FORMULATION OF TOTAL MIXED RATIONS FOR FATTENING GOATS IN ZANZIBAR

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A DISSERTATION SUBMITTED IN PARTIAL FULLFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

A study was conducted to evaluate the effect of three mixed rations formulated using locally available feed resources on growth performance, carcass characteristic and the potential revenue returns from goats fattening enterprise in Zanzibar. Seventy two un-castrated local goats (9 – 12 months old) with initial body weight of 14.24 ± 1.39 to 14.59 ± 3.7 kg were divided into three groups of 24 animals each and were randomly allocated into three dietary treatments (D1, D2 and D3) for 90 days. Each treatment was replicated three times with eight (8) animals per replication. The three diets contained 30% concentrates and 70% roughages from three species (*Gliricidia sepium, Tripsicum laxum*. and *Cynodon dactylon).* The roughages were mixed at 10:25:35 of respectively *Gliricidia Sepium, Tripsicum . Laxum and C.dactylon* for D1. In D2 the corresponding mixture was 10:35:25 while for D3 it was 10:30:30. The concentrate part was formed by combination of Rice polish: Maize bran at respectively 15:5 in D1; 10:10 in D2 and 5:15 in D3. All diets also contained 5% copra cake, 4% fish meal and 1% minerals. Feed intake was measured daily whereas, weight changes were recorded fortnightly. At the end of feeding trial 9 individuals were randomly selected for slaughter. DMI was 406 ± 21.03, 406 ± 14.01, 398 ± 14.42 g/day for respectively D1, D2, D3 with no significant ($p>0.05$) differences among all diets. Total CP intake was 62.56 ± 3.24, 55.77± 1.92 and 63.83 ± 2.23 g/day for D1, D2 and D3 respectively; D1 and D3 being significantly ($p<0.05$) higher than D2. The average daily gain was 45.5 ± 9.18, 25.2 ± 11.67, 49.40 ± 14.44g/day for D1, D2 and D3 respectively. Animals in D1 and D3 had significantly higher ($p<0.05$) daily gain than those fed D2. Feed efficiency in D2 was significantly lower

($p<0.05$) than D1 and D3. Animals in D2 had significantly ($p<0.05$) lower slaughter weight, hot carcass weight, empty body weight and dressing percentage than D1 and D3. The lean : fat was 15.1 :1, 15.8 : 1, 14.9 :1 and lean : bone ratios was 1.98 :1, 1.69 : 1, 1.64 :1 for D1, D2 and D3 respectively and ratios had no significant ($p>0.05$) differences among all diets. Apparent digestibility in DM and CP were 604.5 ± 65.34, 610.4 ± 41.00, 572.8 ± 48.99 g/kg DM and 585.5 ± 66.57, 536.3 ± 57.39, 555.7 ± 98.66 g/kg DM for D1, D2 and D3 respectively, there were no significant ($p>0.05$) differences among all diets. The economic analysis indicated that animals fed D1 had the highest net returns of Tsh. 38,721.07/goat. It is concluded that using more rice polish than maize bran in the mixed ration gave more cost effective diet and that the forage component should limit *Tripsicum laxum* to no more than 25%.

DECLARATION

I, KHAMIS MOHAMMED KHAMIS, do hereby declare to the senate of Sokoine University of Agriculture, that this dissertation is my own original work, and has neither been submitted nor being concurrently submitted for a degree award in any other institute.

_________________________________ _______________

Khamis Mohammed Khamis **Date**

(MSc. Tropical Animal Production Candidate)

The above declaration is confirmed by;

_________________________________ _______________

Professor A.A.O. Aboud **Date**

(Supervisor)

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DEDICATION

I dedicate this work to my parents, my wife Zuwena and our children Mohammed, Said, Majidah and Sajidah.

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
Ca	Calcium
CF	Crude Fiber
CP	Crude Protein
CPI	Crude Protein Intake
CPPP	*Contagious Caprine Pleural Pneumonia*
Cu	Copper
d	Day
D1	Diet one
D2	Diet two
D3	Diet three
DASP	Department of Animal Science and Production
DCP	Digestible Crude Protein
DDM	Digestible Dry Matter
DM	Dry matter
DMI	Dry matter intake
DP	Dressing Percentaeg
EBW	Empty Body Weight
EE	Ether Extract
FE	Feed Efficiency

Fe	Iron
g	gram
GIT	Gastro Intestinal Truct
GLM	General Leaner Model
HCW	Hot Carcass Weight
INVDM	*In vivo* Dry Matter
INVOM	*In vivo* Organic Matter
K	Potassium
KATI	Kizimbani Agricultural Training Institute
Kg	Kilogram
LWG	Live Weight Gain
ME	Metabolizable Energy
Mg	Magnesium
MJ	Mega Joules
Mn	Manganese
Na	Sodium
NDF	Neutral Detergent Fibre
NSCA	National Sample Census of Agriculture
OTC	Oxytretacycline
P	Phosphorous
SAS	Statistic Analytical System
SEA	Small East Africa
Spp	Species
SRP	Small Ruminant Production

SWT	Slaughter Weight
TDI	Total Digestible Nutrients
Tshs	Tanzania shillings
TVLA	Tanzania Veterinary Laboratory Authority
TWG	Total Weight Gain
VFI	Voluntary Feed Intake
$W^{0.71}$	Metabolic Body weights
WCL	Weight of Carcass Left
WCR	Weight of Carcass right
Zn	Zinc

CHAPTER ONE

1.0 INTRODUCTION

Small ruminant production (SRP) is an attractive preposition for resource constrained farmers. SRP is of particular relevance to farmers operating under shortage of grazing land and seasonal variation of forages. Indoor rearing as well as tethering is the commonest practice for raising sheep and goats in Zanzibar. In all cases the basic feeds used are forages of variably and inconsistent quantity and quality. More often feeding practice does not meet the animal requirement leading to low animal performance in respect to reproduction, growth and carcass quality (Mushi, 2004). It is common observation to see animals taking too long to mature or reach market weight.

In Zanzibar, goat production is still limited when compared with other livestock. Nevertheless, goats are extensively used for meat production particularly during religious and festive occasion (Amani and Salih, 2009). Despite these attributes, the production in the traditional system is constrained by poor nutrition, low genetic potential and poor marketing infrastructure. This is reflected clearly in low growth rate, delays in attaining slaughter weight and low meat yield (Sebsibe and Mathur, 2000). Generally, sheep and goats in Tanzania take over 2 years to reach slaughter weight of 20kg with daily growth rates of less than 21g/day, often producing low quality carcass (Safari *et al.,* 2009). However, with elevated plane of nutrition, the local goats have been shown to respond well and yield cost effectively, high quality carcasses (Shija, 2012). Meat from small ruminants accounts for almost 30% of meat consumed in Africa (Reed *et al*., 1988, cited by Hango, 2005). Goat meat has 10% and 19% more lean carcass than cattle and lamb respectively (Samir, 2010). At the same time the fat content is lower by 47% and 54% compared to beef and mutton, respectively (Sen *et al*., 2004).

Confining of grazing animal for intensive management for fattening purposes, primarily for optimal growth and high weight gain is necessary for the economic preparation of animals for slaughter (Gebremeskel and Kefelegn, 2011). Prasad *et al.* (1993) reported that, commercial fat goat production under intensive system of management with better genetic make up was profitable provided the cost of feed was minimized. In Pakistan, Talat (2006) reported that fattening goats for 90-100 days could add 9-10 kg weight per carcass and will also improve the quality of meat. Under good feeding system the body weight gain can be improved from 60 to 80 g per day through intensive feeding system (Hassan and Farhad, 2012).

The Ministry of Livestock and Fisheries in Zanzibar is currently promoting intensive goats rearing. This opens opportunities for availability of crossbred surplus males that could be raised for meat production in Zanzibar. Likewise, importation of growing lambs from Tanzania mainland is on the increase just for export market to Comoro and other Gulf countries.

Small holder could benefit by tapping on to this lucrative market. However, for this to be realised, efforts need to be directed at enhancing the small holder knowledge on proper feeding and management of goats. The main objective of this study was to formulate ration using cheap and locally available feed resources to improve growth performance and carcass characteristics of goats under intensive feeding system in Zanzibar.

1.1 Statement of the Problem and Justification

In Zanzibar, rapid increase in human population has put pressure on the land for crop production, resulting in less land available for grazing and leading to an increase in feed shortage to the livestock. These have been a sudden upsurge in the demand for meat and other livestock products by consumers in Zanzibar. This arises from the twin effects of fall in fish catches and the consequent rise in their prices. Coupled with relatively higher incomes and the expansion of the tourist industry, the consumers are willing to pay attractive prices for meat. However, the supply falls short of the current demand. Thus, most of the meat is imported from Tanzania mainland, usually at a price that cannot be afforded by majority of consumers. Such scenario calls for enhancing local production of goats through intensive rearing to ensure increase in meat supply. However, intensive rearing of small ruminants is a fairly new concept in Zanzibar and has not been adequately emphasized by the authorities. Experiments conducted elsewhere have proven that goats reared on well balanced diets have a capacity to reach market weight fast enough to offset the cost of rearing (Mushi, 2004). Furthermore, the recent growth of tourism and establishment of international hotels in Zanzibar have increased demand for good quality meat. Apart from that, the live animal demand in Zanzibar tends to increase as many residents practice a compulsory ritual of sacrifice during Eid-Hajj. Thus, fattening of goats through utilization of well formulated diets using locally available feeds could help improve growth performance of goats and timely availability of the stock for the market.

1.2 Objectives of the Study

1.2.1 General objective

To formulate cost effective feed ration using locally available feed resources for raising meat goats to improve meat supply in Zanzibar.

1.2.2 Specific objectives

i. To evaluate the nutritive values of potential feed resources that may be used for raising meat goats in Zanzibar

ii. To formulate diets based on locally available feed resources for raising meat goats in Zanzibar

iii. To asses through feeding trials feed intake and growth performance of meat goats fed on formulated diets

iv. To conduct cost-benefit analysis of fattening meat using locally available feed resources.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Overview

The total population of small ruminants in Zanzibar is estimated at 68 972 goats and 574 sheep (NSCA, 2007/2008). Most of goats and sheep are raised under tethering system. The main feed for livestock resources are native pastures and crop residues which are characterized by low nutritive value leading to low production performance of the animals.

Majority of farmers in Zanzibar are small-scale producers, with 71% keeping less than five cattle, whereby over 95% are indigenous breeds, among those only 10% of agricultural households keep goats (Shuana, 2011). The climatic condition is dry and wet season, which changes the availability of forages as basal feeds to the animals. It has been noted that in dry periods there is significant decrease in the forages, which in turn affects the productivity of the animals (Shuana, 2011). The nutritive value of pasture drops drastically in the dry season. The content of crude protein decreases while content of crude fibre increases resulting in a decreased digestibility of nutrient in the body (Abdulla and Musallam, 2007). Both protein and energy up take from pasture by the animal decreases considerably during the dry season (De Waal, 1994). Goat meat became the primary red meat consumed by the majority of the people in Zanzibar after the domestication of livestock (NSCA, 2007/2008). The goat's versatile eating habits and many products (milk, meat and manure) made it a useful animal for diverse population. Its small size and temperament made it easy for any family member to handle. Today many subsistence farmers still use goat as a low risk savings account. The production cost far less than larger ruminants. Since, goats multiply quickly in the event of catastrophe such as drought, extra goat can be sold and herd population recover rapidly.

2.2 Role of Goats in Tanzania

In Tanzania, as in many African countries, goats play a number of roles ranging from nutritional, sociological to economic roles (Kadim *et al*., 2003). Goats in the tropic and sub tropic countries provide not only meat and milk for consumption but also some income through the sale (Mushi, 2004). Goats provide to their owners with a vast range of useful products and services, these products include meat, skins, milk and manure. Goat meat represents an important source of animal protein in rural areas. They have high quality meat in term of tenderness and juiciness when compare to beef (Kusina and Kusina, 2001). In addition, some evidence indicates that goat meat was popular among the local population and farmers in Tanzania (Hoza, 2011). Beside, goats have several services to offer to mankind including social security, medicine and control bush encroachment (Kosgey *et al*., 2009).

In developing countries, goats play an important role in the economic life of the smallholder farmer in converting low quality forages to high value products (meat and milk) and also serve as a savings bank and provide available cash incomes. For that matter, goats can be a means to reduce poverty by increasing the household income. Goat meat is highly appreciated in countries where pig and/or cattle meat is not acceptable because of prevailing taboos (Dutta *et al.,* 2006). For example, in

Zanzibar were the pig meat is not acceptable because more than 95% of total human populations are Muslim.

2.3 Demand of Goat Meat

Increasing of the contribution of the sub - sectors toward poverty reduction, household food security and the national economy, meat from small ruminants accounts for about 30% of the meat consumed in Africa, where 23% of meat consumed in the Tanzania comes from small ruminants (Mtenga *et al*., 2004). Raising goat meat is preferred to sheep meat and ranks second to beef in sale and consumption (Sandra, 2007) About 60% of the world population, that live in the developing countries is estimated to be suffering from animal protein deficiency (Attah *et al.,* 2006). In Tanzania, there is no taboo preventing goat meat consumption and almost people of any region consume goat meat. A similar opinion has also been reported by Melewas *et al.* (2004) and El-Waziry *et al*. (2011) that there are virtually no religious or cultural taboos against goat meat consumption and thus goats are readily acceptable to societies in which eating beef, pork or other meat types are prohibited.

With recent growth of tourism, expanding mining industries and establishment of international hotels in Tanzania, the demand for goat meat in urban areas, notably the supermarkets, has increased (Kinunda, 2003). The demand for live animals is also increasing during christmas, Easter and Idd Elfitir. Live animals are in high demand, not only in Tanzania but also countries. Melewas *et al.* (2004) has revealed that live goats are exported to the Persian Gulf countries, Madagascar and Comoro. These potential markets provide opportunities for improvement of goat production and commercialisation of the smallholder production system in Tanzania.

2.4 Fattening Management of Goat

Profitability of goats fattening mainly depends on duration of fattening, feed consumption until slaughtering, carcass dressing percentage and composition, as well as revenues for the meat. Considering these aspects, breed differences may be of great importance. With intensive rearing on concentrate-based diets highest daily gains and optimal feed conversion efficiency are achieved (Priolo *et al.,* 2002). However, high energy intake does not only lead to high growth rates but also to greater retention of body fat in goats (Hoza, 2011). Duration of fattening depends on feed quality, feed intake, feed conversion efficiency and growth potential of the animals. Although goats show lower growth rates compared to sheep and feed input in goat fattening until attainment of a certain live weight (Erlangga and Uke, 2012), goats' meat are highly acceptable by consumers in Zanzibar. Goats are late maturing and deposit substantial amounts of fat only at high live weights (Dhanda *et al*., 1999). Confining of grazing animals for intensive management primarily for optimal growth and high weight gain is necessary for economic preparation of animals for slaughter. The purchase of stock and the cost of feeding will be major economic outlays once the fattening itself is established (Mourad *et al*., 2001).

2.5 Feeds and Feeding

Proper feeding for goats is important at all ages in order to maximize profit potential in goats. It has been suggested that rice polish 35% in formulated diet can be used for increasing body weight of goat, however, care must be taken when starting to feed animals so as to minimize the risks of acidosis (Mohammed *et al*., 2005). Fattening ration recommended for goats consist of 88.5% DM, 18.2% CP, 33.7% NDF and 11MJ/Kg DM (Solaiman *et al*., 2012). An additive to the ration such as minerals and vitamins is very important factor for fatting goats, also roughages in the diet is very necessary for healthy digestion and so is an extremely important part of a goat's diet. Furthermore, it has been stated that a young, rapidly growing goat can eat over 1.3kg of high quality ration per day and grow at over 20 – 90g/day (Luginbuhl and Poore, 1998). According to Lee *et al.* (2008), live weight gain was 158g/day for intensively keeping goats fed with ration of high fibre diet (mixture of roughage with concentrate) with 14.4% CP and 11.8 MEMJ/kg DM than those fed with commercial concentrate diet of 14.0% CP and 11.5% MEMJ/kg DM. Additionally, warm carcass weight in the fibre plus concentrate was relatively higher (18.5 kg) than in the commercial concentrate fed goats (16.3 kg) (Mohammed *et al*., 2012).

It has been documented that growing goats require 4.15g CP/kg of metabolic body weight for maintenance (Njidda and Ikhimioya, 2010). Energy requirement for intensively kept goats weighing between10 to 25kg ranges from 3.25 to 6.47 MJME/day (Solaiman *et al.,* 2012). Furthermore, total energy requirement for both maintenance and growth for goats weighing 10 to 20kg and growing at 100g/day ranges from 5.75 to 7.26 MJ ME/day (Osakwe, 2007). In Tanzania, the performance of East African goats under varying levels of concentrate supplementation range between 23 – 63 g/day (Mtenga and Kitaly, 1990; Atti *et al.,* 2004). Nutrient requirements differ in various stages of maintenance growth, pregnancy and lactation

(Frank and Bruce, 2013). The daily maintenance requirements may range from 50 to 100% of total daily nutrient requirements, depending on whether the animal is physiological status, of animal such as growing, lactating, gestating or fattening (Mousa, 2011).

In tropical countries like Tanzania where extensive production system is mainly practiced, the growth rate and consequently meat production of animals fluctuate because of the seasonality of forage availability and quality (Temu, 2001). Nutrition can influence carcass fatness with grain feeding often resulting in fatter carcasses than carcasses from animals of similar live weight grazed on natural pasture (Sakwe, 2007). The well fed goats with high energy concentrate usually use their fat reserves during the harsh condition, especially in dry season when forage is scarce. However, during dry season the growth performance of most animals decline tremendously. For example, Lisimela and Merkel (2008) reported that carcasses from drought affected Angora goats weighed 6.6 kg has significantly less fat content (8.9% fat) compared to normally grown carcasses (with approximately 14.2% fat).

Angora type goats can become very fat if fed on cereal grain based diets (Mahgoud *et al*., 2005). Notter, *et al*. (1991) reported that, the live weights and carcass weights of the cross between Angora and feral goats fed on grain were 26.9 kg and 13.3kg respectively. According to Owens *et al.* (1995) stated that, the carcasses of the wether goats had a fat content of 29.7% and doe carcasses contained 37.6% fat. The total of carcass, omental, peri-renal, and mesenteric fat was 6.33 and 8.05 kg for withers and does, representing 23.4% and 30.1% of the fasted live weight. Total chemical fat measured would probably have been nearly 5% higher (Mohammad *et al.,* 2005).

2.6 Growth Performance of Goat

Growth performance of small ruminant primary depends on the availability of good quality feeds and the feeding regime employed by the farmer. Low growth rate is acknowledged to be the major limiting factor in goat production and the plane of nutrition can markedly improve weight gain though the degree of response varies with breed (Kassahun, 2000). Under high and balanced plane of nutrition, the growth rate of goats increases between 19.66 g/day to 25.14 g/day (Ayo, 2002). Dietary nutrients, especially energy and protein are major nutritional factors affecting meat production in goats (Tshabalala *et al.,* 2003; Zahraddeen *et al.,* 2008). Higher intake of energy and protein in goats given *ad libtium* diet resulted in significantly ($P<0.05$) superior values for daily live weight change (5.86 to 6.27g/day) than those that received restricted diet (Talata, 2006). Protein to energy ratio for optimum growth of goats was recommended as 9.38g CP per MJ ME (Lisimela and Merkel, 2008). Generally animals of large breed grow at a faster rate than smaller breeds and have higher pre- slaughter live weights and carcass weight than those of smaller breed at a similar age. The post weaning growth of indigenous Malawi goats was reported to be 40 g/day (Kirk *et al*., 1994) where as the black Bengal at the same age grows at 9 – 23 g/day (Sebsibe *et al.,* 2007). The average daily gain for *ad libitum* concentrate allowance of Norwegian × SEA crossbred goats was 95.7 g/day (Safari *et al*., 2009). However, SEA goats under similar dietary regime grew at 49.5 g/day with dressing percentage range between 53 and 57% (Safari *et al*., 2009). In addition, breed effect on meat quality is associated with differences in muscle distribution, muscle physical and biochemical properties in the carcass (Adam *et al.,* 2010).

2.7 Dressing Percentage of Goat

Dressing percentage is both a yield and value determining factor and is therefore an important parameter in assessing performance of meat from animal (Massae and Mtenga, 1990). Dividing the empty body weight into the weight of the hot carcass without skin, head, feet and viscera will yield dressing percent values range between 45-52% (Frank and Bruce, 2013).

It has been stated that feeding, breed, sex, slaughter weight, age, gut fill and method of dressing the animal affect dressing percentage (Hango, 2005). The higher gut fill, the lower the dressing percentage of slaughter animal (McGregor *et al*., 2000). Gut fill occupies up to 30% of total weight of animal depending on nutritional regimes and feed quality (Gemeda *et al*., 2003). It has been noted that the higher the protein in a ratio the lower the gut fill, where as higher fibre content in the diet it increase the gut fill (Chanjula, 2011). The energy density of diets fed to goats can influence carcass characteristics across various slaughter weight (Mahgoub and Lodge, 1998). Dressing percentage rises with slaughter and length of time on feed. Feed efficiency increases as heavier carcasses are produced (Gebremeskel and Kefelegn, 2011). As a percentage of live weight, carcass weight gain usually is a much higher percentage under intensive feeding system at the matured stage of the animal than growing stage of production due to dressing percentage increase with maturation and greater with concentrate than with roughage diet (Owens *et al.,* 1995). In tropics dressing percentage with respect to slaughter weight has been reported to range from 45 to 55% (Asnakew, 2005). In Tanzania dressing percentage of local goats have been reported to range from 32 to 39% and 39 to43% (Assenga, 1997).

2.8 Carcass and Non Carcass Composition of Meat Goats

Carcasses of meat animals are generally evaluated commercially in terms of yield and quality of lean. Carcasses yield refers to the percentage of closely trimmed, boneless retail cuts (edible lean) on a carcass weight basis. Quality of lean refers to the palatability of the lean and is perceived as being strongly influenced by the degree of marbling (Shija, 2012).

Carcass composition is a very important factor in determining carcass quality, due to its high variability and its effect in the commercial value of a carcass (Arguello *et al.,* 2003; Sharif *et al.,* 2005). Complete dissection into lean, fat and bone are the best method for evaluation of carcass composition, but it is very expensive and time consuming (Webb *et al*., 2005). Carcass composition varies according to species, age of the animal and live weight at slaughter (Asnakew, 2005).

A higher plane of nutrition increase the percentage of fat while under nutrition reduces fat percentages and to some extent retards muscle development (Kirk *et al.,* 1994; Awet, 2007). Fat is the most labile tissue in the animal's body and can easily be manipulated by nutrition and management (Ayo, 2002). In Tanzania, several studies show that fat composition in goats varies from 6.7 to 14.5% depending on the plane of nutrition, where as lean content occupies 65% of the total composition of the carcass (Hango, 2005). The tissue composition of the carcass would be the most correct manner of classifying and paying of marketed carcasses (Shija, 2012). So, it is easy to admit that their economic value depends on the composition of their carcass. In this regard, many studies were conducted to determine the composition of the carcasses, with the use of indirect measures taken on the live animal, or by complete dissection or some carcass cuts after slaughter (Sen *et al*., 2004; Santos *et al*., 2008; Shija *et al*., 2012). Carcass composition is a most important aspect of meat quality and is normally assessed amount of physical dissected (muscle, fat and bones) or chemical analyzed constituents i.e. protein, fat, water and tenderness (Helen *et al.,* 2013).

In most tropical countries, non-carcass components such as the head, kidneys, heart, blood, gut fat, spleen, lungs and trachea are significant importance because they are edible, saleable and contribute to overall supply of animal protein (Assenga, 1997). Andrea *et al.* (2011) reported that, the yield of non-carcass components in relation to the weight at slaughter is 17.05%. Similar with Tshabalala *et al.* (2003) reported that, the mean yield of non-carcass components represents approximately 18% of the total yield in relation to the live weight at slaughter weight of animals. Non-carcass components as percentage slaughter weight show that, head ranged from 6.02 to 6.44%, while the values of blood range from 4.32 to 4.88% and empty gastro intestinal truck (GIT) range from 6.94 to 7.52% (Malole, 2002). Carcass to bone ratio is the ratio of the weight of the entire carcass compared to the weight of the bone in it. Similar terms are meat to bone ratio and muscle to bone ratio. Meat and muscles are interchangeable terms for what's left after deboning the carcass and usually include carcass fat (Mtenga and Kitaly, 1990). Ideally, carcass to bone ratio can be described that a minimum average weight of fat is 0.81 kg, a maximum weight bone is 4.3 kg and an optimum weight of muscle is 8.3 kg Awah and Adeleye (1994). Therefore, although we often consider carcass to bone ratio and dressing percentage to be measurement of the meatiness of an animal, they are also indicators of the body condition of an animal (Shija, 2012). Fatter carcass will tend to have higher carcass to bone ratios and higher dressing percentage (Ameha, 2006).

2.9 Conclusion

Growth performance of local goats depends on the availability of good quality feeds and the feeding regime employed by the farmer. With intensive rearing on well balanced diets highest daily gains and optimal feed conversion efficiency are achieved. According to this review energy and protein are the major and most important nutritional factors affecting meat production in goats. Where higher intake of energy and protein in goats given in good ration have been reported to result in significantly higher daily live weight gain. Confining of grazing animals for intensive management, primarily for optimal growth and high weight gain is not common practice in Zanzibar. Most goats are raised by smallholder farmers for subsistence and trading in local markets. Consequently economic returns from small ruminant sector have been very much below the potential. This study therefore, was to evaluate the growth performance and carcass characteristics of local goats fed formulated ration using cheap and locally available feeds resources under intensive feeding system.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted at Kizimbani Agricultural Training Institute (KATI) in Zanzibar. The Institute is situated at latitude 6^0 South, longitude 39^0 East and 20 m above sea level. The area receives an average annual rainfall 1564 mm/annum and annual average temperature of 25.7^oC. The natural vegetation around KATI has been largely modified by agricultural activities. Fodder commonly used by local farmers include established banks of Gliricidia (*Gliricidia sepium*), Guatemala grass (*Tripsicum laxum*), Elephant grass (*Pennisetum purperium*) and Mulbery (*Molus alba*). The undergrowth is characterized by Star grass (*Cynodon dactylon),* Bahia grass (*Paspalam notatum)* and Tropical kudzu (*Pueraria phaseoloides*). Ttraditionaly goats are tethered to graze under coconut groves on a short leash. The practice involves changing grazing stations at least once during the grazing time.

3.2 Source of Experimental Animals

Seventy two male intact Tanzania local goats were purchased from small holders of various locations around the East Coast of Zanzibar. Most of the goats were obtained from Chwaka and Marumbi villages (Fig.1). Goats were selected on the basis of age ranging between 9 - 12 months. Care was taken to verify the goats age from farmers records and corroborate the records with dentition.

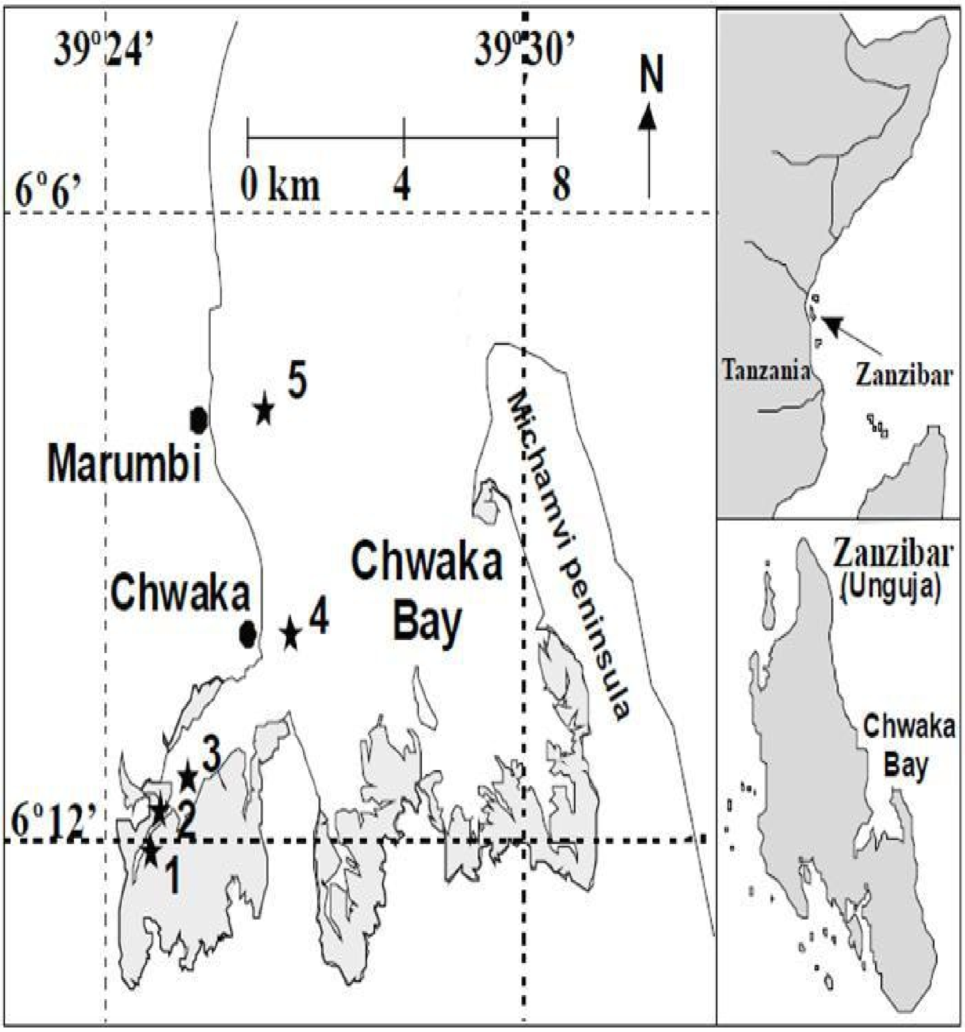

Figure 1: Villages where experimental goats were purchased

3.3 Management of Experimental Animals

3.3.1 Housing

The Experimental animals were raised fully indoor in a specially constructed shed. The shade had raised slatted floor made of timber and thatched with coconut leaves. The shade was oriented north-southwardly with the long sides facing east and west to maximized entry of sunlight (Plate 1 and 2). Inside the shed pens measuring 3m ×

5m were erected to hold 8 goats each at approximately 2 m^2 floor allowance per goat. Each pen had one trough for roughages where as concentrates were offered in 20 Litres plastic containers cut in half (Plate 2). Goats had *ad libtium* access to clean water which was given through buckets.

Plate 1: Goats housing used in this experiment

Plate 2: Partitions of goat's house

3.3.2 Disease control

The animals were dewormed by using a broad spectrum anthelmentic (Super ivermectin) drug, according to their body weight and sprayed with acaricide (Parannex) against external parasites. *Ox-tetracycline* (OTC) 20% was administered to all goats to control *Contagious Caprine Pleural neumonia* (CPPP) before onset of the experiment.

3.4 Experimental Feeds and Experimental Layout

Grasses (*Cynodon dactylon* and *Tripsicum laxum*.) and tree legume (*Gliricidia sepium*) were collected from study area, while other feed ingredients such as rice polish, maize bran, copra meal, fish meal, salt and limestone were purchased from Agricultural and veterinary input shops in Zanzibar. The collected feed materials were analyzed for their chemical composition at the Tanzania Veterinary Laboratory Agency (TVLA) Dar-es-salaam and Department of Animal Science and Production (DASP) laboratory at Sokoine University of Agriculture (SUA).

3.4.1 Sampling and chemical analysis of feeds

Chemical analyses of feeds ingredients were done at Tanzania Veterinary Laboratory Agency (TVLA) Dar-es-salaam and also formulated rations were analysed at Department of animal Science and Production (DASP) laboratory, Sokoine University of Agriculture. Determination of dry matter (DM), ash, crude protein (CP), ether extract (EE), crude fiber (CF) were done according to AOAC (2000). The neutral detergent fibre (NDF), acid detergent fiber (ADF) analysis were done as per Goering and Van Soest (1991) procedures., at DASP laboratory, Sokoine University of Agriculture.

3.4.2 Feed formulation and feeding plan

After the chemical analysis the three forages i.e. *Gliricidia sepium, Tripsicum laxum and Cynodon dactylon* were used as the principal component (70%) of the experimental diets. In formulating the diets the levels of the forages were interchanged as shown in Table 1. Concentrates made up 30% of the diets and principals ingredients were rice and maize (energy sources) and fish and copra meal as protein sources Table 2 shows the composition of formulated diet.

Table 1: Combination of ingredients in the Experimental Diets

FEED INGREDIENTS		INCLUSION (% as fed)		
		DI	D2	D3
Roughages (70%)	*Tripsicum laxum*	25	35	30
	Cynodon dactylon	35	25	30
	Gliricidia sepium	10	10	10
	Rice polish	15	10	5
	Maize bran	5	10	15
	Copra meal	5	5	5
Concentrate (25-35%)	Fish meal	4	4	4
	Salt	0.5	0.5	0.5
	Limestone	0.5	0.5	0.5
	TOTAL	**100**	**100**	**100**
	Calculated CP%	14.72	14.86	13.13
	Calculated Energy ME MJ/kg DM	13.114	13.004	11.186

3.4.3 Experimental layout and feeding of the experimental animals

Shortly after arrival all the goats were weighed and randomly assorted into three groups (of 24 individuals each) to correspond to the three experimental diets D1-3 (Table 2). Each group was further subdivided into 3 replicates of 8 individuals each. The animals were then kept on a preliminary period of 14 days. Forages were chopped to about 5 to 10 cm long using bush knife and offered as total mixed ration with the concentrates. In total the daily allowance was fixed at 1.5 kg of feed (as fed) per head divided equally into morning and evening meals. This amount was decided after it was established that there was at least 15% left over from the daily allowance. Animals were also provided with clean drinking water *ad libitum*.

3.5 Data Collection

3.5.1 Observations on common forages used in Zanzibar

Selection of the experimental forages was based on previous experience on goat feeding at KATI. The three identified forages were first analysed for their nutritional content at TVLA before they were used for formulation of experimental diets.

3.5.2 Voluntary feed intake (VFI) measurement

Group VFI was estimated by arithmetic difference between amount offered and the amount refused after each meal. The daily intake was thus a summation of morning and afternoon left overs. All the concentrates were apparently completely consumed as no traces of left overs could be observed.

3.5.3 Growth performance measurement

The experimental animals were weighed for three consecutive days towards end of 14 days preliminary period. The animal's, average weight taken over the three days was recorded as the initial body weight. Thereafter measurement of weight was done fortnightly in early morning and on each occasion animals were fasted on the previous night. Similarly, the final body weight was taken as the average weight of three days after overnight fasting at the end of 90 days of feeding experiment.

Body weight changes of animals were computed as:

Average daily gain (ADG) = (Final weight (kg) – Initial weight)/Number of days) x 100.

3.5.4 Final slaughter weight and carcass evaluation

The animals were subjected to experimental period for three months. At the end of the growth study nine goats from each of the three treatments were randomly selected for slaughter and carcass evaluation. The slaughtering process was done at Kizimbani Agricultural Training Institute in Zanzibar. The animals were fasted overnight given only water before they were slaughtered for carcass evaluation. The slaughter procedure followed the *halal* method. The blood from each animal was collected separately in a plastic container and weighed. After bleeding the animal was hung by both hind legs, the head was removed at the occipito-atlantal articulation, and the fore and hind feet at the proximal metatarsal and metacarpals joints, respectively. The carcass was then skinned and eviscerated. The appendages (head, skin and feet), the Pluck (heart, lungs and trachea) and viscera organs (liver, spleen, kidney pancreas were separated and weighed.

The rumen and the intestines were first weighed with contents (fill) and later when emptied. The rumen and the intestines fill was subtracted from the slaughter weight to obtain the empty body weight (EBW). Hot carcass weight was computed after subtracting the individual weights of the skin, head, fore feet (at the carpal-metacarpal joint), hind feet (at the tarsal-metatarsal joint), viscera and fat depot. Weights of the internal organs (kidneys, liver, heart, lungs, spleen and pancreas) and fat depots such as scrotal fat, pelvic, kidney and gut fat also were subtracted for the slaughter weight. Dressing percentage was calculated as proportion of hot carcass weight to slaughter weights, using the following formula: Dressing percentage (DP) = (Hot carcass weight/Empty body weight) x 100.

The warm carcass was split into right and left halves by sawing along the vertebral column. Each half was weighed separately. The left half was divided into fore and hind saddles cutting between the 12^{th} and 13^{th} rib. The hind part was further dissected into three wholesale cuts (leg, chump and loin). The fore saddle was separated into neck, shoulder, brisket and fore shank (Fig. 2). The weight of each cut was recorded and was used to evaluate lean, fat and bone portions. Plate 3 shows one of the goats slaughtered at the end of the experiment. The carcasses of slaughtered goats shown in plate 4.

D1

D2

D3

Plate 3: Some of the goats slaughtered at the end of the experiment (D1, D2 and D3)

D1

D2

D3

Plate 4: Hot carcass for the goats receiving experiment diets (D1, D2and D3)

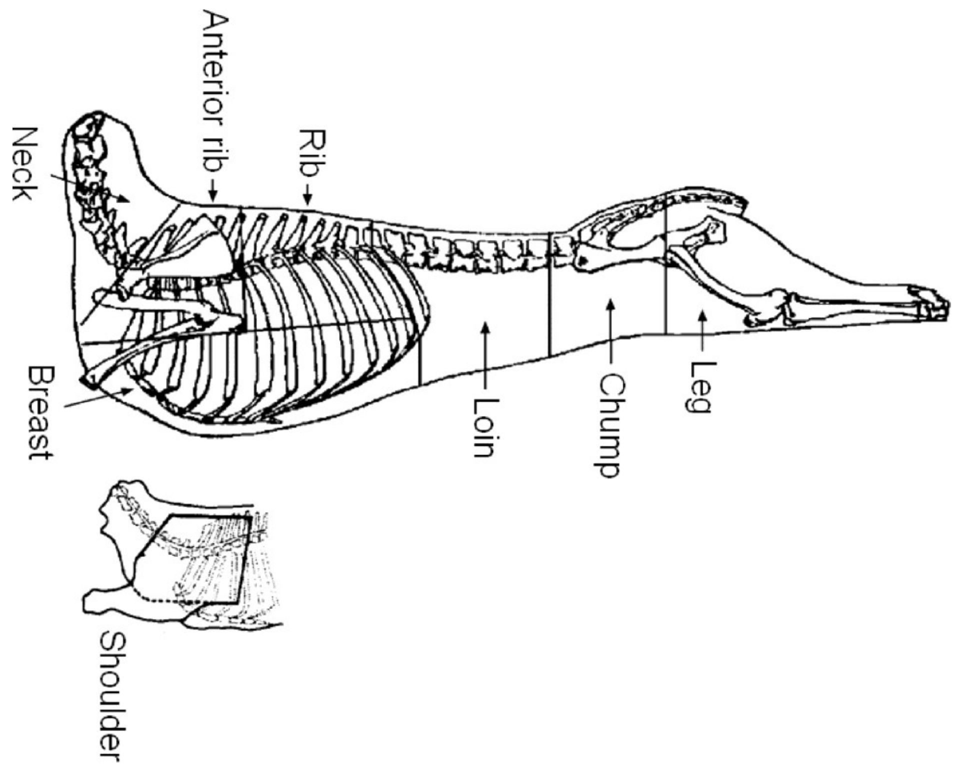

Figure 2: Standard carcass joints used in this study

3.5.5 Carcass components assessment and chemical analysis of meat

Proportions of carcass components (Lean, Fat and Bones) were determined on the right half of the chilled carcass. Fats and lean was trimmed manually using filleting knife and weighed separately. The bones remaining were also weighed. Longissimus dorsi muscle was used for chemical analyses of the lean meat. The proximate analysis was done at DASP laboratory Sokoine University following the standard proximate. The protocol followed was as described by AOAC (2000). Minerals content (Ca, P, Mg, K, and Na) and trace elements (Mn, Zn and Cu) were determined using atomic absorption spectroscopy.

3.6 Cost-Benefit Analysis of Fattening

The mean values of feed used, carcass yield and edible offal for each treatment were used to determine feed cost and revenues from experimental goats. The cost items listed on expenses included feeds, labour charges, veterinary costs, housing cost and the original purchase price of the animals. Entries for expected revenue included the current goat meat price, the price of edible offal's and the value of the skin.

3.7 Digestibility Trials

To corroborate findings from the study, a digestibility trial was set for further evaluation of the nutritional value of the diets. Twelve animals (ranging in weight >16 kg) were drawn from each treatment for the digestibility trail. Altogether 36 animals were used. The selected animals were placed in individual metabolic cages and assigned randomly to the three diets.

Experimental diets were offered at 1.5 kg/day corresponding to 3.5% kg DM^{-} $kg^{w0.71}$. Data on feed intake, feacal and urine output were gathered for 14 days after a preliminary period of 21 days. Standard protocols for *invivo* digestibility trials were followed. Feacal collection was done using bags attached to the animals and the collected contents were weighed every morning. A sample of about 10% of the daily fecal excretion of each goat was stored kept in air tight plastic containers and stored in a freezer. At the end of the collection period, the fecal sample for each animal was thoroughly mixed and sub-samples were taken to determine the chemical composition of the feaces. Urine output was collected via plastic containers placed under a polyethene sheet fixed under the cage floor. Aliquots of about 10% of daily outputs were pooled for each individual and finally a sub-sample was drawn for nitrogen analysis.

3.8 Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedure of statistical analysis system (SAS, 2002) with (diets) as the main effect in the model.

The models used were:

(i) For growth performance trial

$Yij = \mu + Ti + b(Xij - \sum x/n) + eij$,……………………..………………………….(1)

Where:

Yij = Response variable (Average daily gain)

μ = Overall mean

Ti = i^{th} Diet effect

b = regression coefficient of initial weight of an animal on subsequent performance.

$(Xij - \sum x/n)$ = overall mean of the covariate on subsequent initial body weight of individual animal

eij, = Random error term

(ii) Digestibility trial:

$Yij = \mu + Ti + eij$,……………………………………………………………….(2)

Where:

Yij = Response variable (Digestibility of i^{th} component)

μ = Overall mean

Ti = ith Diet effect

eij = Random error term.

(iii) Feed intake

$Yij = \mu + Ti + eij$

Where:

Yij = response variable (Feed intake of ith component)

μ = Overall mean

Ti = ith Diet effect

eij = Random error term

CHAPTER FOUR

4.0 RESULTS

4.1 Overview

The findings from series of experiments reported in this chapter reflect answers to the principal objectives that were listed in Chapter 1 subsection 1.2 - 1.2.2. Generally the experiments were executed as planned without any major deviations from the original plan. However, three animals receiving diets 1 and 2 died during the 8th week and a fourth one died in the last week of data collection. The cause of these deaths could not be affirmatively established. All the four were observed to have profuse watery diarrhoeas and serious loss of condition. Thus data from these individuals were excluded from analysis.

Some data on chemical composition of common feed resources around KATI were drawn from a parallel study by Tiffany (2014) and are partly presented in Appendix (10) with author kind permission. All ingredients used in the feeding and the subsequent digestibility trials were analysed in duplicates at two separate laboratories. This was deliberately done as a way for double-checking of the findings. Impromptu survey of the local market for goat meat gave an impression of customers unconcerned about meat quality. Therefore studies on carcass characteristics excluded observations on quality parameters (meat pH and tenderness) as they were deemed expensive and unnecessary at this stage. The findings from these studies are presented in Sections 4.2 – 4.7. Sections 4.2 – 4.3.2 centre on observations of feed parameters, voluntary intake and growth performance parameters. Section 4.4 - 4.5 deal with findings from the slaughter parameters whereas sections 4.6 - 4.6.1 focus on digestibility trial. Cost benefit analysis is presented in Section 4. 7.

4.2 Chemical Composition of Experimental Feeds

The chemical composition of feed ingredients and formulated Diets I used in the present study are shown in Table 2. It can be observed that all forages used were still green and succulent with dry matter content not exceeding 30%. The cell walls contents were fairly high for *Tripsicum laxum* and *Cynodon dactylon* but within typical ranges for the *Pueraria phaseoloides*. The ME values were calculated on the basis of the proximate composition of the ingredients. Proximate composition of the compounded diets shows that all diets had fairly similar contents of DM, CP and ME. Notable differences were observed for ADF but not with NDF. However both ADF and NDF values for Diet 3 were substantially lower than the other two diets.

Table 2: Mean Chemical composition of feed ingredients used in experimental diets formulation

Parameters	DM	CP	NDF	ADF	MEMJ/kgDM
Tripsicum laxum	29.86	9.7	79.5	44.2	7.88
Cynodon dactylon	24.78	15	67.1	39.6	8.68
Gliricidia sepium	19.66	28.4	30.9	17.8	12.44
Maize bran	88.61	9.1	29.17	16.49	11.58
Rice polish	87.41	10.87	48.21	35.25	8.66
Fish meal	79.79	54.9	28.44	0.74	14.03
Copra meal	84.82	15.18	37.19	41.53	7.67
Ration DIET 1	**30.59**	**15.41**	**44.4**	**30.68**	**9.37**
DIET 2	**31.19**	**13.73**	**44.5**	**28.52**	**9.70**
DIET 3	**29.88**	**15.53**	**42.8**	**25.33**	**10.20**

DM = Dry matter; CP = Crude protein; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ME = Metabolizable energy.

4.3 Voluntary Feed Intake and Growth Performance

4.3.1 Feed intake

Means ± SE for, dry matter, Crude protein and ME (MJ/d) are shown in Table 3. The corresponding ANOVA tables for feed intake are shown in Appendix 1. Dry matter intake were not significantly different ($P<0.05$) among the diets. The ME intake for D1 was significantly lower than D2 and D3 ($P < 0.05$). The CP intake for D_2 was significantly lower than both D_1 and D_3 ($P < 0.05$).

Table 3: Mean and SE of DM, CP and ME (MJ) intake by goats given experimental rations

Parameter	Treatments			P- Value
	D1	D2	D3	
DMI(g/d)	406 ± 21.03^{a}	.406 ± 14.01^{a}	.398 ± 14.42^{a}	0.4135
DMI /kg $W^{0.71}$	48.23±4.48^{a}	50.40 ± 4.74^{a}	47.62±4.48^{a}	0.2702
CPI(g/kg)	62.56 ± 3.24^{a}	.55.77 ± 1.92^{b}	61.83 ± 2.23^{a}	<.0001
CPI/kg$W^{0.71}$	29.14 ± 2.60^{a}	30.74 ± 3.24^{a}	27.27 ± 2.81^{a}	0.8515
ME (MJ/d)	3.80 ± 0.19^{b}	3.94 ± 0.13^{a}	4.06 ± 0.14^{a}	0.0020

$^{a\ b}$ =Means in the same raw with difference superscript are differ significantly at ($P>0.05$); DMI = Dry matter intake, CPI = Crude protein intake

4.3.2 Growth performance

Means of initial and final live weight, average daily gain (ADG), total weight gain (TWG) and feed efficiency (FE) of the experimental goats are presented in Table 4. ANOVA tables are presented in Appendix 2. Initial body weight was not significantly different among animals in all the treatments. Goats receiving Diet 2 had significantly lower (p< 0001) TWG and ADG than those on Diet 1 and Diet 3. No significant differences ($p>0.05$) were observed in the final weight of animals in Diet 1 and Diet 3 but those on Diet 3 had significantly superior ($p<.0001$) ADG and FE than goats in all other diets. The animals finished under D1, D2, and D3 have been shown on Plate 3.

Table 4: Growth performance of goats receiving experimental diets

	Treatments			
Parameters (kg)	D1	D2	D3	P. Value
initial weight (kg)	14.24 ± 1.39^{a}	14.29 ± 1.06^{a}	14.59 ± 3.71^{a}	0.1065
final weight (kg)	18.34 ± 1.87^{a}	16.56 ± 1.17^{b}	18.98 ± 3.62^{a}	0.0242
ADG g/day	45.50 ± 9.18^{b}	25.2 ± 11.67^{c}	49.40 ± 14.44^{a}	<.0001
Total weight gain (kg)	4.11 ± 0.77^{a}	2.27 ± 0.98^{c}	4.39 ± 1.21^{b}	<.0001
FE (gADG/g DMI)	9.00 ± 4.12^{b}	16.25 ± 3.64^{a}	7.90 ± 4.06^{c}	<.0001

[ab] = Within diets in the same row, means with a common superscript are not significantly different (P>0.05); ADG = Average daily gain; FE = Feed Efficiency, DMI = Dry Matter Intake.

4.4 Killing Out Characteristics and Carcass Components of Goats Fed Experimental Diets

4.4.1 Killing out characteristics

The slaughter characteristics of the experimental animals are shown in Table 5. Appendixes 3 show the summary of ANOVA for all slaughter parameters. Animals on Diet 1 and 3 had significantly superior slaughter weight than those on Diet 2. However, animals in diet 3 showed apparently higher slaughter weight than animals in diet 2. Similar pattern holds for EBW, but for dressing percentage the superiority of animals on Diet 1 ranged from 4 - 7 units above those of respectively Diet 3 and Diet 2.

Table 5: Killing out characteristics of goats receiving experimental diets.

Parameters	Treatment			P- value
	D1	D2	D3	
SWT(kg)	16.28 ± 2.55^{a}	13.91 ± 0.85^{b}	15.45 ± 1.97^{ab}	0.0457
EBW(kg)	14.29 ± 2.99^{a}	11.45 ± 1.03^{b}	12.69 ± 1.79^{ab}	0.0282
HCW(kg)	8.13 ± 1.63^{a}	5.78 ± 0.63^{b}	6.83 ± 1.11^{b}	0.0014
DRESSING%	57.05 ± 3.88^{a}	50.46 ± 2.18^{c}	53.75 ± 3.10^{b}	0.0007

$^{a\ b}$ =Means in the same raw with difference superscript are differ significantly at (P>0.05); SWT = slaughter weight; EBW = Empty body weight; HCW = Hot carcass weight.

4.4.2 Weight of carcass joints

The mean weights of the carcass joints are presented in Table 6. Appendix 4 provides summary of the ANOVA for comparison of joints among the three diets. The findings show that there were no significant (P>0.05) differences among all treatments in the weights and proportions of joints from both the forequarters and the hind quarters.

Table 6: Carcass joints weights of goats under different levels of formulated diets

Parameter	Treatments			P- Value
	D1	D2	D3	
Thigh(kg)	0.53 ± 0.12^{ab}	0.37 ± 0.11^{b}	0.57 ± 0.16^{a}	0.0090
Chump(kg)	0.42 ± 0.10^{a}	0.41 ± 0.18^{a}	0.50 ± 0.11^{a}	0.3162
Loin(kg)	0.32 ± 0.09^{ab}	0.21 ± 0.06^{b}	0.36 ± 0.10^{a}	0.0034
Shoulder(kg)	0.34 ± 0.09^{a}	0.26 ± 0.09^{a}	0.33 ± 0.07^{a}	0.1143
Chest(kg)	0.86 ± 0.27^{ab}	0.64 ± 0.16^{b}	0.96 ± 0.23^{a}	0.0161
Brisket(kg)	0.20 ± 0.09^{a}	0.15 ± 0.03^{a}	0.22 ± 0.06^{a}	0.0782
Neck(kg)	0.37 ± 0.10^{a}	0.35 ± 0.03^{a}	0.41 ± 0.06^{a}	0.1983
WCL(kg)	2.95 ± 0.79^{a}	2.01 ± 0.33^{b}	2.97 ± 0.71^{a}	0.0051
WCR(kg)	3.24 ± 0.78^{a}	2.17 ± 0.38^{b}	3.04 ± 0.66^{a}	0.0030
Percentage as 1/2 carcass				
Thigh	18.50 ± 2.54^{a}	18.32 ± 3.90^{a}	19.36 ± 3.00^{a}	0.7636
Chump	14.73 ± 3.39^{a}	21.88 ± 14.81^{a}	17.29 ± 3.79^{a}	0.2555
Loin	11.01 ± 2.09^{a}	10.21 ± 1.74^{a}	12.09 ± 1.88^{a}	0.1354
Shoulder	11.67 ± 2.14^{a}	12.89 ± 4.16^{a}	11.30 ± 1.79^{a}	0.4856
Chest	29.26 ± 5.14^{a}	31.77 ± 5.82^{a}	32.42 ± 3.38^{a}	0.3640
Brisket	6.74 ± 2.13^{a}	7.32 ± 1.21^{a}	7.43 ± 1.87^{a}	0.6797
Neck	12.75 ± 3.31^{b}	17.98 ± 4.09^{a}	14.44 ± 3.43^{a}	0.0167
WCL	2.95 ± 0.79^{a}	2.01 ± 0.36^{b}	2.97 ± 0.71^{a}	0.0051
WCR	3.24 ± 0.78^{a}	2.17 ± 0.38^{b}	3.04 ± 0.66^{a}	0.0030

$^{a\ b}$ = Means in the same row with different superscript differ significantly at (P > 0.05). WCL = Weight of carcass left, WCR = Weight of carcass right

4.4.3 Edible offal components of goat fed experimental ration

The weights and proportions of edible offal components of experimental goats are presented in Table 7. Appendix 5 shows the ANOVA table of these parameters. Significantly higher (p>0.05) weights were noted for the weights of head, liver, kidney, empty intestine and abdominal fat in goats under diets 1and 3 compared to those on Diet 2. However, with the exception of abdominal fat there were no significant differences in the proportion of the edible components in carcasses from all experimental diets.

Abdominal fat for goats on Diet1 were proportionately higher than that in carcasses from all other diet.

Table 7: Edible offal components of goats fed experimental diets

Parameters	Treatment			P-Value
	D1	D2	D3	
Head (kg)	1.10 ± 0.23^{a}	0.86 ± 0.07^{b}	1.07 ± 0.29^{ab}	0.0576
Liver (kg)	0.25 ± 0.06^{a}	0.19 ± 0.03^{b}	0.25 ± 0.03^{a}	0.0172
Lung (kg)	0.20 ± 0.23^{a}	0.10 ± 0.04^{a}	0.14 ± 0.04^{a}	0.3275
Kidney (kg)	0.08 ± 0.02^{a}	0.06 ± 0.01^{b}	0.07 ± 0.00^{ab}	0.0317
Empty intestine(kg)	1.23 ± 0.13^{a}	0.98 ± 0.13^{b}	1.26 ± 0.19^{a}	0.0014
Abdominal Fat(kg)	0.35 ± 0.14^{a}	0.12 ± 0.03^{b}	0.21 ± 0.15^{b}	0.0013
Percentage as slaughter weight (Swt)				
Head	7.25 ± 1.52^{a}	7.87 ± 0.51^{a}	7.03 ± 1.49^{a}	0.3612
Liver	1.60 ± 0.23^{a}	1.80 ± 0.15^{a}	1.65 ± 0.23^{a}	0.1358
Lung	1.37 ± 1.68^{a}	0.97 ± 0.39^{a}	0.96 ± 0.31^{a}	0.6183
Kidney	0.53 ± 0.14^{a}	0.59 ± 0.14^{a}	0.49 ± 0.09^{a}	0.2366
Empty intestine	8.12 ± 1.33^{a}	9.02 ± 1.09^{a}	8.36 ± 0.38^{a}	0.1741
Abdominal Fat	2.29 ± 0.88^{a}	1.11 ± 0.23^{b}	1.36 ± 0.76^{b}	0.0031

$^{a\ b}$ = Means in the same row with different superscript differ significantly at ($P > 0.05$). % as SWT = Percentage as Slaughter weight.

4.4.4 Non-edible offal components of goats receiving experimental diets.

The mean value of non- edible offal components of experimental goats are presented in Table 8. The corresponding ANOVA tables are shown in Appendix 6. Most parameters in carcasses of goats on Diet 2 were of significantly lower values to those from animals receiving Diets 1 and 3. The relative proportions of the skin, fore and hind legs of goats in Diet 1 were slightly lower than those of goats in diets 2 and 3.

Table 8: Non – edible offal components of goats receiving experimental diets

Parameters	Treatment			P- Value
	D1	D2	D3	

Blood(kg)	0.54 ± 0.12^{a}	0.35 ± 0.08^{b}	0.48 ± 0.07^{a}	0.0009
Skin(kg)	1.12 ± 0.58^{ab}	0.86 ± 0.12^{b}	1.32 ± 0.26^{a}	0.0537
Foreleg(kg)	0.27 ± 0.06^{a}	0.24 ± 0.02^{b}	0.28 ± 0.03^{a}	0.0132
Hind leg(kg)	0.26 ± 0.05^{ab}	0.23 ± 0.03^{b}	0.29 ± 0.03^{a}	0.0149
Spleen(kg)	0.08 ± 0.04^{a}	0.03 ± 0.01^{b}	0.04 ± 0.02^{b}	0.0005
Trachea(kg)	0.06 ± 0.02^{a}	0.04 ± 0.01^{b}	0.06 ± 0.01^{a}	0.0024
Testis(kg)	0.13 ± 0.04^{a}	0.08 ± 0.02^{b}	0.14 ± 0.03^{a}	0.0010
Percentage as slaughter weight (Swt)				
Blood	3.53 ± 0.68^{a}	3.23 ± 0.68^{a}	3.22 ± 0.59^{a}	0.5243
Skin	6.87 ± 2.60^{b}	7.88 ± 0.39^{ab}	8.69 ± 0.75^{a}	0.0686
Foreleg	1.76 ± 0.28^{b}	2.17 ± 0.26^{a}	1.91 ± 0.27^{b}	0.0115
Hind leg	1.73 ± 0.29^{a}	2.13 ± 0.29^{b}	1.92 ± 0.25^{ab}	0.0200
Spleen	0.51 ± 0.17^{a}	0.29 ± 0.09^{b}	0.25 ± 0.11^{b}	0.0005
Trachea	0.36 ± 0.07^{a}	0.33 ± 0.08^{a}	0.42 ± 0.15^{a}	0.2154
Tests	0.83 ± 0.23^{ab}	0.74 ± 0.15^{b}	0.94 ± 0.13^{a}	0.0661

$^{a\ b}$ = Means in the same row with different superscript differ significantly at (P > 0.05). % SWT = Percentage of slaughter weight

4.4.5 Total weight of tissues in half carcass

Table 9 shows the total weight and relative weights of lean, fat and bones tissues in experimental animals. Appendix 7 provides summary of the ANOVA tables for total weight and percentage of lean, bone and fat tissues in half carcass. Animals receiving Diet 2 showed significantly lower (P<0.05) weight of lean and bone tissues in the half carcass. Carcasses from Diet 1 and 3 had about 0.5 - 0.6 kg more lean than those in Diet 2. All carcasses had about the same amount of fat. When total weights of tissues were expressed as percentages of ½ carcass weight, there were no significant differences among goats for lean and fat contents. Similar observations were noted for lean: fat ration in all carcasses.

Table 9: Total weight and percentage of lean, bone and fat tissues in half carcass

Parameters	Treatment	P- value

	D1	D2	D3	
Lean(kg)	1.97 ± 0.55[a]	1.428 ± 0.27[b]	2.08 ± 0.54[a]	0.0162
Bone(kg)	0.99 ± 0.35[b]	0.84 ± 0.11[b]	1.27 ± 0.27[a]	0.0079
Fat(kg)	0.13 ± 0.12[a]	0.09 ± 0.09[a]	0.14 ± 0.06[a]	0.579
Percentage as 1/2 carcass				
lean	66.76 ± 6.06[a]	70.95 ± 5.25[a]	70.13 ± 10.60[a]	0.4815
bone	33.50 ± 10.8[b]	42.98 ± 9.38[ab]	43.71 ± 9.12[a]	0.0667
Fat	4.38 ± 4.55[a]	4.33 ± 4.00[a]	4.63 ± 1.77[a]	0.9831
Ratio				
Lean : fat	15.1:1	15.8: 1	14.9:1	0.3918
Lean : bone	1.98:1	1.69:1	1.64:1	0.1059

[a b] = Means in the same row with different superscript differ significantly at (P > 0.05).

4.4.6 Lean and bone tissue components of carcass joints

Proportionate distributions of carcass tissues are given in table 10 and the ANOVA for these parameters is summarized in Appendix 8. No significant differences were detected for tissue distribution in all carcass joints. However, carcasses from Diet 3 had apparently superior distribution of muscles in most joints compared to those from the other diets.

Table 10: Lean and bone tissue components of carcass joints weights

Parameter (%)	Tissue distribution (% of ½ carcass)	P.Value

	D1	D2	D3	
Hind quarter				
Thigh				
Lean	71.46 ±7.25^{a}	76.72 ±4.39^{a}	74.75 ± 6.08^{a}	0.1952
Bone	26.49 ± 3.67^{a}	29.38 ± 4.38^{a}	26.15 ± 5.61^{a}	0.2847
Chump				
Lean	63.63 ±9.25^{ab}	58.14 ± 10.61^{b}	69.07 ± 6.77^{a}	0.0540
Bone	39.92 ± 10.07^{a}	37.26 ±7.66^{ab}	29.96 ± 7.55^{b}	0.0535
Loin				
Lean	69.95 ±7.54^{a}	67.59 ±11.16^{a}	65.98 ±11.76^{a}	0.7178
Bone	32.18 ± 8.12^{b}	43.91 ± 8.77^{a}	34.21 ± 8.96^{b}	0.0182
Fore quarter				
Chest				
Lean	58.45 ± 3.73^{a}	58.48 ± 8.43^{a}	59.89 ± 9.44^{a}	0.9000
Bone	38.70 ± 4.67^{a}	40.10 ± 8.98^{a}	39.83 ± 9.23^{a}	0.9245
Shoulder				
Lean	64.49 ± 6.38^{a}	64.62 ± 4.12^{a}	63.51 ± 5.78^{a}	0.8977
Bone	69.88 ± 14.4^{a}	41.78 ± 20.05^{a}	35.92 ± 5.59^{a}	0.4677
Brisket				
Lean	56.31 ± 14.24^{a}	65.61 ± 6.95^{a}	61.38 ± 4.32^{a}	0.1360
Bone	36.53 ± 9.11^{a}	34.38 ± 6.95^{a}	38.84 ± 4.29^{a}	0.4236
Neck				
Lean	62.76 ± 5.50^{a}	59.02 ± 4.52^{a}	59.30 ± 5.80^{a}	0.2690
Bone	37.25 ± 6.03^{a}	40.30 ± 5.61^{a}	38.87 ± 3.37^{a}	0.4628

$^{a\ b}$ = Means in the same row with different superscript differ significantly at ($P > 0.05$).

4.5 Chemical Composition of Goat Meat

Chemical compositions of meat from the experimental goats are presented in Appendix 11. There were no significant differences in all chemical parameters among goats from all treatments.

4.6 Digestibility Trial

An *in vivo* digestibility trial was set for further evaluation of nutritive value of the experimental diets with the view to elaborate on the underlying causes of variations noted in the growth studies.

4.6.1 *In vivo* digestibility of the experimental diets

Table 11 summarizes findings from the *invivo* digestibility trials. The corresponding ANOVA tables are shown in Appendix 9. There was no significant differences ($P>0.05$) in intake and the digestibility of the dry matter. Goats receiving Diet 2 had significantly lower ($p<.0001$) organic matter intake than those on Diet 1 and Diet 3. Intake of crude protein was significantly lower in Diet 2 compared to Diet 1 and Diet 3. The NDF and ADF digestibility's however, were significantly lower in Diet 3 compared to both Diet 1 and Diet 2.

Table 11: Mean Intake (g/d) and *in vivo* digestibility (g/kgDM) of experimental diets

Parameter	Treatments			P- Value
	D1	D2	D3	
Liveweight (kg)	20.1±1.92[a]	18.9±2.46[a]	19.9±2.67[a]	0.4158
Intake (g/d)	406.11 ± 21.03[a]	406.2 ± 14.01[a]	398.1± 14.42[a]	0.4135

DM				
DMI(g/KgW $^{0.71}$	48.23± 4.48^{a}	50.40 ± 4.74^{a}	47.62± 4.41^{a}	0.2702
OM	371.5± 19.25^{a}	339.2 ± 11.70^{b}	367.5± 13.31^{a}	<.0001
CP	62.5± 3.24^{a}	55.7 ± 1.92^{b}	61.8 ± 2.23^{a}	<.0001
CPI(g/KW $^{0.71}$	29.14± 5.08^{a}	30.76 ± 4.40^{a}	27.27± 3.81^{a}	0.8515
Dig.DMI (g/d)	245.36±36.69^{a}	247.94± 22.27^{a}	228.03±23.17^{a}	0.1746
Dig.CPI (g/d)	36.59± 4.88^{a}	29.08 ±3.51^{b}	34.34 ±6.40^{a}	0.0089
NDFI	180.03± 9.34^{a}	180.07± 6.23^{a}	170.04±6.17^{b}	0.0021
ADFI	124.5±6.45^{a}	115.8 ± 3.99^{b}	100.7 ±3.64^{c}	<.0001
***In-vivo* Digestibility (g/kgDM)**				
DM	604.5± 65.34^{a}	610.4±41.00^{a}	572.8±48.99^{a}	0.1896
OM	718.4± 60.79^{a}	693.9±43.49^{a}	699.0±58.51^{a}	0.5199
CP	585.5± 66.57^{a}	536.3±57.39^{a}	555.7±98.66^{a}	0.2883
NDF	264.0± 75.21^{a}	277.9±53.13^{a}	175.9±52.18^{b}	0.0007
ADF	446.6± 67.20^{a}	387.6±91.59^{a}	256.6±90.95^{b}	<.0001

$^{a\ b}$ = Means within the same row with different superscript letters differ significantly at $p<0.05$ CPI = Crude Protein Intake, DMI = Dry Matter Intake, OMI = Organic Matter Intake, DMD = Dry matter digestibility; Crude protein digestibility; NDF = Neutral detergent fibre; ADF = Acid detergent fibre.

4.7 Cost-Benefit Analysis of Raising Goats on the Three Experimental Diets

Table 12 provides a summary of costs and revenues extrapolated from the present studies. It can be observed that goats receiving Diet 1 produced carcasses of higher net returns compared to those on the other diets. Diet 2 produced goats that could only yield about half the revenues recorded from those on Diet 1. Diet 3 had superior returns above those of Diet 2 but were still about 10 percent units lower than goats on Diet 1.

Table 12: Cost-benefit summary of raising goats on three experimental diets

Parameters	D1	D2	D3
Purchasing price/goat	50 000	50 000	50 000
Initial weight(kg)	14.2	14.3	14.6
Cost/kg live weight	3 521	3 497	3 425
Total feed intake (kg)	36.9	36.9	35.1

Price for concentrate/kg	328.333	470	415.714
Total cost of concentrate/goat (Tsh).	**3 634.65**	**4 335.75**	**5 107.05**
Cost of housing/goat	2 508	2 508	2 508
Labour cost/goat	463	463	463
Veterinary expenses/goat	694	694	694
Total cost/goat	**57 299**	**58 000**	**58 772**
Final weight/goat(kg)	18.34	16.56	18.98
Slaughter weight /goat(kg)	16.3	13.9	15.5
Dressing percentage/goat	57	50	53
Recovered carcass weight/kg	10.4538	8.28	10.0594
Price of meat/kg (Tsh)	8 000	8 000	8 000
Sub revenue	**83 630.4**	**66 240**	**80 475.2**
Liver weight (kg)	0.25	0.19	0.25
Kidney weight (kg)	0.08	0.6	0.07
Head weight (kg)	1.1	0.86	1.1
Intestine weight (kg)	1.2	0.94	1.3
Total Edible offal weight(kg)	**2.63**	**2.09**	**2.72**
Price/kg edible offal (Tsh)	3 000	3 000	3 000
Revenue from edible offal(Tsh)	**7 890**	**6 270**	**8 160**
Skin	3 000	3 000	3 000
others	1 500	1 500	1 500
TOTA REVENUES	**96 020.4**	**77 010**	**93 135.2**
Net income (Tsh)	**38 721.07**	**19 009.57**	**34 363.47**
% Returns to investment	**67.6**	**32.8**	**58.5**

CHAPTER FIVE

5.0 DISCUSSION

5.1 Overview

This study was conducted with the main objective of exploring the possibility of raising goats for meat production using locally available feed resources. Goats used were drawn from local types commonly raised by smallholder farmers in Zanzibar. It was hypothesized that by improving nutrition through supplementary feeding, the local goats can achieve growth rates adequate to reach market weights with profitable margins. This chapter discusses the findings in four subsections, each addressing the specific objective listed in Chapter 1 Subsection 1.2.2.

5.2 Evaluation of the Nutritive Values of Potential Feed Resources for Raising Meat Goats in Zanzibar

Three forages were evaluated for their chemical composition and were later used in compounding the experimental diets. These forages are the most abundant around KATI and are widely used by the local farmers. In addition, more information was sought form a parallel study by (Tiffany, 2014) that focused on the nutritive of common browses e.g. *Gliricidia sepium* which was used in the study. However, these were not included in the formulation of experimental diets and were therefore only recorded in the Appendices.

5.2.1 Forages

Chemical analysis of the *Cynodon dactylon, Gliricidia sepium and Tripsicum laxum* indicated that the values recorded for Crude protein, NDF and ADF for all three forages were within the commonly reported ranges for these forages in East Africa

(Sahlu *et al*., 2004). The low DM values for all forages used are because these feeds were harvested at pre-bloom stage from established plots within the station. This also explains the rather high CP value (28.4%) for *Gliricidia sepium* and *Cynodon dactylon* (15%) compared to a range of 15-22 % and 8.8- 9.3% for respectively *Gliricidia sepium* and *Cynodon dactylon* reported by Shem *et al*. (1990), Mlay *et al*. (2006) and Arthington *et al*. (2005). For *Tripsicum laxum* the nutritive value was lower than those reported by Babayemi and Bamikole (2006) and Hira *et al.* (2002). The NDF and ADF values were particularly high and may have contributed to the low ME content (approxmently 7.9 MJ/ kgDM). *Tripsicum laxum* in Zanzibar matures very rapidly due to the high humidity, rainfall and temperatures especially during January to April. All the forages used in the study were collected on the day of use, keeping them fresh at time of feeding. In this way it was possible to maintain the nutritive properties by minimizing leaf loss.

5.2.2 Concentrates

Maize bran and rice polish were used as the main energy concentrates, whereas copra and fish meal provided the protein component of the supplement. Chemical analysis showed that maize bran had lower crude protein content than values commonly reported in Tanzania. However, this is because most values reported are based on hominy feed wrongly described as maize bran (Tsegay *et al.,* 2012). The bran used in this study was derived from a processing plant that employs advanced technologies which avoid the mixing of maize germ in the bran. Thus the high NDF and ADF values are consistent with expected ranges for maize bran (Arthington and Brown, 2005). The rice polish used in the study was derived from local millers around paddy growing areas in Zanzibar. The milling involves a single stage polishing; a process that yields rice polish mixed with rice bran. Thus the product used in this study had lower CP (10.8% vs 14-16%) and ME values (8.6 MJ vs 12.9 MJ) due to the dilution effect of the bran. Similarly values of ADF and NDF were higher than those reported by (Hamid *et al.,* 2007) in Pakistan where the milling process produces rice polish separate from rice bran.

Copra meal used as protein source in this study had lower than expected protein content (15.2%). Most reports indicate values higher than 18% CP (Amina, 2013). Variation in copra's CP values in Zanzibar is normally accounted by the different raw materials used in the oil extraction. Higher CP values are recorded on copra meals produced by oil millers using raw stoke derived from domestic hand pressed residues. Such products normally would have lower residual oil in the meal thus increasing the proportion of CP in the final residues. This also explains the lower ME content recorded in the present study compared to that reported by Amina (2013). The fish meal applied in the study had a CP value (55%) similar to that earlier recorded by Amina (2013). The meal was made from trash-fish, a by-product of the fishing industry readily available in Zanzibar. At high tides this product attracts lower prices consequent to higher fish landings in Zanzibar.

5.2.3 Experimental Diets

When compounding the experimental diets the proportions of *Tripsicum laxum* with *Cynodon dactylon* were interchanged while that of *Gliricidia sepium* was kept constant. The same was done for maize bran and rice polish (Table 2) while Copra meal and Fish meal were held constant. The intention was to vary the principal energy components of the diets while maintain relative amount of forage in the final diet at 70%. This was largely achieved as the energy content changed from 9.7 to 10.2 MJME/ kg DM whereas that of CP remained at around 15% except for Diet 2 that was shown to have about 14% consequent to the higher content of *Tripsicum laxum*. So as, increasing energy content in the formulated diet lead to greater intake and growth performance of goats

5.2.4 Digestibility estimates of the diets

Findings from the *in-vivo* trials indicated that Diets 1 and 3 were apparently superior to Diet 2 due to the significantly higher intake of digestible crude protein. However, the apparently higher digestibility of the fibre fraction in Diet 2 compared to Diet 3 was inconsistent to observations on other parameters. Such inconsistencies have also been reported by (Temu, 2001). Goats used in this trial ranged in weight between 16-22 kg live weights. Payne (1990) suggests that tropical goats in this range of weight should be fed diets with about 36.0gg of digestible protein to support a weight gain of around 50g/d. Diets 1 and 3 provided respectively 36.5 and 34.3 g digestible protein. The amount was sufficient to support a daily gain of respectively 45.5 and 49.4 g/d. This level of performance compares favourable with earlier studies by Shirima (2013) who offered higher levels of concentrates than was done in this study

5.3 Ration Formulation, Feed Intake and Growth Performance of Goats Raised on Experimental Diets

Intensive rearing of goats and sheep for meat production commonly practiced in Asia, Ethiopia and West Africa (Ajayi *et al.*, 2005) involves short term feeding of high concentrate diets. Diets for these operations usually include high levels of grain and other energy rich sources such as Molasses. The current prices of grain needed for rapid fattening in Zanzibar are prohibitive and the local sugar processing factory has stopped operations for a long time, hence the need for options that could minimize use of whole grains. This study employed a combination of high quality fodder with grain by-product as the main ingredients for raising meat goats. In Diet 1 the forage part was constituted with 50% *Cynodon dactylon* and 35% *Tripsicum laxum*. Rice polish made 75% of the principal energy component with maize bran completing the remaining 25% of the grain by-products. This produced a ration with about 13 MJME/kg DM, a level that is about 2 MJ higher than what was recommended by Hassan (2012) and Solaiman *et al.* (2012) for goats of similar weight. Diet 3 had *Cynodon dactylon* and *Tripsicum laxum* included at the same ratio in the forage component; with rice polish making 40% and maize bran completing the 60% portion of the grain by-product. This gave a ration with 11.2 MJME/kg DM, similar to the diets used by Lee *et al*. (2008) and Solaiman *et al*. (2012). Diet 2 in which *Tripsicum laxum* made up 50% with *Cynodon dactylon* grass constituting 35% gave a ration containing 13 MJME/kg DM. All the three diets contained crude protein around 14%, a level recommended for meat goats by most workers in the tropics (Kassahun, 2000). Thus all three diets had energy and protein levels adequate to support weight gain of at least 60g/d.

Attempts were made to produce diets that would support at least 65g of gain/day over a period of 90 days of feeding. This would have resulted in animals gaining about 6 kg live weight to reach market weight at 20 kg live weight from an average initial weight of 14 kg. Diets 1 and 3 (Table 4) managed to support respectively between 45-54g/d and 48-62g/d. This level fell short of the target by between 9-

20g/d for Diet 1 and by around 3-17g/d for Diet 3. The shortfall in achieving required weight gain could be partly explained by the low initial weight of the animals, the relatively short duration of feeding and the restriction of feed allowance to a fixed amount of 1.5 kg/d throughout the feeding trial. Goats in the current study consumed about 1.3 kg/day from diets that between 29- 31% DM.

Thus the dry matter intake for all groups (398 – 406 g/d) was at least 100 g less than the expected voluntary feed intake (VFI) for goats ranging in weight between 14.5 and 15.5 kg assuming a VFI of 3.5% of live weight (Rahman *et al.,* 2013). The rapid decrease in the rate of gain notable particularly after the 5th week of feeding could be due to the restricted feed allowance as goats in all groups grew past the 15.5 kg live weight. Similar observation were reported by Talata (2006) who showed that goats on restricted feed allowance had lower feed conversion efficiency compared to those given *ad libitum* access to feed.

Decreasing the content of *Tripsicum laxum* in the forage component appeared to improve the total feed value regardless of the ratio between rice polish and maize bran. Chemical analysis of *Tripsicum laxum* had indicated that it contained the highest amount of NDF (79.5 g/kg DM) and the lowest level of crude protein (9.7 g/kg DM) among all the forages used. Adding *Tripsicum laxum* in the diet translated into addition of fiber and dilution of crude protein in the diet.

5.4 Growth Performance and Killing Out and Carcass Characteristics

5.4.1 Growth performance

Rapid rate of gain is the principal determinant of viability of fattening enterprises. In Ethiopia and Somalia goats aimed for export market are fattened for 90-120 growing at the rate of 100 – 150 g/d (Mohammed *et al*., 2012). Ethiopian fattening operations employ high levels of molasses, nough cake or chick pea and whole grain in the formulations, with animals allowed free access to hay or teff straw (Gebremeskel and Kefelegn, 2011). Where feed cost prohibits high levels of grain usage, manipulation of the forage component could help sustain acceptable performance. Such approach was reported by Aboud *et al.* (1991) on Ethiopian Menz sheep and local goats

In the current study the average rate of gain (AVG) ranged from 25-49g/day. This level of performance was achieved at feed efficiency of 9, 16 and 8 g of feed /g gain; for respectively Diets 1, 2 and 3. The final gains at point of disposal were 29, 16 and 30% above the initial weight for respectively Diets 1, 2, and 3. This level of performance is comparable to those reported by Kitaly (1982), Mushi (2010) and Shirima (2013) for intensively fattened local sheep and goats in Tanzania.

5.4.2 Killing out and carcass characteristics

The aim of fattening operation is to produce animals of desired weight and condition. Such animals should yield carcasses of qualities required by the market. In Zanzibar carcasses are valued more for their weight than for other parameters. However, carcasses with good distribution of body fat may attract more consumers without actually fetching higher prices.

Animals on Diets 1 and 3 produced significantly heavier carcasses with good finish than those given Diet 2. The killing out percentage ranged from 50-57% giving carcasses of between 8.2 - 10.5 kg, values that are superior to those reported by Mushi (2004) and Shirima (2013) for similar goats in Tanzania. The killing out percentage for goats on Diet 2 (50%) though inferior to Diet 1 and Diet 3 still compares favorably with ranges reported by Kitaly (1982), Massae and Mtenga, (1992) and Mohammed *et al.* (2012).

The distributions of carcass joints for animals in all treatments were within the expected ranges. This also applies to lean: bone ratios. However, the fat content in the carcasses were lower than those commonly reported for intensively raised goats (Hango, 2005). This may be due to the inclusion of high forage component (70%) in the diets and the relatively young age of the goats used.

5.4.3 Edible and Non edible offal components

Edible and non edible components of the carcass constitute a significant segment in the total fattening enterprise (Malole, 2002). Skin made up about between 10-13% of the recovered carcass weight. In most abattoir operations in Tanzania, this component pays for basic maintenance cost of the slaughter services (Mzindakaya, 2012 personal communication). Other non-edible components (Blood, Spleen, Feet, and hooves) usually find application in the animal feed industry whereupon their value may amount to significant income. Animals on diets 1 and 3 had significantly higher mean weight of edible offals compared to that recorded on animals receiving diet 2 this arises from the generally higher live weight of animals under Diets 1 and 2.

5.4.4 Chemical composition of goat meat

Findings from this study indicate that the feeding regimes applied did not influence the chemical characteristics of the carcass in any form. Values observed were all within the expected ranges (Asnakew, 2005) reported in most studies on goats in East Africa. Little attention was directed to deliberate further on theses parameters as no organoleptic tests were conducted. Neither were there any indications that chemical composition would have mattered to consumers in Zanzibar.

5.5 Cost- Benefits Assessment of Raising Meat Goats Using Formulated Rations

To maximize profits from fattening enterprises farmers normally aim at producing desired carcasses at the least possible cost. In the current study it could be shown that goats on Diet 1 finished at apparently lower carcass weight than those on Diet 3, but the dressing out percentage for Diet 1 was significantly superior to both that of Diet 2 and 3. Diet 1 was also shown to be Tsh 810 and Tsh 1367 cheaper than respectively Diet 2 and Diet 3. This difference in feed cost also reflected favorably on higher revenues accrued from goats on Diet 1 on account of their higher dressing percentage.

When only the carcass was considered as source of revenue, goats on Diet 1 returned 45.9% as net profit above investment cost compared to 13.9 and 37. 2% accrued from goats on Diets 2 and 3 respectively. Inclusion of edible and non-edible components on the sales showed that goats on Diet 1 gave better returns than Diet 2 and 3.

Observations on the change in feed cost as ingredients were shuffled shows that the most important determinant of change in cost was the content of maize bran in the formulations. When maize bran was changed from 16.6% to 50% inclusion in the total concentrate formulation, the change in feed cost went up by 37.6%. The apparent superior feed efficiency (Table 4) and growth performance of goats on Diet 3 could not offset the increase in feed cost (Table 12). At current prices maize bran cost 5 times more than the price of rice polish, thus a small shift in change of quantities results into a big change in total feed cost. These findings are in agreement with study by Hango *et al.,* (2007) stated that the quantity and quality of carcasses from goats sold in the markets in Tanzania can be improved significantly through feed supplementation.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

Findings from this study have clearly demonstrated that fattening goats on locally available feed resources in Zanzibar is feasible and potentially lucrative enterprise. Notwithstanding the limitations on types of feeds evaluated and the range of weight of goats at point of entry into fattening regime, it may still be stated that:

i. Using 15% as an inclusion level of rice polish than maize bran in formulations gave diets that were cost-effective and able to support adequate rate of gain for goats starting at 14.5 kg live weight.

ii. Rice polish favored at 1:3 against maize bran produced diets that were 26.5% cheaper with Net Return to Investment 14.6% higher.

iii. Inclusion of *Tripsicum laxum* in total mixed rations for meat goats should be limited to a maximum of 25% due to its high NDF content and low CP value.

iv. The feed resources used in this study are locally available and their use will greatly increase meat production for the export and domestic markets.

6.2 Recommendations

i. Further studies should be made on evaluation of appropriate entry weight for goats in fattening operations in Zanzibar.

ii. Observations are needed on inclusion of browse species in diet formulations to minimize use of expensive protein supplements.

iii. Establishment of Fatteners Cluster of smallholders who can operate micro-feedlots to meet the high demand for meat goats in Zanzibar.

iv. Establishment of slaughter units for processing goat meat to meet standard for export market.

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APPENDICES

Appendix 1: Feed intake

1.1 Dependent variable: DM intake

R-Square	Coeff Var	Root MSE	DMI Mean
0.052119	4.164394	16.80384	403.5123

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	512.356793	256.178396	0.91	0.4135
Error	33	9318.182145	282.369156		
Corrected Total	35	9830.538937			

1.2 Dependent variable: DM intake/kg W $^{0.71}$

R-Square	Coeff Var	Root MSE	DMI/kgW 0.71 Mean
0.076245	9.243239	4.549567	49.22048

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	56.3781449	28.1890724	1.36	0.2702
Error	33	683.0524359	20.6985587		
Corrected Total	35	739.4305807			

1.3 Dependent variable: CP intake

R-Square	Coeff Var	Root MSE	CPI Mean
0.611668	4.214956	2.531537	60.0608

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	333.1151695	166.5575848	25.99	<.0001
Error	33	211.4863589	6.4086775		
Corrected Total	35	544.6015284			

1.4 Dependent variable: CP intake/kg W $^{0.71}$

R-Square	Coeff Var	Root MSE	CPI/kgW0.71 Mean
0.611668	4.214956	2.531537	60.0608

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	77.7187036	38.8593518	1.95	0.1585
Error	33	657.9562979	19.9380696		
Corrected Total	35	735.6750015			

Appendix 2: ANOVA Tables for growth parameters

2.1 Dependent variable: Initial weight (kg)

R-Square	Coeff Var	Root MSE	INIWT Mean
0.066581	16.43974	2.421599	14.73015

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	27.1890379	13.594519	2.32	0.1065
Error	65	381.1690606	5.8641394		
Corrected Total	67	408.3580985			

2.2 Dependent variable: Final weight (kg)

R-Square	Coeff Var	Root MSE	FWT Mean
0.108143	14.3049	2.588177	18.09294

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	52.7962205	26.3981102	3.94	0.0242
Error	65	435.4129913	6.6986614		
Corrected Total	67	488.2092118			

2.3 Dependent variable: Average daily gain (g)

R-Square	Coeff Var	Root MSE	AVDG Mean
0.276528	30.08127	12.04246	40.03309

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	3602.97053	1801.48526	12.42	<.0001
Error	65	9426.35912	145.02091		
Corrected Total	67	13029.32965			

2.4 Dependent variable: Total weight gain (kg)

R-Square	Coeff Var	Root MSE	TWTG Mean
0.276478	30.08309	1.011632	3.362794

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	25.41955207	12.70977604	12.42	<.0001
Error	65	66.52101705	1.02340026		
Corrected Total	67	91.94056912			

2.5 Dependent variable: Feed efficiency

R-Square	Coeff Var	Root MSE	FCR Mean

0.013802	37.48868	11.99894	32.00683

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	66.494261	33.247131	0.23	0.7951
Error	33	4751.160199	143.974551		
Corrected Total	33	4817.654461			

Appendix 3: ANOVA Table for killing out characteristics

Dependent variable: Slaughter weight (kg)

R-Square	Coeff Var	Root MSE	SWT Mean
0.445224	17.64213	2.443893	13.85259

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	115.0368074	57.5184037	9.63	0.0008
Error	24	143.3427111	5.972613		
Corrected Total	26	258.3795185			

3.1 Dependent variable: Empty body weight (kg)

R-Square	Coeff Var	Root MSE	EBW Mean
0.454984	18.46006	2.013719	10.90852

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	81.2450074	40.6225037	10.02	0.0007
Error	24	97.3215333	4.0550639		
Corrected Total	26	178.5665407			

3.2 Dependent variable: Hot carcass weight (kg)

R-Square	Coeff Var	Root MSE	HOTCARC Mean
0.410011	21.3442	1.209742	5.667778

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	24.40886667	12.20443333	8.34	0.0018
Error	24	35.1234	1.463475		
Corrected Total	26	59.53226667			

3.3 Dependent variable: Dressing percentage

R-Square	Coeff Var	Root MSE	DRESS

			Mean
0.034148	6.300487	3.255088	51.66407

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	8.9906741	4.495337	0.42	0.6591
Error	24	254.2943778	10.5955991		
Corrected Total	26	263.2850519			

Appendix 4: ANOVA Table for weight of carcass joints

4.1 Dependent variable: Thigh weight (kg)

R-Square	Coeff Var	Root MSE	THIGH Mean
0.324648	27.36909	0.134818	0.492593

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.2096963	0.10484815	5.77	0.009
Error	24	0.43622222	0.01817593		
Corrected Total	26	0.64591852			

4.2 Dependent weight: Chump weight (kg)

R-Square	Coeff Var	Root MSE	CHUMP Mean
0.091493	30.7072	0.136022	0.442963

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.04471852	0.02235926	1.21	0.3162
Error	24	0.44404444	0.01850185		
Corrected Total	26	0.48876296			

4.3 Dependent variable: loin weight (kg)

R-Square	Coeff Var	Root MSE	LOIN Mean
0.377618	30.00757	0.089022	0.296667

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.1154	0.0577	7.28	0.0034
Error	24	0.1902	0.007925		
Corrected Total	26	0.3056			

4.4 Dependent variable: Shoulder weight (kg)

R-Square	Coeff Var	Root MSE	SHOLDER Mean
0.165339	27.89315	0.086056	0.308519

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.03520741	0.0176037	2.38	0.1143
Error	24	0.17773333	0.00740556		
Corrected Total	26	0.21294074			

4.5 Dependent variable: Brisket weight (kg)

R-Square	Coeff Var	Root MSE	BRISKET Mean
0.191307	34.57752	0.065057	0.188148

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.02402963	0.01201481	2.84	0.0782
Error	24	0.10157778	0.00423241		
Corrected Total	26	0.12560741			

4.6 Dependent variable: Chest (kg)

R-Square	Coeff Var	Root MSE	CHEST Mean
0.290991	27.68671	0.226826	0.819259

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.50678519	0.25339259	4.93	0.0161
Error	24	1.2348	0.05145		
Corrected Total	26	1.74158519			

4.7 Dependent variable: Neck weight (kg)

R-Square	Coeff Var	Root MSE	NECK Mean
0.12612	19.63627	0.073818	0.375926

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.01887407	0.00943704	1.73	0.1983
Error	24	0.13077778	0.00544907		
Corrected Total	26	0.14965185			

4.8 Dependent variable: Weight of half carcass left (kg)

R-Square	Coeff Var	Root MSE	WTHCL Mean
0.355471	24.31671	0.642682	2.642963

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	5.46720741	2.7336037	6.62	0.0051
Error	24	9.91295556	0.41303981		
Corrected Total	26	15.38016296			

4.9 Dependent variable: Weight of half carcass right (kg)

R-Square	Coeff Var	Root MSE	WTHCR Mean
0.384493	22.31549	0.628883	2.818148

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	5.92934074	2.96467037	7.5	0.003
Error	24	9.49186667	0.39549444		
Corrected Total	26	15.42120741			

4.10 Dependent variable: Thigh %

R-Square	Coeff Var	Root MSE	THIGH% Mean
0.022225	17.0757	3.198025	18.72851

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	5.5793163	2.7896581	0.27	0.7636
Error	24	245.4566663	10.2273611		
Corrected Total	26	251.0359825			

4.11 Dependent variable: Chump%

R-Square	Coeff Var	Root MSE	CHUMP% Mean
0.107486	50.32249	9.043204	17.9705

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	236.370558	118.185279	1.45	0.2555
Error	24	1962.708808	81.779534		
Corrected Total	26	2199.079367			

4.12 Dependent variable: Loin %

R-Square	Coeff Var	Root MSE	LOIN% Mean
0.153499	17.22657	1.912596	11.10259

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	15.9197878	7.9598939	2.18	0.1354
Error	24	87.7925698	3.6580237		
Corrected Total	26	103.7123575			

4.13 Dependent variable: Shoulder %

R-Square	Coeff Var	Root MSE	SHOLDER% Mean
0.058418	24.20985	2.894435	11.95561

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	12.4746867	6.2373434	0.74	0.4856
Error	24	201.0661006	8.3777542		
Corrected Total	26	213.5407873			

4.14 Dependent variable: Brisket %

R-Square	Coeff Var	Root MSE	BRISKET% Mean
0.031665	24.86604	1.781001	7.162381

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	2.48939896	1.24469948	0.39	0.6797
Error	24	76.12711592	3.17196316		
Corrected Total	26	78.61651488			

1.15 Dependent variable: Chest%

R-Square	Coeff Var	Root MSE	CHEST% Mean
0.080761	15.6869	4.886402	31.14957

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	50.3454481	25.1727241	1.05	0.364
Error	24	573.0461989	23.876925		
Corrected Total	26	623.3916471			

4.16 Dependent variable: Neck%

R-Square	Coeff Var	Root MSE	NECK% Mean
0.289076	24.09943	3.628392	15.05593

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	128.4776041	64.2388021	4.88	0.0167
Error	24	315.9654562	13.1652273		
Corrected Total	26	444.4430604			

Appendix 5: ANOVA Table for edible offal components

5.1 Dependent variable: Head (kg)

R-Square	Coeff Var	Root MSE	HEAD Mean
1.49180741	21.95683	0.221357	1.008148

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.31582963	0.15791481	3.22	0.0576
Error	24	1.17597778	0.04899907		
Corrected Total	26	1.49180741			

5.2 Dependent variable: Liver (kg)

R-Square	Coeff Var	Root MSE	LIVER Mean
0.287185	16.96484	0.038956	0.22963

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.01467407	0.00733704	4.83	0.0172
Error	24	0.03642222	0.00151759		
Corrected Total	26	0.0510963			

5.3 Dependent variable: Lung (kg)

R-Square	Coeff Var	Root MSE	LUNG Mean
0.088826	90.60137	0.134627	0.148593

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.04240474	0.02120237	1.17	0.3275
Error	24	0.43498578	0.01812441		
Corrected Total	26	0.47739052			

5.4 Dependent variable: Kidney (kg)

R-Square	Coeff Var	Root MSE	KIDNEY Mean
0.25	17.40979	0.012509	0.071852

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.00125185	0.00062593	4	0.0317
Error	24	0.00375556	0.00015648		
Corrected Total	26	0.00500741			

5.5 Dependent variable: Empty intestine weight (kg)

R-Square	Coeff Var	Root MSE	INTEMPTY Mean
0.420026	13.34844	0.154347	1.156296

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.41407407	0.20703704	8.69	0.0014
Error	24	0.57175556	0.02382315		
Corrected Total	26	0.98582963			

5.6 Dependent variable: Abdominal fat (kg)

R-Square	Coeff Var	Root MSE	ABNFAT Mean
0.424169	51.4634	0.117985	0.229259

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.2460963	0.12304815	8.84	0.0013
Error	24	0.33408889	0.01392037		
Corrected Total	26	0.58018519			

5.7 Dependent variable: Head%

R-Square	Coeff Var	Root MSE	HEAD% Mean
0.081362	17.1456	1.265496	7.380881

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	3.40415908	1.70207954	1.06	0.3612
Error	24	38.43553838	1.60148077		
Corrected Total	26	41.83969746			

5.8 Dependent variable: Liver%

R-Square	Coeff Var	Root MSE	LIVER% Mean
0.153274	12.50504	0.210591	1.684048

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.1926707	0.09633535	2.17	0.1358
Error	24	1.06436478	0.04434853		
Corrected Total	26	1.25703549			

5.9 Dependent variable: Lung%

R-Square	Coeff Var	Root MSE	LUNG% Mean
0.039268	92.12841	1.0146	1.101289

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	1.00979635	0.50489817	0.49	0.6183
Error	24	24.70591546	24.70591546		
Corrected Total	26	25.71571181			

5.10 Dependent variable: Kidney%

R-Square	Coeff Var	Root MSE	KIDNEY% Mean
0.113168	23.39863	0.125756	0.537452

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.04843422	0.02421711	1.53	0.2366
Error	24	0.37955181	0.01581466		
Corrected Total	26	0.42798603			

5.11 Dependent variable: Empty intestine%

R-Square	Coeff Var	Root MSE	EMPTY INTESTINE % Mean
0.135559	11.95999	1.016479	8.499

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	3.88868104	1.94434052	1.88	0.1741
Error	24	24.79751996	1.03323		
Corrected Total	26	28.686201			

5.12 Dependent variable: Abdominal fat%

R-Square	Coeff Var	Root MSE	ABDOMINALTFAT %Mean
0.381872	43.08835	0.684328	1.588196

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	6.94350133	3.47175066	7.41	0.0031
Error	24	11.23930362	0.46830432		
Corrected Total	26	18.18280495			

Appendix 6: ANOVA Table for non edible offal components

6.1 Dependent variable: Blood weight (kg)

R-Square	Coeff Var	Root MSE	BLOOD Mean
0.444686	20.19538	0.092226	0.456667

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.16346667	0.08173333	9.61	9.61
Error	24	0.20413333	0.00850556		
Corrected Total	26	0.3676			

6.2 Dependent variable: Skin weight (kg)

R-Square	Coeff Var	Root MSE	SKIN Mean
0.216276	33.9944	0.374064	1.10037

Source	DF	sum of sguares	Mean Square	F Value	Pr > F
Model	2	0.92671852	0.46335926	3.31	0.0537
Error	24	3.35817778	0.13992407		
Corrected Total	26	4.2848963			

6.3 Dependent variable: Fore leg weight (kg)

R-Square	Coeff Var	Root MSE	FORELEG Mean
0.302572	12.26898	0.032217	0.262593

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.01080741	0.0054037	5.21	0.0132
Error	24	0.02491111	0.00103796		
Corrected Total	26	0.03571852			

6.4 Dependent variable: hind leg weight (kg)

R-Square	Coeff Var	Root MSE	HINGLEG Mean
0.295513	14.09704	0.036705	0.26037

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.01356296	0.00678148	5.03	0.0149
Error	24	0.03233333	0.00134722		
Corrected Total	26	0.0458963			

6.5 Dependent variable: Spleen weight (kg)

R-Square	Coeff Var	Root MSE	SPLEEN Mean
0.466271	51.90058	0.026335	0.050741

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.01454074	0.00727037	10.48	0.0005
Error	24	0.01664444	0.00069352		
Corrected Total	26	0.03118519			

6.6 Dependent variable: Trachea weight (kg)

R-Square	Coeff Var	Root MSE	TRECHEA Mean
0.395833	26.82383	0.01371	0.051111

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.00295556	0.00147778	7.86	0.0024
Error	24	0.00451111	0.00018796		
Corrected Total	26	0.00746667			

6.7 Dependent variable: Testis weight (kg)

R-Square	Coeff Var	Root MSE	TESTIS Mean
0.4375	26.60346	0.031136	0.117037

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.0180963	0.00904815	9.33	0.001
Error	24	0.02326667	0.00096944		
Corrected Total	26	0.04136296			

6.8 Dependent variable: Blood%

R-Square	Coeff Var	Root MSE	BLOOD% Mean
0.052382	19.53966	0.64999	3.326519

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.56049568	0.28024784	0.66	0.5243
Error	24	10.13969848	0.42248744		
Corrected Total	26	10.70019416			

6.9 Dependent variable: Skin%

R-Square	Coeff Var	Root MSE	SKIN% Mean
0.200115	20.2286	1.580763	7.814496

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	15.00367334	7.50183667	3	0.0686
Error	24	59.97148859	2.49881202		
Corrected Total	26	74.97516193			

6.10 Dependent variable: Fore leg%

R-Square	Coeff Var	Root MSE	FORELEG% Mean
0.310909	13.7174	0.267304	1.948648

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.77370838	0.38685419	5.41	0.0115
Error	24	1.71483125	0.0714513		
Corrected Total	26	2.48853963			

6.11 Dependent variable: Hind leg%

R-Square	Coeff Var	Root MSE	HINDLEG% Mean
0.27805	14.36136	0.276821	1.927541

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.708313	0.3541565	4.62	0.02
Error	24	1.83911661	0.07662986		
Corrected Total	26	2.54742961			

6.12 Dependent variable: Spleen%

R-Square	Coeff Var	Root MSE	SPLEEN% Mean
0.467212	36.95034	0.130359	0.352796

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.35764763	0.17882381	10.52	0.0005
Error	24	0.40784588	0.01699358		
Corrected Total	26	0.76549351			

6.13 Dependent variable: Trachea%

R-Square	Coeff Var	Root MSE	TRECHEA% Mean
0.120105	28.55998	0.10565	0.369922

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.03656602	0.01828301	1.64	0.2154
Error	24	0.26788471	0.01116186		
Corrected Total	26	0.30445073			

6.14 Dependent variable: Testis%

R-Square	Coeff Var	Root MSE	TESTIS% Mean
0.202597	20.66901	0.172387	0.834037

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.1812077	0.09060385	3.05	0.0661
Error	24	0.71321622	0.02971734		
Corrected Total	26	0.89442392			

Appendix 7: ANOVA tables for weight of tissues, percentages and ratios

7.1 Dependent variable: Lean weight (kg)

R-Square	Coeff Var	Root MSE	LEAN Mean
0.290814	25.86503	0.472085	1.825185

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	2.19334074	1.09667037	4.92	0.0162
Error	24	5.34873333	0.22286389		
Corrected Total	26	7.54207407			

7.2 Dependent variable: Bone weight (kg)

R-Square	Coeff Var	Root MSE	BONE Mean
0.332201	25.68165	0.265377	1.033333

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.8408	0.4204	5.97	0.0079
Error	24	1.6902	0.070425		
Corrected Total	26	2.531			

7.3 Dependent variable: Fat weight (kg)

R-Square	Coeff Var	Root MSE	FAT Mean
0.044516	80.2436	0.096887	0.120741

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.0104963	0.00524815	0.56	0.579
Error	24	0.22528889	0.00938704		
Corrected Total	26	0.23578519			

7.4 Dependent variable: Lean %

R-Square	Coeff Var	Root MSE	LEAN% Mean
0.059091	11.07969	7.675884	69.27889

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	88.8056	44.4028	0.75	0.4815
Error	24	1414.060667	58.919194		
Corrected Total	26	1502.866267			

7.5 Dependent variable: Bone %

R-Square	Coeff Var	Root MSE	BONE% Mean
0.202005	24.46735	9.802529	40.0637

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	583.78183	291.890915	3.04	0.0667
Error	24	2306.1496	96.089567		
Corrected Total	26	2889.93143			

7.6 Dependent variable: Fat %

R-Square	Coeff Var	Root MSE	FATP Mean
0.00142	81.95366	3.642689	4.444815

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	0.452763	0.2263815	0.02	0.9831
Error	24	318.4603111	13.2691796		
Corrected Total	26	318.9130741			

7.7 Dependent variable: Lean : Fat ratio

R-Square	Coeff Var	Root MSE	L:FR Mean
0.075107	55.41093	12.54668	22.64296

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	306.802252	153.401126	0.97	0.3918
Error	24	3778.058711	157.419113		
Corrected Total	26	4084.860963			

7.8 Dependent variable: Lean: Bone ratio

R-Square	Coeff Var	Root MSE	L:BR Mean
0.170633	30.39384	0.566564	1.864074

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	1.58498519	0.79249259	2.47	0.1059
Error	24	7.70386667	0.32099444		
Corrected Total	26	9.28885185			

Appendix 8: ANOVA Tables For Lean and bone tissue components

8.1 Dependent variable: Thigh – meat %

R-Square	Coeff Var	Root MSE	Thmeat% Mean
0.127279	8.102437	6.020953	74.3104

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	126.8892639	63.4446319	1.75	0.1952
Error	24	870.0450554	36.2518773		
Corrected Total	26	36.2518773			

8.2 Dependent variable: Thigh – bone%

	R-Square	Coeff Var	Root MSE	THbone%Mean	
	0.099406	16.92219	4.626103	27.3375	

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	56.692563	28.3462815	1.32	0.2847
Error	24	513.6199461	21.4008311		
Corrected Total	26	570.312509			

8.3 Dependent variable: Chump - meat%

	R-Square	Coeff Var	Root MSE	CHmeat%Mean	
	0.215874	14.17467	9.016986	63.61336	

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	537.214283	268.607142	3.3	0.054
Error	24	1951.344819	81.306034		
Corrected Total	26	2488.559102			

8.4 Dependent variable: Chump - bone%

	R-Square	Coeff Var	Root MSE	CHbone%Mean	
	0.216497	23.81484	8.50593	35.71694	

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	479.80612	239.90306	3.32	0.0535
Error	24	1736.420344	72.350848		
Corrected Total	26	2216.226463			

8.5 Dependent variable: Loin - meat%

	R-Square	Coeff Var	Root MSE	LOmeat%Mean	
	0.027256	15.21827	10.32412	67.84031	

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	71.678028	35.839014	0.34	0.7178
Error	24	2558.100558	106.587523		
Corrected Total	26	2629.778586			

8.6 Dependent variable: Loin - bone%

R-Square	Coeff Var	Root MSE	LObone%Mean
0.283995	23.44774	8.620391	36.76426

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	707.390813	353.695406	4.76	0.0182
Error	24	1783.467208	74.311134		
Corrected Total	26	2490.85802			

8.7 Dependent variable: Chest - meat%

R-Square	Coeff Var	Root MSE	CHEmeat% Mean
0.008737	12.92088	7.615779	58.94164

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	12.269235	6.134617	0.11	0.9
Error	24	1392.002202	58.000092		
Corrected Total	26	1404.271437			

8.8 Dependent variable: Chest - bone%

R-Square	Coeff Var	Root MSE	CHEbone%Mean
0.00652	20.01408	7.914608	39.5452

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	9.865924	4.932962	0.08	0.9245
Error	24	1503.384656	62.641027		
Corrected Total	26	1513.25058			

8.9 Dependent variable: Shoulder - meat%

R-Square	Coeff Var	Root MSE	SHmeat% Mean
0.008954	8.588205	5.514647	64.21187

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	6.5944164	3.2972082	0.11	0.8977
Error	24	729.8720419	30.4113351		
Corrected Total	26	736.4664583			

8.10 Dependent variable: Shoulder - bone%

R-Square	Coeff Var	Root MSE	SHbone% Mean
0.061367	124.9506	61.46806	49.1939

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	5928.60013	2964.30006	0.78	0.4677
Error	24	90679.73665	3778.32236		
Corrected Total	26	96608.33678			

8.11 Dependent variable: Brisket - meat%

R-Square	Coeff Var	Root MSE	BRmeat%Mean
0.153198	15.524	9.484768	61.09744

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	390.603336	195.301668	2.17	0.136
Error	24	2159.059809	89.960825		
Corrected Total	26	2549.663145			

8.12 Dependent variable: Brisket - bone%

R-Square	Coeff Var	Root MSE	BRbone Mean
0.069087	19.31851	7.067762	36.58544

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	88.974358	44.487179	0.89	0.4236
Error	24	1198.878102	49.953254		
Corrected Total	26	1287.85246			

8.12 Dependent variable: Neck - meat%

R-Square	Coeff Var	Root MSE	NEmeat% Mean
0.103642	8.784647	5.302641	60.3626

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	78.0280962	39.0140481	1.39	0.269
Error	24	674.8320486	28.118002		
Corrected Total	26	752.8601448			

8.13 Dependent variable: Neck - bone%

R-Square	Coeff Var	Root MSE	NEbone% Mean
0.062183	13.24256	5.13918	38.80805

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	42.0292871	21.0146436	0.8	0.4628
Error	24	633.867999	26.4111666		
Corrected Total	26	675.8972862			

Appendix 9: ANOVA Tables For in vivo digestibility of feeds

9.1 Dependent variable: DM intake (g/d)

R-Square	Coeff Var	Root MSE	DMI Mean
0.052119	4.164394	16.80384	403.5123

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	512.356793	256.178396	0.91	0.4135
Error	33	9318.182145	282.369156		
Corrected Total	35	9830.538937			

9.2 Dependent variable: DM intake /kg W $^{0.71}$

R-Square	Coeff Var	Root MSE	DMI/kgW 0.71 Mean
0.076245	9.243239	4.549567	49.22048

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	56.3781449	28.1890724	1.36	0.2702
Error	33	683.0524359	20.6985587		
Corrected Total	35	739.4305807			

9.3 Dependent variable: OM intake (g/d)

R-Square	Coeff Var	Root MSE	OMI Mean
0.497763	4.203236	15.10821	359.4424

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	7465.41761	3732.7088	16.35	<.0001
Error	33	7532.51798	228.25812		
Corrected Total	35	14997.93559			

9.4 Dependent variable: CP intake (g/d)

R-Square	Coeff Var	Root MSE	CPI Mean
0.611668	4.214956	2.531537	60.0608

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	333.1151695	166.5575848	25.99	<.0001
Error	33	211.4863589	6.4086775		
Corrected Total	35	544.6015284			

9.5 Dependent variable: CP intake/kg W $^{0.71}$

R-Square	Coeff Var	Root MSE	CPI/kgW0.71 Mean
0.611668	4.214956	2.531537	60.0608

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	77.7187036	38.8593518	1.95	0.1585
Error	33	657.9562979	19.9380696		
Corrected Total	35	735.6750015			

9.6 Dependent variable: Digestible DM intake (g/d)

R-Square	Coeff Var	Root MSE	Dig.DMI(g/d) Mean
0.100379	11.68557	28.1651	241.0246

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	2920.93246	1460.46623	1.84	0.1746
Error	33	26178.00725	793.27295		
Corrected Total	35	29098.93971			

9.7 Dependent variable: Digestible CP intake (g/d)

R-Square	Coeff Var	Root MSE	Dig.PCI(g/d) Mean
0.248821	15.06751	5.072892	33.66775

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	281.299971	140.649985	5.47	0.0089
Error	33	849.229782	25.734236		
Corrected Total	35	1130.529752			

9.8 Dependent variable: NDF intake (g/d)

R-Square	Coeff Var	Root MSE	NDFI Mean
0.312598	4.176595	7.399726	177.1713

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	821.713849	410.856924	7.5	0.0021
Error	33	1806.946123	54.755943		
Corrected Total	35	2628.659972			

9.9 Dependent variable: ADF intake (g/d)

R-Square	Coeff Var	Root MSE	ADFI Mean
0.817508	4.276199	4.863406	113.732

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	3496.587228	1748.293614	73.92	<.0001
Error	33	780.539579	23.652715		
Corrected Total	35	4277.126807			

9.10 Dependent variable: Digestible DM (g/kg)

R-Square	Coeff Var	Root MSE	DMD Mean
0.095859	8.854913	52.76491	595.883

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	9740.9044	4870.4522	1.75	0.1896
Error	33	91876.4941	2784.1362		
Corrected Total	35	101617.3985			

9.11 Dependent variable: Digestible OM (g/kg)

R-Square	Coeff Var	Root MSE	DOM Mean
0.038871	7.787541	54.80866	703.7992

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	4009.1994	2004.5997	0.67	0.5199
Error	33	99131.6328	3003.9889		
Corrected Total	35	103140.8322			

9.12 Dependent variable: Digestible CP (g/kg)

R-Square	Coeff Var	Root MSE	DCP Mean
0.0726	13.48904	75.43413	559.2251

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	14699.988	7349.994	1.29	0.2883
Error	33	187780.1541	5690.3077		
Corrected Total	35	202480.1421			

9.13 Dependent variable: Digestible NDF (g/kg)

R-Square	Coeff Var	Root MSE	DNDF Mean
0.355625	25.41132	61.11312	240.4957

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	68019.8833	34009.9416	9.11	0.0007
Error	33	123248.8409	3734.8134		
Corrected Total	35	191268.7242			

9.14 Dependent variable: Digestible ADF (g/kg)

R-Square	Coeff Var	Root MSE	DNDF Mean
0.493692	23.10562	84.02091	84.02091

Source	DF	sum of squares	Mean Square	F Value	Pr > F
Model	2	227158.8582	113579.4291	16.09	<.0001
Error	33	232963.9401	7059.5133		
Corrected Total	35	460122.7983			

Appendix 10: Chemical composition of some trees and shrubs in Zanzibar

Name	*Location**	*Crude Protein*	*Crude Fiber*	*Ether Extract*	*Neutral Detergent Fiber*	*Acid Detergent Fiber*	*Acid Detergent Lignin*	*Dry Matter Digestibility*
Baobab	C	13.53	24.26	4.11	44.62	18.87	7.02	33.26
Mchengele	C	11.36	12.54	3.41	46.14	37.56	25.90	16.41
Mdimu msitu	C	16.02	18.33	4.73	46.25	22.62	7.20	50.58
Mdimu msitu	K	12.02	23.74	3.85	41.20	26.31	9.69	43.47
Mfuu	C	9.74	32.57	2.89	59.21	44.20	14.87	15.79
Mfuu	K	7.58	36.50	2.73	61.65	39.28	10.44	18.15
Mango	K	6.58	29.30	2.10	48.40	33.10	12.24	30.05
Gliricidia	C	23.95	15.53	5.50	47.78	24.52	13.30	62.86
Mkungu	C	14.41	22.70	3.85	38.07	24.13	4.17	37.75
Mkungu	K	9.31	20.47	2.86	33.78	22.71	5.23	26.04
Mkuyu	C	11.09	14.47	3.11	49.58	36.29	17.85	23.18
Mkwamba	C	18.85	11.41	5.69	25.40	13.40	3.42	51.86
Mlandege	C	16.38	14.41	4.63	35.43	20.85	7.24	52.62
Mlapaa	C	11.28	15.08	3.08	55.74	43.95	28.80	24.25
Papaya	K	16.76	13.75	4.87	23.24	13.27	2.66	67.92
Mpilipili	C	11.21	21.72	3.36	41.75	25.76	11.10	22.43
Mpilipili	K	8.85	21.46	2.65	45.97	30.98	13.54	23.37
Moringa	C	29.92	11.36	5.61	28.19	13.38	3.07	60.10
Moringa	*K*	*10.18*	*20.81*	*3.11*	*49.17*	*32.35*	*15.10*	*38.79*
Breadfruit	K	11.89	20.60	3.70	44.15	24.87	5.60	28.40
Mtunguja	C	22.26	27.87	4.82	48.84	33.53	8.17	78.76
Mzambarau	C	7.51	18.88	2.39	48.96	40.18	20.06	8.02
Mzambarau	K	7.69	17.46	2.38	48.11	36.73	19.80	17.04
22 Samples total: 18 different trees and shrub species 9 from KATI and 11 from the coral rag were analyzed.								
*KATI (K) or Coral rag (C)								

Source: Tiffany, 2014.

Appendix 11: Chemical composition of goat meat

Parameters (%)	Dietary treatment D1	D2	D3	P-value
DM	26.08 ± 3.13^a	25.76 ± 1.57^a	26.19 ± 4.54^a	0.9600
CP	20.23 ± 1.95^a	20.54 ± 2.08^a	20.94 ± 2.11^a	0.7710
EE	0.57 ± 0.55^a	0.29 ± 0.19^a	0.47 ± 0.58^a	0.4500
ASH	4.57 ± 0.57^a	4.63 ± 0.87^a	5.11 ± 0.68^a	0.2390
Ca	0.02 ± 0.01^a	0.02 ± 0.01^a	0.03 ± 0.01^a	0.5260
P	0.04 ± 0.01^a	0.04 ± 0.01^a	0.04 ± 0.01^a	0.6640
K	0.25 ± 0.05^a	0.25 ± 0.04^a	0.25 ± 0.04^a	0.9080
Na	0.06 ± 0.03^a	0.08 ± 0.05^a	0.05 ± 0.01^a	0.2500
Mg	0.02 ± 0.00^a	0.02 ± 0.04^a	0.02 ± 0.00^a	0.8500
Mn	0.003 ± 0.00^a	0.003 ± 0.00^a	0.002 ± 0.00^a	0.5590
Zn	0.02 ± 0.01^a	0.02 ± 0.01^a	0.02 ± 0.01^a	0.9900
Cu	0.003 ± 0.00^a	0.004 ± 0.00^a	0.004 ± 0.00^a	0.9940
Fe	0.038 ± 0.02^a	0.055 ± 0.06^a	0.04 ± 0.03^a	0.6420

[ab] = Means within the same row with different superscript letters differ significantly at ($p < 0.05$). DM = Dry matter; CP = Crude protein; EE = Ether extract; Ca = calicium; P = Phosphorous; K = Potassium; Na = Sodium; Mg = Magnisium; Mn = Manganise; Zn = Zinc; Cu = Copper; Fe Iron.

Source: Khamis, 2014.