THE USE OF MULBERRY (*MORUS ALBA) DRY* LEAVES AS A PROTEIN SUPPLEMENT FOR TANZANIA BLENDED GOATS FED WITH LOW QUALITY ROUGHAGE

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ABSTRACT

A study was conducted to evaluate the effect of substituting *Morus alba* dry leaves (MDL) for sunflower seed cake (SSC) as a protein supplement on the performance of blended goats fed with poor quality roughages. In a growth study, 32 growing blended goats (4 to 7 months old) weighing 14±2.4 kg were randomly allocated to four dietary rations so formulated that MDL replaced 0, 50, 75 and 100% SSC as a source of supplementary nitrogen in treatments T_1, T_2, T_3 and T_4 respectively. There were 8 animals (4 ♂ and 4 ♀) in each group. On top of the basal diet (hay) each animal received an amount of its respective treatment ration estimated to meet its DCP requirements (adjusted fortnightly) for maintenance plus an allowance for 50 gd^{-1} live weight gain. Each animal was also given 10 and 2% of its estimated dry matter intake (DMI) as hominy meal (HM) and mineral mix respectively plus *ad libitum* fresh drinking water daily. After the 84 days of growth study, 3 males from each treatment were slaughtered for carcass yield and killing-out characteristics. Nutrient digestibilities and N utilization were measured in a digestibility trial with 4 treatment groups each with 3 mature males. T_1 ration (100% SSC), was poorly accepted by the animals leading to slow growth rates and weight losses towards the end of the growth study. There were significant treatment effects on daily feed intakes with highest values in T_3 and lowest in T_1. Energy intakes were significantly ($P<0.05$) lower (2.6 MJ ME d^{-1}) for T_1 and higher for the other groups, which were not significantly ($P>0.05$) different. T_1 animals showed poor growth but the other groups gained between 30 and 53 g d^{-1}, the highest being for T_4. Highest feed conversion ratio was in T_1, which differed significantly ($P<0.05$) from the rest of the

treatments. Hot carcass weight (HCW) % of slaughter weight (SW), was highest in T_2 followed by T_3, T_4 and T_1 in decreasing order. SW, empty body weight (EBW), HCW and gut fill were significantly ($P<0.05$) influenced by the treatments, the mean values being generally higher for T_4 and lower for T_1. There were no significant ($P>0.05$) treatment effects on gut fill. Yield of total edible non-carcass components was significantly ($P<0.05$) higher in T_4 than T_3, T_2 and T_1, the order being reversed when expressed as % of EBW. There were no significant ($P>0.05$) treatment effects on the yield and proportions of total non-edible non-carcass components or the proportions of lean in the sample joints from animals in all treatment groups. Sample joints from T_1 animals had the lowest fat and the highest bone proportions ($P<0.05$) than T_2, T_3 and T_4 animals whose differences were generally small and insignificant ($P>0.05$). All treatment rations supported positive N balances, high *in vivo* feed digestibility with higher energy intakes being associated with rations containing higher levels of MDL. It was concluded that, MDL can substitute SSC as a protein supplement to growing meat goats without reduction in performance and that a better effect of CP supplementation is achieved when some SSC is offered together with *M. alba* preferably in the ratio of 25 : 75 (SSC : MDL) in terms of DCP contribution for meeting maintenance and a growth rate of 50 gd^{-1}. The use of SSC as a sole protein supplement to growing goats on poor quality roughages is likely to cause low dietary energy intake leading to lower feed utilization efficiency.

DECLARATION

I, **VITALIS WILBALD KISINGO TEMU,** do hereby declare to the senate of Sokoine University of Agriculture, Morogoro, that the dissertation presented here is my own original work, and that to the best of my knowledge, it has never been submitted for a higher degree award in any other university.

Signature.....

Date 30/06/2001

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DEDICATION

This dissertation is dedicated to my parents Ida Isac Silayo and Wilbald Kisingo Temu who toiled for my primary and secondary education and to my late paternal uncles Charles and John Kisingo who aroused in me the love for education. May the Almighty Father rest their souls in eternal peace. AMEN.

TABLE OF CONTENTS

LIST OF TABLES

Table No. **Page**

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS AND SYMBOLS

ADF	Acid Detergent Fibre
CP	Crude Protein
CPI	Crude Protein Intake
DCP	Digestible Crude Protein
DM	Dry Matter
DMD	Dry Matter Digestibility
DMI	Dry Matter Intake
EBW	Empty Body Weight
EE	Ether Extracts
FCR	Feed Conversion Efficiency
g	Gram
GIT	Gastro-intestinal tract
HCW	Hot Carcass Weight
HM	Hominy Meal
kg	Kilogram
L	Litre
LW	Live Weight
MBW	Metabolic Body Weight
MDL	*Moru alba* Dry Leaves
ME	Metabolizable Energy
MJ	Mega Joule
MPT	Multipurpose Trees and Shrubs

N	Nitrogen
NDF	Neutral Detergent Fibre
NH_3	Ammonia
NPN	Non Protein Nitrogen
OM	Organic Matter
OMI	Organic Matter Intake
SED	Standard Error of Difference
SSC	Sunflower Seed Cake
SW	Slaughter Weight
$W^{-0.75}$	Metabolic Body Weight

CHAPTER ONE

INTRODUCTION

In most developing tropical countries, there exist highly unsatisfied demands for goat meat (Kiwuwa, 1986) among other animal products with very low *per capita* meat consumption, which is about 11 g against 22 g in developed countries (FAO, 1988) in the case of Tanzania. Increased small ruminant productivity is hindered by biological, economic and environmental constraints (Kiwuwa, 1986) and of these, environmental constraints are the most important. Nutrition is the major limiting factor affecting the performance of livestock in semi-arid regions of Tanzania and other tropical countries where by tamed animals are seldom allowed to express their genetic potential (Devendra, 1986; De Wolf, 1990; Kimambo *et al.*, 1990; Massae and Mtenga, 1992). Available feed resources, mainly natural pastures, are inadequate in quantity and quality especially during the dry season. The seasonal variations in forage quality and quantity impose fluctuations in growth pattern characterised by alternate gains and losses in animal productivity (Crowder and Chheda, 1982).

Although natural pastures are the major source of ruminant feeds in rural areas in the tropics (Crowder and Chheda, 1982; Devendra, 1986), most of them and crop residues in the tropics lack enough energy and crude protein to support maintenance and production (French, 1944; Kyomo, 1978). Supplementary feeding is often necessary to meet the animal requirements. It has been demonstrated that supplementing poor roughage with proteinaceous materials improves voluntary dry matter intake (VDMI), nitrogen balance, microbial nitrogen yield and digestibility

(Kitalyi, 1982; Mtenga, 1986; Kimambo *et al.*, 1991). Supplementation has been shown to result in significant increases in small ruminant performance in several tropical countries e.g. West Indies (Devendra, 1972), India (Sachdeva *et al.*, 1974) and Malaysia (Devendra, 1979). This usually involves supplying agricultural by-products like rice bran and hominy meal as energy sources and oil seed cakes as protein sources. However, to most smallholder farmers in remote areas of Tanzania and other tropical countries with poor infrastructure, these by-products are either scarce or too expensive to be afforded. This makes commercial supplements unreliable for improving the nutritional status of the majority of ruminants in rural areas.

Some physical methods used to improve voluntary intake of low quality roughage include chopping and pelleting, but they do not provide opportunity for selection of the best parts of the plant material resulting in intakes of inadequate amounts of digestible nutrients. Chemical treatment with urea or Ammonium or Sodium hydroxide have also been used to improve intake and digestibility of low quality roughage (Kategile *et al.*,1981; Urio, 1981; Iwuanyanwu *et al.*, 1990; Kimambo *et al.*,1991; Mgheni *et al.*,1993;). However, to most rural people, the chemicals are either difficult to handle due to associated dangers of toxicity and hazards to the user or not readily available.

Many authors including Yilala (1989) and Osuji *et al.* (1993) have suggested that, supplementation with locally available feed resources like leaves and soft twigs of

shrubs and trees may be a better alternative to most rural based smallholders. The inclusion of locally available forages from shrubs and trees with high crude protein (CP) in ruminants' rations has been reported as an economical and sustainable way of enhancing rumen microbial activity (Preston and Leng, 1987; Bonsi,*et al.*, 1996). In recent years, there has been a growing trend throughout the developing world to identify potentially important feed sources among shrub and tree leaves and to explore possibilities for including them in ruminants' diets (Devendra 1990). Several multipurpose trees and shrub species, useful as livestock feed resources in the tropics, have been identified and screened (Shayo, 1991; Shem,1993; Temu *et al.*,1998) and their potential as green supplements to poor quality roughage has been demonstrated by many workers in the tropics and elsewhere (Reed *et al.*, 1990; Goromela, 1996).

Morus alba has been identified as a potential green supplement for ruminants (Le Houerou, 1980; Shayo, 1998; Saifalyazal, 1998; Malamsha, *et al.*, 1999). Saifalyazal, (1998) observe increased DMI when *Cenchrus ciliaris* hay was supplemented with *M. alba* leaves while Malamsha *et al.*, (1999) reported a general increase in growth rates of growing goats. However, there is scarce information regarding its effect as a protein supplement on the performance of goats fed low quality feeds. There is therefore, a need to investigate the potential of *M. alba* as an alternative protein supplement to SSC, which is the mostly used seed cake in the study area, for goats on low quality roughages both on station and on farm. The present study was therefore

designed to investigate the potential of *M. alba* as a protein supplement to growing goats on low quality roughage with the following specific objectives.

i) To investigate the effect of substituting sunflower seed-cake with *M. alba* leaf meal as a protein supplement on the performance of growing goats.

ii) To investigate the effect of substituting sunflower seed cake with *M. alba* leaf meal as a protein supplement on feed *in vivo* digestibility and nitrogen retention by growing blended goats.

iii) To estimate the economic benefit of substituting sunflower seed cake with *M. alba* leaf meal as protein supplement for growing blended goats.

CHAPTER TWO

LITERATURE REVIEW

2.1 Feed intake

2.1.1 Voluntary feed intake

Voluntary intake can be defined as the amount of feed an animal will ingest when an excess of 15% is offered (Blaxter *et al.,* 1961). It should be noted that, the supply and availability of nutrients in quantitative and qualitative terms control to a large extent the level of performance by goats. The amount of feed which ruminats voluntarily consume greatly influences the efficiency with which they convert feed nutrients into valuable products like meat and milk (Preston and Leng, 1987; Ketelaars and Tolkamp 1992). Knowledge of the Dry matter intake (DMI) of an animal is, therefore, of primary importance in that it indicates the animal's capacity to utilize food in terms of voluntary intakes. DMI is, therefore, the first among the two principle factors that determine the utilisation of the available nutrients, the other being feed digestibility (Devendra, 1986). Selectivity, which is the animal's ability to choose the most nutritious plant species or plant parts in *ad libitum* supply is determined by plant, animal and environmental factors (Malechek and Balph, 1987). In most cases free grazing animals have greater chances of selecting among various forage species than their confined counterparts. However, confined animals also eat selectively when feed is offered generously (Zemmelink, 1980; Aboud, *et al.,* 1992). The latter reported that, when forages are offered in excess, animals will choose a more digestible diet by generally rejecting stem portions thus increasing their intake in both quantity and quality. This ability is favoured when the material is fed in a

long form and is reduced when chopped (Zemmelink, 1980). Under intensive stall-feeding systems, man controls most of the factors influencing the ingestive behaviour of the animal (Arnold, 1981). Whether confined or free grazing, ruminants have their degree of selectivity invariably affected by feed availability, seasonal variations, stocking rate, environmental stress, quantity and frequency of offer (Lu, 1988). So in order to optimise the utilization of low quality roughages in dry season feeding of ruminants, one may allow the animals excess offers to favour selectivity when availability is not limiting. When both quality and quantity of the low quality roughages are limiting, manipulations like chopping, chemical treatments and supplementation to increase intake with reduced feed selectivity are necessary.

DMI of goats has been reported as varying from 2.8 to 8 percent of body weight (Devendra and Burns, 1970). For tropical goats, DMI has been reported by Majundar (1960) cited by Kitalyi (1982) is 3% of live body weight which a is comparable to 2.8 reported by Oyenuga and Akinsoyinu (1976). Daily DMI for East African goats fed to appetite as reported by Devendra and Burns (1983) ranges from 1.8 to 4.7 percent of body weight. This has been supported by Kitalyi, *et al.,* 1985; cited by Mtenga, 1986) who reported mean daily DMI ranging from 2.8 to 4% of live weight for Tanzania local goats. This big variation can be explained by inherent differences in breed, sex, age, physiological status and level of production of the animals used.

2.1.2 Factors affecting voluntary feed intake

Skerman and Riveros (1990) reported that, daily intakes by goats for tropical pastures, ranges from 24 g/kg$W^{0.75}$ for mature tropical grasses to 100 g/kg$W^{0.75}$ for

immature temperate ones. Basically, three major factors namely the animal itself, plant and environment may affect voluntary feed intake.

2.1.2.1 Animal factors affecting voluntary feed intake

Animal factors such as age, breed, sex, physiological state (growth, pregnancy disease and lactation) and environmental factors such as temperature and humidity influence the ingestive capacity of a particular animal. Feed intake was observed to increase during lactation and in young animals during the last phase of lactation (Langlands,1968). This was attributed to the high basal metabolism and maintenance energy requirements at these physiological states. Generally, when feed supply is not limiting, animals will stop eating when they have reached their physical capacity or their requirements met (Kearl, 1982). Therefore, in designing animal experiments to evaluate different technologies for promoting voluntary DMI of low quality roughages, one ought to consider such basic animal differences, which may affect the anticipated response to treatment by the animals. Similarly, in practical animal nutrition, knowledge of these animal differences will influence management decisions on whether to use techniques for increasing DMI or opt for more concentrated rations in order to meet the animal's nutrient requirements by intake.

2.1.2.2 Plant factors affecting voluntary feed intake

It has been observed that, as forages mature, their proportion of fibre increases while that of protein and non-structural carbohydrates decreases. These changes result into reduced intake and digestibility of the forages (Van Soest, 1965). Van Soest (1994),

suggested that total cell wall contents (NDF) may negatively affect the intake of a poor quality roughage. Freer (1981) reviewed the mechanisms regulating intake of low quality roughage and concluded that their intake is limited by the passage rate of the digesta through the reticulo-rumen. This also depends on rumen volume and the rate of disappearance of digesta by microbial digestion and onward passage of undigested material (McDonald *et al.*, 1995).

Fibrous feeds like stovers and other poor quality roughages are associated with slow physical and enzymatic breakdown, which in turn slow down the animal's rate of intake of new feed (Ketelaars and Tolcamp 1992; Oliveros *et al.*, 1993). It follows, therefore, that the more digestible the food is, the faster it is removed from the rumen resulting in increased intake. The authors had also noted that, more digestible oat hay was consumed in larger quantity than a similar hay of lower digestibility (McDonald *et al.*, 1995). The difference is most likely due to their difference in passage rate resulting from their differences in digestibilities.

Physical differences between forage species and forage parts are other plant factors known to influence intake. Leguminous forages, for example, are consumed more than grasses of similar digestibility (Crampton, 1957; Cited by Malamsha, 1999). It has also been observed that, leaves in grasses and legumes are eaten in greater quantities than stems (Minson, 1982; Larbi *et al.*, 1991). The higher intake of leaf fraction was found to be associated with the their shorter retention time in the rumen compared with the stem fraction which have relatively more lignified cell walls.

Other plant factors such as the physical state (chopped or in long form, ground or pelleted) at which the feed is offered to the animals may have an influence on voluntary feed intake. Physical processing such as grinding or pelleting have been reported to increase voluntary feed intake (Schneider and Flatt 1975) due to faster passage rates through the rumen thus permitting more forage to be consumed (Laredo and Minson, 1975).

2.1.2.3 Environmental factors affecting voluntary feed intake

DMI is negatively correlated with high ambient temperature and humidity. As can be summarised from reports by different workers on different classes of animals (Johnson *et al.*, 1963; Shafie *et al.*, 1994), animals will usually increase their DMI under cold conditions so as to ingest enough energy to keep their bodies warm, where as high ambient temperatures will depress their voluntary feed intake. The tendency for animals to eat less when ambient temperature increases, can partly be a mechanism to reduce their heat load by avoiding the heat increment associated with the feeding exercise (heat increment of feed), and partly a result of lesser requirement for energy the animal has in a hot weather. It may, therefore, be necessary to adopt different strategies for improving voluntary intake of forages by ruminants in different seasons.

2.2 Methods for improving the nutritive value of low quality roughages

The utilization of fibrous crop residues and other low quality roughages by animals is limited by low intake of digestible energy (Fick *et al.*,1973; Dixon, 1985) as well

as easily available N source for rumen micro organisms (Moir, 1963). Increasing the digestible energy and protein intake by animals consuming fibrous diets is one alternative for improving their utilization to which end, different practices exist.

2.2.1 The use of concentrate supplements

The utilization of low quality roughages can be improved by supplementing them with highly digestible feedstuffs such as concentrates, which are low in fibre and high in readily fermentable carbohydrates. Ngwa and Tawah (1992) observed significantly higher DMI in sheep on rice straws supplemented with cotton seed cake than their unsupplemented counterparts. Similar findings were reported by Wanyoike *et al.* (1989) who observed higher total DMI (g d^{-1}) of wheat straw in sheep receiving cotton seed cake (CSC) which also increased as the level of inclusion of CSC increased. The increase in intake of straw could be due to improvement in nutritive value and palatability of the straw. Although energy, and not protein, is usually the limiting factor to animal production in temperate regions (Holmes, 1951; Crampton, 1957) cited by (Devendra, 1986), protein is the major clearly limiting factor in many parts of the world (Moir, 1963). But, in the tropics, both factors are limiting and seriously impair animal performance. Any efforts to improve the nutrition of ruminants on low quality roughage through supplementation, should therefore, consider both energy and protein requirements of the animals in question making sure that the critical energy and protein levels are met.

With the exception of non-protein nitrogen (NPN), all protein supplements provide the body with energy, particularly in situations where glucose availability limits metabolism (Butterworth, 1985). Balanced supplements (in terms of energy, protein and minerals) are more effective in improving the nutritive value of low quality roughages than either starch or protein-rich supplements alone. Crabtree and Williams (1971) observed that, concentrates of plant origin (from cereals and protein-rich oil cakes are good sources of additional energy and protein for roughage eaten *ad libitum*. Other supplements of plant origin include seed cakes like those of sunflower, cotton, legume seeds, hominy meal and molasses.

2.2.2 The role of protein supplements in ruminant nutrition

2.2.2.1 Effect of protein supplementation on feed intake

There is ample evidence to show that voluntary intake of roughages by ruminants is related to the rate of passage of the digesta through the reticulo-rumen (Balch and Campling, 1962). However, it has been demonstrated that, voluntary intake of roughages by ruminants is closely related to their N content (Zuckler and Steger, 1975; McGregory, 1979). The authors noted that feed intake tends to increase with increasing level of protein supplementation, but beyond a particular level, this increase in feed intake is less spectacular. There is, therefore, an optimum level of dietary protein above which there is little or no response in feed intake with increasing levels of protein in the diet. It has been demonstrated by several workers (Weston, 1967; Ammerman *et al.*,1972; Forbes, 1986; Preston and Leng, 1987) that, dietary nitrogen either as natural protein or as NPN can effectively improve the

utilization of low quality roughages. The effect of dietary protein supplementation on feed intake is possibly due to its influence on the digestive process in the rumen (Satter and Roffler, 1977). Protein supplements increase the supply of N to the rumen micro-organisms which increases their population and efficiency (Schneider and Flatt, 1975). This in turn enhances the rate of breakdown of the digesta resulting into a higher passage rate and increased feed intake (Campling, *et al.*, 1962). Weston (1971) and Egan (1977) suggested that increased feed intake in animals fed low quality roughage has been a result of increasing the supply of amino acid to the tissues.

Improved DMI through dietary protein supplementation is also brought about by the increased tissue accretion and other physiological functions resulting from increased supply of protein, which is an essential nutrient. Different protein sources have been used as supplements with variable responses. This variability may be due to the protein level of the basal ration. Hennessy and Williamson (1981), studied the effect of different dietary protein sources on the intake of low quality roughages by cattle. The authors supplemented a poor quality hay with cotton-seed meal and urea-molasses supplements and observed an increased feed intake with the cotton-seed meal supplement but not with the urea-molasses supplement. The authors attributed the positive response on feed intake with the cotton-seed meal supplement to the supply of amino acids from the undegraded cotton-seed meal protein which in turn improves the N status of the animals resulting into increased tissue accretion. This implies that, supplements based on natural protein sources are preferable to NPN

supplements although the latter are faster in supplying N to the rumen micro-organisms. Rational supplementation, therefore, should consider a mixture of natural protein sources and NPN compounds.

It has been reported (Milford and Minson, 1966; 1968) that, voluntary intake of roughages decreases when the dietary CP level falls below 7%. A CP content below 7% is supposedly inadequate to supply sufficient NH_3-N for maximum fibre digestion in the rumen. Andrews *et al.*, (1972) found that appetite was limited for diets whose CP contents were less than 8%. It is, therefore, necessary to improve first the CP concentration of the diet so as to increase its intake before embarking on other measures for improving DMI.

2.2.2.2 Effect of protein supplementation on apparent digestibility of feed

The utilization of available nutrients by ruminants is determined by firstly the amount of DMI, and secondly, the digestibility of the feed eaten. A third factor associated with the two above is the level of dietary protein (Devendra, 1986), which influences DMI through its effect on dry matter digestibility (DMD). Several workers have reported variable results of the effect of protein supplementation on feed digestibility coefficients. Some workers (Elliot and Topps, 1963; Iwuanyanwu, *et al.*, 1990; Mtenga, *et al.*, 1991) have reported improved digestibility of low quality roughage attributable to protein supplementation while others have reported that dietary CP level has no influence on DMD (Peterson, *et al.*, 1973; McGregor, 1979; Mero and Uden, 1998). Lyons *et al.*, (1970), working with cattle, observed a

significant increase in DMD as the CP content of the supplement increased from 10.3 to 33.3 percent on DM basis at restricted roughage intake. The same workers observed that at *ad libitum* roughage intake, protein supplementation had no significant effect on DMD. Possible explanation of these observations could be the higher roughage: concentrate ratio at *ad libitum* roughage feeding which would tend to lower the digestion coefficients.

It should be recalled that with poor quality roughages, high roughage: concentrate ratios result into low energy intakes. Mero and Uden (1998) after reviewing related literature on effect of dietary protein supplementation on DMD noted that, response in digestibility to increased CP intake much depends on the amount of energy potentially available by fermentation. Muhikambele *et al.*, (1993) documented that, although the level of protein in the diet influences intake, digestibility and overall feed utilisation efficiency in livestock, the effect of protein on performance depends on the balance of other nutrients particularly energy in the case of ruminants. In investigating the effect of protein supplementation on utilization of poor quality roughage therefore, it is important to meet the animals' requirement for energy. This can be done by including an energy concentrate like hominy meal in the supplement in appropriate amounts.

Increase in DMD as the CP content of the diet increases may also be attributed to the influence of dietary protein on the apparent digestibility of the other food fractions. There is much evidence from literature showing that dietary protein supplementation

results into increased apparent digestibility of CP in cattle (Lyons *et al.*, 1970; Lindsay and Davies, 1976), in sheep (Elliot and Topps, 1963; Adeneye and Oyenuga, 1976; Fonnesbeck *et al.*, 1981; Mafwere, 1989) and in goats (Kitalyi, 1982; Shoo, 1986). Lyons, *et al.* (1970) found that, protein supplementation resulted in significantly lower apparent digestibility coefficients for most feed components at *ad libitum* feeding.

It has also been reported that, increase in dietary protein content is associated with decreasing positive responses in apparent CP digestibility. This may be due to the assumed constant metabolic faecal N (MFN) which contributes a greater portion of the total N excretion at lower protein levels (Schneider and Flatt, 1975) Reynolds (1981), studied N metabolism in goats by varying daily N intake from 0.37 g per kg $W^{0.75}$ to 1.86 g per kg $W^{0.75}$ and observed that MFN accounted for about 46 and 18% of the total N excretion for the low and high N diets, respectively. The apparent digestibility of N in the cited study was 19.5 and 71.6% for the low and high N diet, respectively. CP digestibility in the feed increased rapidly (from about 2 to 9%) and thereafter increased slowly as the CP increased.

Increasing dietary protein level has also been associated with improved crude fibre (CF) digestibility (Schneider and Flatt, 1975; McGregory, 1979; Kitalyi, 1982). This may be due to the increased efficiency of rumen micro-organisms caused by the N from the protein supplement. Protein supplementation increases the efficiency of cellulolytic bacteria through the supply of some branched chain fatty acids, which are

necessary for the growth of the more active bacteria. (Schwartz and Gilchrist, 1976; cited by Kitalyi, 1982).

2.2.2.3 Effect of protein supplementation on growth rate

Growth can be defined as the increase of live weight and body size of an animal with time, that is associated with actual biological synthesis of body tissues (Mtenga, 1979; Kyomo, 1978). How long an animal takes to reach a certain target weight is usually determined by its growth rate within a particular period. Growth rate is affected by many factors some of which are animal related (breed, sex, type of birth) while others are environmental like nutrition, general management practices and diseases. Environmental factors have a major influence on the performance of animals and poor nutrition particularly low dietary protein intake, which is the major limiting factor especially in the tropics.

Grazing ruminants in the tropics usually experience poor growth rates especially during the dry season (Spedding (1970). Stobbs (1979; cited by Mafwere, 1989) has suggested that the protein content of the forage consumed is the limiting factor. When animals under these conditions were supplemented with small amounts of dietary protein, increased growth rates were observed (Ørskov, 1970; Preston and Willis, 1970). Mtenga (1986) reported (from various experiments with goats in Morogoro) tremendous improvements in growth rate, feed conversion efficiency and carcass composition achieved by protein supplementation. Mtenga and Kitalyi (1985) cited by Mtenga (1986) observed a tendency for growth rate to increase with

increasing levels of protein in the supplement where by goats receiving supplements containing 21% CP were superior in growth by 178% to their unsupplemented counterparts and by 16% to goats receiving supplements containing 11 and 17% CP. The response to N supplementation on growth rate has also been variable depending on the source of protein used. With NPN, for example, when provided to ruminants feeding on poor quality roughage, performance was increased but to a lesser extent compared to good quality supplements containing natural proteins (Winks *et al.*, 1972).

The inherent differences like amino acid profile and their balance between different natural sources of supplementary protein may equally cause different responses in terms of growth rates in animals fed low quality roughages. Leng *et al.*, (1977) supplemented animals on low quality pasture with urea and observed increased intakes of the basal feed but with little response in growth rates. Similar findings were reported by Smith *et al.*, (1980), after comparing the performances of young cattle on poor quality roughage receiving supplemental N from different sources. In the cited study urea supplemented diets supported lower growth rates than fish meal-supplemented diets. The observed differing effects of the different sources of N can be explained by the advantage natural protein sources have over NPN compounds. With natural protein supplements the animal may get some amount of protein that is not degradable in the rumen (by-pass protein) thus supplying the animal with some amino acids that rumen bacteria, can not synthesize. Animals supplemented with natural protein sources also obtain energy from the same source, which may improve

their dietary energy: protein ratio, which in turn improves protein utilization. This is not the case with NPNs especially when they are not combined with readily available carbohydrates.

Differences in digestible energy content of different protein supplements may be responsible for different responses in animals supplemented with the same level of dietary protein. The combining effect of energy and protein intakes has been well discussed by Mtenga (1986) based on research findings on feeding experiments with goats in Tanzania. As mentioned earlier, both dietary protein and energy content are limiting in the tropics. Dietary protein for ruminants supplies the rumen micro-organisms with available N for synthesizing their body protein and to do so, they need a supply of energy from the feed. Response to protein supplementation therefore, may be limited by low dietary energy supply and protein energy supplementation should be the best approach.

Growth rate in meat animals is affected by many factors most of which are closely interrelated. It is therefore, difficult to separate the influence of one factor from other factors. It follows that the effect of dietary protein on feed in take will be reflected on the rate of gain. Generally, growth rate increases with increasing dietary protein level and can be observed to follow the trend described for feed intake. It has been reported from several studies on influence of dietary protein on growth rate (Kay and Mcdearmid, 1973) that, at high dietary protein levels the response decreases. In such studies using steers in three live weight ranges there were no further increase in live

weight gain over 250 kg live weight when the CP content of the diet was more than 11.5% DM. Similar findings were also reported by Ørskov *et al.* (1971) with sheep. The authors observed no further increase in live weight gain of sheep (35 kg live weight) when the CP content of the diet was more than 11% DM. Offering very high levels of protein concentrate to ruminants is wasteful and may even result in decreased growth rate and other metabolic disorders associated with low-fibre-high-protein diets.

2.2.2.4 Effect of protein supplementation on dressing percentage

In meat production, most measures of efficiency are related to the final live weight just before slaughter (slaughter weight). The ratio of hot or cold carcass weight to slaughter weight (dressing percentage) is therefore an important trait. Dressing percentage (DP), is mostly determined by the type of diet (Berg and Butterfield, 1976). Robinson and Forbes (1970) reported on the effect of dietary protein on DP. The authors had fed weaned lambs with rations ranging from 7.3 to 23.06% CP concentration in DM and observed an increase in DP from 49.0 to 52.4% at the lowest and highest dietary CP levels respectively. Nyaki (1981) reported that, DP of lambs tends to increase with improved nutrition. Kitalyi (1982) also observed significant increase in the DP of goats (31.3 to 39.0%) when dietary protein level varied from 6.5 to 20.8% CP in DM. The influence of dietary protein supplementation on DP may be through its effect on the live weight gain composition. Non-carcass components (lung, heart, and gut) are least affected by

plane of nutrition. The resulting high growth rate with increasing dietary protein supplementation may therefore, be due to high gains of carcass tissues.

Gut fill is another factor that can affect DP (Stobbo, 1964). Depending on nutritional regime, the gut contents can account for up to 30% of live weight and in adult animals, this would result in large difference in DP. ARC (1980) reported that lower gut fills are associated with high intake of low fibre rations, which are usually of high CP content. Animals on high protein diets have lower gut-fills as a proportion of their live weights and hence higher DPs. This argument supports the findings of Butterfield, *et al.* (1971) who observed high DPs with milk fed calves compared to their non-milk fed counterparts. Similar findings, have been reported by Kitalyi (1982). Hence, by improving roughage DMD one may concomitantly reduce gut fill and increase DP.

2.2.2.5 Effect of protein supplementation on carcass composition

Dressing percentage is important as an estimator of carcass yield from a given slaughter weight. However, more important are the proportions of the major carcass tissues (lean, bone and fat). The distribution of these tissues, largely determines the carcass value. In most developed countries, the proportion of these tissues and their distribution is of much concern to both producers and consumers (Berg and Butterfield, 1976), but for developing countries where some non-carcass components are also consumed, total yield of the edible part of the animal may be more relevant (Mtenga, 1979).

Protein is a major nutrient and its deficiency in the ration influences protein and other components of the body. Dietary protein supplementation has been reported to influence the physical and chemical body composition (Berg and Butterfield, 1976). Norton, *et al.* (1970) fed young lambs in different groups rations containing different protein (CP) levels (12, 28.5 and 45.5% of DM) and observed a marked increase in body protein between lambs on 12% rations and the rest. The difference between lambs on 28.5 and 45.5% CP diets was small. In the same study, a marked increase in the level of carcass fat for lambs on the 12% CP ration was observed. Those on 28.5 and 45.5% CP rations were only slightly different. Andrews and Ørskov (1970), with heavier lambs, observed more fat deposited relative to live weight in lambs on lower protein rations (10 and 12.5%) than those on 15% CP or more. Kitalyi (1982) investigating the effect of dietary protein level on performance of goats, observed significant differences in total side lean and fat between goats receiving no protein supplement and those receiving 200 g air-dry supplements containing 11.4, 17.2 and 20.8 % CP. Again there were no significant differences between goats on 17.2 and those on 20.8% CP containing supplements. From the reviewed research findings it is clear that protein supplementation for ruminants should aim at filling the gap between the basal ration's CP content and the critical CP content for optimum rumen microbial functioning.

Efficient meat production requires decreased rate of tissue accretion and an increased rate of growth of skeletal muscle. This is so because, efficiency of feed utilisation for carcass gain much depends on the partition of feed above maintenance between

protein synthesis and fat deposition. Relative to muscles, fat is a more expensive tissue to deposit in terms of energy requirement. It requires more than twice as much energy, to deposit a unit weight of body fat as the synthesis of an equal weight of muscle. Many workers have reported that, high-energy diets will generally favour the production of fat carcasses than low-energy diets (Waldman, *et al.*, 1971; Bond *et al.*, 1972; Utley *et al.*, 1975 and Woody *et al.*, 1983). Similarly McCarthy *et al.* (1985) observed that cattle receiving high-energy diets deposited 13.7 and 39.9% of the empty body weight (EBW) gain as protein and fat respectively, whereas their counterparts receiving low energy diet deposited 15% protein and 31.7% fat per unit of EBW gain. It is apparent that, for higher production efficiency in ruminant livestock, there is an optimum requirement for both rumen degradable and undegradable protein for efficient supply of amino acid required by the tissues (ARC, 1980).

2.2.2.6 Effect of protein supplementation on nitrogen utilisation

In animals, the main routes of excretion of nitrogenous metabolites of body tissue are usually urine and faeces. To make up for the endogenous and exogenous N losses in urine and faeces respectively, the animal requires constant supplies of dietary N. The difference between dietary N and total N excreted is the N balance of particular animal and may be positive or negative depending on the dietary N supply. Nitrogen retention (g/ day) has been found to increase with increasing level of dietary N (Akinsoyinu, *et* al., 1975; Reynolds, 1981; Kitalyi, 1982; Shoo, 1986; Mafwere, 1989). Increases in N-intake resulted in decrease in N retention expressed as

percentage of N digested (Mafwere, 1989). The author also observed increased urinary N at higher N-intakes. This is usually the case with animals on poor-quality roughage and protein rich concentrates due to low availability of energy in such diets (Elliott and Topps, 1963) cited by Mafwere (1989). As observed by Tagari *et al.* (1964) high levels of dietary protein lead to high level of urinary N as urea. This is mainly due to the fact that, with high dietary N levels, the breakdown of protein usually exceeds microbial protein synthesis resulting in high levels of ammonia in the rumen, which is absorbed into the blood and carried to the liver and finally excreted in urine. Efficient dietary N utilization therefore, should be expected with low to moderate levels of protein supplementation than with higher levels. Combined protein and energy supplementation will usually lead to higher N utilization efficiency.

2.3 Multipurpose trees and shrubs (MPTs) as livestock feeds

Trees and shrubs play a significant role as livestock feeds in various farming systems of tropical Africa (Atta-Krah, 1989; cited by Goromela, 1996), in Asia (Nguyen, 1999) and in the Philipines (Trung, 1990) among others in tropical regions. The greatest value of MPTs lies in their role as diet supplements in the form of dietary nitrogen, energy, minerals and vitamins (Dzowela *et al.*, 1997). In Tanzania, they are particularly important in arid and semi-arid regions like those of central Tanzania where they are used to supplement low quality roughage in the dry season (Shayo, 1998). However, Otsyina and Mckell (1985) noted that browse species (a valuable resource) are still under-utilised and ways to increase their number and quality are

still a problem in Africa. Efforts to optimise the use of MPTs to improve dry season feeding are more important now than ever before due to increasing demand for animal products and high costs of conventional protein supplements.

Many fodder tree species have been screened in E. Africa for use as feed resource for ruminant protein supplements. Some assessed genera include *Grevilea robusta, Cordia holstii, Dracaena afromontana,* and *Albizia sp (*Shem, 1993). Others, are *Cajanus, Calliandra, Crotalaria, Gliricidia, Leucaena, Manihot, Magaritaria, Mimosa, Morus, Sesbania, Tithonia,* and *Triumfetta* (Roothaert and Paterson, 1997; Shayo, 1998; Saifalyazal, 1998). Temu, *et al.* (1998) mentioned *Fluoegea virosa* and *Albizia anthelmintica* as potential MPT feeds for ruminants.

2.3.1 Effect of supplementation with MPTs on DMI and growth rate

Different studies have been conducted to evaluate the potential of different MPTs to support sustainable livestock production and encouraging results have been reported. Studies on *Leucaena* as a protein supplement to ruminants on poor quality roughage have shown an improved DMI of the basal ration. *Leucaena* offers the slowly degradable protein, which increases performance by increasing the proportion of undegradable protein and by allowing NH_3 to be released at a rate commensurate with the rate of roughage degradation (Osuji *et al.,* 1993; Glen, 1995). Goromela (1996) reported increased milk yield and kid weight gains by dual-purpose goats fed low quality hay when supplemented with dried leaves of *Grewia similis.* There is a paucity of information on how forage supplements affect animal response (Mosi and

Butterworth, 1985; Said and Tolera, 1993). Some authors like Nherera *et al.* (1998) noted that high N content of most MPTs was positively correlated with OMI and DMD in ruminants consuming them. The authors suggested that tree fodder supplements alleviate N deficiency thereby improving the rate of degradation of the basal diet, passage rate and hence increasing feed intake. In Zimbabwe, Ndlovu and Sibanda (1996) reported growth rates as high as 67 g/day in goat kids offered 300-400 g/day of *Accacia tortilis* pods and concluded that, *A. tortilis* pods are suitable supplements for penned kids. Jones (1994) and Norton (1994) concluded from published findings on MPTs in Australia that, *Leucaena* as a protein supplement for dry and cool seasons can substantially improve live weight gain up to double that from pure pastures at inclusion levels of 10 to 33% of DMI or 0.3 to 1.1 % of LBW.

Sesbania sp have also been shown to compare well with cotton seed cake in terms of milk yield and live weight changes when fed to lactating crossbred cows on elephant grass basal diet (ILCA, 1992). Muinga *et al.* (1992) observed increased total DMI, milk yield and reduced live weight loss when lactating crossbred cows were supplemented with graded leaves of *Leucaena*. However, Khalili and Varvikko (1992) observed a linear decline in total DMI and milk yield when a concentrate mix was substituted with wilted *Sesbania* forage. The authors concluded that wilted *Sesbania* forage can not replace a concentrate supplement based on agricultural by products without reducing milk yield. Tanner, *et* al. (1990) also reported failure to achieve target response when forage supplements were used. This contradiction

could possibly be due to low energy consumption by the animals supplemented with *Sesbania* in the study by Khalili and Varvikko (1992).

2.3.2 Effect of MPTs supplements on dry matter digestibility

Forbes (1995) observed increased DMI and digestibility of low quality forages supplemented with tree fodder. Ademosun *et al.* (1988) cited by Saifalyazal (1998) had reported similar results in goats for grass diets supplemented with *Leucaena* and *Gliricidia*. Supplementation of basal diets with MPTs increases essential nutrients available to rumen microbes and rate of passage. They affect protozoal population, milk yield and growth in cattle. Browse plants contain proteins, minerals and vitamins essential for the growth of microbes degrading feedstuffs in the rumen prior to subsequent gastric and intestinal digestion by the host. In the dry period, browses are richer than grasses in CP (Le Houerou, 1980) and their CF content tends to be lower than that of grasses and usually ranges between 20 - 40% (Pellew,1980). This agrees well with the assertion by Msuya (1997), that browse plants are highest in proteins and lowest in cellulose. Due to their low CF content compared to dry grasses, browses appear to be richer than dry grasses in energy.

2.3.3 Anti-nutritive factors in MPTs

The potential of many MPTs as sources of feed for ruminants is usually limited by their content of anti-nutritive factors like mimosine in *Leucaena*, and tannins, common in *Calliandra, Gliricidia* and *Leucaena* (Norton, 1994). Various phenolic compounds have been reported to exist in the bark of cultivated mulberry trees with

significant effect on arachidonate metabolism in rat platelet homogenates (Kimura *et al.,* 1986). Reed *et al.* (1990), reported that, some MPTs may have ant-nutritional factors some of which are toxic to animals. However, there is limited information on the effect of these compounds on livestock performance. Many studies have been reported on anti-nutritive factors in forage tree legumes (Jones and Lowry., 1990; Jones, 1994; Norton, 1994). Some of the reported works were aimed at identifying the anti-nutritional or toxic compounds in the forages, their mode of action once ingested, tolerance inclusion levels if any, as well as other ways of rendering them less or not harmful to livestock. Jones (1994) reported with special reference to *Leucaena sp* that most anti-nutritional factors are secondary metabolites with chemical structures varying across and within genera. These compounds are more wide spread in tropical than temperate forages especially in the woody than herbaceous genera (Jones and Lowry, 1990), and may be toxic, or confer unpalatability and reduce their intake by grazing herbivores (Jones, 1994; Norton, 1994).

Ruminants may be less affected by most anti-nutritive factors due to the ability of some rumen micro-organisms and the liver to degrade these compounds rendering them less harmful to the animal (Norton, 1994). Jones and Lowry (1984) cited a case of mimosine degrading microbes found in rumens of goats in Hawaii whereby infusing Australia goats with rumen liquor from the former, immediately enabled them to consume large quantities of leucaena without any harm. This was later supported by Morris and Toit (1996). More over, Acamovic and D'Mello (1981) reported that addition of metal ions and polyethylene glycol (PEG) to diets

containing leucaena eliminates or substantially reduces the mimosine toxicity. A similar effect was observed when Ferrous sulphate was used at the rate of 1 – 2% dietary level. Mimosine has also been reported to be sensitive to heat (D'Mellow and Acamovic, 1989) whereby application of heat during processing effectively inactivated a number of anti-nutritive factors in leucaena. Other possible solutions to the problem of anti-nutritive factors in MPTs include collecting and screening germplasms of species with high CP and low levels of anti-nutritional factors (Jones and Lowry 1984), the use of scientific methods to identify and in some cases remove such anti nutritional factors or limiting the inclusion level of MPTs within their respective safe ranges.

2.4 *Morus alba* as a livestock feed

2.4.1 Description and Distribution of *M. alba*

Morus alba, a deep rooted (Tap root system), broad leaved, deciduous perennial tree/shrub, belongs to the family moraceae. The spread of the roots in the soil is much influenced by pruning, soil conditions and management practices like, manure application and cultivation (Zheng, *et al.,* 1988) According to Le Houerou (1980; Zheng, *et al.*, 1988) *M. alba* is widespread in the Mediterranean, semi-arid to humid zones where the forage is traditionally used for feeding silkworms (*Bombixy mori).* It has a wide ecological adaptation and disease resistance (Tikader *et al.,* 1993; Mbuya *et al.*, 1994). It is found in Mgeta highlands in Morogoro region where it is widely used as fodder for goats (Jähnig, 1996). It has been reported to thrive well in East African highlands and widely planted in Arusha, Kilimanjaro (Mbuya *et al.,* 1994) and sparsely

in semi-arid areas of central Tanzania (Shayo, 1997). It also does well in other places of the world like China where it has been used as an anti-phlogistic, diuretic, expectorant and laxative in traditional medicine (Kimura *et al.*, 1986). Corresponding findings were reported by Wang *et al.* (1989) in which extracts from mulberry leaves were effectively used as a drug of choice in treatment of elephantiasis with no obvious side effects. In a pharmacological study, the extract of the root bark was reported to show marked hypotensive effects (Suzuki, 1941; cited by Kimura *et al.*, 1986). Mulberry trees may also be grown around homesteads for shade, fruits and to a lesser extent as vegetables and fuel wood (Shayo, 1997).

2.4.2 Nutritive value of *Morus alba*

The potential of Mulberry trees as a source of feed for ruminants has been recently recognised by many researchers as reviewed by Shayo (1997). The leaves have high CP and Ash content (Table 2.1) and are highly digestible. Based on CP and digestibility, Mulberry leaves compare very well with other MPTs like *Leucaena* and *Gliricidia* species. *M. alba* has even been reported to be comparable to the best feeds such as alfa alfa (Le Houerou, 1980). Makkar, *et al.* (1989; cited by Shayo, 1997) noted that mulberry is classed as a low tannin fodder and so far there is limited or no documented information on its content of poisonous compounds to livestock.

2.4.3 Chemical composition of *M. alba*

Chemical composition as an important factor used to express the nutritive value of any feed staff is influenced by both intrinsic (inherent, stage of growth, plant part), and

extrinsic (season of the year, climatic) factors and may vary between and within species. This is supported by the findings of Kimambo *et al.* (1992) who reported a variation of protein for various multipurpose trees and shrubs with season of the year. The authors reported a range of 22.5 to 29.4% CP in wet season and 19.4 to 28.8% CP in the dry season. This conforms with the range of 18-24% CP for *M. alba* as reported by Le Houerou, (1980). Crude protein values for *M. alba* reported by earlier wokers, (Desukh *et al.*, 1993; Jähnig, 1996; Shayo, 1997; and Msuya, 1997) also fall within that range. Lower values, however, in the range of 8 - 11% were reported by Casoli *et al.* (1986) for *M. alba* collected at two stages of vegetative cycles. Table 2.1 shows reported varying chemical composition values of *M. alba*.

Table 2.1: Variations in reported chemical composition of *Morus alba*

	DM	(% DM)								
PART		CP	CF	NDF	ADF	ADL	NFE	ASH	EE	SOURCE
Sun dried leaf	88	18.5	7.8	_	_	_	56.4	12.6	4.7	*
Leaf		15	15.3				48	14.3	7.4	1
Freeze dried leaf	93.9	22.2	6.9	_	_	_	43.6	11.3	9.9	*
Leaf		14.5	10.2	_	_	_	54.0	14.6	6.8	2
Leaf	89.34	20.84	_	32.83	19.54	_	_	14.21	2.35	3
Leaf	33.6	22.1	5.9	36.35	31.52	_	45.7	13.4	3.9	*
Leaf	_	24.8	10.7	_	_	_	46.6	13.1	_	*
Leaf	_	18.6	_	24.6	20.8	8.1	_	14.3	_	4
Bark	_	7.8	_	46.8	36.9	7.1	_	6.1	_	4
_	38	15	11.8	_	_	_	_	15.5	5.1	5
Bark	_	11	10	_	_	_	_	13.9	5.9	6
Leaves	93.87	18.6	23.95	_	_	_	_	7.65	9.25	7

*Cited by Saifalyazal (1998), 1= Göhl (1982), 2 = Prasad and Reddy (1991), 3 = Malamsha (1999), 4 = Shayo (1998), 5 = Singh *et al.* (1984), 6 = Casoli *et al.* (1986), 7 = Msuya (1997).

2.4.4 Intake and digestibility of *Morus alba*

Based on reported research findings, *M. alba* can be classed as a highly palatable browse for sheep and goats. Prasad and Reddy (1991) fed Mulberry leaves to sheep and

goats and reported a DM intake of 2.74 and 3.55 kg/100 kg body weight in goats and sheep respectively. The intakes were 78 and 146% of the animals' requirements, implying that mulberry leaves were highly palatable and more so to sheep than goats. In trials with weather sheep, Casoli *et al.* (1986) reported the digestibility of 62.1, 72.4, 62.9, 64.2 and 82.1 for DM, organic matter, crude protein, fibre and nitrogen-free extracts respectively. Digestible energy and metabolizable energy reported by these authors were 11.2 and 9.1 MJ, respectively. Positive N balance has been recorded in sheep (Prasad and Reddy, 1991), and according to the authors, the higher N-balance might have been accentuated by higher DM intake and digestibility of CP. Possibly, the rumen also received matching supply of energy by way of higher CF digestibility to synthesize their body protein from the absorbed N. Further information obtained by Prasad and Reddy (1991) showed that, *M. alba* leaves contain 10.7 and 12.2% DCP and 71.3 and 70.0% TDN for goats and sheep, respectively. The higher values of DCP in these animals give a good reflection for higher CP digestibility. These findings agree with earlier assertion of Shen *et al.* (1978) that *M. alba* leaves are comparable to conventional leguminous fodders like cow pea in terms of chemical composition, digestibility and nutritive value.

In vitro DM digestibility of Mulberry leaves is about 82.1% (Shayo, 1998) while its metabolisable energy content is about 11.5 MJ/kg DM. This was confirmed by Malamsha, *et al.* (1999) who reported 12.43 MJ/kg DM. Having studied the chemical composition and nutritive value of different morphological parts of mulberry (leaf, bark and stem) as well as intake and *in vivo* DM digestibility of the leaves as a sole

diet for goats, Shayo and Udén (1999) concluded that *Morus alba* could be used as a sole feed to support growth in small ruminants because of its high DMI and digestibility.

2.4.5 Effect of *M. alba* supplementation on the performance goats

Few studies have been conducted in Tanzania on the use of *M. alba* as a protein supplement to goats with encouraging results. Examples include the study of Saifalyazal (1998) who supplemented *Cenchrus ciliaris* hay with *M. alba* leaves and observed increased total DMI by 115g/day/animal by goats. The goats also showed increase DMD. Malamsha *et al.* (1999) investigating the effect of *M. alba* as a supplement to *Pennisetum purpureum* on growth of dairy goat kids, observed a general increase in growth rates of the growing goats from 25.71 to 62.69 g/day with increasing levels of *M. alba* in the rations. However, similar studies need to be conducted under different experimental conditions before drawing general conclusions on the usefulness of the plant as a protein supplement. None of the reported studies has compared the shrub with any conventional protein supplement or investigated its effects if any on carcass composition or N utilization efficiency.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location and climate of the study area

The experiments were conducted at the Livestock Production Research Institute, Mpwapwa district in central Tanzania. The institute is located in the semi-arid agro-ecological zone of central Tanzania, situated approximately $36^{0}32'$ E longitude, and $6^{0}21'$S latitude, at an elevation of 1100 m above sea level. It experiences a dry savannah type of climate characterised by a long dry season between May and November and short wet season from December to April with an average annual rainfall of 650 mm per year. Feedstuffs for the experiments were collected between October and November towards the end of a long dry period but the experiments were conducted between February and May the following year.

3.2 Experiment I:

Effect of substituting sunflower seed cake with mulberry dry leaves on feed intake, growth rate and slaughter characteristics of blended goats fed with poor quality roughage.

3.2.1 Experimental design and treatments

A two by four factorial design was used whereby a total of 32 blended growing goats, some of which appear on Plate 1, (16 males and 16 females) were randomly put into 4 treatment groups balanced by sex and assigned to four treatment diets in individual pens as seen on Plate 2. The treatment diets were sunflower seed cake (SSC), *Morus alba* dry leaves (MDL) and a mixture of the two (SSC + MDL) as CP

supplements. MDL substituted SSC as a dietary source of DCP such that, MDL replaced 0, 50, 75 and 100% SSC by DCP contribution in the 4 treatment diets (T_1, T_2 T_3 and T_4) respectively. The amount of supplementary ration supplied to each animal was estimated to meet its DCP requirement for maintenance (based on its LBW) plus an allowance for 50g daily weight gain. On top of the treatment rations, each animal was provided with 10 and 2% of their estimated daily DMI as hominy meal and mineral mix respectively. It was assumed that each animal would consume about 4% of its LBW as DM daily. After every 2 weeks the respective amounts of treatment ration, Hominy meal and mineral mix offered (on DM basis) were adjusted to match the increase in LBW. Each animal was provided with *ad libitum* hay to allow for about 20% refusal and allowed free access to fresh drinking water daily.

3.2.2 Experimental animals

The animals were obtained from LPRI Mpwapwa, aged between 4 and 7 months and weighed 14.3±2.4 kg. It was initially intended to use animals of younger age (4 months) but unfortunately they were not available in sufficient numbers at the onset of the experiment. A three-week long preliminary period prior to the commencement of the feeding trial was allowed in order to accustom the animals to the diets. During this period, all animals were dewormed using Tramisal and sprayed weekly against ectoparasites with steladone. Spraying was repeated fortnightly but drenching was done only at the beginning of the study. The pens were cleaned and disinfected before introducing the animals.

Plate 1: Some of the blended goat kids used for the growth study

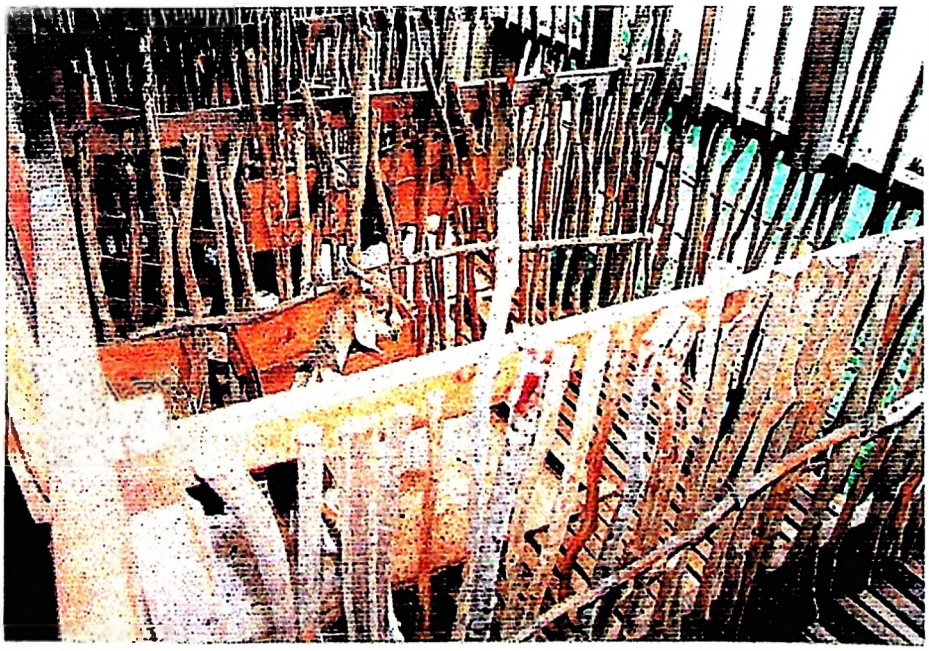

Plate 2: Growing blended goats feeding in individual pens

3.2.3 Diets and feeding allowances

The basal diet consisted of a mixture of *Cenchrus ciliaris, Heteropogon contortus* and *Brachiaria sp* hay harvested late in the dry season (October 1999) from established pastures of LPRI's Ilolo farm. The hay was chopped into 5 – 10 cm length in order to promote intake. The MDL, which were fed intact, were obtained by cutting Mulberry branches (Plate 3) and spreading them in a well ventilated house to dry. The dry leaves were then plucked off the branches after which they were heaped in a clean dry room ready for use (Plate 4). The Mulberry trees were established in 1994 and the material harvested for the experiment was a three-month-old re-growth. Hominy meal (HM) was purchased from local milling machines in Mpwapwa and the sunflower seed cake (SSC) purchased as a by-product from a local oil seed-pressing machine in Mpwapwa. The mineral mix and drugs were purchased from KV vet clinic in Morogoro. During the experiment, hay and MDL samples were collected weekly, oven dried and bulked for subsequent chemical analyses.

Throughout the preliminary and the 84 days long experimental periods, all animals were supplied with the pre-weighed respective treatment rations at 07:30 hours individually after removing all the hay refusals from previous days feeding from the feeders and the floor. Three hours later, hay was provided *ad libitum* (about 20% in excess of previous days intake). To avoid spoilage, hay was provided in two portions, first half at 10:30 and the second half at 15:00 hours. Sufficient fresh water was provided in 4 L plastic containers daily.

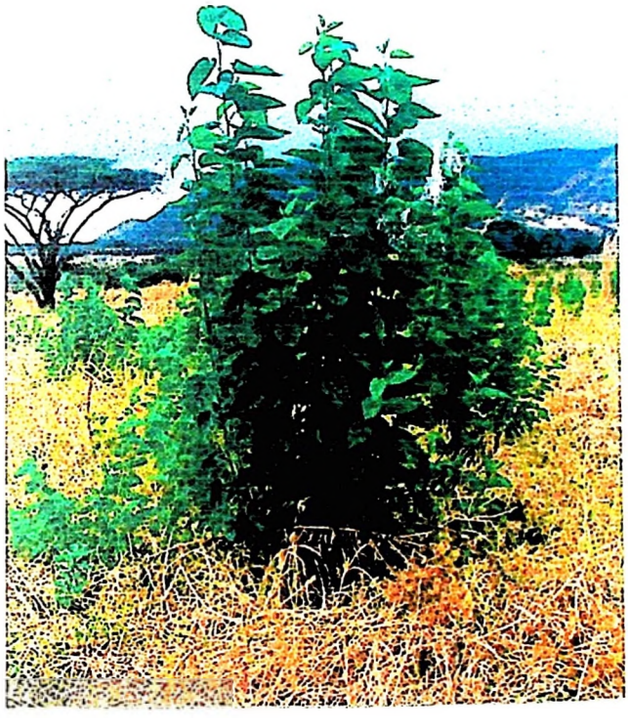

Plate 3: *Morus alba* in the field ready for harvesting. Note the background covered with dry grass, a common phenomenon in dry seasons

Plate 4: Dried *Morus alba* leaves ready for feeding

3.2.4 Feed intake and live weight recording

Daily hay intake was calculated as the difference between the total daily allowance and the weight of refusal measured on the next day. Every morning, all the refusals were removed from the feeders and weighed to the nearest 0.001 kg before feeding. Individual LW recording using a spring balance was done fortnightly in the morning before feeding and was recorded to the nearest 0.25 kg.

3.2.5 Slaughter and carcass analysis

3.2.5.1 Slaughtering procedure

At the end of the 84 days feeding period, 3 males from each treatment group were selected at random and slaughtered for analysis of carcass characteristics. The slaughter procedure adopted by Kyomo (1978) was used with minor modifications. The animals were not starved overnight and were weighed just before slaughter to obtain final LW at slaughter. They were not stunned but were bled by severing the carotid arteries and jugular veins on both sides of the neck using a sharp knife to cut through the neck between the occipital bone (*Os occipitale*) and the first cervical vertebra (atlas bone) separating the head from the trunk. Blood was collected in a 4 L plastic bucket and weighed immediately to the nearest 0.05 kg. The dressing procedure described by Kyomo (1978) was used.

The following non-carcass components were separated, weighed and recorded: Skin, head, feet, liver, testes + urinary bladder, heart + lungs + trachea, gut fat and the gut. The total gastrointestinal tract (GIT) was weighed when full and when empty and gut

fill content obtained by difference. The hot carcasses were then weighed on a spring balance and weight recorded to the nearest 0.05 kg.

3.2.5.2 Jointing and dissection

The carcasses were split into two halves using a special handsaw to cut along the vertebral column from the caudal vertebrae to the first cervical vertebra, exposing the spinal cord. The separate halves of each carcass were immersed in a special water bucket fitted with an overflow spout and the volume of the water displaced measured in a measuring cylinder. This was considered the volume of the respective carcass half and was recorded to the nearest 10 cm^3. The hot carcass weight over the weight of water it displaced gave its relative density. The left half of each carcass was put in a freezer and maintained frozen till the end of the 3 day long slaughtering period.

Starting with the first batch of carcasses and handling three per day, the following cuts were separated from the carcasses and dissected to determine the proportions of the major carcass components (lean, fat and bone). These were the hind and fore legs. The hind leg was separated from the rest of the carcass half by sawing through the hip bone at the head of femur and cutting across the thigh muscle ends. The fore leg was separated from the rest of the carcass by cutting the sternal muscles and then loosening the connective tissue between the ribs and the scapular and then cutting across the trapesian muscles. The two sample cuts (hind leg and fore leg) were weighed separately and then dissected into lean, fat and bone using scalpel blades

and sharp pointed knives. Lean, fat and bone from each cut were weighed separately and recorded as a percent of the total weight of the respective cut.

3.2.6 Chemical analyses

The samples of feeds offered and refusals collected were analysed for their CP, EE and Ash content according to AOAC (1990). NDF and ADF contents were determined according to Van Soest *et al.* (1991). IVDMD of the feeds offered were determined using a two-stage digestion technique (Tilley and Terry, 1963).

3.3 Experiment II:

Effect of substituting sunflower seed cake with mulberry dry leaves on diet digestibility by blended goats fed with poor quality roughage

3.3.1 Experimental design

Twelve blended male goats with an average LBW of 27.7±7.3 kg were randomly allotted to 4 treatment diets (three animals per treatment) and fed individually in digestibility cages. The treatment diets composition were as for experiment I and the animals were dewormed two weeks before the start of the experiment then allowed a preliminary period of 10 days for them to get used to the experimental protocols. This was followed by 7 days collection period. The cages and the animals were thoroughly cleaned at the beginning and end of the preliminary periods. During the preliminary period, all animals received a mixture of SSC, MDL and HF at 08:30 am and three hours later hay was provided in two portions to avoid spoilage and wastage. The amount of hay offered was adjusted daily for the first 5 days to allow not more than 5% refusal.

From the 7th day of the preliminary period, the animals were supplied with their respective treatment diets in amounts calculated from their assumed daily DMI based on their LBW as for experiment I. Simultaneously, the animals were also fitted with special harnesses for collecting the faeces. Urine voided daily was also collected and measured daily to estimate the amount of dilute H_2SO_4 (10%) that would be required for preserving the urine NH_3 during the collection period.

The animals were weighed at the end of the preliminary period and the 7 days collection period to get their initial and final LBW and recorded to the nearest 0.25 kg. All the faeces voided were removed from the harnesses every morning, weighed and recorded to the nearest 0.1 kg. Of the 24 hours faeces collected, 10% was kept for laboratory analyses and was kept frozen in polythene bags. Twenty-four hours urine for each animal was trapped in a special plastic container in which 50 mils of 10% dilute H_2SO_4 were added after every emptying. The volume of the urine produced was measured using a measuring cylinder and recorded to the nearest 0.5 mils. 10% of the total amount was put into plastic sample bottles and frozen for subsequent N determination. A plastic 1.0-mm sieve was used to trap any foreign materials that might have found their way into the containers.

After collecting the faeces and urine, all the refusals from the previous days feeding were removed from the feeders and the respective treatment diets offered at around 08:30 hours. Three hours later, half of the respective pre-weighed amount of hay was offered, the other half being offered at 15:30 hours. The hay was chopped down to

between 5 and 10 cm lengths to facilitate intake. The sequence for collecting faeces and urine as well as that of feeding was the same through out the experimental period starting with the same animal. Sufficient fresh drinking water was provided in 4 L plastic containers.

Two samples of the feeds offered were taken daily one of which was bulked to the end of the experiment, ground in a hammer mill with 1mm sieve, thoroughly mixed and sub sampled for subsequent chemical analyses. The other sample was dried in an oven at 105°C for DM content determination. The refusal for each animal was weighed and recorded to the nearest 0.001 kg and a representative samples from each pen were bulked and dried in an oven at 105°C for DM determination. The difference between the amount of hay offered and the refusal collected was assumed to be the amount consumed by the respective animal.

3.3.2 Chemical analyses

The samples of feeds offered, refusals collected and the faeces were analysed as described in section 3.2.6 above. Urine samples were analysed for CP content by standard laboratory procedures (AOAC, 1990).

3.4 Data analysis and presentation

General Linear Model (GLM) procedure of statistical analysis system (SAS, 1990) was used to analyse the data using initial body weight as a covariate to eliminate the influence of differences in live weight on response to treatments.

The following statistical model was used for analysing the data from the growth experiment:

$Yij = \mu + Ti + Bj + b(Xij - m) + Eijk$

Where: Yij = record of the animal of the ith sex assigned to the jth treatment

μ = Overall mean

Ti = Effect of the ith sex

Bj = Effect of the jth dietary treatment

b = Regression coefficient of Yij on Xij

Xij = Record of the covariate in the individual indicated by the subscripts

m = Overall mean of the covariate

Eijk = Random element specific to each individual

For the data on killing out characteristics and those from the digestibility experiment, the model was:

$Yij = \mu + Ti + b(Xij - m) + Eijk$

Where: Yij = record of the ith animal assigned to the jth treatment

μ = Overall mean

Tj = Effect of the jth treatment

b = Regression coefficient of Yij on Xij

Xij = Record of the covariate in the individual indicated by the subscripts

m = Overall mean of the covariate

Eij = Random element specific to each individual

CHAPTER FOUR

RESULTS

4.1 Growth Study

4.1.1 Health of Animals

One animal from treatment 4 died of pneumonia during the preliminary period. All remaining animals were immediately treated with 10% Oxy Tetracycline and recovered soon. Occasionally, few animals in T_1 and T_4 developed diarrhoea, which was arrested by administering Sulphadimidine orally. Two animals, one from T_3 and the other from T_4 got abscesses, which were surgically operated and Alamycine spray applied to the wounds. Both animals recovered without any marked feed intake depression.

Generally, most animals in T_1 looked weak with reduced feed intake that led to weight losses during the last 2 weeks of the growth study and 2 males were more seriously affected loosing up to 1.25 kg in total. The experiment had to be terminated one week earlier than the planned 90 days for fear of deaths and data from the 2 seriously affected animals were omitted in the statistical analyses for growth. Post-mortem examination of the slaughtered animals from T_1 never revealed any reasons that could explain the observed ill health.

4.1.2 Chemical composition and *In vitro* digestibility

Chemical composition and *in vitro* digestibility of the feeds used in this study are shown in Table 4.1. The hay used had low CP and EE content, and very high NDF and ADF contents. The *in vitro* digestibility of hay was also low. Expressed as a

percent of DM sunflower seed cake (SSC) had the highest CP concentration followed by mulberry dry leaves (MDL) and hominy meal (HM) while hay had the lowest. SSC had the least NDF and Ash concentrations and was highly digestible. MDL had the highest IVDMD, followed by HM, which had the least Ash concentration.

Table 4.1: Chemical composition and *in vitro* digestibility of the feedstuffs used

		DM	As % DM						
Feedstuff			**OM**	**CP**	**NDF**	**ADF**	**EE**	**ASH**	**IVDMD**
Hay		98.7	90.7	3.50	81.93	48.02	1.15	8.00	43.15
SSC		94.8	89.8	23.99	57.10	34.86	18.64	5.00	62.50
M. alba leaves		97.8	83.8	14.98	23.00	22.06	2.95	14.0	87.03
Hominy meal		92.4	87.6	10.65	47.24	8.81	14.22	4.80	71.95
Hay refusals	T_1	92.0	86.4	2.70	-	55.50	-	5.60	-
	T_2	91.7	86.5	2.20	-	54.30	-	5.20	-
	T_3	91.9	86.3	2.2	-	54.60	-	5.60	-
	T_4	91.9	86.1	2.5	-	53.30	-	5.80	-

4.1.3 Feed intake and growth performance of growing goats

Values for total feed and hay intakes, live weight gain (LWG) and feed conversion ratios (FCR) for each animal are shown in Appendix Table F1, while treatment mean intakes are summarised in Table 4.2. Fig 1 shows mean daily feed intake by goats in each treatment plotted against time (fortnightly). Inclusion of MDL in the supplements resulted in significantly ($P<0.05$) higher total DM, OM, CP, NDF and ADF intakes (g/day). However, animals in T_2, T_3 and T_4 were not significantly ($P>0.05$) different in total DM, OM, CP or NDF intakes although animals in T_3 tended to eat more than the rest. Total ADF intake was significantly ($P<0.05$) low for T_1 animals followed by T_4, T_2 and T_3 animals in that order but ADF intake in T_2 and T_3 animals were not significantly ($P>0.05$) different. The same tendency was

observed for hay DMI. In all treatment groups, males and females were comparable (P>0.05), with males tending to eat more than females.

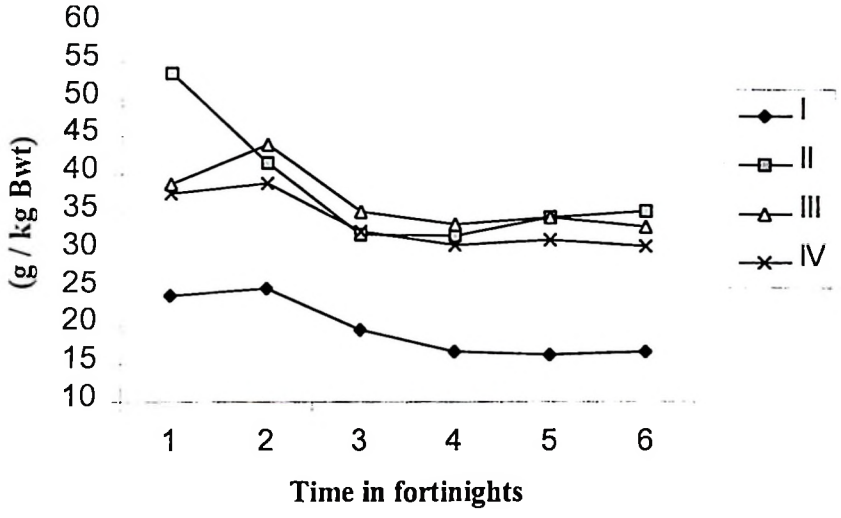

Figure 1: Effect of treatment rations on total DM intake by growing blended goats (g/ kg Bwt/ day)

Table 4.2: Voluntary daily feed intake (LS means ±SE) of growing goats in different treatments (g)

	T_1	T_2	T_3	T_4	F Value
DM	291.8±18.4^b	515.3±18.9^a	548.9±16.2^a	519.5±16^a	43.85***
OM	115.1±15.2^b	284.3±15.6^a	296.1±13.4^a	244.3±13.5^a	28.59***
CP	40.5±1.2^b	47.4±1.2^a	48.3±1.0^a	46.8±1.0^a	9.69***
NDF	138.2±13.7^b	326.4±14.1^a	358.5±12.1^a	338.6±12.2^a	58.70***
ADF	98.4±7.7^c	180.5±7.9^a	187.3±6.8^a	162.6±6.8^b	27.03***
HayDM	104.6±15.3^c	271.8±15.7^a	282.1±13.5^a	227.7±13.5^b	27.10***
ME (MJ)	2.6±0.2^c	5.3±0.2^a	5.4±0.17^a	4.5±0.2^b	45.42***

^{abc}Within a raw, means with different superscripts are significantly different (P<0.05)
***Means are highly significantly different (P<0.001). This applies to all subsequent tables

Mean initial and final live weights, growth rates, FCRs (g DMI/g LBW) and gains for individual treatments are presented in Table 4.3 while mean live weight changes as affected by treatments are presented by Fig 2. Individual growth performance data for the growing goats are presented in Appendix Table F1. The analysis of covariance revealed significant treatment effects on the rate of gain. Animals on T_1 had significantly ($P<0.05$) slower growth rates and utilized feed less efficiently than animals on the other treatments, which had small and insignificant ($P>0.05$) differences in FCR.

Table 4.3: Treatment Weight gain & FCR (LS means ±SE) of goats over 84 days

Body weight	T_1	T_2	T_3	T_4	F Value
Initial (kg)	15.63±1.46	10.44±4.02	12.94±2.62	13.69±2.93	-
Final (kg)	15.91±2.25	15.5±1.55	16.88±3.38	18.16±3.45	-
Total gain (kg)	2.5 ± 0.9^{b}	3.9 ± 0.7^{ab}	3.9 ± 0.6^{ab}	4.8 ± 0.6^{a}	2.6^{NS}
Daily gain (g)	29.8 ± 10.5^{b}	46.3 ± 8.1^{ab}	46.8 ± 7.1^{ab}	57.3 ± 7.2^{a}	2.6^{NS}
FCR	57.5 ± 10.5^{a}	11.9 ± 8.2^{b}	12.9 ± 7.1^{b}	12.5 ± 7.2^{b}	5.89^{**}

^{ab}Within a raw, means with different superscripts differ significantly ($P<0.05$)
**Means are highly significantly different ($P<0.01$), ^{NS}Means not significantly different ($P>0.05$). These apply to all subsequent tables.

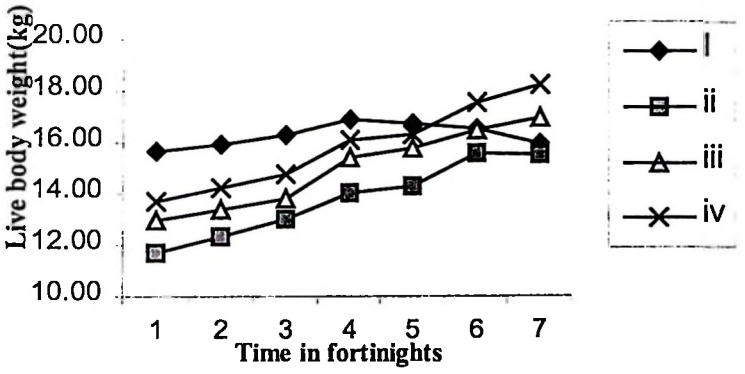

Figure 2: Effect of treatments on growth rates of goats (kg)

As in the case of feed intake there were no significant (P>0.05) differences between sexes for the studied parameters although males grew faster and utilized feed more efficiently than females.

4.1.4 Effect of treatment rations on the killing-out characteristics of goats

Table 4.4 shows the treatment mean values for slaughter weight (SW) empty body weight (EBW) hot carcass weight (HCW) and dressing percent. The individual values for these parameters are shown in Appendix Table F2. The analyses of variance to show the treatment effect on these characteristics are summarised in Appendix Tables B1-25. Treatment rations had significant (P<0.05) effects on the studied killing-out characteristics when expressed in absolute weights. When hot carcass weight was expressed as percent of empty body weight, dressing percentage increased from 49.2% for T_1 to 53.2% for T_2, thereafter decreased with increasing level of *M. alba* in the supplements but treatments were not statistically different (P>0.05). This was also the case when hot carcass weight was expressed as percent of live weight at slaughter, the lowest and highest values being 37.3 and 43.6 obtained from T_1 and T_2 animals respectively. Gut fill in absolute weights ranged from as low as 2.9 in T_1 and increased with the level of inclusion of MDL in the supplements to as high as 4.6 kg in T_4 animals and differed significantly (P<0.05) except for T_1 and T_2. However, when expressed as percent of slaughter weight no significant (P>0.05) treatment effects were observed for this parameter.

Table 4.4: Killing out characteristics (LS means ±SE) ±SE) of male goats

	T_1	T_2	T_3	T_4	F Value
Absolute weight (kg)					
SW	11.9±0.3^c	17.6±0.3^b	18.4±0.3^b	20.7±0.3^a	194.29***
EBW	9.0±0.4^c	14.4±0.5^b	14.5±0.4^b	16.1±0.4^a	47.19***
HCW	4.3±0.4^b	7.7±0.4^a	7.5±0.4^a	8.4±0.4^a	22.49***
Gut fill	2.9±0.2^c	3.2±0.2^c	3.9±0.2^b	4.6±0.2^a	19.05***
Proportions					
HCW % SW	37.3±1.9^a	43.6±2.2^a	40.6±1.9^a	39.6±1.9^a	1.40NS
HCW % EBW	49.2±1.6^a	53.2±1.8^a	51.9±1.6^a	51.5±1.5^a	0.89NS
Gut fill % SW	24.0±1.8^a	18.0±2.0^a	21.6±1.8^a	22.6±1.7^a	1.67NS

^{abc}Within a raw, means with different superscripts are significantly different (P<0.05)

4.1.5: Effect of treatment rations on carcass composition

Individual values for major carcass tissues (lean, bone, fat) in absolute weight and weight expressed as percent of selected cuts are shown in Appendix Table F3. The mean weights of selected cuts and means of major carcass tissues in absolute weight and as percent of the respective cuts are shown in Table 4.5. Generally, animals in T_1 produced significantly (P<0.05) lesser lean from the hind leg in absolute weights than animals in other treatments. There was a tendency for yield of hind leg lean to increase with increasing level of *M. alba* in the supplements but when hind leg lean was expressed as percent of the cut weight, differences between carcasses from all treatment groups were small and insignificant (P>0.05) with values ranging from 64.9 to 69.1 for animals in T_1 and T_2 animals respectively. There were significant treatment differences (P<0.05) for fore leg lean weight, lowest in animals on T_1 and highest in animals on T_4 with no significant difference (P>0.05) between T_2 and T_3. When expressed as percent of foreleg weight, differences between carcasses from all treatments were small and insignificant (P>0.05) with values ranging from 63.3 to 64.3 for T_1 and T_2 carcasses respectively. Generally, carcasses of animals from T_2, T_3

and T_4 were distinctively more fat coated than those fromT_1 as seen on Plates 5 and 6. As a proportion of hind or foreleg weight, fat was lowest for carcasses from T_1 animals (7.8%) and highest for those from T_3 (14.9%). The proportion of bone in the hind leg was significantly higher for carcasses from T_1 animals (25.4%) and lowest for T_2 carcasses (19.2%). The distribution of the same tissue in the fore leg was such that carcasses from T_1 had the highest mean value (28.9%) and those from T_4 the lowest (21.1%). Sample joints from animals which received *M. alba* at different levels were not significantly ($P>0.05$) different in the proportions of bone but were all significantly ($P<0.05$) lower than those from T_1 and there was no any clearly defined trend.

25 SSC:75 MDL	0 SSC:100 MDL	50 SSC:50 MDL	100 SSC:0 MDL

Plate 5: Carcasses of blended goats supplemented with rations containing *Morus alba* dry leaves and sunflower seed cake at the indicated inclusion levels (%)

0 SSC:100 MDL	25 SSC:75 MDL	50 SSC:50 MDL	100 SSC:0 MDL

Plate 6: Carcasses of blended goats supplemented with rations containing *Morus alba* dry leaves and sunflower seed cake at the indicated inclusion levels (%)

Table 4.5: Distribution of major carcass components (LS mean ±SE) in selected cuts of carcasses of male goats

	T_1	T_2	T_3	T_4	F Value
Hind leg wt (g)					
Total	489.23±30^{c}	899.9±33.8^{b}	895.4±30.0^{b}	1019.4±28.3^{a}	61.27***
Lean	312.7±27.6^{c}	624.2±31.2^{a}	608.6±27.6^{a}	693.3±26.1^{a}	37.73***
Fat	46.7±5.6^{b}	101.2±6.3^{b}	117.2±5.6^{a}	114.0±5.3^{a}	36.83***
Bone	130.0±5.8^{c}	173.4±6.6^{b}	172.3±5.8^{b}	212.3±5.5^{a}	35.18***
% of hind leg wt					
Lean	64.9±1.3^{a}	69.1±1.5^{a}	67.8±1.3^{a}	67.5±1.3^{a}	1.53^{NS}
Fat	9.7±1^{b}	11.6±1.1^{ab}	13.0±1.0^{a}	11.5±0.9^{ab}	2.21^{NS}
Bone	25.4±0.9^{a}	19.2±1.1^{b}	19.4±0.9^{b}	21.0±0.1^{b}	9.10**
Lean:Fat ratio	6.9^{a}	6.2^{a}	5.2^{a}	5.9^{a}	1.85^{NS}
Lean:Bone ratio	2.5^{b}	3.6^{a}	3.5^{a}	3.2^{a}	9.4**
Fore leg wet (g)					
Total	411.6±23.3^{c}	774.1±26.3^{b}	751.1±23.3^{b}	839.9±22.0^{a}	68.45***
Lean	258.9±15^{c}	498.7±16.9^{ab}	476.4±15^{b}	534.6±14.1^{a}	68.81***
Fat (g)	25.4±10.4^{b}	105.9±11.8^{a}	113.2±10.4^{a}	124.8±9.8^{a}	19.74***
Bone (g)	127.6±3.8^{c}	169.1±4.3^{ab}	161. 9±3.8^{b}	180.7±3.6^{a}	35.51***
% of fore leg wt					
Lean	63.3±0.5^{a}	64.3±0.6^{a}	63.3±0.5^{a}	63.3±0.5^{a}	0.76^{NS}
Fat	7.8±1.3^{b}	13.3±1.5^{a}	14.9±1.3^{a}	14.6±1.3^{a}	6.61*
Bone	28.9±1.1^{a}	22.3±1.2^{b}	21.8±1.1^{b}	22.1±1^{b}	10.79**
Lean:Fat ratio	8.3^{a}	5.2^{a}	4.2^{b}	4.3^{b}	7.71*
Lean:Bone ratio	2.1^{b}	2.9^{a}	2.9^{a}	2.9^{a}	15.87**

^{abc}Within a raw, means with different superscripts are significantly different (P<0.05)
*Means are significantly different (P<0.05), **Means are significantly different (P<0.01). This applies to all subsequent Tables

4.1.6 Effect of treatment rations on yield of non-carcass components

Individual values for the non-carcass components expressed in absolute weight and as %EBW are shown in Appendix F.2 and analyses of variance for the same in Appendices B.1 - 25. Mean values for non-carcass components are presented in Table 4.6. Treatment effects on most of the non-carcass components were small and insignificant (P>0.05). Expressed as percent of EBW yields of non-carcass components were higher for slaughtered animals from T_1 but not significantly (P>0.05) and there was a tendency for proportion of individual non-carcass

components in the empty body weight to decrease as *M. alba* proportion rations increased in the treatment but not in any defined pattern.

Table 4.6: Yield of non-carcass components (LS means ±SE) by male goats

	T_1	T_2	T_3	T_4	F Value
Weight of component					
Viscera + Visc fat (kg)	0.98±0.05^{c}	1.58±0.06^{b}	1.41±0.05^{b}	1.79±0.05^{a}	46.08***
Plucks (g)	259.4±22.5^{b}	282.4±25.4^{a}	392.8±22.5^{a}	348.6±21.3^{a}	7.91*
Liver (g)	140.5±7.9^{b}	217.6±8.9^{a}	223.9±7.9^{a}	234.7±7.5^{a}	30.79***
Blood (g)	552.3±72.6^{b}	821.9±81.8^{a}	852.3±72.6^{a}	790.1±68.5^{a}	3.71^{NS}
Head (kg)	0.95±0.03^{c}	1.27±0.02^{b}	1.28±0.03^{b}	1.41±0.03^{a}	56.97***
Feet (kg)	0.75±0.11^{a}	1.07±0.12^{a}	0.70±0.11^{a}	0.93±0.1^{a}	1.70^{NS}
Skin (kg)	0.82±0.1^{b}	1.24±0.1^{a}	1.18±0.1^{a}	1.36±0.1^{a}	13.48**
Edible non-carcass (kg)	1.39±0.05^{c}	2.09±0.064^{b}	2.04±0.05^{b}	2.38±0.05^{a}	68.13***
Non-edible non-carcass	3.09±0.13^{c}	4.42±0.15^{ab}	4.04±0.13^{b}	4.51±0.13^{a}	21.73***
% EBW					
PlucksViscera + Visc fat	10.8±0.2^{a}	11.0±0.2^{a}	9.8±0.2^{b}	11.2±0.2^{a}	9.20**
Plucks	2.7±021^{a}	2.0±0.2^{a}	2.8±0.2^{a}	2.2±0.2^{a}	2.41^{NS}
Liver	1.53±0.1^{a}	1.56±0.1^{a}	1.54±0.1^{a}	1.49±0.1^{a}	0.19^{NS}
Blood	5.9±0.6^{a}	5.9±0.7^{a}	5.9±0.6^{a}	4.9±0.6^{a}	0.92^{NS}
Head	10.2±0.2^{a}	8.99±0.3^{b}	8.92±0.2^{b}	8.89±0.2^{b}	6.99*
Feet	8.19±0.75^{a}	7.59±0.84^{ab}	4.86±0.75^{b}	5.75±0.71^{ab}	4.67*
Skin	8.95±0.4^{a}	8.64±0.5^{a}	8.19±0.5^{a}	8.58±0.5^{a}	0.46^{NS}
Edible non-carcass[1]	11.5±0.2^{a}	12.1±0.2^{a}	11.1±0.2^{a}	11.6±0.2^{a}	2.87^{NS}
Non-edible non-carcass[2]	25.48±0.58^{a}	25.67±0.66^{a}	21.97±0.58^{b}	21.8±0.55^{b}	14.10**

^{abc}Within a raw, means with different superscripts are significantly different (P<0.05)
[1]Edible non-carcass components include viscera, pluck and liver while [2]Non-edible non-carcass components include the external genitalia, feet, skin, blood and the head.

4.2 Digestibility study

4.2.1 Chemical composition of feeds and refusals

The chemical composition of hay and supplements fed to the goats during the digestibility study was the same as that used in the growth study (Table 4.1). The chemical compositions of refusals are also presented in Table 4.1. The hay fed to animals and refusals were different in the concentration of all fractions determined. The refusals had higher levels of ADF but lower levels of CP than the fed hay.

4.2.2 *In vivo* digestibility

Table 4.7 shows the *in vivo* digestibility coefficients of feed DM, OM and CP. Individual values and the summary of analyses of variance for the same parameters are shown in Appendix Tables F4 and D1-18. Results show that animals in all treatment groups had the same level of DMI whether as absolute weights or as percent of live body weight. However, DMI per metabolic body weight was significantly lower for animals in T_1 and higher for those in T_3. The level of CP intake was the same for animals in all treatments while OM intake was lowest for animals in T_1 and highest for those in T_2 with no significant difference between T_3 and T_4 animals. This same pattern was observed for hay DM intake. There were no significant ($P>0.05$) differences between animals in all treatments for DM, OM or CP digestibility, T_2 animals being superior in DMD and OMD while T_1 animals led in CP digestibility.

4.2.3 Effect of treatment rations on nitrogen utilization

Mean values for nitrogen (N) balance data are presented in Table 4.8. Individual values for N balance and the summary of analyses of variance showing treatment effects are in Appendix Table F5 and E1-11 respectively. All treatment groups were not significantly ($P>0.05$) different in N intake (g/day) but when expressed as g/day/kg$W^{0.75}$ N intake was lowest for T_1 followed by T_4, T_2 and T_3 animals with no significant ($P>0.05$) difference between T_2 and T_3 animals. Animals on T4 significantly ($P<0.05$) lost much of the dietary N through faeces. N excreted in faeces increased as the proportion of *M. alba* in the supplement increased but not significantly ($P>0.05$) so from T_2 to T_3.

Table 4.7: Feed intake and *in vivo* digestibility (LS means ±SE) by male goats

Feed intake	T_1	T_2	T_3	T_4	F Value
DM					
g d^{-1}	592.02±39.6^a	689.77±20.6^a	670.6±31.2^a	675.88±24.6^a	2.25^{NS}
% LW	2.3^a	2.5^a	2.6^a	2.5^a	2.07^{NS}
g/kg$W^{0.75}$	44.7±1.7^c	56.5±1.7^b	63.4±1.7^a	60.2±1.7^{ab}	2.62^{NS}
OM					
g d^{-1}	523.3±48.1^b	660.1±25.1^a	611.3±37.9^{ab}	626.3±29.9^{ab}	3.46^{NS}
g/kg$W^{0.75}$	44.64±3.6^b	54.7±1.9^a	52.5±2.8^{ab}	52.8±2.2^{ab}	2.94^{NS}
CP					
g d^{-1}	65.9±2.5^a	70.9±1.3^a	69.6±1.9^a	69.7±1.5^a	1.62^{NS}
g/kg$W^{0.75}$	5.56±0.1^a	5.9±0.1^a	5.9±0.1^a	5.8±0.1^a	1.88^{NS}
DCP (g d^{-1})	53.9±3.1^{ab}	54.1±1.6^a	50.1±2.4^{ab}	47.9±1.9^b	1.87^{NS}
Hay DM					
g d^{-1}	303.9±28.3^{ab}	298.2±14.8^a	259.6±22.3^{ab}	226.7±17.6^b	3.11^{NS}
g/kg$W^{0.75}$	26.6±1.6^a	24.8±0.9^a	23.0±1.3^a	19.1±1.0^b	7.69*
ME (MJ d^{-1})	5.6±0.6^b	7.6±0.3^a	7.2±0.5^b	7.5±0.4^b	4.03^{NS}
P:E (g DCP/MJ ME)	9.1±0.3^a	7.1±0.1^b	7.0±0.2^b	6.4±0.2^c	24.26**
Digestibility (% DM)					
DM	59.3±5.0^a	63.1±2.6^a	59.5±3.9^a	62.2±3.1^a	0.53^{NS}
OM	60.5±13.5^a	68.9±7.0^a	66.9±10.6^a	70.6±8.4^a	0.53^{NS}
CP	80.4±3.9^a	76.4±2.1^a	71.6±3.1^a	68.6±2.5^a	2.13^{NS}

^{abc}Within a raw, means with different superscripts are significantly different (P<0.05)

Animals in all treatment groups were not significantly (P>0.05) different in excretory N in urine both in g/day/animal and in g/day/kg$W^{0.75}$. However, values were higher for animals in T_1 and decreased as the level of inclusion of *M. alba* in the ration increased. Generally, animals in all treatment groups were not significantly (P>0.05) different in total N retained and were all in positive N balance.

Table 4.8: Nitrogen balance (LS means±SE) of the experimental animals

	T_1	T_2	T_3	T_4	F Value
N intake					
g/day	10.5±0.4^{a}	11.3±0.2^{a}	11.1±0.3^{a}	11.1±0.3^{a}	1.62^{NS}
g/day/ kg $W^{0.75}$	0.89±0.02^{b}	0.94±0.01^{ab}	0.95±0.01^{a}	0.94±0.01^{ab}	2.2^{NS}
Faecal N					
g/day	1.92±0.4^{b}	2.69±0.2^{ab}	3.12±0.3^{ab}	3.47±0.3^{a}	2.71^{NS}
g/day/ kg $W^{0.75}$	0.18±0.04^{a}	0.23±0.02^{a}	0.27±0.03^{a}	0.29±0.02^{a}	1.90^{NS}
Urinary N					
g/day	2.06±0.48^{a}	1.59±0.25^{a}	1.64±0.38^{a}	1.24±0.29^{a}	0.95 ^{NS}
g/day/ kg $W^{0.75}$	0.18±0.05^{a}	0.13±0.02^{a}	0.13±0.04^{a}	0.09±0.03^{a}	1.06 ^{NS}
Total N excreted					
g/day	3.99±0.68^{a}	4.28±0.34^{a}	4.75±0.54^{a}	4.71±0.42^{a}	0.23 ^{NS}
g/day/ kg $W^{0.75}$	0.36±0.07^{a}	0.36±03^{a}	0.40±0.05^{a}	0.38±0.04^{a}	0.19 ^{NS}
N retained					
g/day	6.56±0.89^{a}	7.06±0.47^{a}	6.37±0.71^{a}	6.43±0.56^{a}	0.42 ^{NS}
g/day/kg $LW^{0.75}$	0.52±0.08^{a}	0.580.04^{a}	0.55±0.06^{a}	0.55±0.04^{a}	0.31 ^{NS}
% of daily intake	59.9±7.6^{a}	62.1±3.9^{a}	57.4±6.0^{a}	58.6±4.7^{a}	0.20 ^{NS}

^{ab}Within a raw, means with different superscripts are significantly different ($P<0.05$)

CHAPTER FIVE

DISCUSSION

5.1 Growth study

5.1.2: Chemical composition of feedstuffs

The CP content (3.5 % DM) of the hay used in this study was well bellow the critical level of 7% DM suggested by Milford and Minson (1966, 1968) below which, intake and digestibility may be affected. However, the level was close to 2.7% obtained by Kidunda and Luoga (1988) in Morogoro and Goromela (1996) in Mpwapwa for *Cenchrus ciliaris* hay harvested between July and August. At this time, the grasses are dry and usually deficient in nutrient content (Kusekwa and Kidunda, 1988). The grass hay had also very high NDF (81.93%) and ADF (48.02%) fractions, which also agrees with the findings of Shayo and Msangi (1989) and Mbwile (1990) that, as maturity advances, cell wall constituents increase while cell contents decrease. The fact that the hay used in the present study was harvested late in the dry season may also explain its high fibre content due to leaf shuttering in the process of handling it, leading to high stem:leaf ratio. For the same reasons, *in vitro* DMD of the hay was very low (43.15% DM). The hay was therefore, a typical poor quality roughage, which requires chemical treatment or supplementation with protein concentrates to improve its utilization by ruminants.

Protein content of 14.5% DM for *M. alba* used in the present study was lower than values earlier reported (Yen, *et al.*, 1996, cited by Saifalyazal, 1998; Shayo, 1998; Malamsha, *et al.*, 1999) but agrees, with those reported by Göhl (1981) and by

Prasaad and Reddy (1991). Differences in stage of maturity, fertility status of the soil and drying conditions especially the ambient temperature and the temperature setting for oven drying may partly explain the variability of values between workers. The same explanation could hold true for the NDF (57.1% DM) and ADF (22.06% DM), which were also higher than those in literature (see Table 2.1). The SSC used had a CP content of 23.99% DM which was about 8 units lower than those reported by Kitalyi (1982) and Teggo (1995) ranging from 30 to 42% DM for undecorticated SSC. OM content or 89.8% of DM in the present study was lower than the one reported by Kitalyi (1982) but the EE content was higher (more than twice) compared to 7.8% of DM reported by Kitlayi (1982) in Morogoro. Values for EE reported by other workers ranged from 3.6 to 12.8% of DM (Teggo, 1995). The unusually higher EE of the SSC used in the present study might have been caused by inefficient fat extraction, from the seeds which may have also caused the lower CP concentration.

5.1.3 Feed intake

DMI values obtained in the present study compares well with those suggested by Kearl (1982) and Ndemanisho *et al.* (1998) for growing goats under tropical environment. They also fall within the range reported by Skerman and Riveros (1990) for tropical grasses. As expected, all except animals supplemented with 100% SSC showed higher DMI (g/day) than those reported by Kitalyi (1982) for unsupplemented grass hay. The observed insignificant differences between animals receiving MDL at different inclusion levels, are interesting. As suggested by Van

Soest (1994), NDF content appears to limit DMI when its concentration in the diet reaches the range of 50 to 60 % DM. One would, therefore, expect the lowest hay intake by animals supplemented with MDL alone, which was not the case. This may be due to the fact that, animals usually eat to satisfy their nutrient requirements and the lower the feed energy content, the more the animal will have to eat in order to satisfy its energy requirements. The inferiority of animals supplemented with SSC alone to the rest in DMI could be attributed to high EE content of the SSC with which they were supplemented. Forbes (1995) noted that, dietary fat seems to interfere with rumen fermentation and that voluntary feed intake is often depressed by high dietary fat. This argument supports an earlier observation by Van Soest (1994) that excess amounts of unsaturated fatty acids and triglycerides can cause profound alterations in the rumen by suppressing the methane bacteria. Kowakyzk, *et al.* (1997, cited by Abdullah, *et al.*, 2000) also observed decreased feed consumption when higher concentrations of animal fat were added to dairy rations and similar findings have been reported by Ketelaars and Tolkamp, (1992). It is also likely that the high EE content of the SSC (over 10 units higher than MDL) negatively affected the rumen environment, thus slowing down the rate of microbial fermentation and hence the reduced DMI. It may also be possible that, deterioration of residual fat in SSC (e.g. Oxidative rancidity) occurred, producing harmful compounds to the rumen microbes and hence negatively affecting microbial fermentation and feed intake.

Voluntary intake of hay-concentrate diets is usually a function of hay quality, proportion of concentrate in the diet and the concentrate protein level (Murdoch,

1964; Crabtree and Williams, 1971). Protein supplementation normally affects roughage DMI through its effect on digestion in the rumen and or through an increase in the flow of dietary protein to the intestine (Egan, 1977; Lyons *et al.*, 1970). The results of the present study suggest that suppression of feed intake for animals receiving 100% SSC was mainly due to the high fat content of the SSC and the resulting interference with the microbial fermentation. The higher DMI of hay showed by animals receiving some amount of MDL versus those supplemented on SSC alone in the present study, therefore, indicates possible improvement of rumen condition for roughage digestion in the respective animals brought about by inclusion of MDL in their supplements. Improved DM intakes from studies in which *M. alba* supplemented roughages have been reported (Luis, 1990, cited by Malamsha, 1999; Gonzalez, *et al.*, 1996). In the study by Gonzalez, *et al.* (1996), the improved total DMI observed on supplementing beef cattle on napier with fresh *M. alba* leaves was attributed to higher CP and digestibility values in the supplement. Feeds with high nutritive values are easily digested in the rumen, pass through the gut faster, and thus enable the animal to eat more feed (Elliot and Topps, 1963; McDonald *et al.*, 1995).

It should also be recalled that goats are browsers in nature and will always prefer a higher proportion of browse material in their diets. Such diets will be more consumed relative to those without browse and hence DMI in g per day was higher for treatments containing MDL.

Animals receiving MDL at 75% inclusion level were superior to those supplemented on MDL alone in total OM, ADF and hay DM intake. Differences in the bulkiness of the material the animals were supposed to chew, in which case animals supplemented with MDL alone had relatively more bulk to handle than those receiving some amount of SSC may partly explain this superiority of the former over the latter group in feed intake. The observed significantly lower values for NDF and OM in animals on 100 % SSC could be due to several reasons. One possible reason could be the difference in fibre contents of SSC and *M. alba* used in making the respective supplements. MDL had more than twice as much fibre as in SSC. Animals on pure SSC supplement would therefore, be expected to consume lesser fibre than those in the other treatments. More over, the former group had the lowest hay DMI and would most likely be lower in intake of dietary fibres than their counterparts.

Though small and insignificant, there was superiority of males over females in DM, CP and NDF intake. This can be justified by the fact that males usually grow faster than their female counterparts due to their superiority in muscle cell numbers and the influence of androgens after sexual maturity (Mtenga, 1992). They, therefore, tend to eat more to meet their higher nutrient requirements. However, such differences are not likely to have masked the treatment effects since there were equal numbers of each sex in each treatment.

5.1.4 Growth performance

Mean growth rates ranging from 29.8 to 57.3 $gd^{-1}$for animals in the present study are slightly lower than values in literature for goats on poor roughages under different levels of supplementation. Kitalyi (1982) reported a growth rate of 62.5 gd^{-1} for goats on *Chloris gayana* hay supplemented with SSC and Malamsha (1999) reported a growth rate of 62.7gd^{-1} in kids consuming *P. purpureum* supplemented with fresh *M. alba* leaves. Comparable results include those of Shoo (1986), Ndemanisho (1996) and Saifalyazar (1998). However, the growth rate values obtained in the present study were quite lower than the one reported by Ibeawuchi and Adam (1990) for goats supplemented with *Acacia* pods (78.2 gd^{-1}). Other studies on goats that reported higher growth rates include that of Susuma and Madsen, (1992) who reported 94 gd^{-1} for Norwegian - Tanzania crosses on low quality roughage and that of Yates and Pangabean (1988) who reported 76 gd^{-1} and 43 $gd^{-1}$for Katjang female goats supplemented with conventional concentrates and *Leucaena leucocephala* leaves respectively. The high growth rates observed by these authors could be attributed to higher energy intakes by the animals compared to the present study. The level of energy intake together with protein:energy ratio have been found to be of significant importance in the performance of growing goats (Mtenga and Madsen, 1992). According to Devendra and McLeroy (1982) maintenance energy requirement for goats weighing between 10 and 20 kg ranges from 3.25 to 5.47 MJ ME d^{-1} and the calculated energy intake values for animals receiving 50 to 100% MDL in the present study fell within this rage while the ME intake of 2.64 MJ ME d^{-1} for animals supplemented on SSC alone was below the maintenance range. It follows that the

energy and protein intakes being reported were adequate for maintenance and some growth in all treatment groups except those on 100% SSC where energy was below maintenance and hence the observed poor growth rates.

Supplementation was done in such a way that each animal received a quantity of the respective treatment ration estimated to meet its DCP requirements for maintenance and some growth as described in Chapter four. Yet, animals supplemented with SSC alone gained more slowly than in the other treatments (29.8 gd^{-1} versus 46 to 53 gd^{-1}). This difference in performance can partly be due to differences in feed intake by the respective animals of which the same animals had the lowest values, and partly an effect of high EE content of the SSC (discussed in 5.1.2 above) on the rumen ecosystem leading to reduction in microbial fermentation and therefore, poor release of nutrients for biological syntheses. Data on feed conversion ratio (FCR) with significantly higher values for animals supplemented solely with SSC, also indicate that these animals utilized feed less efficiently and hence their slower growth rates. This finding is in agreement with earlier reports (Braman, *et al.*, 1973; Kitaly, 1982; Adamu, *et al.*, 1988) that feed efficiency increases with increasing protein level in the diet. This is perhaps, because animals on low protein level deposit more fat, which requires more energy per unit weight compared to protein (Ørskov, *et al.*, 1971; Rattray and Joyce, 1976). However, this was not the case for animals receiving 100% SSC in the present study where data for ME intake show clearly that, these animals had low dietary energy intake with values below the maintenance range suggested by Devendra and McLeroy (1982). Shahjalal, *et al.* (1992) found that

optimum levels of both protein and energy intake are important for better feed utilization efficiency in which case high energy, high protein dietary combinations produced better results than those with either lesser protein or energy relative to requirements. Parameters studied included growth rate, DMI and feed conversion efficiency. Availability of dietary energy is very important for rumen microbial growth (Balch, 1967; Chappel and Fontenot, 1968), which determines the rate at which NH_3 from rumen degraded protein is picked up for microbial protein synthesis which is later digested and absorbed in the lower gut.

Insignificant differences in growth rates were observed between male and female goats. This is contrary to what earlier workers (Bhattachary 1989; Kyomo 1978; Kassahun *et al.*, 1989; Das, 1990; Das and Sendalo, 1991; Berhanu *et al.*, 1992) had observed. These workers observed superiority in growth rates of males to females of 1.79 - 9.65 gd^{-1}. This superiority of males over females in growth rates has always been attributed to genetically determined muscle cell number being greater in males than females (Bradfield, 1968; Mtenga, 1992) and hormonal differences between sexes and their resultant effects on growth (Bell *et al.*, 1970; Mtenga, 1992) However, insignificant sex differences in growth studies with goats have also been reported by Malamsha, *et al.* (1999) who obtained a difference of 6.6 gd^{-1} in favour of males. FCRs and their related growth rates are influenced by many factors like sex, age, health status of the animal, breed and composition of the gain. Variation in findings from different studies and between workers is therefore, not surprising.

5.1.5 Killing-out characteristics

Values obtained from the present study for dressing percent (DP) based on slaughter weights (37.3 to 43.6%) are in agreement with the range of 37.7 to 39% reported by Mtenga (1986) for meat goats under different levels of supplementation, and are lower than those reported by Kyomo (1978). The difference may be due to pre-slaughter conditions, in which case, animals for the present study were slaughtered un-starved while those in Kyomo's study were starved for 24 hours and hence DP was expressed as a proportion of carcass to shrunk live weight. DP is also much affected by stage of maturity, level of feeding, type of diet and degree of fatness (Economides, 1986). However, the DP of 49.2 to 53.2% based on empty body weights from the present study are comparable to reported values of 49.82% for the Malawi indigenous goats (Owen and Norman, 1977), and those of 47.9 to 53.8% for male kids of Angora crossbred goats (Ghanekar, *et al.*, 1973). The observed least carcass yields from animals supplemented with SSC alone could be explained by their poor feed intake leading to poor growth rates compared to their counterparts given MDL at different inclusion levels. Two reasons can explain the small, though not significant decline in DP as the level of inclusion of MDL in the treatment rations increased. That, increasing the inclusion level of MDL in the supplements resulted in higher feed intakes and more fatness in the respective carcasses. Since goats usually deposit much fat around the GIT, which is a non-carcass component, the respective carcasses as a proportion of the EBW will be relatively lower.

Higher carcass yield and EBW values from all animals receiving supplements containing MDL compared with those receiving SSC alone could probably be associated with their higher total CP intake. These results indicate that animals given MDL received better supplementary rations, which led to higher growth rates compared to their counterparts supplemented with SSC alone. EBW as percentage of SW has been reported to increase with protein supplementation (John, 1976) and is due to lower gut fill as a percentage of live weight caused by the increased dietary protein level. The closeness of gut fill values for all animals given some MDL may imply that the supply of dietary protein from supplements containing MDL was similar.

The treatments showed small and generally insignificant effect on total weights of internal organs (liver, feet, pluck and the gut) as %EBW. This was expected because these organs are early maturing and there is a strong relationship between organs and empty body weight (Hammond, 1932), which is unlikely to have been disturbed by nutritional treatments imposed in the present study. The values obtained are in agreement with those of Mtenga (1979) and Kitalyi (1982). However, there were significant differences for weights of some vital organs like the liver, which is an important reserve of labile protein (Munro, 1964; cited by Mafwere, 1989).

5.1.6 Carcass composition

Results from the present study on the distribution of major carcass components in the selected cuts show that, animals supplemented with SSC alone, utilised protein less

efficiently probably due to their observed low energy intake. This agrees with findings of Sanz Sampelayo, *et al.* (1995) that protein retention in kid goats occurs even at ME intake much lower than the estimated maintenance intake, but fat deposition occurs at ME intake much higher than this which shows that, lipid mobilization to protein retention would take place. Shahjalal, *et al.* (1992) also found that optimum levels of protein and energy intake are crucial for better growth rate, DMI and feed utilization efficiency among other performance indicators. The combined effect of low dietary protein and energy intake would lead to reduced growth rate or loss of weight if severe. The importance of energy in utilization of dietary protein, can not be overemphasized. Nutritional effects on carcass yield and composition for goats in Tanzania have been reported by Mtenga (1979), Kitalyi (1982), Shoo (1986) and Kakengi *et a.*, 2000). Percent lean ranged from 60.9 – 64.2% (Kitalyi, 1982) in agreement with 60.9% - 63.5% reported by Mtenga (1979) for goats weighing 12.7 to 15.7 kg at slaughter. Carcass appraisal by total dissection of whole or half carcass is laborious, expensive and time consuming (Berg and Butterfield, 1976; Kyomo, 1978) and the use of sample carcass joints as predictors of total carcass composition has been advocated as a simple cheap and less destructive alternative (Hutchison, 1962; William and Pomeroy, 1975; Cuthbertson, 1978) for estimating the distribution of lean, fat and bone in goat carcasses. Prediction equations to that effect, have also been developed by Daka, (1987) in Tanzania and most recently by Asenga (1997) with high correlation coefficients, which confirmed earlier findings reported by (Kirton, 1970). The results of the present study which was intended to detect differences if any, in response to different sources of

supplemental CP, therefore, give a clear picture of the influence of the treatment rations on carcass composition.

Usually, fat content in carcasses of goats older than 9 months varies from 6 to 15% though values as high as 30% under intensive fattening have been reported in Sudanese desert goats (Gaili, 1978). In Tanzania, Kitalyi (1982) obtained a range of 6.7 to 14.3% of carcass weight in goats depending on plane of nutrition. Sample joints from carcasses of 100% SSC supplemented (present study) animals had the lowest proportions of fat than the rest. The lower proportions of fat in these animals' sample joints may be a contributory effect of their lower dietary energy intake, which was below maintenance level, suggesting that they utilized some of the fat depots for energy (Black and Griffiths, 1975). Fat deposition is an energy expensive process and usually happens at a later stage of growth relative to lean. Slow growing animals like those given 100% SSC would take longer to start depositing fat compared to their fast growing counterparts and hence their lower proportions of fat. The results of this study suggest that inclusion of MDL in the protein supplements led to better intakes of both dietary protein and energy as well as improved rumen environment leading to better performances of the goats.

Earlier workers including Owen *et al.* (1978), Butler-Hogg and Johnson (1986) and Cameron and Bracken (1992) have shown that, the quantity and distribution of lean, fat and bone are of great value to both producers and consumers as they determine the economic value of the animal. Further more, the relative value attached to

proportions of lean, fat and bone in the carcass depends on the consumer's preference (Simm, 1992). In developed markets, leanness of meat is most preferred (Butler-Hogg and Johnson 1986; Cameroon and Bracken 1992) in which case, an ideal carcass should contain the most of lean, just enough bone to support the animal and optimum level of fatness depending on the fat requirement of the market (Simm, 1992). In Tanzania, carcass preferences have not been studied much although it is speculative that it differs from one location to another. Nyakyi (1981) found that in Morogoro, the tendency was for customers to reject very fat or very lean carcasses of sheep implying that a moderate range of fatness is acceptable. From the present study, it is apparent that better proportions of major carcass components in the selected cuts were achieved by in by including MDL in the treatment rations.

5.1.7 Economic implications of substituting *M. alba* for sunflower seed cake

A simple economic analysis (Table 6.1) of substituting sunflower seed cake with *M. alba* dry leaves shows that more profit per kg of carcass produced was obtained when the cake and the dry leaves were combined in the supplements. This was obtained by subtracting the mean cost of feeds per animal (cost of purchasing Hay, SSC + that of harvesting and processing MDL) for the whole experimental period from the respective carcass value. The cost of hominy meal and mineral mix were assumed to be constant for all treatments. Extra labour involved in the use of MDL was equated to that of pounding the cake before it was offered. When *M. alba* was assumed to be grown by the farmer as a hedge row or on marginal land thus not depriving him of a cropping land, the use of MDL as a sole protein supplement looked more profitable.

Table 6.1: Effect of substituting MDL for SSC on the economic returns of goat meat production (Mean of 3 animals per treatment)

INPUT	T_1	T_2	T_3	T_4
Mean cost of SSC per animal[1]	1,569.25	710.00	377.97	0.00
Mean cost of MDL per animal[2]	0.00	647.72	1,034.46	3,108.80
Total cost of Supplements /animal	1,561.25	1,357.72	1,412.43	3,108.80
Mean cost of hay per animal[3]	634.25	1,428.86	1,535.48	1,253.80
Total cost of hay & suppl / animal	2,195.50	2,786.58	2,947.91	4,362.6
Cost per kg of carcass T.Sh[4]	510.58	361.89	393.05	519.36
OUTPUT				
Mean carcass yield/ animal (kg)	4.3	7.7	7.5	8.4
Carcass value (T.Sh 1500 kg^{-1})	6,450	11,550	11,250	12,600
Mean edible non-carcass /animal	1.39	2.09	2.04	2.38
Edible non-carc value TSh 750 kg^{-1}	1,042.50	1,567.50	1,530.00	1,785.00
Total revenue per animal TSh	7,492.50	13,117.5	12,780.00	14,385.0
Marginal profit per animal	5,297.00	10,330.92	9,832.09	10,022.40
Marginal profit : cost ratio	2.4	3.7	3.3	2.3
Profit / kg carcass produced	989.42	1,138.11	1,106.95	980.64
Marginal profit ignoring MDL cost[2]	5,931.25	10,978.64	10,866.55	13,131.20

[1] Total SSC used per treatment X price of SSC (TSh 125/= per kg) / 8 animals
[2] Total MDL used per treatment X cost of MDL (TSh 63/= per kg) / 8 animals
[3] Total hay used per treatment X cost of hay (TSh 60/= per kg) / 8 animals
[4] Total value of costed inputs / mean carcass yield per animal

5.2.1 Digestibility

The observed insignificant differences in, DM, OM and CP digestibility of the total rations for all treatment groups can be explained by the fact that, digestibility in ruminants is usually influenced by intake of dietary protein and energy. Energy intakes have been found to improve nutrient (CP, OM and CF) digestibility (Shahjalal, *et al.*, 2000) concurring with earlier results by Ash and Norton (1987). It is implied here therefore, that all treatment rations met the necessary requirements for protein and energy for microbial digestion. Mean DCP intakes from the present experiment which ranged from 47.9 to 54.1 g/day, was above the range of 13.9 to 29 g/day for tropical goats weighing between 15 and 40 kg LW (Devendra and McLeroy, 1982). Usually protein supplements for ruminants are intended to supply

the rumen micro-organisms with initial Nitrogen for their body cell synthesis thus increasing their population size which then attack dietary fibres in the rumen in search for more N and energy for more cell synthesis.

The results on OM and CP digestibility may also indicate that, in terms of dietary Protein / Energy (P/E) ratios which ranged from 6.4 to 9.1 g DCP/MJ ME, all treatment rations were equally favourable for rumen microbial fermentation. The observed low DM and OM digestibility values for animals on 100% SSC compared to those on the other treatments, though not significant, may be due to their lower energy intake leading to a significantly higher P/E ratio. Mtenga and Madsen (1992) based on various experiments at SUA recommended a content of about 6 g DCP per MJ ME for the whole ration which is comparable to the ratios obtained for animals supplemented with rations containing MDL in the present study. The dietary P/E ratio from the present study decreased as the level of MDL inclusion increased implying that higher energy intakes were achieved on offering a mixture of SSC and MDL as supplements. The decrease in CP digestibility values, though not significant, as the level of inclusion of *M. alba* in the supplements increased could also be due to higher proportions of cell wall contents in their diets, which would require relatively more time to digest.

5.2.2 Nitrogen utilization

Urine and faeces are the main routes of excretion of nitrogenous metabolites of body tissues. For an animal to achieve nitrogen equilibrium, it requires a constant supply

of dietary nitrogen to make up for endogenous urinary losses and exogenous losses in faeces. In the present study, the observed insignificant inferiority of animal on 100% SSC to those in the other treatments in N retention can be partly explained by their significantly lower N intake compared to the rest. Earlier workers (Akinsoyinu *et al.*, 1975; Reynolds, 1981; Kitalyi, 1982, Shoo, 1986; Mafwere, 1989) have also reported similar observations with increasing levels of N intake. However, all animals in the 4 treatment groups were in positive N balance as expected and not significantly different, as expected, since they were all supplemented to the same level of DCP requirement.

The N balance mean values in g/day/ $kgW^{0.75}$ from the present study are higher than the range of 0.01 to 0.39 reported by Kitalyi (1982) for meat goats, but within the range of 0.35 to 0.56 reported by Mafwere (1989) for sheep on poor quality roughage receiving protein supplements. The values are also comparable to those of Onwuka and Akinsoyinu (1989) for West African goats supplemented with cassava leaves at different levels. Animals fed on poor-quality roughage and protein rich concentrates are likely to have low nitrogen retention and high urinary nitrogen excretion (Elliott and Topps, 1963). Tagari, *et al.*(1964) supported by Onwuka and Akinsoyinu (1989) observed that if high protein diets are fed, breakdown of protein usually exceeds microbial protein synthesis leading to high levels of NH_3 in the rumen, which is absorbed into the blood, carried to the liver and excreted in urine. Ørskov *et al.* (1972) also, working with sheep reported similar findings in young lambs. Riis (1983) observed that high protein intakes with low energy levels lead to increased

urinary N excretion and attributed this to increased transamination and diamination of amino acid and consequently higher urinary N excretion. Similar findings include those of Shoo (1986), Muhikambele (1990) and Mtenga and Madsen (1992).

The obtained higher but insignificant urinary N for animals supplemented with SSC alone in the present study, can be justified by their higher dietary P/E ratio. Differences in N retention between animals receiving similar levels of dietary protein have also been observed (Black and Griffiths, 1975; Chowdhury,*et al.*,1995) in which case positive N balances were associated with moderate to high levels of energy intake. These observations confirmed those of Hovel, *et al.* (1983) who also observed lower N retention when sheep were infused with progressively decreasing amounts of VFA. It is also worthy mentioning that N retention measurements by N balance studies have been reported to overestimate N balance in most studies due to random experimental errors like physical losses of urine through splashes at urination and or collection, NH_3 losses during urine and faecal collection and through expired nitrogenous gasses. Variation in findings from different studies therefore, is expected.

The fact that animals in all treatment groups were in positive N balance indicate that, all supplementary rations supported high protein but low energy intakes which led to inefficient N utilization and hence higher levels of N excretion. This was some how expected since the animals' feed intakes were restricted at maintenance level which is necessary for *in vivo* digestibility studies

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Increasing the inclusion level of MDL in the dietary protein supplement resulted into increased feed intake, growth rate and feed conversion efficiency. The increase in feed intake was associated with increased hay intake suggesting that MLD as a protein supplement can improve rumen microbial digestion in growing goats. Using MDL as a sole protein supplement resulted in positive live weight gains comparable to results from previous studies with protein supplementation. This suggests that *M. alba* can be an alternative protein supplement for growing blended goats with promising results.

Killing-out characteristics were significantly affected by the inclusion of MDL in the dietary supplements, with carcass yield and EBW at slaughter increasing with the level of MDL inclusion in the supplements. Dressing percentages were higher for animals in treatments combining SSC and MDL and values were comparable to earlier reports for goats on poor quality roughage supplemented with dietary protein.

Inclusion of MDL in the supplementary rations significantly affected the distribution of major carcass components such that, more fat carcasses were associated with animals receiving higher proportions of MDL in the supplements.

The economics of substituting sunflower seed cake with *M. alba* as a protein supplement to growing goats were discussed. Based on this analysis it can be concluded that inclusion of *M. alba* in supplementary rations for goats is beneficial and the level of inclusion will depend on the availability of the browse material as well as labour demand in a particular farming system.

6.2 RECOMMENDATIONS

In the present study the potential of *M. alba* to replace commercial supplements was evaluated in growing goats fed on poor quality hay. Further research on the effect of *M. alba* substitution for commercial supplements on the performance of small ruminants needs to be conducted with other types of low quality roughages such as straws and stovers. The contribution of crop residues as important dry season feed resources in semi arid areas can not be overemphasized.

The poor performance of animal supplemented with Sunflower seed cake alone together with its poor acceptance calls for more controlled experiments to investigate the keeping quality of the cake from different sources as well as possible methods for improving its utilization by small ruminants. Effect of *M. alba* substitution on milk yield and composition, fertility and reproductive performance in small ruminants also need to be investigated.

More systematic studies are needed to investigate the economic implications of adopting the use of *M. alba* as a protein supplement in different farming systems.

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APPENDICES

Appendix Table A.1: ANOVA for Total DMI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	14394753.64612480	14394753.64612480	0.97	0.3348
SEX	1	75620050.57056950	75620050.57056950	5.10	0.0337
TRT	3	1951164287.73261000	650388095.91087200	43.85	0.0001
SEX*TRT	3	116018001.13472600	38672667.04490880	2.61	0.0760
Error	23	341112347.52310500	14830971.63143930		
Corrected Total	31	2498309440.60714000			

R-Square	C.V.	Root MSE	TDMI Mean
0.863463	9.777593	3851.10005472	39386.99656250

Appendix Table A.2: ANOVA for Daily DMI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	2040.48351634	2040.48351634	0.97	0.3347
SEX	1	10716.05098613	10716.05098613	5.10	0.0337
TRT	3	276523.09173335	92174.36391112	43.85	0.0001
SEX*TRT	3	16442.11735064	5480.70578355	2.61	0.0760
Error	23	48342.86093541	2101.86351893		
Corrected Total	31	354064.60452187			

R-Square	C.V.	Root MSE	DMID Mean
0.863463	9.777506	45.84608510	468.89343750

Appendix Table A.3: ANOVA for Total OMI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	98079638.34711830	98079638.34711830	9.68	0.0049
SEX	1	37511641.42895620	37511641.42895620	3.70	0.0668
TRT	3	869311080.45514200	289770360.15171400	28.59	0.0001
SEX*TRT	3	48529338.29239630	16176446.09746540	1.60	0.2176
Error	23	233077993.39146500	10133825.79962890		
Corrected Total	31	1286509691.91507000			

R-Square	C.V.	Root MSE	TOMI Mean
0.818829	16.13061	3183.36705386	19734.94906250

Appendix Table A.4: ANOVA for Daily OMI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	13900.29705782	13900.29705782	9.68	0.0049
SEX	1	5316.11346897	5316.11346897	3.70	0.0668
TRT	3	123201.04274741	41067.01424914	28.59	0.0001
SEX*TRT	3	6877.29395398	2292.43131799	1.60	0.2176
Error	23	33033.85255932	1436.25445910		
Corrected Total	31	182328.59978750			

R-Square	C.V.	Root MSE	OMID Mean
0.818822	16.13095	37.89794795	234.93937500

Appendix Table A.5: ANOVA for Total DMI from hay over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	108897340.83435600	108897340.83435600	10.66	0.0034
SEX	1	36198773.63929240	36198773.63929240	3.54	0.0725
TRT	3	830480108.63590000	276826702.87863300	27.10	0.0001
SEX*TRT	3	46397180.80478850	15465726.93492950	1.51	0.2375
Error	23	234954674.19386300	10215420.61712450		
Corrected Total	31	1256928078.10820000			

R-Square	C.V.	Root MSE	TDMIH Mean
0.813072	17.17284	3196.15716402	18611.69750000

Appendix Table A.6 ANOVA for Daily DMI from hay over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	15433.43766636	15433.43766636	10.66	0.0034
SEX	1	5130.01999850	5130.01999850	3.54	0.0725
TRT	3	117699.85476315	39233.28492105	27.10	0.0001
SEX*TRT	3	6575.00858661	2191.66952887	1.51	0.2375
Error	23	33299.82893225	1447.81864923		
Corrected Total	31	178138.14994687			

R-Square	C.V.	Root MSE	DMHD Mean
0.813067	17.17317	38.05021221	221.56781250

Appendix Table A.7 ANOVA for Total CPI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1083189.00750457	1083189.00750457	17.50	0.0004
SEX	1	178867.05962577	178867.05962577	2.89	0.1027
TRT	3	1798935.16050049	599645.05350016	9.69	0.0003
SEX*TRT	3	696707.40431365	232235.80143788	3.75	0.0250
Error	23	1423868.40320246	61907.32187837		
Corrected Total	31	5181567.03514693			

R-Square	C.V.	Root MSE	TCPI Mean
0.725205	6.469959	248.81182021	3845.64781250

Appendix Table A.8: ANOVA for Daily CPI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	153.50273392	153.50273392	17.51	0.0004
SEX	1	25.35300295	25.35300295	2.89	0.1025
TRT	3	254.88921905	84.96307302	9.69	0.0003
SEX*TRT	3	98.73350385	32.91116795	3.75	0.0249
Error	23	201.64489024	8.76716914		
Corrected Total	31	734.12335000			

R-Square	C.V.	Root MSE	CPD Mean
0.725326	6.467584	2.96094058	45.78125000

Appendix Table A.9: ANOVA for Total NDFI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	57394647.77033920	57394647.77033920	6.92	0.0149
SEX	1	42618336.03130690	42618336.03130690	5.14	0.0331
TRT	3	1459787986.62044000	486595995.54014700	58.70	0.0001
SEX*TRT	3	54900973.29706430	18300324.43235470	2.21	0.1145
Error	23	190659592.15164300	8289547.48485406		
Corrected Total	31	1805361535.87079000			

R-Square	C.V.	Root MSE	TNDF Mean
0.894393	11.80112	2879.15742620	24397.32437500

Appendix Table A.10: ANOVA for Daily NDFI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	8134.59137984	8134.59137984	6.92	0.0149
SEX	1	6040.71572369	6040.71572369	5.14	0.0331
TRT	3	206889.31112555	68963.10370852	58.70	0.0001
SEX*TRT	3	7779.99675552	2593.33225184	2.21	0.1145
Error	23	27021.34218727	1174.84096466		
Corrected Total	31	255865.95717188			

R-Square	C.V.	Root MSE	NDFD Mean
0.894393	11.80122	34.27595315	290.44406250

Appendix Table A.11: ANOVA for Total ADFI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	10727444.88932180	10727444.88932180	4.10	0.0546
SEX	1	9290119.48543227	9290119.48543227	3.55	0.0722
TRT	3	212168736.09736300	70722912.03245460	27.03	0.0001
SEX*TRT	3	15350524.50844130	5116841.50281377	1.96	0.1488
Error	23	60172333.53058750	2616188.41437337		
Corrected Total	31	307709158.51114600			

R-Square	C.V.	Root MSE	TADF Mean
0.804451	12.24829	1617.46357436	13205.62781250

Appendix Table A.12: ANOVA for Daily ADFI over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1520.50454456	1520.50454456	4.10	0.0546
SEX	1	1316.46208788	1316.46208788	3.55	0.0722
TRT	3	30069.32760555	10023.10920185	27.03	0.0001
SEX*TRT	3	2175.24214830	725.08071610	1.96	0.1488
Error	23	8527.63631059	370.76679611		
Corrected Total	31	43609.17269688			

R-Square	C.V.	Root MSE	ADFD Mean
0.804453	12.24812	19.25530566	157.21031250

Appendix Table A 13: ANOVA for ME intake (MJ d^{-1}) over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.71066814	0.71066814	3.25	0.0845
SEX	1	1.19710524	1.19710524	5.47	0.0283
TRT	3	29.79687132	9.93229044	45.42	0.0001
SEX*TRT	3	0.96998600	0.32332867	1.48	0.2466
Error	23	5.02905681	0.21865464		
Corrected Total	31	37.70368750			

R-Square	C.V.	Root MSE	MEI Mean
0.866616	10.47708	0.46760522	4.46312500

Appendix Table A.14: ANOVA for Total gain (kg) over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	65.72041421	65.72041421	23.15	0.0001
SEX	1	10.12206104	10.12206104	3.57	0.0736
TRT	3	22.11228688	7.37076229	2.60	0.0808
SEX*TRT	3	41.35234901	13.78411634	4.86	0.0107
Error	20	56.77047507	2.83852375		
Corrected Total	28	196.07758621			

R-Square	C.V.	Root MSE	TGKG Mean
0.710469	43.43019	1.68479190	3.87931034

Appendix Table A.15: ANOVA for Daily gain (g) over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	9313.63607396	9313.63607396	23.15	0.0001
SEX	1	1434.56557398	1434.56557398	3.57	0.0736
TRT	3	3133.25558598	1044.41852866	2.60	0.0808
SEX*TRT	3	5860.63304068	1953.54434689	4.86	0.0107
Error	20	8045.14427024	402.25721351		
Corrected Total	28	27787.23454483			

R-Square	C.V.	Root MSE	GDG Mean
0.710473	43.42952	20.05635095	46.18137931

Appendix Table A.16: ANOVA for FCR over the experimental period

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	2309.42932945	2309.42932945	5.67	0.0273
SEX	1	211.22955776	211.22955776	0.52	0.4796
TRT	3	7191.87614003	2397.29204668	5.89	0.0047
SEX*TRT	3	163.90488509	54.63496170	0.13	0.9385
Error	20	8140.54596353	407.02729818		
Corrected Total	28	18016.98587586			

R-Square	C.V.	Root MSE	FCR Mean
0.548174	99.66826	20.17491755	20.24206897

Appendix Table B.1:ANOVA for slaughter weights of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	45409561.64207500	45409561.64207500	220.13	0.0001
TRT	3	120235919.36393100	40078639.78797710	194.29	0.0001
Error	7	1444010.66066055	206287.23723722		
Corrected Total	11	167089491.66666600			

R-Square	C.V.	Root MSE	WTS Mean
0.991358	2.643577	454.18854811	17180.83333333

Appendix Table B.2: ANOVA for Gut fill of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1835090.54325957	1835090.54325957	19.47	0.0031
TRT	3	5386891.43872242	1795630.47957414	19.05	0.0010
Error	7	659684.68468469	94240.66924067		
Corrected Total	11	7881666.66666667			

R-Square	C.V.	Root MSE	GUTFIL Mean
0.916301	8.334473	306.98643169	3683.33333333

Appendix Table B.3: ANOVA for Gut fill (% SW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.04609133	0.04609133	0.01	0.9427
TRT	3	41.48694442	13.82898147	1.67	0.2597
Error	7	58.06394050	8.29484864		
Corrected Total	11	99.59697625			

R-Square	C.V.	Root MSE	GUTFPS Mean
0.417011	13.34930	2.88007789	21.57475000

Appendix Table B.4: ANOVA for Gut fill (% EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.13457225	0.13457225	0.01	0.9421
TRT	3	114.15968234	38.05322745	1.61	0.2724
Error	7	165.95700232	23.70814319		
Corrected Total	11	280.25125692			

R-Square	C.V.	Root MSE	GUTFPE Mean
0.407828	17.58978	4.86910086	27.68141667

Appendix Table B.5: ANOVA for EBW of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	29201249.29577470	29201249.29577470	51.76	0.0002
TRT	3	79855235.83936050	26618411.94645350	47.19	0.0001
Error	7	3948881.53153148	564125.93307593		
Corrected Total	11	113005366.66666600			

R-Square	C.V.	Root MSE	EBW Mean
0.965056	5.562892	751.08317321	13501.66666667

Appendix B. Table 6: ANOVA for Carcass weight (HCW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	11506057.21132350	11506057.21132350	29.47	0.0010
TRT	3	26341456.39603380	8780485.46534462	22.49	0.0006
Error	7	2732642.64264264	390377.52037752		
Corrected Total	11	40580156.25000000			

R-Square	C.V.	Root MSE	CARCW Mean
0.932661	8.933719	624.80198493	6993.75000000

Appendix Table B.7: ANOVA for DP (HCW % SW) of selected males

Dependent Variable: DRESP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	6.75189498	6.75189498	0.65	0.4469
TRT	3	43.61795045	14.53931682	1.40	0.3208
Error	7	72.78644625	10.39806375		
Corrected Total	11	123.15629167			

R-Square	C.V.	Root MSE	DRESP Mean
0.408991	8.003316	3.22460288	40.29083333

Appendix Table B.8: ANOVA for Dressing percent (HCW % EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	12.01753242	12.01753242	1.70	0.2330
TRT	3	18.77146908	6.25715636	0.89	0.4928
Error	7	49.35349850	7.05049979		
Corrected Total	11	80.14250000			

R-Square	C.V.	Root MSE	CARPEW Mean
0.384178	5.158383	2.65527772	51.47500000

Appendix Table B.9: ANOVA for weight Viscera from selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	162826.99670244	62826.99670244	24.16	0.0017
TRT	3	931814.98903330	310604.99634443	46.08	0.0001
Error	7	47180.93093093	6740.13299013		
Corrected Total	11	1141822.91666667			

R-Square	C.V.	Root MSE	VISERV Mean
0.958679	5.702922	82.09831296	1439.58333333

Appendix Table B.10: ANOVA for weight Viscera % of EBW of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1.75759284	1.75759284	17.36	0.0042
TRT	3	2.79486043	0.93162014	9.20	0.0080
Error	7	0.70890771	0.10127253		
Corrected Total	11	5.26136098			

R-Square	C.V.	Root MSE	VSERPEW Mean
0.865262	2.969958	0.31823345	10.71508333

Appendix Table B.11: ANOVA for weights of plucks of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	554.57746479	554.57746479	0.41	0.5431
TRT	3	32232.58469737	10744.19489912	7.91	0.0119
Error	7	9504.50450450	1357.78635779		
Corrected Total	11	42291.66666667			

R-Square	C.V.	Root MSE	LUNGHR Mean
0.775263	11.48514	36.84815271	320.83333333

Appendix Table B.12: ANOVA for weights of plucks (% EBW)of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.89573816	0.89573816	9.18	0.0191
TRT	3	0.70541346	0.23513782	2.41	0.1523
Error	7	0.68274237	0.09753462		
Corrected Total	11	2.28389400			

R-Square	C.V.	Root MSE	LNHRTP Mean
0.701062	12.82042	0.31230534	2.43600000

Appendix Table B.13: ANOVA for weights of livers of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	665.24144869	665.24144869	3.98	0.0864
TRT	3	15455.25404680	5151.75134893	30.79	0.0002
Error	7	1171.17117117	167.31016731		
Corrected Total	11	17291.66666667			

R-Square	C.V.	Root MSE	LIVER Mean
0.932270	6.335433	12.93484315	204.16666667

Appendix Table B.14: ANOVA for weights of livers (% EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.14494498	0.14494498	10.36	0.0147
TRT	3	0.00817775	0.00272592	0.19	0.8966
Error	7	0.09789818	0.01398545		
Corrected Total	11	0.25102092			

R-Square	C.V.	Root MSE	LVPEW Mean
0.610000	7.734896	0.11826012	1.52891667

Appendix Table B.15: ANOVA for Wts of edbl non carcass components

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	163039.56318178	163039.56318178	23.15	0.0019
TRT	3	1439825.69706117	479941.89902039	68.13	0.0001
Error	7	49309.09985707	7044.15712244		
Corrected Total	11	1652174.36010002			

R-Square	C.V.	Root MSE	EDNON Mean
0.970155	4.246057	83.92947708	1976.64500000

Appendix Table B.16: ANOVA for Wts of Edible Nons (% EBW)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	4.56343964	4.56343964	46.69	0.0002
TRT	3	0.84285681	0.28095227	2.87	0.1129
Error	7	0.68416180	0.09773740		
Corrected Total	11	6.09045825			

R-Square	C.V.	Root MSE	EDSPLW Mean
0.887667	2.699331	0.31262981	11.58175000

Appendix Table B.17: ANOVA for weights of blood from of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	37347.55756763	37347.55756763	2.66	0.1471
TRT	3	156569.48447441	52189.82815814	3.71	0.0694
Error	7	98374.62462462	14053.51780352		
Corrected Total	11	292291.66666667			

R-Square	C.V.	Root MSE	BLD Mean
0.663437	15.71901	118.54753394	754.16666667

Appendix Table B.18: ANOVA for weights of blood (% EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.53411754	0.53411754	0.57	0.4761
TRT	3	2.60266073	0.86755358	0.92	0.4788
Error	7	6.59629464	0.94232781		
Corrected Total	11	9.73307292			

R-Square	C.V.	Root MSE	BLDPEW Mean
0.322280	17.13895	0.97073570	5.66391667

Appendix Table B.19: ANOVA for weights of heads of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	72233.54012967	72233.54012967	38.35	0.0004
TRT	3	321874.94335382	107291.64778461	56.97	0.0001
Error	7	13183.18318318	1883.31188331		
Corrected Total	11	407291.66666667			

R-Square	C.V.	Root MSE	HEAD Mean
0.967632	3.530615	43.39714142	1229.16666667

Appendix Table B.20: ANOVA for weights of heads (%EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1.56771464	1.56771464	9.43	0.0180
TRT	3	3.48503082	1.16167694	6.99	0.0164
Error	7	1.16346521	0.16620932		
Corrected Total	11	6.21621067			

R-Square	C.V.	Root MSE	HDPEW Mean
0.812834	4.403944	0.40768777	9.25733333

Appendix Table B.21: ANOVA for weights of feet of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	101190.61591773	101190.61591773	3.27	0.1137
TRT	3	157591.29098918	52530.43032973	1.70	0.2541
Error	7	216843.09309309	30977.58472758		
Corrected Total	11	475625.00000000			

R-Square	C.V.	Root MSE	EXTS Mean
0.544088	20.40632	176.00450201	862.50000000

Appendix Table B.22: ANOVA for weights of feet (%EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.02874676	0.02874676	0.02	0.8936
TRT	3	20.93972050	6.97990683	4.67	0.0427
Error	7	10.45522566	1.49360367		
Corrected Total	11	31.42369292			

R-Square	C.V.	Root MSE	EXTESP Mean
0.667282	18.51830	1.22213079	6.59958333

Appendix Table B.23: ANOVA for weights skins of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	88533.42275877	88533.42275877	8.13	0.0246
TRT	3	440254.11477876	146751.37159292	13.48	0.0027
Error	7	76212.46246246	10887.49463749		
Corrected Total	11	605000.00000000			

R-Square	C.V.	Root MSE	SKIN Mean
0.874029	9.073318	104.34315808	1150.00000000

Appendix Table B.24: ANOVA for weights of skins (%EBW) of selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.88547983	0.88547983	1.40	0.2751
TRT	3	0.87887352	0.29295784	0.46	0.7166
Error	7	4.42253557	0.63179080		
Corrected Total	11	6.18688892			

R-Square	C.V.	Root MSE	SKNPEW Mean
0.285176	9.249374	0.79485269	8.59358333

Appendix Table B.25: ANOVA for weights of Non edibles from selected males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1157463.59398057	1157463.59398057	24.13	0.0017
TRT	3	3125971.49249534	1041990.49749845	21.73	0.0006
Error	7	335715.10480871	47959.30068696		
Corrected Total	11	4619150.19128460			

R-Square	C.V.	Root MSE	NONNON Mean
0.927321	5.451252	218.99612026	4017.35433333

Appendix Table B.26: ANOVA for weights of Non edibles (%EBW)of males

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	5.69357752	5.69357752	6.26	0.0408
TRT	3	38.44644343	12.81548114	14.10	0.0024
Error	7	6.36340405	0.90905772		
Corrected Total	11	50.50342500			

R-Square	C.V.	Root MSE	NONPLW Mean
0.874001	4.017466	0.95344519	23.73250000

Appendix Table C.1:ANOVA for weights of leg hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	186963.63018611	186963.63018611	77.78	0.0001
TRT	3	441836.10438595	147278.70146198	61.27	0.0001
Error	7	16825.37459460	2403.62494209		
Corrected Total	11	645625.10916667			

R-Square	C.V.	Root MSE	WTL Mean
0.973939	5.936104	49.02677781	825.90833333

Appendix Table C.2:ANOVA for weight of lean from hind leg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	103806.87580497	103806.87580497	50.85	0.0002
TRT	3	231079.88866388	77026.62955463	37.73	0.0001
Error	7	14289.12282282	2041.30326040		
Corrected Total	11	349175.88729167			

R-Square	C.V.	Root MSE	LEANL Mean
0.959078	8.072622	45.18078419	559.67916667

Appendix Table C.3:ANOVA for percent lean in hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	7.48446700	7.48446700	1.58	0.2493
TRT	3	21.71022759	7.23674253	1.53	0.2898
Error	7	33.19300541	4.74185792		
Corrected Total	11	62.38770000			

R-Square	C.V.	Root MSE	PLEANL Mean
0.467956	3.234431	2.17758075	67.32500000

Appendix Table C.4 ANOVA for weigh of fat from hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	629.33441538	629.33441538	7.46	0.0293
TRT	3	9322.47731135	3107.49243712	36.83	0.0001
Error	7	590.54827327	84.36403904		
Corrected Total	11	10542.36000000			

R-Square	C.V.	Root MSE	FATL Mean
0.943983	9.688808	9.18498988	94.80000000

Appendix Table C.5:ANOVA for weight of fat percent fat in hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	13.14043228	13.14043228	5.18	0.0570
TRT	3	16.82587643	5.60862548	2.21	0.1745
Error	7	17.75395796	2.53627971		
Corrected Total	11	47.72026667			

R-Square	C.V.	Root MSE	PFATL Mean
0.627958	13.91296	1.59257016	11.44666667

Appendix Table C.6:ANOVA for weights of bone from hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	7609.76370724	7609.76370724	83.51	0.0001
TRT	3	9617.68473870	3205.89491290	35.18	0.0001
Error	7	637.90072072	91.12867439		
Corrected Total	11	17865.34916667			

R-Square	C.V.	Root MSE	BONEL Mean
0.964294	5.549809	9.54613400	172.00833333

Appendix Table C.7:ANOVA for percentage of bone in hind legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1.29896057	1.29896057	0.53	0.4905
TRT	3	66.99322719	22.33107573	9.10	0.0082
Error	7	17.17390390	2.45341484		
Corrected Total	11	85.46609167			

R-Square	C.V.	Root MSE	PBONEL Mean
0.799056	7.360323	1.56633804	21.28083333

Appendix Table C.8: ANOVA for Hind leg Lean : Bon ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.00477183	0.00477183	0.08	0.7914
TRT	3	1.78120655	0.59373552	9.40	0.0075
Error	7	0.44228829	0.06318404		
Corrected Total	11	2.22826667			

R-Square	C.V.	Root MSE	LEGLBR Mean
0.801510	7.814436	0.25136436	3.21666667

Appendix Table C.9: ANOVA for Hind leg Lean : Fat ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	3.57017145	3.57017145	4.35	0.0755
TRT	3	4.56614672	1.52204891	1.85	0.2255
Error	7	5.74604850	0.82086407		
Corrected Total	11	13.88236667			

R-Square	C.V.	Root MSE	LEGLFR Mean
0.586090	14.94664	0.90601549	6.06166667

Appendix Table C.10:ANOVA for weights of fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	137741.29016097	137741.29016097	95.06	0.0001
TRT	3	297573.60267687	99191.20089229	68.45	0.0001
Error	7	10143.24382883	1449.03483269		
Corrected Total	11	445458.13666667			

R-Square	C.V.	Root MSE	WTA Mean
0.977230	5.483330	38.06619015	694.21666667

Appendix Table C.11:ANOVA for weight of lean from fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	65329.42350995	65329.42350995	109.02	0.0001
TRT	3	123705.70069426	41235.23356475	68.81	0.0001
Error	7	4194.54246246	599.22035178		
Corrected Total	11	193229.66666667			

R-Square	C.V.	Root MSE	LEANA Mean
0.978292	5.536143	24.47897775	442.16666667

Appendix Table C.12:ANOVA for percentage of lean in fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	7.73648572	7.73648572	10.88	0.0131
TRT	3	1.62414168	0.54138056	0.76	0.5505
Error	7	4.97766426	0.71109489		
Corrected Total	11	14.33829167			

R-Square	C.V.	Root MSE	PLEANA Mean
0.652841	1.326704	0.84326443	63.56083333

Appendix Table C.13:ANOVA for weigh of fat from fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	3750.31702716	3750.31702716	12.93	0.0088
TRT	3	17179.58668905	5726.52889635	19.74	0.0009
Error	7	2030.38545045	290.05506435		
Corrected Total	11	22960.28916667			

R-Square	C.V.	Root MSE	FATA Mean
0.911570	18.44014	17.03100303	92.35833333

Appendix Table C.14:ANOVA for percentage of fat in fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.19251711	0.19251711	0.04	0.8464
TRT	3	94.42414813	31.47471604	6.61	0.0189
Error	7	33.33902643	4.76271806		
Corrected Total	11	127.95569167			

R-Square	C.V.	Root MSE	PFATA Mean
0.739449	17.23941	2.18236524	12.65916667

Appendix Table C.15:ANOVA for weigh of bone from fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	3021.42053711	3021.42053711	77.95	0.0001
TRT	3	4129.34616709	1376.44872236	35.51	0.0001
Error	7	271.34246246	38.76320892		
Corrected Total	11	7422.10916667			

R-Square	C.V.	Root MSE	BONEA Mean
0.963441	3.895924	6.22601067	159.80833333

Appendix Table C.16:ANOVA for percentage of bone in fore legs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	4.97533476	4.97533476	1.65	0.2399
TRT	3	97.63096629	32.54365543	10.79	0.0051
Error	7	21.11096562	3.01585223		
Corrected Total	11	123.71726667			

R-Square	C.V.	Root MSE	PBONEA Mean
0.829361	7.298771	1.73662092	23.79333333

Appendix Table D.1:ANOVA for feed Total DMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	322538.23838120	322538.23838120	5.33	0.0544
TRT	3	409370.79045305	136456.93015102	2.25	0.1695
Error	7	423909.45525747	60558.49360821		
Corrected Total	11	1155818.48409170			

R-Square	C.V.	Root MSE	TDMI Mean
0.633239	5.350222	246.08635397	4599.55416667

Appendix Table D.2:ANOVA for daily DMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	6583.27376200	6583.27376200	5.33	0.0543
TRT	3	8354.97357865	2784.99119288	2.25	0.1695
Error	7	8651.20695102	1235.88670729		
Corrected Total	11	23589.45429167			

R-Square	C.V.	Root MSE	TDMID Mean
0.633260	5.350206	35.15518038	657.08083333

Appendix Table D.3:ANOVA for daily DMI (% LW)in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	2.47583229	2.47583229	557.63	0.0001
TRT	3	0.02755470	0.00918490	2.07	0.1929
Error	7	0.03107968	0.00443995		
Corrected Total	11	2.53446667			

R-Square	C.V.	Root MSE	DMIPLW Mean
0.987737	2.672446	0.06663298	2.49333333

Appendix Table D.4:ANOVA for daily DMI /kg MBW in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	631.00632497	631.00632497	232.95	0.0001
TRT	3	21.27874249	7.09291416	2.62	0.1328
Error	7	18.96142421	2.70877489		
Corrected Total	11	671.24649167			

R-Square	C.V.	Root MSE	DMI75D Mean
0.971752	2.928229	1.64583562	56.20583333

Appendix Table D.5:ANOVA for Total hay DMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1394.13422447	1394.13422447	0.04	0.8381
TRT	3	289320.13917680	96440.04639227	3.11	0.0979
Error	7	217141.55502374	31020.22214625		
Corrected Total	11	507855.82842502			

R-Square	C.V.	Root MSE	DMIH Mean
0.572435	9.276298	176.12558629	1898.66250000

Appendix Table D.6:ANOVA for daily hay DMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	28.39516004	28.39516004	0.04	0.8383
TRT	3	5904.73288290	1968.24429430	3.11	0.0979
Error	7	4431.61224872	633.08746410		
Corrected Total	11	10364.74029167			

R-Square	C.V.	Root MSE	DMIHD Mean
0.572434	9.276400	25.16122938	271.23916667

Appendix Table D.7: ANOVA for daily hay DMI/kg MBW in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	190.23863775	190.23863775	88.53	0.0001
TRT	3	49.55012569	16.51670856	7.69	0.0128
Error	7	15.04146156	2.14878022		
Corrected Total	11	254.83022500			

R-Square	C.V.	Root MSE	DMH75D Mean
0.940975	6.269098	1.46587183	23.38250000

Appendix Table D.8: ANOVA for Total OMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	195307.21205610	2195307.21205610	24.57	0.0016
TRT	3	928221.13168572	309407.04389524	3.46	0.0798
Error	7	625414.96442477	89344.99491782		
Corrected Total	11	3748943.30816659			

R-Square	C.V.	Root MSE	TOMI Mean
0.833176	7.055022	298.90633134	4236.78833333

Appendix Table D.9: ANOVA for daily OMI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	44801.65391271	44801.65391271	24.57	0.0016
TRT	3	18943.77544321	6314.59181440	3.46	0.0798
Error	7	12764.08793575	1823.44113368		
Corrected Total	11	76509.51729167			

R-Square	C.V.	Root MSE	OMID Mean
0.833170	7.055160	42.70176968	605.25583333

Appendix Table D.10: ANOVA for OMI/kg MBW d^{-1} in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	126.99546736	126.99546736	12.46	0.0096
TRT	3	90.05071971	30.01690657	2.94	0.1081
Error	7	71.34777959	10.19253994		
Corrected Total	11	288.39396667			

R-Square	C.V.	Root MSE	OMI75D Mean
0.752603	6.241798	3.19257575	51.14833333

Appendix Table D.11: ANOVA for Total CPI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	50551.55704496	50551.55704496	214.83	0.0001
TRT	3	1142.08715253	380.69571751	1.62	0.2698
Error	7	1647.19549417	235.31364202		
Corrected Total	11	53340.83969167			

R-Square	C.V.	Root MSE	TCPI Mean
0.969119	3.174814	15.33993618	483.17583333

Appendix Table D.12: ANOVA for daily CPI in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	1031.31819191	1031.31819191	214.57	0.0001
TRT	3	23.26282259	7.75427420	1.61	0.2707
Error	7	33.64467717	4.80638245		
Corrected Total	11	1088.22569167			

R-Square	C.V.	Root MSE	CPID Mean
0.969083	3.176201	2.19234633	69.02416667

Appendix Table D.13: ANOVA for daily CPI/kg MBW in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.62456357	0.62456357	50.72	0.0002
TRT	3	0.06943655	0.02314552	1.88	0.2213
Error	7	0.08619988	0.01231427		
Corrected Total	11	0.78020000			

R-Square	C.V.	Root MSE	CP75D Mean
0.889516	1.909977	0.11096967	5.81000000

Appendix Table D 14: ANOVA for DCP intake in digestibility experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	928.72500989	928.72500989	122.04	0.0001
TRT	3	42.74973795	14.24991265	1.87	0.2225
Error	7	53.27094383	7.61013483		
Corrected Total	11	1024.74569167			

R-Square	C.V.	Root MSE	DCPI Mean
0.948015	5.355990	2.75864728	51.50583333

Appendix Table D.15: ANOVA for DM digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	211.63867455	211.63867455	10.68	0.0137
TRT	3	31.29264456	10.43088152	0.53	0.6781
Error	7	138.71668089	19.81666870		
Corrected Total	11	381.64800000			

R-Square	C.V.	Root MSE	DMD Mean
0.636532	7.292909	4.45159170	61.04000000

Appendix Table D.16: ANOVA for OM digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.31638347	0.31638347	0.00	0.9638
TRT	3	247.89772233	82.63257411	0.58	0.6487
Error	7	1003.68116087	143.38302298		
Corrected Total	11	1251.89526667			

R-Square	C.V.	Root MSE	OMD Mean
0.198271	18.86701	11.97426503	63.46666667

Appendix Table D.17: ANOVA for CP digestibility

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	84.65881572	84.65881572	6.84	0.0346
TRT	3	79.18180392	26.39393464	2.13	0.1842
Error	7	86.58784703	12.36969243		
Corrected Total	11	250.42846667			

R-Square	C.V.	Root MSE	CPD Mean
0.654241	4.735715	3.51705735	74.26666667

Appendix Table D.18: ANOVA for daily energy intake ME MJ/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	0.01352869	0.01352869	0.05	0.8363
TRT	3	3.55425066	1.18475022	4.03	0.0587
Error	7	2.05838732	0.29405533		
Corrected Total	11	5.62616667			

R-Square	C.V.	Root MSE	MEKGDM Mean
0.634140	7.737484	0.54226869	7.00833333

Appendix Table D.19: ANOVA for daily Protein:Energy in feed eaten

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
WTI	1	20.78678045	20.78678045	351.50	0.0001
TRT	3	4.30407719	1.43469240	24.26	0.0004
Error	7	0.41396736	0.05913819		
Corrected Total	11	25.50482500			

R-Square	C.V.	Root MSE	PER Mean
0.983769	3.289597	0.24318346	7.39250000

Appendix Table E.1: ANOVA for daily N intake by blended barks

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	26.44036659	26.44036659	216.23	0.0001
TRT	3	0.59337873	0.19779291	1.62	0.2698
Error	7	0.85594635	0.12227805		
Corrected Total	11	27.88969167			

R-Square	C.V.	Root MSE	DNI Mean
0.969310	3.166222	0.34968278	11.04416667

Appendix Table E.2: ANOVA for daily N intake (g/kg/ MBW) by blended barks

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.01540893	0.01540893	49.97	0.0002
TRT	3	0.00203274	0.00067758	2.20	0.1762
Error	7	0.00215833	0.00030833		
Corrected Total	11	0.01960000			

R-Square	C.V.	Root MSE	DNIKG75 Mean
0.889881	1.888110	0.01755942	0.93000000

Appendix Table E.3: ANOVA for Faecal N (g/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.06724250	0.06724250	0.47	0.5130
TRT	3	1.15095841	0.38365280	2.71	0.1254
Error	7	0.99166575	0.14166654		
Corrected Total	11	2.20986667			

R-Square	C.V.	Root MSE	FNGD Mean
0.551255	13.42638	0.37638615	2.80333333

Appendix Table E.4: ANOVA for Faecal N (g/kg MBW/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.01469116	0.01469116	13.31	0.0082
TRT	3	0.00627642	0.00209214	1.90	0.2187
Error	7	0.00772409	0.00110344		
Corrected Total	11	0.02869167			

R-Square	C.V.	Root MSE	DFNKG75 Mean
0.730790	13.79298	0.03321808	0.24083333

Appendix Table E.5: ANOVA for Urinary N (g/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	1.80272662	1.80272662	9.89	0.0163
TRT	3	0.52138607	0.17379536	0.95	0.4655
Error	7	1.27638731	0.18234104		
Corrected Total	11	3.60050000			

R-Square	C.V.	Root MSE	UNGD Mean
0.645497	26.11707	0.42701410	1.63500000

Appendix Table E.6: ANOVA for Urinary N (g/MBW/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.00003920	0.00003920	0.02	0.8854
TRT	3	0.00555972	0.00185324	1.06	0.4264
Error	7	0.01229275	0.00175611		
Corrected Total	11	0.01789167			

R-Square	C.V.	Root MSE	DUNKG75 Mean
0.312935	30.85099	0.04190593	0.13583333

Appendix Table E.7: ANOVA for Total excreted N (g/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	2.56288658	2.56288658	7.03	0.0329
TRT	3	0.25375365	0.08458455	0.23	0.8714
Error	7	2.55238478	0.36462640		
Corrected Total	11	5.36902500			

R-Square	C.V.	Root MSE	TNVGD Mean
0.524609	13.60773	0.60384302	4.43750000

Appendix Table E.8: ANOVA for Total N excreted (g/kg MBW/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.01284428	0.01284428	3.53	0.1023
TRT	3	0.00211134	0.00070378	0.19	0.8976
Error	7	0.02546938	0.00363848		
Corrected Total	11	0.04042500			

R-Square	C.V.	Root MSE	DNVKG75 Mean
0.369960	15.97876	0.06031983	0.37750000

Appendix Table E.9: ANOVA for Total N retained (g/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	12.48554790	12.48554790	19.71	0.0030
TRT	3	0.80260579	0.26753526	0.42	0.7430
Error	7	4.43513798	0.63359114		
Corrected Total	11	17.72329167			

R-Square	C.V.	Root MSE	NRGD Mean
0.749757	2.04972	0.79598438	6.60583333

Appendix Table E.10: ANOVA for N retained (g/kg MBW/day)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	0.00049170	0.00049170	0.10	0.7578
TRT	3	0.00446856	0.00148952	0.31	0.8168
Error	7	0.03346473	0.00478068		
Corrected Total	11	0.03842500			

R-Square	C.V.	Root MSE	DNRKG75 Mean
0.129090	12.51447	0.06914244	0.55250000

Appendix Table E.11: ANOVA for faecal N as %N intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
LWT	1	37.99568363	37.99568363	0.83	0.3919
TRT	3	27.79781432	9.26593811	0.20	0.8911
Error	7	319.47719372	45.63959910		
Corrected Total	11	385.27069167			

R-Square	C.V.	Root MSE	DNRPNI75 Mean
0.170772	11.35588	6.75570863	59.49083333

Appendix Table F.1: Individual values for feed intake, weight gain, growth rate and FCR

SEX	TRT	TDMI	DMID	TOMI	OMId	OMII	OMIId	TDMIII	DMIID	TCPI	CPD	TCPII	CPIID
M	I	26812.8	319.20	11123.94	132.43	10076.12	121.534	10208.83	121.53	3545.70	42.21	357.31	4.25
M	I	24547.74	292.24	9010.00	107.26	7970.36	96.135	8075.34	96.14	3446.78	41.03	282.64	3.36
M	I	26124.36	311.00	10457.59	124.50	9410.41	113.504	9534.36	113.50	3514.26	41.84	333.70	3.97
M	I	28888.31	343.91	13672.17	162.76	12657.99	152.675	12824.71	152.68	3538.40	42.12	448.86	5.34
F	I	25566.09	304.36	10028.28	119.38	8989.29	108.425	9107.69	108.42	3479.56	41.42	318.77	3.79
F	I	23519.77	280.00	8520.96	101.44	7516.76	90.6639	7615.77	90.66	3384.14	40.29	324.08	3.86
F	I	29956.03	356.62	11530.40	137.27	10298.78	124.219	10434.43	124.22	4072.91	48.49	365.20	4.35
F	I	27452.08	326.81	9692.85	115.39	8504.46	102.577	8616.48	102.58	3887.29	46.28	301.58	3.59
M	II	47142.52	561.22	26053.20	310.16	24597.74	296.687	24921.72	296.69	4344.76	51.72	872.26	10.38
M	II	41843.64	498.14	24054.77	286.37	22827.77	275.339	23128.44	275.34	3759.69	44.76	809.50	9.64
M	II	35989.24	428.44	18730.43	222.98	17535.87	211.51	17766.84	211.51	3499.17	41.66	621.84	7.40
M	II	37113.43	441.83	19065.79	226.97	17816.37	214.893	18051.03	214.89	3632.05	43.24	631.79	7.52
F	II	44635.16	531.37	27597.30	328.54	26425.90	318.738	26773.96	318.74	3759.50	44.76	937.09	11.16
F	II	40974.97	487.80	23504.60	279.82	22299.26	268.964	22592.97	268.96	3691.25	43.94	790.75	9.41
F	II	43483.17	517.66	26140.26	311.19	24946.20	300.89	25274.77	300.89	3760.08	44.76	884.62	10.53
F	II	36412.85	433.49	18374.31	218.74	17124.89	206.553	17350.45	206.55	3607.53	42.95	607.27	7.23
M	III	54981.31	654.54	29249.76	348.21	27448.58	331.073	27810.11	331.07	4862.27	57.88	973.35	11.59
M	III	50265.55	598.40	28172.82	335.39	26627.23	321.166	26977.95	321.17	4302.72	51.22	944.23	11.24
M	III	51478.08	612.83	26125.11	311.01	24347.40	293.668	24668.08	293.67	4706.67	56.03	863.38	10.28
M	III	45978.19	547.36	24951.55	297.04	23478.94	283.193	23788.19	283.19	4034.43	48.03	832.59	9.91
F	III	46825.52	557.45	27689.03	329.63	26352.03	317.847	26699.12	317.85	3850.35	45.84	934.47	11.12
F	III	41710.16	496.55	22640.17	269.53	21303.17	256.95	21583.76	256.95	3666.84	43.65	755.43	8.99
F	III	41866.30	498.41	23312.59	277.53	22012.77	265.508	22302.70	265.51	3619.90	43.09	780.59	9.29
F	III	34153.32	406.59	16218.63	193.08	14955.54	180.387	15152.52	180.39	3290.08	39.17	530.34	6.31
M	IV	51291.65	610.61	25041.71	298.12	23190.60	279.715	23496.05	279.71	4445.28	52.92	822.36	9.79
M	IV	48666.16	579.36	24665.95	293.64	22962.13	276.959	23264.56	276.96	4212.26	50.15	814.26	9.69
M	IV	42708.51	508.43	18229.24	217.01	16484.99	198.835	16702.11	198.83	4057.41	48.30	584.57	6.96
M	IV	37942.76	451.70	17793.20	211.82	16357.71	197.3	16573.16	197.30	3451.26	41.09	580.06	6.91
F	IV	49077.41	594.97	23547.21	280.32	21669.59	261.369	21955.01	261.37	4492.73	53.48	768.43	9.15
F	IV	37577.18	447.35	18545.69	220.78	17190.75	207.347	17417.18	207.35	3319.19	39.51	609.60	7.26
F	IV	43458.39	517.36	20453.70	243.50	18816.95	226.962	19064.79	226.96	3918.66	46.65	667.27	7.94
F	IV	41041.24	488.59	17325.16	206.25	15635.31	188.586	15841.24	188.59	3907.61	46.52	554.44	6.60

SEX	TRT	TNDF	NDFD	TNDFH	NDFHD	TADF	ADFD	ADFH	ADFHD	TGkg	WTI	FCR	GDg
M	I	13067.32	155.56	8364.10	99.57	8964.74	106.72	4902.28	58.36	-1.25	16	-21.45	-14.88
M	I	11276.80	134.25	6616.13	78.76	7910.90	94.18	3877.78	46.16	0.25	15	98.19	2.98
M	I	12489.99	148.69	7811.50	92.99	8631.50	102.76	4578.40	54.50	1.25	14.5	20.90	14.88
M	I	15037.07	179.01	10507.28	125.09	10098.66	120.22	6158.42	73.31	0.5	14	57.78	5.95
F	I	12097.86	144.02	7461.93	88.83	8397.28	99.97	4373.51	52.07	0	15.5	0.00	0.00
F	I	12045.58	143.40	7586.31	90.31	8343.07	99.32	4446.41	52.93	-1.25	14.5	-18.82	-14.88
F	I	14073.61	167.54	8548.92	101.77	9720.40	115.72	5010.61	59.65	2.5	18	11.98	29.76
F	I	12407.99	147.71	7059.48	84.04	8699.94	103.57	4137.63	49.26	0.25	17.5	109.81	2.98
M	II	29839.07	355.23	20418.36	243.08	16556.36	197.10	11967.41	142.47	3.5	15.5	13.47	41.67
M	II	26914.22	320.41	18949.13	225.58	15013.16	178.73	11106.28	132.22	5.25	11	7.97	62.50
M	II	22321.17	265.73	14556.37	173.29	12352.19	147.05	8531.63	101.57	3.5	11	10.28	41.67
M	II	22906.47	272.70	14789.21	176.06	12649.51	150.59	8668.11	103.19	2.5	12.5	14.85	29.76
F	II	29545.31	351.73	21935.91	261.14	16602.50	197.65	12856.86	153.06	4.5	10	9.92	53.57
F	II	26326.56	313.41	18510.42	220.36	14699.83	175.00	10849.14	129.16	3.5	11.5	8.54	41.67
F	II	28447.67	338.66	20707.62	246.52	15948.14	189.86	12136.94	144.49	4.25	10	10.23	50.60
F	II	22332.48	265.86	14215.22	169.23	12313.08	146.58	8331.69	99.19	3.5	12	10.40	41.67
M	III	35721.65	425.26	22784.82	271.25	18580.04	221.19	13354.41	158.98	5	17.5	11.00	59.52
M	III	33208.43	395.34	22103.03	263.13	17466.95	207.94	12954.81	154.22	6.75	12.5	7.45	80.36
M	III	32968.12	392.48	20210.56	240.60	17009.77	202.50	11845.61	141.02	4.25	16	12.11	50.60
M	III	30097.10	358.30	19489.66	232.02	15745.93	187.45	11423.09	135.99	3	13.5	15.33	35.71
F	III	31519.05	375.23	21874.59	260.41	16764.02	199.57	12820.92	152.63	3	11.5	15.61	35.71
F	III	27328.04	325.33	17683.58	210.52	14307.63	170.33	10364.52	123.39	2	12	20.86	23.81
F	III	27640.97	329.06	18272.61	217.53	14551.99	173.24	10709.76	127.50	3	10.5	13.96	35.71
F	III	21528.24	256.29	12414.46	147.79	11008.63	131.06	7276.24	86.62	4.5	10	7.59	53.57
M	IV	33484.40	398.62	19250.31	229.17	16168.66	192.48	11282.80	134.32	6.25	18	8.21	74.40
M	IV	32275.44	384.23	19060.66	226.91	15811.45	188.23	11171.64	133.00	7.75	12	6.28	92.26
M	IV	27218.00	324.02	13684.04	162.91	12767.61	152.00	8020.35	95.48	6.25	13.5	6.83	74.40
M	IV	24751.36	294.66	13578.39	161.65	11899.80	141.66	7958.43	94.74	5	10	7.59	59.52
F	IV	32564.12	387.67	17987.74	214.14	15648.22	186.29	10542.79	125.51	3	16.5	16.66	35.71
F	IV	24826.02	295.55	14269.89	169.88	12099.15	144.04	8363.73	99.57	3	10	12.53	35.71
F	IV	28324.11	337.19	15619.79	185.95	13624.59	162.20	9154.91	108.99	3.25	14	13.37	38.69
F	IV	26130.16	311.07	12978.73	154.51	12224.39	145.53	7606.97	90.56	1.25	15.5	32.83	14.88

Appendix Table F.2: Individual values for killing out characteristics of slaughtered males

Trt		1			2			3			4	
Animal	1	2	3	4	5	6	7	8	9	10	11	12
Initial W (kg)	16	15	15.5	11	12.5	11.75	13.5	17.5	15.5	10	18	14
SW (g)	13100	13650	13370	14000	15850	14950	17500	22250	19850	16100	25000	20550
GutFill (g)	3700	2550	3100	3000	2700	2850	3950	4350	4150	4000	5250	4600
EW (g)	9400	11100	10270	11000	13150	12100	13550	17950	15700	12100	19750	15950
HCW (g)	4300	6000	5150	5650	6800	6225	7000	9650	8300	5750	10800	8300
Viscera (g)	1000	1200	1100	1300	1400	1350	1300	1750	1550	1400	2150	1775
% EW	10.638	10.811	10.711	11.818	10.646	11.157	9.5941	9.7493	9.8726	11.57	10.886	11.128
Lungs+hrt (g)	250	250	250	300	300	300	450	300	400	350	350	350
% EW	2.66	2.252	2.434	2.727	2.281	2.479	3.321	1.671	2.548	2.893	1.772	2.194
Liver	150	150	150	200	200	200	200	250	250	200	250	250
% EW	1.596	1.351	1.461	1.818	1.521	1.653	1.476	1.393	1.592	1.653	1.266	1.567
Edbl Non (g)	1413.3	1613.06	1513.15	1814.55	1912.93	1863.64	1962.92	2311.42	2212.42	1964.46	2762.66	2375.23
%E W	10.789	11.817	11.317	12.961	12.069	12.466	11.217	10.388	11.146	12.202	11.051	11.558
Blood (g)	500	700	600	850	600	750	900	900	900	550	1000	800
% EW	5.319	6.306	5.842	7.727	4.563	6.198	6.642	5.014	5.732	4.545	5.063	5.016
Head (g)	1000	1050	1000	1050	1250	1150	1250	1450	1350	1200	1600	1400
% EW	10.64	9.459	9.737	9.545	9.506	9.504	9.225	8.078	8.599	9.917	8.101	8.777
Feet (g)	900	800	850	750	1000	900	750	1200	450	700	1200	850
% EW	9.574	7.207	8.277	6.818	7.605	7.438	5.535	6.685	2.866	5.785	6.076	5.329
Skin (g)	900	900	900	850	1300	1100	1100	1450	1250	1150	1550	1350
% EW	9.574	8.108	8.763	7.727	9.886	9.091	8.118	8.078	7.962	9.504	7.848	8.464
NonNon (g)	3325.53	3472.97	3373.86	3524.09	4171.67	3923.14	4021.40	5019.78	3967.20	3620.25	5369.24	4419.12
% EW	25.39	25.44	25.23	25.17	26.32	26.24	22.98	22.56	19.99	22.49	21.48	21.5
HCW % SW	32.82	43.96	38.39	40.36	42.9	41.63	40	43.37	41.69	35.71	43.2	39.46
HCW % EW	45.7	54.7	50.1	51.4	51.7	51.4	51.7	53.9	52.9	47.5	54.7	52

Appendix Table F. 3: Individual values for distribution of major carcass tissues in selected cuts

Trt		1			2			3			4	
Animal	1	2	3	4	5	6	7	8	9	10	11	12
Wl (kg)	16	15.5	15	11	11.75	12.5	13.5	15.5	17.5	10	14	18
Leg W (g)	541.2	588.6	637.3	638.7	714.1	789.9	864.7	989.9	1131	684.3	1005.1	1326.1
Leg Lean (g)	337.7	388.1	438.7	416	483.95	551.9	580.3	684.1	787.8	441.3	683	923.3
% Leg W	62.40	65.94	68.84	65.13	67.77	69.87	67.11	69.11	69.66	64.49	67.95	69.63
Leg Fat (g)	53	53.7	54.2	100.9	86.7	77.4	107.6	124.2	140.7	91.6	113.2	134.4
% Leg W (g)	9.79	9.12	8.50	15.80	12.14	9.80	12.44	12.55	12.44	13.39	11.26	10.13
Leg Bone (g)	150.5	147.4	144.4	121.8	140.8	160.6	176.8	189.7	202.5	151.4	209.8	268.4
% Leg W	27.81	25.04	22.66	19.07	19.72	20.33	20.45	19.16	17.90	22.12	20.87	20.24
Arm W (g)	468.9	498.7	529.7	568.6	612	654.5	675.6	837.2	1003	566.8	827.5	1088.1
Arm Lean (g)	299	318.8	338.5	350	386.9	425.6	429.2	535.8	644	346.9	526.2	705.1
% Arm W	63.77	63.93	63.90	61.55	63.22	65.03	63.53	64.00	64.21	61.20	63.59	64.80
Arm Fat (g)	27.1	40.7	54.2	90.7	77.7	64.6	92.3	128.4	164.6	76.2	122.7	169.1
% Arm W	5.78	8.16	10.23	15.95	12.70	9.87	13.66	15.34	16.41	13.44	14.83	15.54
Arm Bone (g)	142.8	140	137	127.9	146.2	164.3	154.1	174.3	194.4	143.7	179.1	213.9
% Arm W	30.45	28.07	25.86	22.49	23.89	25.10	22.81	20.82	19.38	25.35	21.64	19.66
Ribs W (g)	203.8	251.1	298.7	196.4	190.8	186.3	243.9	177.9	111.8	179	237.15	295.3
Ribs Lean (g)	87.5	153.1	177.8	100	102.1	103.6	134.1	98.2	62	100.6	145.9	191.2
% Ribs W	42.93	60.97	59.52	50.92	53.51	55.61	54.98	55.20	55.46	56.20	61.52	64.75
Ribs Fat (g)	11.7	52.2	72.6	50.4	44.3	38	62.5	36.5	9.6	48.1	57.8	67.3
% Ribs W	5.74	20.79	24.31	25.66	23.22	20.40	25.63	20.52	8.59	26.87	24.37	22.79
Ribs Bone (g)	32	50.9	48.3	46	45.7	45.3	47.3	43.9	40.2	30.3	33.6	36.8
% Ribs W	15.70	20.27	16.17	23.42	23.95	24.32	19.39	24.68	35.96	16.93	14.17	12.46

Appendix Table F.4: Individual values for feed intake, *in vivo* DM, OM and CP digestibility

Trt	LWT kg	TDMI G	TDMI/d g	DMI g/d/ kgLW$^{0.75}$	DMIH g	DMIH/d g	DMH g/d/ kgLW$^{0.75}$	TOMI g	OMI/d G	OMI g/d/ kgLW$^{0.75}$	TCPI g	CP/d g	CPI g/d/ kgLW$^{0.75}$	DMD %	OMD %	CPD %
1	32.25	4699.08	671.3	49.62	2184.68	312.1	23.07	4463.17	637.6	47.12	534.24	76.32	5.64	55.7	61.47	79.03
1	36.75	4646.02	663.72	44.46	1898.52	271.22	18.17	4446.75	635.25	42.55	563.02	80.43	5.39	55.83	61.97	79.77
1	41.5	4593.58	656.23	40.14	1580.78	225.83	13.81	4802.31	686.04	41.96	597.41	85.34	5.22	50.08	60.75	78.08
2	30.75	5184.87	740.7	56.71	2134.27	304.9	23.35	4815.49	687.93	52.67	545.68	77.95	5.97	61.28	67.07	74.14
2	28.5	4822.91	688.99	55.88	2032.71	290.39	23.55	4853.63	693.38	56.23	502.34	71.76	5.82	61.36	69.4	75.56
2	26.5	4643.28	663.33	56.79	2026.68	289.53	24.79	4492.94	641.85	54.95	475.6	67.94	5.82	64.79	70.71	78.93
3	17	3845.45	549.35	65.63	1886.85	269.55	32.2	3069.61	438.52	52.39	351.88	50.27	6.01	62.43	62.82	70.32
3	21	4345.84	620.83	63.29	1932.24	276.03	28.14	3660.47	522.92	53.31	417.25	59.61	6.08	63.01	65.57	72.64
3	25.25	4839.6	691.37	61.4	2050.8	292.97	26.02	4204.34	600.62	53.34	474.86	67.84	6.02	64.56	70.25	75.08
4	25.5	4509.27	644.18	56.76	1468.47	209.78	18.48	4605.87	657.98	57.97	464.48	66.35	5.85	55.68	66.85	63.51
4	23.75	4676.39	668.06	62.09	1837.19	262.46	24.39	4007.79	572.54	53.21	450.86	64.41	5.99	65.58	32.01	69.31
4	22	4388.36	626.91	61.7	1750.76	250.11	24.62	3419.09	488.44	48.08	420.49	60.07	5.91	72.18	72.73	74.83

Appendix Table F.5: Individual values for N utilization by bended barks

Treatment	T1			T2			T3			T4		
Animal	1	2	3	4	5	6	7	8	9	10	11	12
LW kg	32.25	36.75	41.5	30.75	28.5	26.5	17	21	25.25	25.5	23.75	22
NI g/d	12.21	12.87	13.66	12.47	11.48	10.87	8.04	9.54	10.85	10.62	10.31	9.61
NI g/d/kg LW$^{0.75}$	0.90	0.86	0.84	0.96	0.93	0.93	0.96	0.97	0.96	0.94	0.96	0.95
FN g/d	2.56	2.60	2.99	3.23	2.81	2.29	2.39	2.61	2.71	3.87	3.16	2.42
FN g/d/kg LW$^{0.75}$	0.19	0.17	0.18	0.25	0.23	0.20	0.29	0.27	0.24	0.34	0.29	0.24
UN g/d	1.74	2.30	2.92	1.89	1.66	1.33	1.95	1.47	0.96	1.12	1.14	1.14
UN g/d/kg LW$^{0.75}$	0.13	0.15	0.18	0.15	0.13	0.11	0.23	0.15	0.08	0.10	0.11	0.11
Total N excr g/d	4.30	4.90	5.91	5.12	4.46	3.62	4.34	4.08	3.66	4.99	4.31	3.56
TNv g/d/kg LW$^{0.75}$	0.32	0.33	0.36	0.39	0.36	0.31	0.52	0.42	0.33	0.44	0.40	0.35
NR g/d	7.91	7.97	7.74	7.35	7.02	7.25	3.70	5.46	7.19	5.62	6.00	6.06
NR g/d/kg LW$^{0.75}$	0.58	0.53	0.47	0.56	0.57	0.62	0.44	0.56	0.64	0.50	0.56	0.60
NR%N Intake	64.76	61.93	56.72	58.95	61.12	66.73	46.04	57.20	66.27	52.98	58.19	63.00