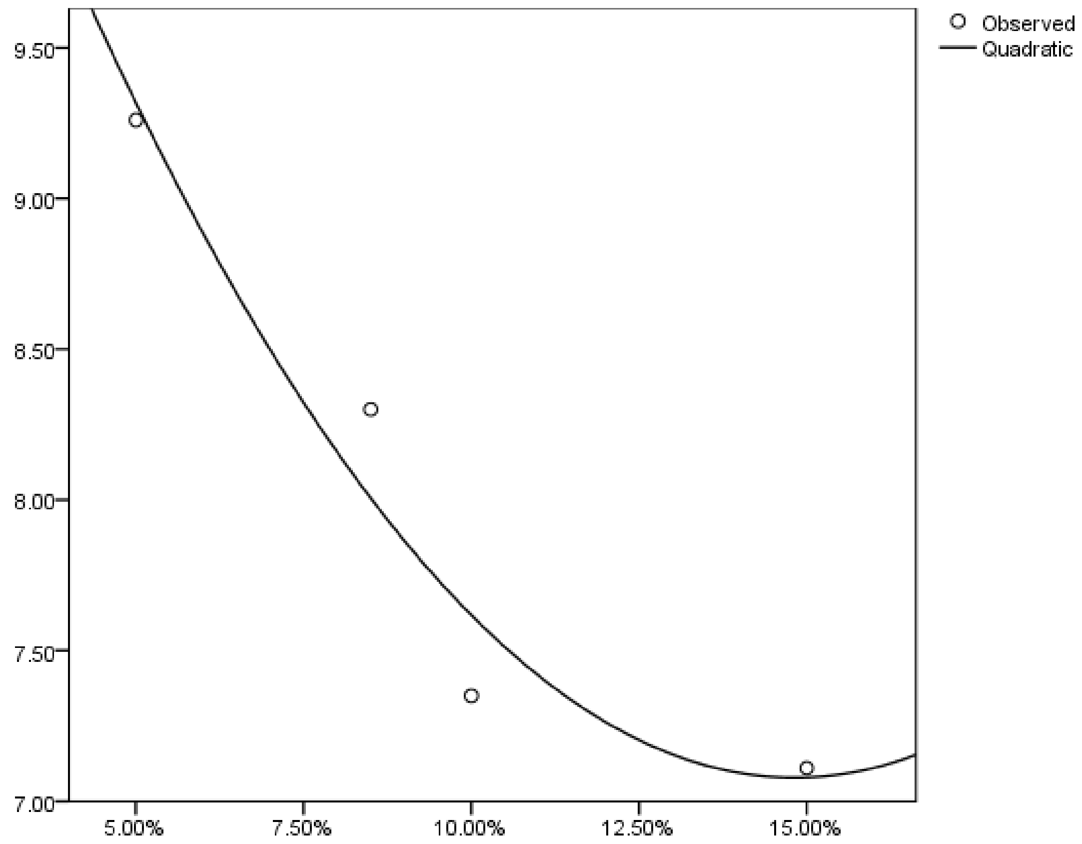


**Figure 4.9** Effect of shredded *Colophospermummopane* wood inclusion as roughage on FCR of feedlot Nguni heifers

**Table 4.3**Shredded *Colophospermummopane* wood inclusion levels for optimal feed intake (kg/animal/day), feed intake per metabolic weight (kg/$W^{0.75}$) and feed conversion ratio (FCR) of feedlot Nguni heifers

| Variable | Formula | $r^2$ | Mopane | Optimal |
|---|---|---|---|---|

| | | | levels | Y- level |
|---|---|---|---|---|
| Intake (kg/animal/day) | | | | |
| OM | $Y= 5.243+0.299x-0.010x^2$ | 0.679 | 14.95 | 7.48 |
| CP | $Y= 0.829+0.055x-0.002x^2$ | 0.724 | 13.75 | 1.20 |
| ADF | Y = 1.051 + 0.129x - 0.005x2 | 0.851 | 12.9 | 1.88 |
| Intake ($kg/W^{0.75}$) | | | | |
| DM | $Y= 0.436+0.088x-0.004x^2$ | 0.618 | 11.0 | 0.92 |
| OM | $Y = 0.397 +0.082x-0.003x^2$ | 0.653 | 13.67 | 0.96 |
| CP | $Y= 0.060 + 0.016x - 0.001x^2$ | 0.621 | 8.0 | 0.124 |
| NDF | $Y= 0.180+0.030x-0.001x^2$ | 0.927 | 15.0 | 0.41 |
| ADF | $Y= 0.250 +0.028x+0.001x^2$ | 0.999 | 14.0 | 0.838 |
| FCR | $Y= 12.178-0.688x+0.023x^2$ | 0.679 | 14.96 | 7.03 |

Results of the effect of shredded *Colophospermummopane* wood inclusion level as roughage on *in vitro*digestibility of feedlot Nguni heifers are presented in Table 4.4.Nguni heifers on diets containing 5, 8.5, 10 or 15% shredded *C. mopane wood*had similar (P>0.05) *invitro* digestibility coefficients.

**Table 4.4** Effect of shredded *Colophospermummopane* wood inclusion level in the diet on *in vitro* digestibility (decimal)

| | Treatment | | | | |
|---|---|---|---|---|---|
| Variable | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ | SEM |

| | | | | | |
|---|---|---|---|---|---|
| Dry matter | 0.61 | 0.60 | 0.60 | 0.59 | 0.021 |
| Organic matter | 0.58 | 0.57 | 0.57 | 0.57 | 0.033 |
| Crude protein | 0.65 | 0.65 | 0.64 | 0.64 | 0.041 |
| Neutral detergent fibre | 0.61 | 0.60 | 0.61 | 0.60 | 0.052 |
| Acid detergent fibre | 0.21 | 0.20 | 0.20 | 0.19 | 0.102 |

SEM : Standard error of the means

Results of the effect of shredded *Colophospermummopane* wood inclusion as roughage on carcass weight, dressing percentage and reticulo-rumen weight of feedlot Nguni heifers are presented in Table 4.5.Nguni heifers on diets containing 5, 8.5, 10 and 15% shredded *Colophospermummopane* wood had similar (P>0.05) carcass weights, dressing percentages and reticulo-rumen weights.

**Table 4.5** Effect of shredded *Colophospermummopane* wood inclusion as roughage on carcass weight, dressing percentage and reticulo-rumen weight of feedlot Nguni heifers

| | Treatment | | | | |
|---|---|---|---|---|---|
| Variable | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ | SEM |
| Warm carcass weight (kg) | 150 | 142 | 141 | 165 | 5.702 |
| Warm dressing % (%) | 56 | 57 | 57 | 58 | 0.726 |
| Cold carcass weight (kg) | 147 | 139 | 138 | 162 | 5.707 |
| Cold dressing %(%) | 55 | 56 | 56 | 56 | 0.710 |
| Reticulo-rumen weight (kg) | 6.47 | 6.53 | 6.23 | 6.15 | 0.120 |

SEM : Standard error of the means

The results of the effect of shredded *Colophospermummopane* wood inclusion as roughage on meat characteristics of feedlot Nguni heifers are presented in Table 4.6. Shredded *C. mopane* wood inclusion level did not affect (P>0.05) meat pH and shear force values. Similarly, meat colour was not affected (P>0.05) by shredded *C. mopane* wood inclusion level in the diets except for red intensity of rump steak. Nguni heifers on diets having 15% shredded *Colophospermummopane*wood inclusion level produced rump steak with higher (P<0.05) red colour intensity than the meat from animals on a diet having 10% shredded *C.mopane* wood inclusion level. However, rump steak from animals on 5, 8.5 or 15% shredded *C.mopane* wood inclusion levels had similar (P>0.05) red colour intensity levels. Similarly, rump steak from heifers on diets having 5,8.5 or 10% shredded *C.mopane* wood inclusion levels had the same (P>0.05) red colour intensity levels.

**Table 4.6** Effect of shredded *Colophospermummopane* wood inclusion as roughage on feedlot Nguni heifer meat pH, colour and shear force values

| | Treatment | | | | |
|---|---|---|---|---|---|
| Variable | $F_{95}M_5$ | $F_{91.5}M_{8.5}$ | $F_{90}M_{10}$ | $F_{85}M_{15}$ | SEM |

| | | | | | |
|---|---|---|---|---|---|
| **Meat pH** | | | | | |
| Rump Steak | 5.56 | 5.46 | 5.61 | 5.50 | 0.037 |
| Sirloin Steak | 5.67 | 5.79 | 5.56 | 5.61 | 0.051 |
| Fillet | 5.51 | 5.57 | 5.72 | 5.75 | 0.045 |
| **Meat colour intensity** | | | | | |
| Rump steak | | | | | |
| $L^*$ | 35.34 | 39.82 | 35.34 | 33.64 | 1.315 |
| a* | 15.62[ab] | 15.39[ab] | 13.40[b] | 18.04[a] | 0.648 |
| b* | 10.52 | 13.09 | 8.37 | 12.28 | 0.840 |
| Sirloin steak | | | | | |
| $L^*$ | 29.67 | 32.71 | 29.01 | 32.74 | 1.087 |
| a* | 17.80 | 16.39 | 16.75 | 16.72 | 0.433 |
| b* | 10.39 | 6.55 | 8.91 | 9.96 | 0.606 |
| Fillet | | | | | |
| $L^*$ | 36.57 | 35.69 | 35.66 | 39.22 | 4.218 |
| a* | 14.36 | 14.27 | 13.72 | 14.81 | 0.707 |
| b* | 11.06 | 9.76 | 11.96 | 11.14 | 0.474 |
| **Meat shear force (Newtons)** | | | | | |
| Rump steak | 30.33 | 24.64 | 34.01 | 29.82 | 1.627 |
| Sirloin steak | 25.15 | 26.82 | 23.93 | 26.83 | 0.975 |

[a,b,c] : Means in the row not sharing a common superscript are significantly different ($P<0.05$)

SEM: Standard error of the means

L*,a*,b*: colour- lightness (L*), red intensity (a*), yellow intensity(b*)

# CHAPTER 5

# DISCUSSION AND RECOMMENDATIONS

## 5.1 Discussion

Shredded *C. mopane* wood inclusion level had effect on diet intake per metabolic weight of Nguni heifers. However, DM, OM,CP,NDF and ADF intakes per metabolic weight of Nguni heifers were optimized at different shredded *C. mopane* wood inclusion levels of 11.0, 13.7, 8.0, 15.0, 14.0 and 14.0%, respectively. This may imply that the shredded *C. mopane* wood inclusion level for optimal nutrient intake by Nguni heifers will depend on the nutrient of interest.A higher shredded *C. mopane* wood inclusion level of 14.96% optimized feed conversion ratio. This might be the ideal shredded *C. mopane* wood inclusion level. However, improved intake and feed conversion ratio seem to have had no impact on body weight gain and hence final live weight of the heifers. Syter and Kamstra (1974) observed that an inclusion level of 10% pine sawdust optimized diet DM intake by Hereford heifers. Similarly, Dinus and Bond (1975) reported that increasing oak wood shavingsinclusion level to 15% resulted in optimal diet DM intake by cattle. Sharma *et al.* (1980), also, reported that increasing aspen wood shavings from 0 to 15% or 30% resulted in increased daily diet intake by cattle. However, the increase in intake by Nguni heifers with increased shredded *C. mopane* wood inclusion level is contrary to the findings of Calderon-Cortes and Zinn (1996) and Satter*et al.* (1972). Calderon-Cortes and Zinn (1996) fed diets having 8 or 16% wood as roughage to crossbred steers and reported that dry matter intake decreased as roughage inclusion level increased from 8 to 16%. Satter*et al.* (1972) reported that aspen sawdust inclusion levels of 10, 20 and 40% had no significant effect on feed intake and weight gain of Holstein cows.

Shredded *C. mopane* wood inclusion levels of 5.0, 8.5, 10.0 and 15.0% had similar effects on *in vitro* DM, OM, CP, NDF and ADF digestibility coefficients. The *in vitro* digestibility coefficients ranged between 0.55 and 0.61. These digestibility coefficients are within the reported *in vitro* and *in vivo* digestibility coefficients in cattle fed grass hay as roughage (Geisert*et al*, 2007). Shelford (1966), also, reported that alder sawdust inclusion levels of 0, 13, 27 or 35% did not affect *in vitro* DM digestibility of the diets. However, Barker *et al.* (1975) found that *in vitro* digestibility of most of the wood is low, around 13.11%. Mellenberger*et al.* (1970) found that sawdust inclusion adversely affected diet *in vitro* and *invivo*digestibilities when offered to ruminant animals. The authors indicated that cattle were unable to effectively digest the high fibre contents of the diets. This is because the close molecular associations between the major constituents of wood celluloses, hemicelluloses and lignin appear to limit bacterial and enzymatic access to the carbohydrates of the cell wall (Lynd *et al.,* 2002;Jung and Buxtono, 1994).

Shredded *C.mopane* wood inclusion levels of 5.0, 8.5, 10.0 and 15.0% had similar effects on carcass weight, dressing percentage and reticulo-rumen weight of feedlot Nguni heifers. These findings are consistent with the results of Shelford (1966) who reported that alder sawdust inclusion levels of 0.0, 13.3, 27.0 or 35.0% had no significant effect on carcass weight and dressing percentage of Hereford steers. In the present study, on average the dressing percentage was 55.5 ± 1.0%, which is in line with the findings of Scholtz (2005) who reported that the dressing percentage of Nguni cattle in a feedlot is between 55 and 58%.

Shredded *C. mopane* wood inclusion levels had similar effects on meat pH, shear force values and meat colour intensities except for red colour intensity of rump steak. No similar results on feedlot cattle fed diets having wood as roughage were found. However, Guerrero *et al.* (2013) reported that factors like animal species, breed, individual genetic aspects, gender, age and weight at slaughter, management, pre-slaughter handling and the type of a diet that the animal receives during fattening influence meat quality. Similarly, Strydom*et al.* (2008) reported that the type of feed that is given to an animal during finishing stage might affect quality of the meat.

## 5.2 Conclusion

Shredded *C. mopane* wood inclusion levels had effect on diet intake, intake per metabolic weight and feed conversion ratio. However, shredded *C. mopane* wood inclusion level had similar effects on final weight, daily gain, *in vitro* digestibility and carcass characteristics. Shredded *C. mopane* levels optimized intake and feed conversion ratio at different inclusion levels and this has implications on ration formulation. The improved diet intake and feed conversion ratio with shredded *C. mopane* wood inclusion level seem to have had no effect on body weight gain, final weight, *in vitro* digestibility and carcass characteristics of Nguni heifers. These results imply that shredded *C. mopane* wood can be included as roughage in diets for feedlot Nguni cattle.

### 5.3 Recommendations

The present study was conducted on a smaller sample size. Results show that shredded *C. mopane* wood can be included in the diets for feedlot Nguni cattle without adverse effects on intake and growth of the animals. It is recommended that further studies be conducted with a large sample size to determine the influence of *C. mopane*inclusion on performance of fattening Nguni cattle.

# CHAPTER 6

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