PROSPECTS FOR COMMERCIAL FEEDLOT FINISHING OF SHEEP IN ZANZIBAR

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ABSTRACT

A study was conducted to evaluate the growth and carcass performance of sheep under two feedlot finishing diets in Zanzibar. Fifty four sheep (age of 9-12 months with initial body weight 18.9±0.6kg) were divided into three groups (T1, T2 and T3) of 18 in 3 replicates (each having 6 individuals). The sheep in T2 and T3 were assigned randomly to two concentrate formulations (Concentrate 1 and Concentrate 2) and a third group of similar number used as a control (T1) was grazed during the day and given no supplements. All animals in T2 and T3 were offered 600g/day concentrates and basal roughage feed of *Brachiaria decumbens, Pennisetum purperium and Gliricidia sepium* mixed at a ratio of 1.2:1.2:1 respectively at *ad libitum* level. The concentrates' principal energy ingredients were rice bran and wheat pollard included in the compounded concentrates as respectively 35% and 25% in T2 and 40% and 20% in T3 while holding all other components constant. Feeding was done for 82 days after which 6 animals were randomly picked from each treatment and slaughtered for carcass analysis. In addition a panel test was run to assess acceptability and ranking of mutton against common beef and goat meat by consumers in Zanzibar. The results of this study revealed that average daily gain of 19.8±4.92, 90.2±3.94 and 85.7±3.85g/day for T1, T2 and T3, respectively. However, there were no significant difference on feed intake and growth performance for T2 and T3. Empty body (23.24 vs. 21.38kg) and hot carcass weight (11.52 vs. 10.87kg) were not significantly ($P>0.05$) different among T2 and T3. All carcass parameters in sheep on T2 and T3 were similar between them but were significantly superior ($P<0.05$) to those on T1. Finding from the taste panel showed that mutton was ranked higher than beef and goat on its merits of superior aroma, flavour, juiciness and softness. A good number of consumers were able to identify mutton from goat meat. The cost-benefit analysis showed that carcasses from sheep on T2 had higher net income of Tsh 41,453.68

compared to those from T3 and T1 (Tsh 35,223.70 and 8,293.04) respectively. It is concluded that the formulation Concentrate 1 containing rice bran and wheat pollard at a ratio of 1.4:1 in favour of rice bran can profitably support an average daily gain (ADG) of at least 90.2g for sheep entering the feedlot at 18kglive weight. It was also shown that mutton can be readily acceptable to consumers if animals are raised to produce carcases of superior quality.

DECLARATION

I, MAULID YUSSUPH HAMDU, 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.

Maulid Yussuph Hamdu **Date**

(MSc. Candidate)

The above declaration is confirmed by;

Professor A.O. Aboud **Date**

(Supervisor)

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DEDICATION

I dedicate my research work to my Mother (Aziza Khamis), Father (Yussuph Hamdu), Wife (Asha Haji) and my children Yussuph and Khadija.

TABLE OF CONTENTS

ABSTRACT .... **ii**

DECLARATION .... **ii**

COPYRIGHT .... **v**

ACKNOWLEDGEMENTS .... **vi**

DEDICATION .... **vii**

TABLE OF CONTENTS .... **viii**

LIST OF TABLES .... **xii**

LIST OF FIGURES .... **xiii**

LIST OF PLATES .... **xiv**

LIST OF APPENDICES .... **xv**

LIST OF ABBREVIATIONS .... **xvi**

CHAPTER ONE **1**

1.0 INTRODUCTION **1**

1.1 Problem statement and justification 2

1.2 Objectives of the study 4

1.2.1 General objective 4

1.2.2 Specific objectives 4

CHAPTER TWO **5**

2.0 LITERATURE REVIEW **5**

2.1 General Overview 5

2.3 Demand for Mutton 6

2.4 Growth Performance 6

2.5 Feeds and Feeding 7

2.6 Sheep Carcass Yield and Composition 9

2.7 Non-Carcass Components Yield 10

2.8 Physical Characteristics of Mutton 11

2.8.1 Meat tenderness 11

2.8.2 Organoleptic test 11

2.9 Economic Analysis 12

2.10 Conclusion 12

CHAPTER THREE 14

3.0 MATERIALS AND METHODS 14

3.1 Study Area 14

3.2 Source of Experimental Animals 14

3.3 Management of Experimental Animals 15

3.3.1 Housing 15

3.4 Experimental Animals 17

3.5 Disease Control 18

3.6 Experimental Feeds and Experimental Layout 18

3.7 Sampling and Chemical Analysis of Feeds 19

3.8 Feed Formulation and Feeding Plan 19

3.9 Data Collection 21

3.9.1 Observations on common forages used in Zanzibar 21

3.9.2 Voluntary feed intake (VFI) measurement 21

3.9.3 Adaptation period 21

3.9.4 Growth performance measurement 22

3.9.5 Final slaughter weight and carcass evaluation 22

3.9.6 Carcass components assessment ... 24
3.9.7 Organoleptic taste ... 24
3.9.8 Tenderness test ... 25
3.9.9 Cost-benefit analysis of sheep finishing ... 25
3.9.10 Statistical analysis ... 25

CHAPTER FOUR ... 27
4.0 RESULTS ... 27
4.1 Overview ... 27
4.2 Chemical Composition of the Experimental Feeds ... 27
4.3 Voluntary Feed intake and Growth Performance ... 29
4.3.1 Feed intake ... 29
4.3.2 Growth performance ... 29
4.4 Killing out Characteristics and Carcass Components of Experimental Sheep ... 30
4.4.1 Killing out characteristics ... 30
4.4.2 Weight of carcass joints ... 31
4.4.3 Edible offal components of experimental sheep ... 32
4.4.4 Non-edible offal components of experimental sheep. ... 32
4.4.5 Total weight of tissues of the half carcass ... 33
4.5 Physical Meat Characteristics ... 34
4.5.1 Meat tenderness and cooking losses ... 34
4.5.2 Organoleptic taste ... 34
4.5.2.1 Comparison of mutton, beef and goat meat for aroma, flavour, juiciness and softness ... 34
4.5.2.2 Comparison on preference and recognition of mutton against beef and goat meat ... 35

4.6 Cost-Benefit Analysis of Experimental Sheep 35

CHAPTER FIVE 37

5.0 DISCUSSION 37

5.1 Overview 37

5.2 Determination of Chemical Composition of the Feed Ingredients and Formulated Rations used in Finishing Sheep 37

5.2.1 Nutritive values of forages 37

5.2.2 Composition of feed ingredients (concentrates) 38

5.2.3 Experimental diets and voluntary feed intake 40

5.3 Growth Performance; Killing out and Carcass Characteristics 41

5.3.1 Growth performance 41

5.3.2 Killing out and carcass characteristics 41

5.3.3 Edible and non edible offal components 41

5.3.4 Percentage lean, bone and fat 42

5.3.5 Organoleptic test 42

5.4 Cost-Benefits Assessment of Raising Mutton using Formulated Rations 43

CHAPTER SIX 44

6.0 CONCLUSION AND RECOMMENDATIONS 44

6.1 Conclusions 44

6.2 Recommendations 45

REFERENCES 46

APPENDICES 62

LIST OF TABLES

Table 1: Concentrate formulae used for Treatment 2 and Treatment 3 20
Table 2: Mixture of roughages used in the experiments 21
Table 3: Panels of Meat Organoleptic test 24
Table 4: Mean chemical composition of feed ingredients used in experimental diets 28
Table 5: Mean and SE of DM, CP and ME (MJ) intake by sheep under experiment 29
Table 6: Growth performance of sheep under experiment 30
Table 7: Killing out characteristics of sheep under experiment. 30
Table 8: Half carcass joints weight of sheep under experiments 31
Table 9: Edible offal components of experimental sheep 32
Table 10: Non – edible offal component of experimental sheep 33
Table 11: Total weight and percentage of lean, bone and fat tissues in half carcass 33
Table 12: Meat tenderness and weight loss 34
Table 13: Organoleptic test of beef, goat meat and mutton on aroma, flavour, juiciness and softness 35
Table 14: Preference and recognition between mutton and Beef 35
Table 15: Cost-benefit summary of raising sheep on three experimental diets 36

LIST OF FIGURES

Figure 1: Standard carcass joint used in this study 23

LIST OF PLATES

Plate 1: Front view of the sheep house 15

Plate 2: Pens for Experimental Sheep 16

Plate 3: Concentrate and water troughs (yellow containers) in experimental pens 16

Plate 4: Sheep under Control group (T1) grazing on surrounding pasture 17

Plate 5: Sheep under Treatment 2 feeding in pen 17

Plate 6: Sheep under Treatment 3 feeding in pen 18

Plate 7: Carcasses from T1-T3 30

LIST OF APPENDICES

Appendix 1: Feed Intake 62

Appendix 2: Growth performance 64

Appendix 3: Killing out characteristics 65

Appendix 4: ANOVA Table for weight of carcass joints.. 66

Appendix 5: ANOVA Table for Edible offal components 69

Appendix 6: ANOVA Table for Non-Edible offal components................................... 72

Appendix 7: ANOVA tables for weight of tissues, percentages and ratios in half carcass 75

Appendix 8: ANOVA Tables for Lean and bone tissue components of the half carcass joints 76

Appendix 9: ANOVA Tables for Shear force values. 81

Appendix 10: Tables for Organoleptic testof Beef, mutton and goat meat 82

LIST OF ABBREVIATIONS

Ab. Fat	Abdominal Fat
ADF	Acid Detergent Fibre
ADG	Average Daily Gain
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
ASH	Mineral Matter
CF	Crude Fibre
CP	Crude Protein
CPI	Crude Protein Intake
DASP	Department of Animal Science and Production
DM	Dry Matter
DMI	Dry Matter Intake
DP	Dressing Percentage
EBW	Empty Body Weight
EE	Ether Extract
FCE	Feed Conversion Efficient
FCR	Feed Conversion Ratio
FO	Feed Offered
FR	Feed Residue
FWBT	Final Body Weight
GIT	Gastro-Intestinal Tract
GLM	General Leaner Model
HCW	Hot Carcass Weight
IBWT	Initial Body Weight

KATI	Kizimbani Agricultural Training Institute
Kg	Kilogram
$KgW^{0.71}$	Kilogram Metabolic Weight
LIG	Lignin
ME	Metabolizable Energy
MJ	Mega Joule
MJ/d	Mega Joule per day
N/cm^2	Newton per Centimetre Square
NDF	Neutral Detergent Fibre
P	Probability
P-Value	Probability Value
PWL	Percentage Weight Loss
SAS	Statistical Analysis System
SE	Standard Error
SEM	Standard Error of the Mean
SFVAL	Shear force Value
SUA	Sokoine University of Agriculture
SW	Slaughter Weight
T	Treatment
TWG	Total Weight Gain
VFI	Voluntary Feed Intake
WTAFC	Weight after Cooling
WTL	Weight Loss

CHAPTER ONE

1.0 INTRODUCTION

Zanzibar has a human population density of over 350/km^2, making it one of the most densely populated locations in Eastern Africa. Over 56% of the inhabitants reside in urban centres, relying on food supplies mainly from Tanzania Mainland (MF, 2013). Local production of red meat is negligible with over 90% of meat reaching the market derived from either imports of live cattle, sheep and goats or of meat from animals' slaughtered outside the Islands (NSCA, 2008). Recent moves towards minimizing over reliance of meat imports has prompted the government to initiate two prongs strategy aimed at seeing Zanzibar meets at least 50% of her red meat supply from local production. The strategy involves increasing tariffs to discourage imports on one hand parallel to encouraging livestock keepers to raise more stocks intensively with concurrent subsidies on drugs and feed supplements.

Sheep usually perform better in terms of pre-slaughter and carcass weight, on the other hand dressing percentage becomes higher than goats maintained under the same feedlot finishing conditions, similar findings reported by Sen *et al.* (2004). The performance is attributed to genetic potential of the animal as reported by Marques *et al.* (2014). In feedlot condition, manipulation of nutrition has shown to significantly bring about improvement in sheep productivity (Madsen *et al.,* 2008). In Ethiopia and Sudan, sheep, goat and cattle feedlot finishing is a prominent farming activity where the animals are reared under intensive system. In that system of production confining animals for a period of (80 - 120) days concurrently with the provision of better management practices significantly improve weight gain, yielding quality and quantity carcass, reported by

Gizaw *et al.* (2010). So far sheep feedlot finishing is also being practiced in Tanzania, resulting to wonderful sheep performance in terms of weight gain and carcass characteristics (Shirima *et al.,* 2012).The achievements attributed by provision of quality concentrates and improved management practices. The commonest feeding system for ruminants in Zanzibar is tethering on short grasses under coconut plantations or elsewhere without any form of supplementation. The practice has multiple disadvantages including low weight gain, long period of rearing and insecurity for the stock. Initiatives are conducted enabling Zanzibar to reduce dependence of red meat importation from outside the Islands. The initiated move on goat finishing using available feed ingredients (Mohammed, 2015) has shown to improve performance and carcass characteristics of the local goats. However, experience in Dodoma Tanzania (Shirima *et al.,* 2014) suggests that sheep finishing is more likely to generate higher returns than goats.

1.1 Problem statement and justification

Zanzibar is facing a challenge of rapidly rising population making every piece of land ever more precious, despite the ever increasing of food demand in the Islands. According to URT (2012), Zanzibar has a population increasing rate of 2.8% annually meaning food demand will always escalate calling for intensive livestock production to improve red meat production. Naturally livestock production based on grazing is being constrained, becoming either untenable or run inefficiently. This rearing practice cannot meet the demand for quality red meat in Zanzibar. A viable commercial production entails application of improved nutrition under feedlot finishing condition, is among the solutions. Currently animal products (especially red meat) are imported to meet the local demands. Furthermore fish catching is predisposed to various factors triggering to low supply of the commodities in the markets. Fish price constantly increasing where most people of low economic status can't afford, this is also contributed to tourist hotels purchase fish at exorbitant prices. Moreover, there is a very prominent market for mutton in the hotels as the Europeans prefer most. People of Zanzibar most of them are Muslims preferring religious scarification during the Edd-el Hajj, since the first choice for the act is sheep followed by goat. Small ruminant feedlot is being practiced in Ethiopia and the rest of the East African countries revealing viability of the business. Supplementing sheep in feedlot with extracted oil seed cakes and grains by-products or their mixtures (Gebreslassie and Melaku, 2015) has shown to improve intake, body weight gain and carcass characteristics.

On the other hand in Tanzania, Hozza *et al.* (2013) reported significant increase in weight gain of local (Small East African goats) against their crosses with Norwegian goat. Feedlot finishing with the use of concentrate feeds has shown to improve weight gain and carcass characteristics, however the use of grains as the source of feed energy brings competition with human food (Fasae *et al.,* 2011). Since the use of cereal by-products and quality roughages are of prerequisite in feedlot finishing of ruminants to increase profitability. Feedlot finishing in Dodoma is economic feasible and improves profitability of the project, reported by Shirima *et al.* (2012) in Tanzania. Goat finishing using locally available feed ingredients was implemented, showing appreciable net profit in Zanzibar (Mohammed, 2015). It is yet to be established if such additional feed cost would still justify a choice of sheep finishing above that of goats in Zanzibar. So far there is no study conducted on feedlot finishing of sheep in the Islands. The situation should call for enhanced techniques of sheep production that would improve mutton production. Therefore, the current study was conducted to finish sheep under feedlot condition using locally available ingredients with the view to improve growth performance and yielding carcass at competitive price in Zanzibar markets.

1.2 Objectives of the study

1.2.1 General objective

To study the performance of sheep finished in feedlot using available local feed materials with the view to producing feeds at least cost and yielding carcasses that can be competitively priced in Zanzibar.

1.2.2 Specific objectives

i. To analyses chemical composition of the feed ingredients and formulated rations.
ii. To measure growth performance of sheep finished with the formulated rations.
iii. To assess carcass characteristics of the experimental sheep basing on the formulated rations.
iv. To assess cost effectiveness of the formulated rations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Overview

In Tanzania there are about 6.4 million sheep reared under extensive, semi intensive and intensive systems of production. Sheep and goats contribute about 22% to the national meat production (MLFD, 2011). This number of livestock is being kept by 30% of the agricultural households with annual off-take rates projected at 29% and 28% with an average carcass weight of 12 and 15 kg for sheep and goats respectively (Njombe and Msanga, 2005). In Zanzibar, sheep and goat production is practiced in similar manner as in Tanzania Mainland. Generally, there is small number of sheep in regards to total livestock units present in the Islands. The total number of sheep is reported to be 574 all of which belonging to indigenous breeds and 70% are found in West and Central districts of Unguja Island (NSCA, 2008). Due to insufficient amount of mutton produced and supplied in the markets, the demand for mutton has drastically increased and up to 17 578 tonnes of mutton is imported from Tanzania mainland and elsewhere to meet the demand (MANREC, 2007).

Sheep production has economic advantages through sale of large number of live sheep in rural and peri-urban areas (Tsega *et al.,* 2014). Sheep production plays various roles in Tanzania communities like in most African countries, ranging from nutritional, sociological to economic aspects (Hartwich *et al.,* 2012). Sheep production serves as a source of cash income and predominantly serve as a source of protein and also as sacrifice slaughter during religious occasions (Bela and Haile, 2009) and other festivals. In addition, it contributes highly to provision of organic fertilizer for crop and vegetable production (Ellis and Mdoe, 2003). Small ruminants are mostly raised by poorer people who are the majority in Tanzania enabling them to meet their livelihood demands. Sheep and goats rank second in rural and peri-urban livestock population, after cattle (Pollott and Wilson, 2009). Since increasing to household's food safety, income and socio-cultural wealth. Sheep production has become an important source of income to farmers throughout developed and developing countries by selling mutton, skin and fur for various uses.

2.3 Demand for Mutton

Africa is among the continents with fast growing human population causing demand for animal protein to increase (Masiga and Munyua, 2014). Due to the increasing human population globally, the demand for meat has tremendously escalated, thus influencing commercialisation of small ruminant production to meet the demand (Alexandratos and Bruinsma, 2012). In Tanzania, mutton is consumed as other types of meat by most of the people, fundamentally there is no religious or cultural taboos against the products' consumption. There is high demand for mutton in local, tourist and export markets. Intensive commercial small ruminants' production is encouraged by the government to increase the supply of meat to meet the increasing demand (Njombe and Msanga, 2009). The recent growth of tourism, expanding mining industries and establishment of international hotels in Tanzania mainland and Zanzibar, has increased meat demand from small ruminants in urban areas, especially in supermarkets (Kaliba, 2008). Mellau *et al.* (2010) reported a significant increase of demand for live animals during religious festivals, not only for local but also export markets.

2.4 Growth Performance

Growth performance of small ruminants is affected by several factors including those from the animal itself and others arising from environment and management at large

(Akhtar *et al.,* 2012). It primarily depends upon the availability of good quality feeds and the feeding regime practiced by the livestock keeper. Similar argument was made by Thiruvenkadan *et al.* (2011), who noted that, the provision of high plane of nutrition with proper feeding programme brings about significant output in Mecheri sheep taking into consideration other factors constant. Atti and Mahouachi (2011) also reported high growth rate on fat-tailed Barbarine sheep kept under feedlot finishing condition with daily gain of up to 350g/day while fairly low weight gain (100g/day) for those grazed on natural pastures. Little evidence was documented on sheep performance under extensive management in Ethiopia (Abebe *et al.,* 2000). Sheep in smallholder level of production are subjected to natural selection in which survival traits such as ability to withstand harsh environmental conditions and resistance against diseases are favoured over production traits. (Gebre *et al.,* 2014).

2.5 Feeds and Feeding

Plane of nutrition is vital in finishing animals to ascertain maximum growth and farm profitability. Feeding roughages alone in any system of production, results to lower growth rates while extending time to attain slaughter or market weight. Ahmed *et al.* (2014) reported significant low weight gain of the desert sheep reared extensively without supplementation. Commercial finishing of sheep with concentrate at *ad libitum* level has shown to be economically feasible intervention. A significant weight gain of 94.3g/day for the sheep fed *ad libitum* concentrates over those under restriction (Shirima *et al.,* 2012). Several cereal by-products and oil seed cakes in Ethiopia used as feed energy and protein sources improves sheep performance Gebeyew *et al.* (2015) under feedlot finishing condition. Rice bran as energy source in formulating concentrates has been widely used in feedlot finishing of ruminants, up to 45% inclusion of the ingredient produces significant animal performance (Muhammad *et al.,* 2008) in Nigeria. Wheat pollard up 47.9% in combination with other feed ingredients has been used in formulating concentrates for dairy cattle in semiarid condition (Figueiredo Monteiro *et al.,* 2014) Ration formulation mostly differ in forage and concentrate ratios in finishing enterprise due to availability and price of raw materials. Since supplementation with other palatable feed ingredients, largely agro-industrial by-products such as barley distillers has been used in many developed countries to improve intake and weight gain of sheep (Yuan *et al.,* 2012). Forage to concentrate ratios of 75:25, 50:50 and 25: 75 have been used in sheep finishing (Souza *et al.,* 2014). However; the diet containing 25:75 ratio of forage to concentrates had significant dry matter intake. According to Shirima *et al.* (2012) in finishing feedlot of Tanzania long fat tailed sheep supplemented roughage to concentrates at 50:50 and 25:75 as the total mixed ration. Noted that as the level of concentrates were increased in the total mixed diet, the performance parameters were also improved.

The National Research Council (NRC) reported by Paul *et al.* (2003), a 20kgs growing sheep with daily weight gain of 100-150g/day, require energy and crude protein of 6.87-7.78ME (MJ/d) and 109-130g respectively for growth and maintenance. Additionally the ration should contain sufficient amount of minerals and vitamins which are prerequisites for lamb fatting (Muíño *et al.,* 2014). Roughage (fibres) in the diet is so important for the health of gastro-intestinal tract as well as production of volatile fatty acids during rumen microbial digestion which serve as energy sources (McDonald *et al.,* 2010). Dry matter intake varies according to live body weight of the animal in question. Diets with a range of 10 -18%CP have been used for lamb finishing with good weight gain, the higher the dry matter and crude protein content of the diet experienced to increase daily weight gain tremendously (Haddad *et al.,* 2001; Titi *et al.,* 2000). It has been observed for Omani sheep receiving 3.12-3.73% dry matter intake of its live body weight to improve daily weight gain significantly during finishing period (Mahgoub *et al.,* 2000). In developing countries of Africa and Asia, extensive system of livestock production is largely practiced in which animals are exposed to harsh weather conditions, excessive exercise in looking for forage and drinking water thus ending up with poor daily weight gain, and eventually produce low quality and quantity of meat (Valbuena *et al.,* 2012). Aye (2013) also reported that West African dwarf sheep in Nigeria fed Panicum-cassava peels supplemented with or without Leucaena-based multi nutrient blocks to increase the performance.

2.6 Sheep Carcass Yield and Composition

Commercial evaluation of animals' meat largely depends on carcass yield and quality. Meat yield refers to the percentage of carefully trimmed, boneless retail cuts (edible lean) from the whole carcass. Lean quantity denotes the lean deliciousness and is considered as being largely influenced by the degree of marbling (Shija, 2012). Extensively reared lambs have lower growth rates, higher proportion of digestive tract and stomach, lower dressing percentage and higher bone to muscle ratio (Armero and Falagán, 2015).

Carcass composition is a critical factor influencing carcass quality since some variability due to breed difference and diets offered to the animal has been experienced (Wachira *et al.,* 2002), it also varies according to species, age of the animal and live weight at slaughter (Ramírez-Retamal and Morales, 2014). Complete dissection into lean, fat and bone is the best method of carcass evaluation, however it is very expensive and time consuming (Webb *et al.*, 2005). A balanced nutrition increases carcass fat whilst poor nutrition reduces fat deposition in the carcass and this results to musculature under development (Priolo *et al.,* 2002). Fat it is the main tissue in the animal body that can be manipulated by nutritional level and management (Sinclair, 2007), carcass fat content vary from 5.6 to 20.6% under extensive and intensive systems respectively, reported by Sultana *et al.* (2010)for native sheep of Bangladesh.

The dressing percentage and carcass tissue composition are parameters mostly preferred in grading carcass for marketing purpose (Shija, 2012). Meat to bone ratio is the weight of lean from the whole carcass related to the weight of bones in it. This is equal to the terms "meat to bone ratio" and "muscle to bone ratio". Meat and muscles are substitutable terms for the refusals after deboning the carcass and usually include carcass fat (Mtenga and Kitaly, 1990). A carcass fat has been observed to increase for Tanzania Long-Fat tailed sheep at the end of finishing, therefore reducing leanness and bone percentage (Shirima *et al.,* 2012). A significant reduction percentages of lean and bone from day zero to day 84 in feedlot, and increase of fat tissue were reported by from 63.0% (control) to 47.6% (in Day 84), bone weight percentage from 30% (in Day 0) to 21.2% (Day 84) and increase in carcass fat from 3.62% (Day 0) to 29.9% (Day 84) was observed (Shirima *et al.,* 2012). In most situations, pre-slaughter weight, hot carcass weights, dressing percentage, muscle development and total non-carcass fat were significantly higher for sheep than goats raised under same feeding and management conditions (Sen *et al.,* 2004).

2.7 Non-Carcass Components Yield

In most African countries, non-carcass components such as the head, kidneys, heart, blood, gut fat, spleen, lungs and trachea are important parts, since they are edible and contribute to overall supply of animal protein (Hoffman *et al.,* 2013 and Hozza *et al.,* 2013). The edible and non-edible components constitute a significant portion, ranging from 30%-32% and 12%-15% from slaughter and hot carcass weight respectively in Priangan Javanese fat tailed rams (Baihaqi and Herman, 2013). There is variation in percentage of edible and non-edible components from slaughter weight of sheep. in other studies Sultana *et al.* (2010) reported head ranges from 6.99 to 7.72 % of female and 7.52 to 8.3% for male sheep with empty gastro intestinal truck (GIT) range from 5.1 to 7.0% respectively.

2.8 Physical Characteristics of Mutton

2.8.1 Meat tenderness

Meat tenderness is a term used to determine meat softness and is conducted by the use of Warner Bratzler Shear Force Machine (Fisher and De Boer, 1994). The attribute enables consumers in setting their preference for consumption. It is positively correlated with juiciness and taste and has a substantial influence on overall consumers' satisfaction (El-Masry *et al.,* 2012; Shackelford *et al.,* 2012). Several studies have shown that consumers would be ready to pay well for a kg of guaranteed tender meat (Sun *et al.,* 2012). Lamb meat tenderness values vary seasonally as reported by Rani *et al.* (2014); becomes lower in winter (24.7±0.49N/cm^2) and higher (32.2±0.49N/cm^2)in spring with a cooking loss of 28.8±0.88%. Chulayo and Muchenje (2013) reported on different shear force values ranging from 22.9±1.33 to 26. 8±1.51N/cm^2 on the effect of pre-slaughter stress and season in South Africa. However, shear force value of 27N/cm^2 has been recommended for Mutton to satisfy the consumers' acceptance (Schmidt *et al.,* 2013). According to Shirima *et al.* (2013) there is variation of meat tenderness of Tanzania long fat tailed sheep raised under extensive and intensive systems. Sheep slaughtered just after purchase had mean tenderness value of 33.9N/cm^2, while increasing number of days in feedlot the shear force values were reduced to mean value of 19.7N/cm^2 at day 70 in the feedlot.

2.8.2 Organoleptic test

Meat flavour, aroma, juiciness and softness are the critical criteria used to convince consumers to accept meat for consumption (Highfill, 2012). Usually some people are familiar to certain meat flavour and hence judge their preference in respect to the aspect (Sanudo *et al.,* 1998: Maughan *et al.,* 2012). The natural behaviour of sheep is grazing on pastures and seldom browse on herbs, therefore aroma of the consumed materials contribute highly to the meat flavour which has great influence on acceptability of the meat to consumers (Watkins *et al.,* 2013).With this respect grasses have no strong aroma that can be introduced into the meat unlike shrubs/herbs that goats prefer to browse.

2.9 Economic Analysis

Sheep finishing is economically viable undertaking in any scale of production and produce wonderful profit margins (Al-Abri *et al.,* 2014). It has been widely practiced with appreciable results in Sudan, farmers finishing sheep for export markets to Middle East (El Dirani *et al.,* 2009). The use of locally available feed materials in supplementing sheep has been shown to be economic feasible than keeping sheep extensively without any form of supplementation (Abebe *et al.,* 2013). In Tanzania sheep feedlot finishing, Shirima *et al.* (2012) reported maximum profit was obtained when the sheep had eighteen months at entry to the feedlot. On the other hand maximum net profit was achieved when *ad libitum* concentrates were offered to the animals.

2.10 Conclusion

Performance of sheep under feedlot finishing system is subjective to availability of quality feeds and the feeding programme engaged by the farmer. Maximum weight gain and appreciable feed conversion efficiency will be the outcome. According to this review energy and protein are the major and most important nutritional factors affecting meat production in sheep. Where higher intake of energy and protein in sheep given in good ration have been reported to result insignificantly higher daily live weight gain. Small ruminants' intensification and provision of better management practices aiming to achieve wonderful performance of sheep is a new phenomenon to farmers in Zanzibar. Most sheep are raised by smallholder farmers for subsistence and trading in local markets and sacrifice in religion festivals. 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 the sheep fed formulated rations using cheap and locally available feeds resources under feedlot finishing 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 average rainfall of 1564 mm/annum and annual average temperature of 25.7^{o}C. The natural vegetation around KATI has been largely modified by agricultural activities with variety of crops and forages. Fodder commonly used by local farmers include established banks of Gliricidia (*Gliricidia sepium*), Guatamala (*Tripsicum laxum*), Elephant grass (*Pennisetum purperium*), *Brachiaria decumbens* and *Stenotaphrum dimidiatum (Pemba grass)*. Traditionally sheep and goats are tethered on a short leash to graze under coconut groves. The practice involves changing grazing stations at least once per day during the grazing time.

3.2 Source of Experimental Animals

Fifty four castrate sheep most of them phenotypically were *Black Head Persian* were purchased from smallholder farmers at Makarwe village in Pangani district, Tanga. The sheep were selected based on sex and age (9-12 months) using dental formula where the sheep were purchased without development of permanent pair of incisor teeth. The animals were then shipped by dhows to Zanzibar where they were quarantined for two weeks immediately upon arrival. During the quarantine all animals were subjected to routine clinical checks and prophylactic treatments against enteric worms and tick borne diseases. A broad spectrum anthelminthic (Albendazole) and an acaricide PARANEX^{TM} were used for control against worms and tick borne diseases respectively.

3.3 Management of Experimental Animals

3.3.1 Housing

The shade used was constructed purposely for small ruminants finishing. It has a raised slatted floor made of timber and roofed with coconut leaves. The shade is oriented north-southwardly with the long sides facing east and west to maximize entry of sunlight (Plate 1). The house was divided into fourteen pens (3m x 5m) which were deemed sufficient to hold 6 sheep at 2.5 m^2 floor allowance per individual (Plate 2). Each pen had one long trough for roughages whereas concentrates were offered in two plastic containers (20 Litres) cut on lateral side (Plate 3). The sheep had free access to clean water which was given twice a day.

Plate 1: Front view of the sheep house

Plate 2: Pens for Experimental Sheep

Plate 3: Concentrate and water troughs (yellow containers) in experimental pens

3.4 Experimental Animals

Animals in (T2) and (T3) were fully confined in pens throughout the experimental period, with exception of those in (T1) were grazed outdoor and kept in shed only at night.

Plate 4: Sheep under Control group (T1) grazing on surrounding pasture

Plate 5: Sheep under Treatment 2 feeding in pen

Plate 6: Sheep under Treatment 3 feeding in pen

3.5 Disease Control

The animals were dewormed using a broad spectrum anthelmintic Albendazole; while external parasites were controlled with weekly application of Paranex™ spray. In addition a single dose of *Imisole* was given intramuscularly for the treatment and prophylaxis against Babesiosis and Anaplasmosis.

3.6 Experimental Feeds and Experimental Layout

Grasses/fodders (*Brachiaria decumbens*, *Pennisetum purpureum and Gliricidia sepium*) were collected from study area, while other feed ingredients such as rice polish, wheat pollard, molasses, copra meal, fish meal, blood meal, salt and limestone were purchased from livestock input service providers and sugar factory in Zanzibar. Additionally Wheat pollard was purchased from local milling factory that uses relatively advanced milling technology Bakhresa Mills Limited (BML). The collected feed materials were analysed for their chemical composition at the Department of Animal Science and Production (DASP) laboratory at Sokoine University of Agriculture (SUA).

The experimental animals were randomly allotted into three treatment groups corresponding to T1 (Control); T2 (35% Rice polish + 25% Wheat pollard) and T 3 (40% Rice polish + 20% wheat pollard). Each treatment had 18 individuals that were divided into three replicates of six animals each. The Control group (T1) was raised on free grazing of *Stenotaphrum dimidiatum* (Pemba grass) and *Brachiaria decumbens* (Signal grass) with no supplementary feed; those under T2 and T3 received a mixture of forages (*ad libitum*) described in Table 2 in addition to the formulated concentrates corresponding to their allocated treatment. The concentrate allocation was 600g/head/day. The feeding period lasted for 11 weeks (82 days).

3.7 Sampling and Chemical Analysis of Feeds

Chemical analyses of forages, individual feed ingredients and compounded feeds were done using A. O. A. C (2000) protocol and Goering and Van Soest (1970) methods for fibre analysis at the (DASP) laboratory, Sokoine University of Agriculture. Forages used in control treatment were not analysed for chemical composition in the study, instead were referred from Reynolds *et al.* (1981).

3.8 Feed Formulation and Feeding Plan

Two experimental concentrate rations were formulated for T2 and T3. The concentrate allocated for T2 had 8.7MJ/KgDM with 162gCP/KgDM while that offered to T3 had 7.4MJ/KgDM with 146gCP/KgDM. Principle ingredients used in the formulations are shown in Table 1. Amount of the concentrate offered was 3.6 kg per group corresponding to an allowance of 600g per sheep per day for T2and T3, all of which being given at once in the morning. The basal chopped forage (Table 2) was offered *ad-libitum* shortly after the concentrates were finished. Refusals were collected in the morning of the next day weighed and recorded.

Table 1: Concentrate formulae used for Treatment 2 and Treatment 3

S/N	Feed Ingredients	Price/Kg	Treatment 2 % Incl.	Price/kg feed	Treatment 3 % Incl.	Price/kg feed
1	Rice bran	70.00	35.0	24.50	40.0	28.00
2	Wheat pollard	257.00	25.0	64.25	20.0	51.40
3	Molasses	800.00	7.0	56.00	7.0	56.00
4	Copra cake	200.00	12.0	24.00	12.0	24.00
5	Fish meal	1 100.00	12.0	132.00	12.0	132.00
6	Blood meal	500.00	5.0	25.00	5.0	25.00
7	Bone meal	300.00	2.3	6.90	2.3	6.90
8	Limestone	50.00	1.5	0.75	1.5	0.75
9	Salt	600.00	0.2	1.20	0.2	1.20
	Total inclusion and price/kg feed		100	334.60	100	325.25
	Analysed Energy (MJ/kgDM)		8.7		7.4	
	Analysed Crude protein (%)		16.2		14.6	

Estimation of energy for concentrates used for T2 and T3 were first analysed by proximate analysis method, then the values were used for the following formulae:-

i. %TDN (in DM basis) = 0.62(100+1.25%EE) – 0.72*%CP……………….....…(1)

Source: Maswada and Elzaawely (2013)……………….……….……………..… (2)

ii. DE (Mcal/kg) = 0.04409*%TDN…………………………..…….…….…..(3)

iii. ME (Mcal/kg) = 1.001*DE(Mcal/kg)-0.45…………………..………..….…..(4)

iv. ME (Mj/kg) =Mcal*4.19……………………………………………….…..(5)

(1Megacalory equal to 4.19Megajoule).

Source: Das[b] *et al.,* 2013.

Table 2: Mixture of roughages used in the experiments

S/N	Fodder species	% Contribution
1	*Brachiaria decumbens*	35
2	*Pennisetum purpureum*	35
3	*Gliricidia sepium*	30
	Total	100
	Calculated energy (MJ/kgDM)	6.8
	Calculated %CP	11.5

3.9 Data Collection

3.9.1 Observations on common forages used in Zanzibar

Selection of the experimental forages was based on their availability at pasture research station nearby the KATI livestock farm (Dairy and shoats units). These forages are also available in urban west, Central, North "A" and "B" districts abundantly.

3.9.2 Voluntary feed intake (VFI) measurement

The voluntary feed intake (VFI) for the replicate was calculated by arithmetic difference between feed offered (FO) and the feed refusal (FR). The daily intake was arrived by deduction of refusals in the morning following the roughages offered from the previous day (formula 1). All the concentrates were completely consumed thus the VFI was assumed to be equal to quantities previously offered.

$VFI = FO\text{-}FR$………………………………………………………………………………… (6)

Where VFI = Voluntary Feed Intake; FO = Feed Offered (kg) and FR = Feed Refusals

3.9.3 Adaptation period

The animals in all treatments were drenched using Albendazole as broad spectrum anthelmintic as well sprayed using Paranex^{TM} against ticks and biting flies, once during the adaptation period. Animals in control were grazing in the paddocks in day time and kept indoor during night. Three buckets of clean drinking water was provided in the buckets during the day time under the shed. Animals in T2 and T3 were given concentrates in small amounts and were gradually increased to 600g/head/day at the end of adaptation period. The mixture of roughages were offered at ad libitum level, and clean drinking water was provided freely.

3.9.4 Growth performance measurement

All animals were subjected to an adaptation period of 14 days. Before their allocation into treatment groups the animals were fasted on the 13 day and empty body weight recorded on the 14^{th} day ready for allotment. This weight was regarded as the initial weight that was later applied as a covariate for comparison of treatments effects. During the feeding trial, weight changes were recorded once every week for the purpose of adjusting feed allowance of the basal forage. The final body weight was taken after overnight fasting at the end of 82 days of experimental feeding. Average Daily Gain (AG) was computed as:

Average daily gain (ADG) = (Final weight (kg) – Initial weight)/Number of days……. (7)

3.9.5 Final slaughter weight and carcass evaluation

At the end of the feeding trial, two animals were randomly picked in each replicate to make a total of six individuals from each treatment and were slaughtered after overnight fasting. Slaughtering was done as per Halal procedures at KATI, ensuring that all blood was collected and weighed for each animal. After bleeding the animals were hung by both hind legs, the head was removed at the occipito-atlantal articulation. The fore and hind feet were removed at the proximal metatarsal and metacarpal 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 and kidneys) were separated and weighed. The rumen and the intestines were first weighed with contents (fill) and later when emptied. The rumen and the intestinal content was subtracted from the slaughter weight to obtain the empty body weight (EBW). Hot carcass weight was computed after subtracting the weights of the skin, head, fore feet, hind feet, and viscera and fat depot from the slaughter weight. Weights of the internal organs (kidneys, liver, heart, lungs, spleen and pancreas) and fat depots such as abdominal, scrotal, pelvic, kidney and GIT fat also were subtracted from the slaughter weight. Dressing percentage was calculated as proportion of hot carcass to empty body weight, using the following formula:-

Dressing percentage (DP) = (Hot carcass weight/Empty body weight) x 100……………. (8)

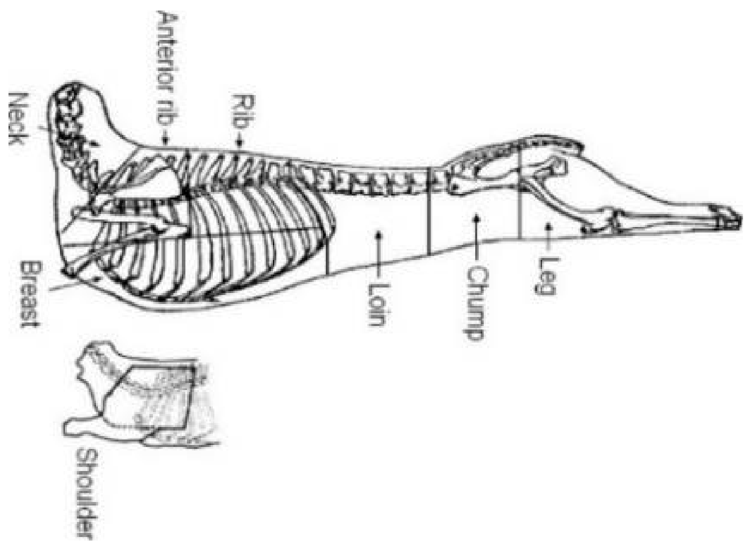

Figure 1: Standard carcass joint used in this study

The hot 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 quarters cutting between the 12th and 13th rib. The hind part was further dissected into three wholesale cuts (leg, chump and loin). The fore quarter was separated into neck, shoulder, brisket and rib (Fig. 1). The weight of each cut was recorded and was used to evaluate lean, fat and bone portions. Meat tenderness and chemical analysis was conducted at DASP, Sokoine University of Agriculture.

3.9.6 Carcass components assessment

Proportions of carcass components (lean, bones and fat) were determined at KATI, the assessment was conducted based on the left half of the chilled carcass. Fats and lean were trimmed manually using filleting knife and weighed separately and the remaining bones were also weighed for each joint of the half carcass.

3.9.7 Organoleptic taste

Organoleptic was conducted at KATI. The taste panel was comprised of 60 persons of mixed gender groups aged between 19-60 years. All samples were first chopped at about two inch long and one inch thickness. The pieces were put in a normal cooking vessel, some water and little salt were added. The pieces were cooked using gas cooker for 45 minutes before presentation to the panellists. The taste panels were divided into 3 groups of 15 individuals each. Group 1, was used for testing the organoleptic tastes of among Mutton, Goat meat and Beef (i.e. ***aroma, flavour, juiciness and softness***). Group 2 was subjected to double-blind test in which consumers were reporting on their preferences between mutton and beef, whereas Group 3 had to choose between goat meat and mutton.

Table 3: Panels of Meat Organoleptic test

Test Panel	Number of participants	Samples provided	Parameters tested
G1	15	beef, mutton and goat meat	Aroma, flavour, juiciness, softness and colour
G2	15	beef vs. mutton	Meat identification and preference.
G3	15	mutton vs. goat meat	Meat identification and preference.

G1= Group 1, G2 = Group 2 G3 = Group 3.

3.9.8 Tenderness test

Meat samples from *Longissimus dorsi* muscles were taken from eighteen sheep for the tenderness test after 48 hours. The meat for tenderness determination was preserved in deep freezer at -20°C for 48hrs then thawed in refrigerator for overnight at 4°C. After thawing the meat samples were reweighed and vacuum packed. Thereafter the meat was cooked in water bath at 70°C for 45 minutes, cooled for 2hrs and then refrigerated again. After refrigeration the meat were removed from polythene packs to drain the juices for determination of cooking losses; weighed and then sliced into 1cm cube thickness. The slices were placed in the Warner Bratzler Shear Force Machine for tenderness determination.

3.9.9 Cost-benefit analysis of sheep finishing

The quantities of feed and their cost were recorded to determine the overall cost in Tanzania shillings of production for each treatment. Carcass yield and edible offal for each treatment determined to estimate revenues at current prices from experimental sheep. The variable cost items listed include expenses included feeds, labour charges, veterinary costs, housing cost and the original purchase price of the animals including transport costs. Entries for expected revenue included the current market price for sheep meat, the edible offal's and the value of the skin. The net revenue was obtained by the difference between the sales less variable costs.

3.9.10 Statistical analysis

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

In Model i, initial weight (Table 6) was subjected to Covariate analysis (Kaps and Lamberson, 2009)

The models used were:

i. **$Yij = \mu + Ti + b\,(Xij - \sum x/n) + eij$** was used to analyse growth performance of the experimental sheep.

Where:-

Yij = Response

μ = General mean

Ti = Treatment effect

B = Covariate analysis of initial body weight of an animal on subsequent performance.

Xij = Initial body weight of individual animal

$\sum x/n$ = mean of initial body weight in the experiment

eij = Random error.

ii. **$Yi = \mu + T_i + e_i$** was used to analyse rest of the results in the study.

Where:

Yi = Response variable

μ = Overall mean

$T_i = i^{th}$ Treatment effect

ei = Random error term

CHAPTER FOUR

4.0 RESULTS

4.1 Overview

This chapter presents findings from the study in a sequence that corresponds to the set of objectives defined in Chapter 1. Generally the study was executed as planed without major shifts from the original proposal. Most experimental animals survived the entire experimental period without suffering from major ailments. However, 8 animals died from Anaplasmosis and Babesiosis during the first two weeks of the experiment. Seven of the eight animals that died were from the free grazing group (T1) highlighting the possibility of high vector (ticks) population in the fields. Following this event all animals had to be given a cover treatment against tick borne diseases and a routine for weekly spraying against ticks using Paranex™ was adopted. No hiccups were recorded on feeds and feeding routines.

4.2 Chemical Composition of the Experimental Feeds

The chemical composition of the feed ingredients and formulated rations (concentrates and forages) are presented in Table 4. The forages used were fresh harvested from fields i.e. green roughages with dry matter content less than 25%. The CP values of forages ranged from 3.4 to 21% (whereas similar values in the principal energy sources (i.e. Rice polish and Wheat pollard) were 8.2 and 17.1% respectively. Wheat pollard was shown to contain 8.3 more energy than rice bran.

Table 4: Mean chemical composition of feed ingredients used in experimental diets

Feed ingredients	%DM	%CP	%CF	%EE	%ASH	MEMJ /KgDM	NDF	ADF	LIG
Rice bran	96.2	8.2	30.0	6.8	12.1	5.4	59.9	41.3	5.0
Wheat pollard	97.3	17.1	7.5	4.6	4.1	13.7	33.0	8.4	1.41
Copra cake	97.3	24.2	15.4	14.0	10.8	11.8	49.3	27.8	3.9
Fish meal	97.7	47.6	0.9	2.7	46.2	9.3	-	-	-
Blood meal	97.5	49.1	0.0	0.3	43.6	9.7	-	-	-
Molasses	66.3	2.5	0.0	0.0	7.6	9.5	-	-	-
Brachiaria decumbens	94.4	3.4	33.0	0.8	5.4	9.1	74.4	37.8	0.4
Pennisetum purperium	95.0	11.2	32.6	2.0	6.5	9.5	72.1	35.7	0.4
Stenotaphrum dimidiatum	95.3	6.2	29.5	3.7	8.5	5.7	-	-	-
Gliricidia sepium	94.7	21.5	18.4	2.2	6.9	11.6	38.4	19.6	0.0
Concentrate 1 (T2)	90.9	16.2	12.8	3.1	17.0	8.7	44.0	24.9	7.0
Concentrate 2 (T3)	91.2	14.6	15.3	3.4	20.9	7.4	45.2	29.4	10.4

CP = Crude protein; CF = Crude fibre; EE = Ether extract; DM = Dry matter; ASH = Minerals content; ME = Metabolizable Energy; Mj = Mega joule; Kg = Kilogramme; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; LGN = Lignin.

4.3 Voluntary Feed intake and Growth Performance

4.3.1 Feed intake

Voluntary feed intake was only measured for animals raised indoors (i.e. T2 and T3). Animals in T1 were grazed for 10 hours every day and did not receive any supplements upon their return for overnight stay in the shed. Thus intake for animals in T1 was estimated on assumption of *Stenotaphrum dimidiatum* and *Brachiaria decumbens* at *ad libitu*m intake limits of 3.5% of body mass. Means ± SE for, dry matter, Crude protein and ME (Mj/d) intakes are shown in Table 5 while the corresponding ANOVA tables for feed intake are shown in Appendix 1. There are insignificant differences (P>0.05) between T2 and T3 in all parameters.

Table 5: Mean and SE of DM, CP and ME (MJ) intake by sheep under experiment

Parameters	Treatments			SE	P-Value
	T1	T2	T3		
DMIg/day	576.27^{a}	798.29^{b}	804.27^{b}	9.473582	<.0001
CPIg/day	27.66^{a}	110.04^{b}	109.00^{b}	1.495994	<.0001
ME(MJ/day)	4.73^{a}	13.86^{b}	12.03^{b}	0.383385	<.0001
DMI(%BWT)	3.5	3.45	3.53	0.051556	0.4944
DMI/$KgW^{0.71}$	77.42^{a}	85.47^{b}	87.33^{b}	1.298763	<.0001
CPI/$KgW^{0.71}$	3.72^{a}	11.86^{b}	11.83^{b}	0.187119	<.0001

^{ab} Means in the same row with different superscript are significantly different (P<0.05)
DMI (g/d) = Dry Matter Intake (gram per day), CPIg/day = Crude Protein intake (grams per day), ME (MJ/d) = Metabolizable Energy (Mega Joule per day), DMI (%BWT) = Dry Matter Intake as Percentage live Body Weight, DMI/$KgW^{0.71}$ = Dry Matter Intake per Kilogram Metabolic Body Weight, CPI/$KgW^{0.71}$ = Crude Protein Intake per Kilogram Metabolic Body Weight,

4.3.2 Growth performance

The initial body weight (IBWT), final body weight (FBWT), total weight gain (TWG) and average daily gain (ADG) for the experimental sheep are presented in Table 6 and ANOVA Tables are presented in Appendix 2. There are insignificant differences (P>0.05) between T2 and T3 in all parameters.

Table 6: Growth performance of sheep under experiment

Parameters	Treatments			P-Value
	T1	T2	T3	
IBWT(Kg)	16.3±0.80[a]	18.9±0.64[b]	18.9±0.62[b]	0.0246
FBWT(Kg)	17.9±0.75[a]	26.1±0.60[b]	25.7±0.59[b]	<.0001
TWG(Kg)	1.6±0.39[a]	7.2±0.32[b]	6.8±0.31[b]	<.0001
ADG(g)	19.8±4.92[a]	90.2±3.94[b]	85.7±3.85[b]	<.0001
FCR(DMI/TWG)	29.5±4.37[b]	9.7±3.51[b]	9.9±3.41[b]	<.0001
FCE(TWG/DMI)	0.04±0.00[a]	0.11±0.00[b]	0.10±0.00[b]	<.0001

[ab] Means in the same row with different superscript are significantly different ($P<0.05$)
INBWT = Initial Body Weight, FBWT = Final Body Weight, TWG = Total Weight Gain, ADG = Average Daily Gain, FCR = Feed Conversion Ratio, FCE = Feed Conversion Efficiency.

4.4 Killing out Characteristics and Carcass Components of Experimental Sheep

4.4.1 Killing out characteristics

The killing out characteristics of the experimental sheep are shown in Table 7 and Appendix 3 shows the summary of ANOVA for all slaughter parameters. There are insignificant differences ($P>0.05$) between T2 and T3 in all parameters.

Plate 7: Carcasses from T1-T3

Table 7: Killing out characteristics of sheep under experiment

Parameters (kg)	Treatments	SEM	P-Value		
	T1	T2	T3		
SW	18.25^{a}	27.63^{b}	26.45^{b}	0.90	<0.0001
EBW	13.57^{a}	23.24^{b}	21.38^{b}	0.90	<0.0001
HCW	6.45^{a}	11.52^{b}	10.87^{b}	0.90	<0.0001
DP	47.37^{a}	49.50^{b}	50.84^{b}	0.90	0.0232

^{ab} =Means in the same raw with difference superscript are significant at (P<0.05)
SWT = slaughter weight; EBW = Empty body weight; HCW = Hot carcass weight and DP = Dressing percentage.

4.4.2 Weight of carcass joints

The mean weights of the half carcass joints are presented in Table 8. Appendix 4 provides summary of the ANOVA for comparison of joints among the three treatments. There are insignificant differences (P>0.05) between T2 and T3 in all parameters.

Table 8: Half carcass joints weight of sheep under experiment

Parameters	Treatments			SEM	P-Value
(kg)	T1	T2	T3		
Neck	0.29^{a}	0.45^{b}	0.46^{b}	0.03	0.0005
Brisket	0.31^{a}	0.62^{b}	0.53^{b}	0.04	0.0001
Ribs	0.52^{a}	0.86^{b}	0.84^{b}	0.06	0.0030
Shoulder	0.62^{a}	0.99^{b}	0.96^{b}	0.04	<0.0001
Hind leg	0.67^{a}	0.99^{b}	0.95^{b}	0.05	0.0008
Champ	0.48^{a}	1.05^{b}	0.92^{b}	0.07	<0.0001
Loin	0.31^{a}	0.67^{b}	0.70^{b}	0.05	<0.0001
Percentage weight of joints from half carcass of sheep under experiment					
Neck	9.21	7.96	8.62	0.38	0.1012
Brisket	9.86	10.98	9.95	0.57	0.3369
Ribs	16.22	15.31	15.63	0.89	0.7716
Shoulder	19.32	17.71	18.04	0.56	0.1330
Hind leg	21.05^{a}	17.67^{b}	17.58^{b}	0.76	0.0079
Champ	14.87^{a}	18.50^{b}	17.14^{b}	0.96	0.0505
Loin	9.46^{a}	11.86^{b}	13.04^{b}	0.69	0.0073

^{ab} = Means in the same row with different superscript differ significantly at (P < 0.05).

4.4.3 Edible offal components of experimental sheep

The weights and percentages of edible offal components of the experimental sheep are presented in Table 9. Appendix 5 shows the ANOVA Table of these parameters. There are insignificant differences (P>0.05) between T2 and T3 in all parameters, except the percentage weight of head, tail and abdominal fat.

Table 9: Edible offal components of experimental sheep

Parameters (kg)	T1	T2	T3	P-Value
Head	1.33±0.07^{a}	1.67±0.08^{b}	1.57±0.09^{b}	0.0217
Heart	0.08±0.01	0.11±0.01	0.08±0.01	0.1667
Lungs	0.15±0.02	0.21±0.03	0.19±0.03	0.2585
Liver	0.31±0.02^{a}	0.41±0.02^{b}	0.36±0.02^{b}	0.0114
Kidneys	0.06±0.00	0.07±0.00	0.07±0.00	0.1141
Tail	0.42±0.15^{a}	1.07±0.16^{b}	0.76±0.18^{b}	0.0361
Ab. fat	0.16±0.04^{a}	0.49±0.04^{b}	0.57±0.04^{b}	<.0001
Percentages (%) of edible offal components as per slaughter weight of the animal				
Head	6.82±0.19^{b}	6.13±0.20^{b}	5.90±0.22^{a}	0.0146
Heart	0.43±0.05	0.40±0.05	0.31±0.06	0.2585
Lungs	0.75±0.10	0.77±0.11	0.72±0.12	0.9444
Liver	1.58±0.08	1.51±0.08	1.37±0.09	0.2328
Kidneys	0.28±0.01	0.26±0.06	0.25±0.02	0.3621
Tail	1.78±0.53^{a}	3.91±0.58^{c}	2.87±0.63^{b}	0.0500
Ab. fat	0.72±0.14^{a}	1.80±0.15^{b}	2.14±0.17^{c}	<.0001

^{ab} = Means in the same row with different superscript differ significantly higher at (P < 0.05) .
Ab. Fat = Abdominal fat

4.4.4 Non-edible offal components of experimental sheep

The mean weight and their percentage values of non-edible offal components for the experimental sheep are presented in Table 10. The corresponding ANOVA Tables are shown in Appendix 6. There are insignificant differences (P>0.05) between T2 and T3 in weight of the parameters, with exception of hind feet and trachea. In percentage wise blood, fore and hind legs and the skin were statistically different among the treatments.

Table 10: Non – edible offal component of experimental sheep

Parameters (kg)	Treatment T1	T2	T3	SEM	P-Value
Blood	0.80	0.86	0.79	0.06	0.6852
Fore feet	0.24	0.29	0.27	0.02	0.0618
Hind feet	0.27[a]	0.34[b]	0.31[c]	0.02	0.0268
Skin	1.29[a]	2.43[b]	2.16[b]	0.09	<0.0001
Trachea	0.04[a]	0.06b[b]	0.04[a]	0.00	0.0114
Spleen	0.02[a]	0.04[b]	0.04[b]	0.00	0.0003
Percentages of non-edible offal components as per slaughter weight of the animal					
Blood	4.53[a]	3.11[b]	2.99[c]	0.39	0.0282
Fore feet	1.32[a]	1.08[b]	1.04[c]	0.04	0.0006
Hind feet	1.47[a]	1.23b[a]	1.16[c]	0.09	0.0524
Skin	7.01[a]	8.81[b]	8.17[c]	0.29	0.0018
Trachea	0.19	0.23	0.16	0.02	0.1529
Spleen	0.10	0.14	0.13	0.01	0.1242

[abc]= Means in the same row with different superscript are significant (P<0.05)

4.4.5 Total weight of tissues of the half carcass

Table 11 shows the mean weight of primary tissues (lean, bone and fat) and their percentages from half carcass. It also shows the relative distribution of the tissues in the half carcass. The corresponding ANOVA Table in Appendix 7 provides details of statistical analysis. There are insignificant differences (P>0.05) between T2 and T3 in weight of all parameters.

Table 11: Total weight and percentage of lean, bone and fat tissues in half carcass

Parameters	T1	T2	T3	SEM	P-Value
Lean (kg)	1.95[a]	3.16[b]	2.95[b]	0.12627535	<.0001
Bone (kg)	1.07[a]	1.58[b]	1.55[b]	0.07832063	0.0004
Fat (kg)	0.09[a]	0.82[b]	0.81[b]	0.04461253	<.0001
Percentage of the total weight of the half carcass tissues					
Lean (%)	62.70[a]	56.92[b]	55.52[b]	0.8189345	<.0001
Bone (%)	34.64[b]	28.48[b]	29.16[b]	0.8870865	0.0003
Fat (%)	2.66[a]	14.59[b]	15.32[b]	0.5781698	<.0001
Ratio					
Lean : Fat	21.82	3.87	3.62	-	-
Lean : Bone	1.83	1.99	1.94	-	-

[abc] = Means in the same row with different superscript differ significantly at (P <0.05).

4.5 Physical Meat Characteristics

4.5.1 Meat tenderness and cooking losses

The meat tenderness and cooking loss of meat from the experimental sheep are presented in Table 12 and Appendix 10. Cooking weight loss was expressed in percentage to provide comparative relative loss in weight for the three treatments. There are insignificant differences (P>0.05) between T2 and T3 in weight of almost all parameters.

Table 12: Meat tenderness and weight loss

Parameters	T1	T2	T3	SEM	P-Value
INWT(g)	95.66^{a}	177.50^{b}	178.88^{b}	9.492663	<.0001
WTAFC(g)	74.40^{a}	127.81^{b}	132.96^{b}	7.433196	<.0001
WTL(g)	21.26^{a}	49.69^{b}	45.92^{b}	2.6433439	<.0001
PWL (%)	22.35^{a}	28.00^{b}	25.68^{b}	0.8277784	0.0008
SVAL(N/cm^2)	24.43	26.71	26.51	2.5931560	0.7922

^{ab}= Means in the same row with different superscript differ significantly at (P <0.05).
INWT = Initial weight, WTAFC = Weight after cooling, WTL = Weight loss, PWL = Percentage weight loss, SVAL = Shear force value

4.5.2 Organoleptic taste

4.5.2.1 Comparison of mutton, beef and goat meat for aroma, flavour, juiciness and softness

Comparison between mutton, beef and goat meat on the parameters are presented in the Table 13. There are significant differences (P<0.05) that mutton ranked higher in all parameters against beef and goat meat.

Table 13: Organoleptic test of beef, goat meat and mutton on aroma, flavour, juiciness and softness

Parameters	Beef	Goat meat	Mutton	SEM	P-Value
Aroma	2.80[b]	2.27[a]	3.33[b]	0.22	0.0058
Flavour	2.67[a]	2.73[b]	3.33[c]	0.18	0.0272
Juiciness	2.40[a]	2.67[b]	3.47[c]	0.21	0.0028
Softness	2.33[a]	2.80[b]	3.87[c]	0.20	<.0001

[abc]Means in the same row with different superscript differ significantly at (P <0.05).

4.5.2.2 Comparison on preference and recognition of mutton against beef and goat meat

Comparison on preference and recognition of the meat types are presented on Table 14. There is significant (P<0.05) difference that people preferred mutton than beef, on the other hand there is significant (P<0.05) that panellists were able to recognise mutton over goat meat.

Table 14: Preference and recognition between mutton and Beef

Parameters	Beef	Mutton	P-value
Preference	1.86±0.47[a]	4.00±0.44[b]	0.0023
Recognition	3.57± 0.52	2.25±0.49	0.0746
Parameters	Goat meat	Mutton	P-value
Preference	2.86±0.53	3.13±0.53	0.7263
Recognition	1.80±0.48[a]	3.40±0.48[b]	0.0251

[ab]Means in the same row with different superscript differ significantly at (P <0.05).

4.6 Cost-Benefit Analysis of Experimental Sheep

Table 17 provides a summary of costs and revenues calculated from the present study. It can be observed that sheep in T2 produced heavier carcasses (P<0.05) than in T3. Animals in T1 could only yield about one third of the revenues recorded from those on T2. Net returns from Animals on T2 were also shown to be higher than that of both T1 and T3. The differences in veterinary expenses were higher in animals in T1 almost twice to that of T2 and T3 but overall higher total cost per sheep observed in T2 and T3.

Table 15: Cost-benefit summary of raising sheep on three experimental diets

Parameters	T1	T2	T3
Purchasing price/sheep	50 000.00	50 000.00	50 000.00
Initial weight(kg)	16.30	18.92	18.87
Cost/kg live weight	3 067.48	2642.71	2649.71
Concentrates (Kg)	-	49.20	49.20
Conc. Price/kg	-	334.60	325.25
Total feed cost	-	16 462.32	16 002.30
Cost of housing/sheep	2 508.00	2 508.00	2 508.00
Labour cost/sheep	12 500.00	12 500.00	12 500.00
Veterinary expenses/sheep	1086.96	694.00	694.00
Sub-Total cost	13 586.96	13 194.00	13 194.00
Total cost/sheep	63 586.96	79 656.32	79 196.30
Final weight/sheep(kg)	17.88	26.12	25.72
Slaughter weight /sheep(kg)	18.25	27.63	26.45
Dressing percentage/sheep	47.37	49.50	50.84
Recovered carcass weight (kg)	6.45	11.52	10.87
Price of meat/kg (Tsh)	9000.00	9 000.00	9000.00
Sub-Total revenues	58 050.00	103 680.00	97 830.00
Liver weight (kg)	0.29	0.42	0.37
Lungs weight (kg)	0.14	0.22	0.18
Kidney weight (kg)	0.05	0.07	0.06
Head weight (kg)	1.25	1.71	1.56
Intestine weight (kg)	1.38	1.89	1.86
Total Edible offal weight (kg)	3.11	4.31	4.03
Price/kg edible offal (Tsh)	3 000	3 000	3 000
Revenue from edible offal(Tsh)	9 330.00	12 930.00	12 090.00
Skin	3 000	3 000	3 000
Others	1 500	1 500	1 500
Sub-Total Rev.	13 830.00	17 430.00	16 590.00
TOTAL REVENUES	71 880.00	121 110.00	114 420.00
Net income (Tsh)	8 293.04	41 453.68	35 223.70
% Returns to investment	13.04	52.04	44.48

CHAPTER FIVE

5.0 DISCUSSION

5.1 Overview

This study was conducted with the primary objective of formulating least cost feeds for sheep finishing using materials locally available in Zanzibar. The target was to finish sheep that would achieve desired carcass weight within 90 days at a cost that shall allow for the mutton to be competitively priced in Zanzibar. It was envisaged that through improved nutrition, sheep recruited into the scheme at 15-18kg live weight shall be finished at a minimum of 20-28kg live weight within 90 days. That was expected to translate to a daily gain of between 55-110g; a range better than what was previously achieved by Mohammed (2015) in Zanzibar. This chapter discusses the findings in four subsections, each addressing the specific objective listed in Chapter 1 Subsection 1.2.2.

5.2 Determination of Chemical Composition of the Feed Ingredients and Formulated Rations used in Finishing Sheep

5.2.1 Nutritive values of forages

The three forages used in this study were all harvested from the established pasture plots at KATI. They represent the most widely used forages by farmers in Zanzibar. The proximate compositions of the forages were within the ranges commonly reported in the literature (Edwards *et al.,* 2012; Bayble *et al.,* 2007). Minor deviations were noted in the %CP values of *Gliricidia sepium* that were shown to be lower than those reported in earlier studies by Mohammed (2015). This can be accounted for by the difference in stage of growth at point of harvest. Mohammed (2015) harvested the forage shortly before the bloom stage while in the present study harvesting was done at advanced stages of growth due to some delays in the start-up of the experiment.

The overall quality of the forages was deemed to be sufficient to support healthy rumen function (Krause and Oetzel, 2006). This enabled the use of relatively higher level of concentrates in the daily feed allowances.

Animals on T1 (control) were grazed using the pattern commonly practiced by local farmers. This involved allowing free access to pastures for periods of around 10 hours when the weather was favourably good. The nutritional quality of the pastures on which the animals were grazed could not be established. However, findings from previous study on the same plots in Zanzibar by Reynolds *et al.* (1981) indicate that the pastures were generally of average quality. Assumptions were made that the grazed sheep were able to consume enough dry matter during their exposure to pasture and that the level of nutrient intake was sufficient to support their daily maintenance and allow for a modest growth.

5.2.2 Composition of feed ingredients (concentrates)

Rice bran and wheat pollard were used as the principle energy source whilst sugar cane molasses had the dual function as an energy source and a binder for rice bran and wheat pollard. Fish meal, copra cake and blood meal were added protein source while Bone meal, limestone and common salt functioned as the macro mineral source. Findings in this study showed that the rice bran had CP and ME values far lower than those reported by other workers (Hossain *et al.,* 2012; Mohammed, 2015). Such variations often arise from differences in processing efficiencies of the local millers. The bran used in the present study was observed to contain a high level of residual husks. Upon further investigation it was established that there is a deliberate adulteration of the bran by some unscrupulous individuals. This is done to increase the volume of the bran as it is commonly sold not on weight but on volume basis. The relatively high NDF, ADF and ash values noted for the bran was likely due to such form of adulteration.

It is an ingredient popularly used in Zanzibar and often cheaper than maize bran. The proximate analysis of the pollard showed that its constituents were very similar to most reports in the literature for nearly all parameters (Chee *et al.,* 2005; Das[a] *et al.,* 2014). This arises from the fact that the BML uses standard processing procedures and maintains stringent quality control on their products.

At current prices i.e. Tsh 257 /kg and Tsh 70/kg for wheat pollard and rice bran respectively and their corresponding equivalent nutrient cost per kilo of the concentrate were Tsh 18.8/= and 12.9/= per unit of ME. By the same extension the unit cost for CP in rice bran is Tsh 0.85/g and that of pollard is Tsh 1.49/g. The CP content in rice bran and wheat pollard were respectively 81.9g and 171.4g/kgDM, thus the equivalent CP substitution ratio of pollard by rice bran was approximately 2.1:1. This means it would cost about Tsh 147/= to buy the same amount of CP in rice bran for replacing wheat pollard, a price that was Tsh 110/= cheaper than using pollard. It therefore justified the need for reduction of the pollard and increase of rice bran in formulation of Concentrate 2. Molasses was used both as a binder and as an additional energy source. Several studies have shown that inclusion of molasses at 4-6% in the diet improves both the feed palatability and growth performance of growing sheep (Latif *et al.,* 2015). In the present study the level of molasses used was 7% in Concentrate 1 and Concentrate 2. This level was higher than most reported values (Moeini *et al.,* 2013) but was observed be necessary for proper binding of the principal ingredients in the diet (i.e. rice bran and wheat pollard).

Fish meal used in the experimental diets was shown to have lower nutritive values than that used by Mohammed (2015). Copra meal used as protein source, had higher crude protein value compared to those reported Mohammed (2015) and Mahmoud (2013) from samples collected in Zanzibar. Observations in Zanzibar (Mtumwa -personal communication) note that some batches of copra cake are derived from direct press extraction of copra kennels while others are drawn from domestic hand-pressed copra waste. The later tend to had higher CP values than the former on account of reduced fat content. Similar observations were reported in Malaysia by Diarra (2015).

5.2.3 Experimental diets and voluntary feed intake

The grass-legume mixture of 70:30 in favour of grasses used in the study for animals on T2 and T3 were shown to contain adequate levels of protein (115g/kgDM) and energy (6.8MJME/kgDM). The protein content was within the range required for proper rumen function (Paul *et al.,* 2003), whereas the energy level should support a growing sheep of up to 18kglwt (Abdel *et al.,* 2013). The grass: legume mixture was offered after the animals had already completed eating their concentrate allowance. However, this did not present a problem of intake substitution as animals were observed to leave less than 15% of the total *ad libitum* allowance of forage mixture.

The total DM intake for T2 and T3 from the diets, translate the ratio of concentrate to forage approximately 2:1. Such level is lower than that reported in a study by Shirima *et al.* (2014) on Fat-tail sheep in Dodoma, Tanzania. Shirima *et al.* (2014) recommended a ratio of 3:1 in favour of concentrates for finishing partially grazed sheep. The present study involved confined sheep, factor which would suggest that confined animals may not need higher intake of concentrate in daily allowances especially where the forage part is made of good quality material. Changing the relative proportions of rice bran and wheat pollard in Concentrate 1 and Concentrate 2 seem not to have affected the voluntary intake despite the significant shift in the concentration of ME. Similar observations were reported by Hossain *et al.* (2003) on sheep supplemented with increasing level of energy concentration in Pakistan.

5.3 Growth Performance; Killing out and Carcass Characteristics

5.3.1 Growth performance

The animals obtained for the experiment had an average live weight of 18.9kg. In this study sheep on T2and T3 achieved ADG of between 85-90g/day, the values closer to other indigenous sheep in Tanzania (Shirima *et al.,* 2014) and those in Sudan by Mohammed *et al.* (2012). This would mean that both formulations of diets were able to support animals of small frame size intended to finish at light weight class (25-30kg) and yield carcasses of between 10-15kg. The FCR observed in the current study (9.7kgDMI/kg gain) is within the range to that reported by Shirima *et al.* (2014) on long fat tailed sheep in Tanzania under feedlot.

5.3.2 Killing out and carcass characteristics

The killings out characteristics for sheep on T2 and T3 were similar. Both of them were far superior to sheep that were grazed without additional supplements. This clearly demonstrates the practical need for supplemental feeding for finishing sheep in Zanzibar. Sheep in the present study had a dressing percentage close to those reported by Shirima *et al.* (2014) on long-fat tail sheep and Alemu *et al.* (2014) on Ethiopian Menz sheep. Sheep in T2 and T3 had most of the surplus energy directed towards fat deposition an observation that corresponds to the findings reported by Ríos-Rincón *et al.* (2014) and Oramari *et al.* (2014).

5.3.3 Edible and non-edible offal components

Edible and non-edible components of ruminants play an important role finishing business

(Malole, 2002). Head and skin are the most valuable parts of edible and non-edible components of small ruminants respectively. They make up about 13-17 percent of the small ruminant slaughter weight. In Tanzania the returns contribute significant value in meeting house hold demands (Hartwich *et al.,* 2012). Generally, other non-edible components (blood, hooves and spleen) are used in the feed industries as animal protein source and mineral sources.

5.3.4 Percentage lean, bone and fat

The higher tail, abdominal and carcass fat weight deposited in the animals' tissues of T2 and T3 was the result of excess energy from the feeds that the animals were consuming during the study. When the energy is above maintenance and growth then it is converted to fat and deposited in the tail, abdomen and subcutaneous tissue of the animals, similar result reported by Guler and Aktumsek (2013).

5.3.5 Organoleptic test

The general perception in Zanzibar is that mutton is inferior in taste and less preferred to when compared to goat meat and beef. During the conduct of this study it was argued that the prejudice against mutton is more a function of ignorance by consumers than an actual poor taste of the meat. It was therefore important to set a test panel to verify this hypothesis. Observations showed that mutton was ranked higher than both beef and goat meat on its merits of aroma, juiciness, and softness. Sanusi and Adewoyin (2014) studied consumers' preference of the domesticated ruminants at Ogbomoso Metropolis of Oyo in Nigeria reported that 72.5% of the consumers ranked on beef, followed by goat meat 18.3% and lastly chicken 5.8%. The current study results were similar to that reported by Abubakar *et al.* (2011) that mutton was ranked highest on the aspect of acceptability and organoleptic parameters in comparing to beef and goat meat.

5.4 Cost-Benefits Assessment of Raising Mutton using Formulated Rations

In all commercial animal production operations, costs of feeds constitute the single most expensive component. When compounded in poorly manner, animal performance tends to have a bad multiplier effect which can have serious consequences on the viability of the enterprise. This study sought to identify a feed formula capable of supporting growth performance that would yield carcasses at profitable cost.

Sheep in T1 that under extensively system, were not receiving supplementary feeds, had significantly low net profit because of low nutrients intake from grazing. Sheep in T2 and T3 were fed same the amount of concentrates throughout the study. Sheep offered concentrate 1 (T2) shown to produce extra net profit of 6 229.98 Tanzania shillings per head of sheep against that feed concentrate 2. This result between the two treatments was attributed by concentrate 1 having nutritive values than concentrate 2 while other factors were maintained at constant. The current study result is in-line with those reported by Shirima *et al.* (2012) and noted that when increasing the level of concentrate from improves profitability. Although the total feed cost for Concentrate 1 was higher than that of Concentrate 2, the overall returns to feed cost was higher in concentrate 1 than that from sheep on received Concentrate 2. This margin of difference translates into net return to investment for Concentrate 1 against Concentrate 2. The most important determinant of change in cost was the content of Wheat Pollard (WP) in the formulations.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

i. It is concluded that, the nutrient contents of forages available in the range are poor in both energy and protein contents to support the growth and carcass quality, hence a need to supplement with other high energy and protein contents.

ii. A ration offered at 600g/day and combining rice bran with wheat pollard at a ratio of 1.4:1 in favour of rice bran can support an average daily gain (ADG) of at least 90.2g for sheep entering the feedlot at 18kglwt.

iii. Finishing the sheep at 82 days was sufficient to produce carcasses of desired weight and composition.

iv. Finishing the sheep has significant increase in saleable components and overall cost-benefit than those animals slaughtered unfinished.

6.2 Recommendations

i. Further studies are needed to evaluate most appropriate weight of entry for sheep fattening in Zanzibar.

ii. Initiate smallholder breeder- clusters/associations for the production of young stock that could be later recruited into feedlot for finishing by other smallholders.

iii. Running comparative studies to evaluate the performance and suitability of other breed-types in Zanzibar.

iv. Establishment of slaughter units for processing mutton to meet standards desired by the high end consumers.

v. Initiate a short term plan for sourcing “ready-for entry stock” from outside Zanzibar as the capacity for local breeding is built.

vi. Run promotion program to popularize mutton among local consumers.

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APPENDICES

Appendix 1: Feed Intake

1.1 Dependent Variable: DMI (g/d)

R-Square	CoeffVar	Root MSE	DMI Mean
0.002122	8.207891	65.76747	801.2713

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	643.9862	643.9862	0.15	0.7008
Error	70	302775.2464	4325.3607		
Corrected Total	71	303419.2326			

1.2Dependent Variable: DMI/KgW$^{0.71}$

R-Square	CoeffVar	Root MSE	DMI/kgW$^{0.71}$ Mean
0.001815	9.037418	7.861876	86.99250

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	7.867222	7.867222	0.13	0.7223
Error	70	4326.636728	61.809096		
Corrected Total	71	4334.503950			

1.3 Dependant Variable: DMI%BW

R-Square	CoeffVar	Root MSE	DMI%BW Mean
0.001115	10.90710	0.383642	3.517361

Source	DF	Squares	Mean Square	F Value	Pr> F
Model	1	0.01150139	0.01150139	0.08	0.7807
Error	70	10.30269722	0.14718139		
Corrected Total	71	10.31419861			

1.4: Dependent Variable: CPI (g/kgDM)

R-Square	CoeffVar	Root MSE	CPI (g/kgDM) Mean
0.002885	9.946125	10.89894	109.5797

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	24.058672	24.058672	0.20	0.6541
Error	70	8315.077122	118.786816		
Corrected Total	71	8339.135794			

1.5: Dependant Variable: CPIg/kgW$^{0.71}$

R-Square	CoeffVar	Root MSE	CPI (g/W$^{0.71}$) Mean
0.002241	11.03741	1.313820	11.90333

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	0.2713389	0.2713389	0.16	0.6930
Error	70	120.8286611	1.7261237		
Corrected Total	71	121.1000000			

1.6: Dependant Variable: MEMj (d)

R-Square	CoeffVar	Root MSE	MEMj (d) Mean
0.314692	7.958359	0.486200	6.109306

Source	**DF**	**Sum of squares**	**Mean Square**	**F Value**	**Pr> F**
Model	1	7.59850139	7.59850139	32.14	<.0001
Error	70	16.54736389	0.23639091		
Corrected Total	71	24.14586528			

Appendix 2: Growth performance

2.1: Dependent variable: INWT (kg)

R-Square	CoeffVar	Root MSE	INWT (kg) Mean
0.158227	14.47241	2.645210	18.27761

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	56.5553425	28.2776713	4.04	0.0246
Error	43	300.8768944	6.9971371		
Corrected Total	45	357.4322370			

2.2: Dependent Variable: FWT

R-Square	CoeffVar	Root MSE	FWT(kg) Mean
0.670855	10.35859	10.35859	23.99826

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	541.5883999	541.5883999	43.82	<.0001
Error	43	265.7228610	6.1796014		
Corrected Total	45	807.3112609			

2.3: Dependant Variable: TWG

R-Square	CoeffVar	Root MSE	TWG(kg) Mean
0.772182	22.81746	1.305357	5.720870

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	248.3475931	124.1737966	72.87	<.0001
Error	43	73.2701721	1.7039575		
Corrected Total	45	321.6177652			

2.4: Dependent Variable: ADG

R-Square	CoeffVar	Root MSE	ADG(kg) Mean
0.773187	22.73691	15.85652	69.73913

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	36855.40908	18427.70454	73.29	<.0001
Error	43	10811.46049	251.42931		
Corrected Total	45	47666.86957			

2.5: Dependent Variable: FCR

R-Square	CoeffVar	Root MSE	FCR Mean
0.000094	27.77419	2.806860	10.10600

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	0.0244135	0.0244135	0.00	0.9559
Error	33	259.9892265	7.8784614		
Corrected Total	34	260.0136400			

2.6: Dependent Variable: FCE

R-Square	CoeffVar	Root MSE	FCR Mean
0.023179	20.93165	0.021948	0.104857

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	1	0.00037723	0.00037723	0.78	0.3826
Error	33	0.01589706	0.00048173		
Corrected Total	34	0.01627429			

Appendix 3: Killing out characteristics

3.1 Dependent Variable: SW

R-Square	CoeffVar	Root MSE	SW (kg) Mean
0.810763	9.156687	2.207474	24.10778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	313.1632111	156.5816056	32.13	<.0001
Error	15	73.0941000	4.8729400		
Corrected Total	17	386.2573111			

3.2 Dependent Variable: EBWT

R-Square	CoeffVar	Root MSE	EBWT (kg) Mean
0.854564	9.768190	1.894785	19.39750

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	316.4352333	158.2176167	44.07	<.0001
Error	15	53.8531292	3.5902086		
Corrected Total	17	370.2883625			

3.3 Dependent Variable: HCW

R-Square	CoeffVar	Root MSE	HCW (kg) Mean
0.837945	11.27948	1.084522	9.615000

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	91.2262333	45.6131167	38.78	<.0001
Error	15	17.6428167	1.1761878		
Corrected Total	17	108.8690500			

3.4 Dependent Variable: DP

R-Square	CoeffVar	Root MSE	DP (%) Mean
0.394439	18.39844317	1.940658	49.23867

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	36.79688633	18.39844317	4.89	0.0232
Error	15	56.49232567	3.76615504		
Corrected Total	17	93.28921200			

Appendix 4: ANOVA Table for weight of carcass joints

4.1 Dependent Variable: Neck

R-Square	CoeffVar	Root MSE	Neck (kg) Mean
0.617393	17.70074	0.070065	0.395833

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.11882500	0.05941250	12.10	0.0007
Error	15	0.07363750	0.00490917		
Corrected Total	17	0.19246250			

4.2 Dependent Variable: Brisket

R-Square	CoeffVar	Root MSE	Brisket (kg) Mean
0.700450	19.11495	0.092601	0.484444

Source	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	0.30076944	0.15038472	17.54	0.0001
Error	15	0.12862500	0.00857500		
Corrected Total	17	0.42939444			

4.3 Dependent Variable: Rib

R-Square	CoeffVar	Root MSE	Rib (kg) Mean
0.529195	21.65528	0.160369	0.740556

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.43361944	0.21680972	8.43	0.0035
Error	15	0.38577500	0.02571833		
Corrected Total	17	0.81939444			

4.4 Dependent Variable: Shoulder

R-Square	CoeffVar	Root MSE	Shoulder (kg) Mean
0.788524	13.59196	0.113153	0.832500

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.71610833	0.35805417	27.97	<.0001
Error	15	0.19205417	0.01280361		
Corrected Total	17	0.90816250			

4.5 Dependent Variable: Hind leg

R-Square	CoeffVar	Root MSE	Hind leg (kg) Mean
0.589487	14.67261	0.127000	0.865556

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.34741111	0.17370556	10.77	0.0013
Error	15	0.24193333	0.01612889		
Corrected Total	17	0.58934444			

4.6 Dependent Variable: Champ

R-Square	CoeffVar	Root MSE	Champ (kg) Mean
0.737102	20.26685	0.162698	0.802778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	1.11325278	0.55662639	21.03	<.0001
Error	15	0.39705833	0.39705833		
Corrected Total	17	1.51031111			

4.7 Dependent Variable: Loin

R-Square	CoeffVar	Root MSE	Loin (kg) Mean
0.701697	23.48007	0.129923	0.553333

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.59560000	0.29780000	17.64	0.0001
Error	15	0.25320000	0.01688000		
Corrected Total	17	0.84880000			

4.8 Dependent Variable: Neck percentage

R-Square	CoeffVar	Root MSE	Neck (%) Mean
0.263153	10.90273	0.937483	8.598611

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	4.70814211	2.35407106	2.68	0.1012
Error	15	13.18312217	0.87887481		
Corrected Total	17	17.89126428			

4.9 Dependent Variable: Brisket percentage

R-Square	CoeffVar	Root MSE	Brisket (%) Mean
0.135024	13.72404	1.408613	10.26383

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	4.64601900	2.32300950	1.17	0.3369
Error	15	29.76286150	1.98419077		
Corrected Total	17	34.40888050			

4.10Dependent Variable: Rib

R-Square	CoeffVar	Root MSE	Rib (%) Mean
0.033985	13.96887	2.196396	15.72350

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	2.54575300	1.27287650	0.26	0.7716
Error	15	72.36231750	4.82415450		
Corrected Total	17	74.90807050			

4.11 Dependent Variable: Shoulder

R-Square	CoeffVar	Root MSE	Shoulder (%) Mean
0.235851	7.472364	1.371731	18.35739

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	8.71139478	4.35569739	2.31	0.1330
Error	15	28.22468550	1.88164570		
Corrected Total	17	36.93608028			

4.12 Dependent Variable: Hind leg

R-Square	CoeffVar	Root MSE	Hind leg (%) Mean
0.475643	9.877736	1.853733	18.76678

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	46.75631878	23.37815939	6.80	0.0079
Error	15	51.54488033	3.43632536		
Corrected Total	17	98.30119911			

4.13 Dependent Variable: Champ

R-Square	CoeffVar	Root MSE	Champ (%) Mean
0.328470	13.90222	2.341025	16.83922

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	40.2099388	20.1049694	3.67	0.0505
Error	15	82.2059923	5.4803995		
Corrected Total	17	122.4159311			

4.14 Dependent Variable: Loin

R-Square	CoeffVar	Root MSE	Loin (%) Mean
0.480854	14.80096	1.694784	11.45050

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	39.90652633	19.95326317	6.95	0.0073
Error	15	43.08441017	2.87229401		
Corrected Total	17	82.99093650			

Appendix 5: ANOVA Table for Edible offal components

5.1 Dependent Variable: Head weight (kg)

R-Square	CoeffVar	Root MSE	Head Mean
0.399992	13.35082	0.201264	1.507500

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.40505679	0.20252839	5.00	0.0217
Error	15	0.60760571	0.04050705		
Corrected Total	17	1.01266250			

5.2 Dependent Variable: Heart weight (kg)

R-Square	CoeffVar	Root MSE	Heart Mean
0.212492	28.23460	0.025333	0.089722

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.00259742	0.00129871	2.02	0.1667
Error	15	0.00962619	0.00064175		
Corrected Total	17	0.01222361			

5.3 Dependent Variable: Lungs weight (kg)

R-Square	CoeffVar	Root MSE	Lungs Mean
0.165052	34.61932	0.063180	0.182500

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.01183631	0.00591815	1.48	0.2585
Error	15	0.05987619	0.00399175		
Corrected Total	17	0.07171250			

5.4 Dependent Variable: Liver weight (kg)

R-Square	CoeffVar	Root MSE	Liver Mean
0.449043	14.76851	0.052715	0.356944

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.03397325	0.01698663	6.11	0.0114
Error	15	0.04168369	0.00277891		
Corrected Total	17	0.07565694			

5.5 Dependent Variable: Kidneys weight (kg)

R-Square	CoeffVar	Root MSE	Kidneys Mean
0.251286	19.04468	0.012115	0.063611

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.00073885	0.00036942	2.52	0.1141
Error	15	0.00220143	0.00014676		
Corrected Total	17	0.00294028			

5.6 Dependent Variable: Tail weight (kg)

R-Square	CoeffVar	Root MSE	Tail Mean
0.357841	55.10520	0.401962	0.729444

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	1.35054444	0.67527222	4.18	0.0361
Error	15	2.42360000	0.16157333		
Corrected Total	17	3.77414444			

5.7 Dependent Variable: ABF weight (kg)

R-Square	CoeffVar	Root MSE	ABF Mean
0.799697	25.82816	0.099295	0.384444

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.59045218	0.29522609	29.94	<.0001
Error	15	0.14789226	0.00985948		
Corrected Total	17	0.73834444			

5.8 Dependent Variable: EGIT weight (kg)

R-Square	CoeffVar	Root MSE	EGIT Mean
0.644923	10.01378	0.171041	1.708056

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.79703218	0.39851609	13.62	0.0004
Error	15	0.43882476	0.02925498		
Corrected Total	17	1.23585694			

5.9 Dependent Variable: Head percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.430740	7.846045	0.496960	6.333889

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	2.80309302	1.40154651	5.67	0.0146
Error	15	3.70453476	0.24696898		
Corrected Total	17	6.50762778			

5.10 Dependent Variable: Heart percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.165062	32.42891	0.124491	0.383889

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.04595778	0.02297889	1.48	0.2585
Error	15	0.23247000	0.01549800		
Corrected Total	17	0.27842778			

5.11 Dependent Variable: Lungs percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.007598	36.03394	0.269654	0.748333

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.00835095	0.00417548	0.06	0.9444
Error	15	1.09069905	0.07271327		
Corrected Total	17	1.09905000			

5.12 Dependent Variable: Liver percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.176642	13.37324	0.200747	1.501111

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.12968635	0.06484317	1.61	0.2328
Error	15	0.60449143	0.04029943		
Corrected Total	17	0.73417778			

5.13 Dependent Variable: Kidneys percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.126677	14.29100	0.037712	0.263889

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	0.00309444	0.00154722	1.09	0.3621
Error	15	0.02133333	0.00142222		
Corrected Total	17	0.02442778			

5.14 Dependent Variable: Tail percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.329211	50.57214	1.413210	2.794444

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	14.70259540	7.35129770	3.68	0.0500
Error	15	29.95744905	1.99716327		
Corrected Total	17	44.66004444			

5.15 Dependent Variable: ABF percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.769157	25.07894	0.370472	1.477222

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	6.85962206	3.42981103	24.99	<.0001
Error	15	2.05873905	0.13724927		
Corrected Total	17	8.91836111			

5.16 Dependent Variable: EGIT percentage (%)

R-Square	CoeffVar	Root MSE	Head Mean
0.120353	11.85355	0.852336	7.190556

Source	DF	Sum of Square	Mean Square	F Value	Pr> F
Model	2	1.49093825	0.74546913	1.03	0.3822
Error	15	10.89715619	0.72647708		
Corrected Total	17	10.89715619			

Appendix 6: ANOVA Table for Non-Edible offal components.

6.1 Dependent Variable: Blood

R-Square	CoeffVar	Root MSE	Blood (kg) Mean
0.049148	17.77262	0.145192	0.816944

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.01634444	0.00817222	0.39	0.6852
Error	15	0.31621250	0.02108083		
Corrected Total	17	0.33255694			

6.2 Dependent Variable: Fore feet

R-Square	CoeffVar	Root MSE	FFT (kg) Mean
0.310010	14.07838	0.038246	0.271667

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00985833	0.00492917	3.37	0.0618
Error	15	0.02194167	0.00146278		
Corrected Total	17	0.03180000			

6.3 Dependent Variable: Hind feet (HF)

R-Square	CoeffVar	Root MSE	HF (kg) Mean
0.382840	13.91069	0.042312	0.304167

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.01665833	0.00832917	4.65	0.0268
Error	15	0.02685417	0.00179028		
Corrected Total	17	0.04351250			

6.4 Dependent Variable: Skin

R-Square	CoeffVar	Root MSE	Skin (kg) Mean
0.847524	11.59683	0.227040	1.957778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	4.29780278	2.14890139	41.69	<.0001
Error	15	0.77320833	0.05154722		
Corrected Total	17	5.07101111			

6.7 Dependent Variable: Trachea

R-Square	CoeffVar	Root MSE	Trachea (kg) Mean
0.449216	30.97112	0.014539	0.046944

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00258611	0.00258611	6.12	0.0114
Error	15	0.00317083	0.00021139		
Corrected Total	17	0.00575694			

6.8 Dependent Variable: Spleen

R-Square	CoeffVar	Root MSE	Spleen(kg) Mean
0.536006	29.13418	0.009129	0.031333

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00144400	0.00072200	8.66	0.0032
Error	15	0.00125000	0.00008333		
Corrected Total	17	0.00269400			

6.7 Dependent Variable: Blood

R-Square	CoeffVar	Root MSE	Blood (%) Mean
0.378692	27.57360	0.977178	3.543889

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	8.73007778	4.36503889	4.57	0.0282
Error	15	14.32315000	0.95487667		
Corrected Total	17	23.05322778			

6.8 Dependent Variable: Fore Feet

R-Square	CoeffVar	Root MSE	Fore feet (%) Mean
0.626739	8.891706	0.102008	1.147222

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.26207778	0.13103889	12.59	0.0006
Error	15	0.15608333	0.01040556		
Corrected Total	17	0.41816111			

6.9 Dependent Variable: Hind feet

R-Square	CoeffVar	Root MSE	Hind feet (%) Mean
0.325009	16.28177	0.209944	1.289444

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.31834444	0.15917222	3.61	0.0524
Error	15	0.66115000	0.04407667		
Corrected Total	17	0.97949444			

6.10 Dependent Variable: Skin

R-Square	CoeffVar	Root MSE	Skin (%) Mean
0.570237	8.914279	0.712895	7.997222

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	10.11507778	5.05753889	9.95	0.0018
Error	15	7.62328333	0.50821889		
Corrected Total	17	17.73836111			

6.11 Dependent Variable: Trachea

R-Square	CoeffVar	Root MSE	Trachea (%) Mean
0.221530	30.12764	0.057745	0.191667

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.01423333	0.00711667	2.13	0.1529
Error	15	0.05001667	0.00333444		
Corrected Total	17	0.06425000			

6.12 Dependent Variable: Spleen

R-Square	CoeffVar	Root MSE	Spleen (%) Mean
0.242790	28.33451	0.035418	0.125000

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00603333	0.00301667	2.40	0.1242
Error	15	0.01881667	0.00125444		
Corrected Total	17	0.02485000			

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

7.1 Dependent Variable: Lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.778119	11.52709	0.309310	2.683333

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	5.03275833	2.51637917	26.30	<.0001
Error	15	1.43509167	0.09567278		
Corrected Total	17	6.46785000			

7.2 Dependent Variable: Bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.648088	13.70054	0.191846	1.400278

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	1.01670278	0.50835139	13.81	0.0004
Error	15	0.55207083	0.03680472		
Corrected Total	17	1.56877361			

7.3 Dependent Variable: Fat weight

R-Square	CoeffVar	Root MSE	Fat (kg) Mean
0.921576	19.07859	0.109278	0.572778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	2.10493611	1.05246806	88.13	<.0001
Error	15	0.17912500	0.01194167		
Corrected Total	17	2.28406111			

7.4 Dependent Variable: Lean percentage

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.742183	3.435929	2.005972	58.38222

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	173.7564778	86.8782389	21.59	<.0001
Error	15	60.3588333	4.0239222		
Corrected Total	17	234.1153111			

7.5 Dependent Variable: Bone percentage

R-Square	CoeffVar	Root MSE	Bone (%) Mean
0.659193	7.063691	2.172909	30.76167

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	136.9864333	68.4932167	14.51	0.0003
Error	15	70.8230167	4.7215344		
Corrected Total	17	207.8094500			

7.6 Dependent Variable: Fat percentage

R-Square	CoeffVar	Root MSE	Fat (%) Mean
0.952730	13.04338	1.416221	10.85778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	606.3728778	303.1864389	151.16	<.0001
Error	15	30.0852333	2.0056822		
Corrected Total	17	636.4581111			

Appendix 8: ANOVA Tables for Lean and bone tissue components of the half carcass joints

8.1.1Dependent Variable: Neck lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.656757	20.49957	0.055121	0.268889

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.08720278	0.04360139	14.35	0.0003
Error	15	0.0003	0.00303833		
Corrected Total	17	0.13277778			

8.1.2 Dependent Variable: Neck bone weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.085871	27.88402	0.034932	0.125278

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00171944	0.00085972	0.70	0.5100
Error	15	0.01830417	0.00122028		
Corrected Total	17	0.02002361			

8.1.3 Dependent Variable: Brisket lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.793889	0.793889	0.060528	0.324722

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.21166944	0.10583472	28.89	<.0001
Error	15	0.05495417	0.00366361		
Corrected Total	17	0.26662361			

8.1.4 Dependent Variable: bone

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.211694	27.67284	0.044200	0.159722

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.00786944	0.00393472	2.01	0.1680
Error	15	0.02930417	0.00195361		
Corrected Total	17	0.03717361			

8.1.5 Dependent Variable: Shoulder lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.777941	14.61604	0.081769	0.559444

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.35135278	0.17567639	26.27	<.0001
Error	15	0.10029167	0.10029167		
Corrected Total	17	0.45164444			

8.1.6 Dependent Variable: Shoulder bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.577562	20.51355	0.056013	0.273056

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.06434444	0.03217222	10.25	0.0016
Error	15	0.04706250	0.00313750		
Corrected Total	17	0.11140694			

8.1.7 Dependent Variable: Rib lean weight

R-Square	CoeffVar	Root MSE	lean (kg) Mean
0.663106	20.87957	0.091290	.437222

Source	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	0.24605278	0.12302639	14.76	0.0003
Error	15	0.12500833	0.00833389		
Corrected Total	17	0.37106111			

8.1.8 Dependent Variable: Rib bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.240110	24.97934	0.074314	0.297500

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model		0.02617500	0.01308750	2.37	0.1275
Error		0.08283750	0.00552250		
Corrected Total		0.10901250			

8.1.9 Dependent Variable: Hind leg lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.574896	15.97498	0.108319	0.678056

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.23801111	0.11900556	10.14	0.0016
Error	15	0.17599583	0.01173306		
Corrected Total	17	0.41400694			

8.1.10 Dependent Variable: Hind leg bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.380566	17.87309	0.033611	0.188056

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.01041111	0.00520556	4.61	0.0275
Error	15	0.01694583	0.00112972		
Corrected Total	17	0.02735694			

8.1.11 Dependent Variable: Champ lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.749345	21.68582	0.128067	0.590556

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.73547778	0.73547778	22.42	<.0001
Error	15	0.24601667	0.01640111		
Corrected Total	17	0.98149444			

8.1.12 Dependent Variable: Champ bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.538383	22.32307	0.047499	0.212778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	0.03946944	0.01973472	8.75	0.0030
Error	15	0.03384167	0.00225611		
Corrected Total	17	0.07331111			

8.1.13 Dependent Variable: Loin lean weight

R-Square	CoeffVar	Root MSE	Lean (kg) Mean
0.697110	23.40266	0.092961	0.397222

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model		0.29833611	0.14916806	17.26	0.0001
Error		0.12962500	0.00864167		
Corrected Total		0.42796111			

8.1.14 Dependent Variable: Loin bone weight

R-Square	CoeffVar	Root MSE	Bone (kg) Mean
0.557721	31.82695	0.045795	0.143889

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model		0.03966944	0.01983472	9.46	0.0022
Error		0.03145833	0.00209722		
Corrected Total		0.07112778			

8.2.1 Dependent Variable: Neck lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.426737	8.731421	5.876247	67.30000

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	385.5657000	192.7828500	5.58	0.0154
Error	15	517.9541000	34.5302733		
Corrected Total	17	903.5198000			

8.2.2 Dependent Variable: Neck bone percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.426865	17.96820	5.875701	32.70056

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	385.6954111	192.8477056	5.59	0.0154
Error	15	517.8578833	34.5238589		
Corrected Total	17	903.5532944			

8.2.3 Dependent Variable: Brisket lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.625737	7.843985	5.142778	65.56333

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	663.288100	331.644050	12.54	0.0006
Error	15	396.722500	26.448167		
Corrected Total	17	1060.010600			

8.2.4 Dependent Variable: Brisket bone percent

R-Square	CoeffVar	Root MSE	Brisket (%) Mean
0.625737	14.93402	5.142778	34.43667

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	663.288100	331.644050	12.54	0.0006
Error	15	396.722500	26.448167		
Corrected Total	17	1060.010600			

8.2.5 Dependent Variable: Shoulder lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.007339	9.421504	9.421504	67.27611

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	4.4552778	2.2276389	0.06	0.9463
Error	15	602.6337500	40.1755833		
Corrected Total	17	607.0890278			

8.2.6 Dependent Variable: Shoulder bone percent

R-Square	CoeffVar	Root MSE	Bone (%) Mean
0.007323	19.36776	6.337992	32.72444

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	4.4448444	2.2224222	0.06	0.9464
Error	15	602.5522000	40.1701467		
Corrected Total	17	606.9970444			

8.2.7 Dependent Variable: Rib lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.504135	9.527205	5.575108	58.51778

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	474.0028111	237.0014056	7.63	0.0052
Error	15	466.2275000	31.0818333		
Corrected Total	17	940.2303111			

8.2.8 Dependent Variable: Rib bone percent

R-Square	CoeffVar	Root MSE	Bone (%) Mean
0.504135	13.43975	5.575108	41.48222

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	474.0028111	237.0014056	7.63	0.0052
Error	15	466.2275000	31.0818333		
Corrected Total	17	940.2303111			

8.2.9 Dependent Variable: Hind leg lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.117925	4.186082	3.268190	78.07278

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	21.4193444	10.7096722	1.00	0.3902
Error	15	160.2160167	10.6810678		
Corrected Total	17	181.6353611			

8.2.10 Dependent Variable: Hind leg bone percent

R-Square	CoeffVar	Root MSE	Bone (%) Mean
0.117925	14.90472	3.268190	21.92722

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	21.4193444	10.7096722	1.00	0.3902
Error	15	160.2160167	160.2160167		
Corrected Total	17	181.6353611			

8.2.11 Dependent Variable: Champ lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.466291	6.723361	4.853109	72.18278

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	308.6621778	154.3310889	6.55	0.0090
Error	15	353.2899833	23.5526656		
Corrected Total	17	661.9521611			

8.2.12 Dependent Variable: Champ bone percent

R-Square	CoeffVar	Root MSE	Bone (%) Mean
0.466291	17.44642	4.853109	27.81722

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	308.6621778	154.3310889	6.55	0.0090
Error	15	353.2899833	23.5526656		
Corrected Total	17	661.9521611			

8.2.13 Dependent Variable: Loin lean percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.033052	7.777679	5.697107	73.24944

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model		16.6413444	8.3206722	0.26	0.7772
Error		486.8553500	32.4570233		
Corrected Total		503.4966944			

8.2.14 Dependent Variable: Loin bone percent

R-Square	CoeffVar	Root MSE	Lean (%) Mean
0.033052	21.29715	5.697107	26.75056

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	16.6413444	8.3206722	0.26	0.7772
Error	15	486.8553500	32.4570233		
Corrected Total	17	503.4966944			

Appendix 9: ANOVA Tables for Shear force values.

9.1 Dependent Variable: Weight loss

R-Square	CoeffVar	Root MSE	WTL (g) Mean
0.819785	16.62134	6.474844	38.95500

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	2860.618233	1430.309117	34.12	<.0001
Error	15	628.854017	41.923601		
Corrected Total	17	3489.472250			

9.2 Dependent Variable: Weight loss percent

R-Square	CoeffVar	Root MSE	WTL (%) Mean
0.610518	8.000312	2.027635	25.34444

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	96.6679111	48.3339556	11.76	0.0008
Error	15	61.6695333	4.1113022		
Corrected Total	17	158.3374444			

9.3 Dependent Variable: Shear force Value SFVALS

R-Square	CoeffVar	Root MSE	SFV (N/cm^2) Mean
0.030576	24.54212	6.351909	25.88167

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model		19.0880333	9.5440167	0.24	0.7922
Error		605.2012167	40.3467478		
Corrected Total		624.2892500			

Appendix 10: Tables for Organoleptic testof Beef, mutton and goat meat

10.1 : Dependent Variable: Aroma

R-Square	CoeffVar	Root MSE	Aroma Mean
0.217687	30.51762	0.854493	2.800000

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr> F**
Model	2	8.53333333	4.26666667	5.84	0.0058
Error	42	30.66666667	0.73015873		
Corrected Total	44	39.20000000			

10.2: Dependent Variable: Flavour

R-Square	CoeffVar	Root MSE	Aroma Mean
0.157712	24.63448	0.717137	2.911111

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr> F**
Model	2	4.04444444	2.02222222	3.93	0.0272
Error	42	21.60000000	0.51428571		
Corrected Total	44	25.64444444			

10.3: Dependent Variable: Juiciness

R-Square	CoeffVar	Root MSE	Aroma Mean
0.243845	29.04467	0.826160	2.844444

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr> F**
Model	2	9.24444444	4.62222222	6.77	0.0028
Error	42	28.66666667	0.68253968		
Corrected Total	44	37.91111111			

10.4: Dependent Variable: Softness

R-Square	CoeffVar	Root MSE	Aroma Mean
0.421212	25.95614	0.778684	3.000000

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr> F**
Model	2	18.53333333	9.26666667	15.28	<.0001
Error	42	25.46666667	0.60634921		
Corrected Total	44	44.00000000			

10.5: Questionnaire for the panel 1

Name of the respondent	**Gender**	**Age**	**Meat**	**Aroma**	**Flavo**	**Juice**	**Softn**
Mohammed JumaBakari	M	26	G	3	4	4	3
Edward Joseph	M	33	G	3	4	3	4
Ibrahim Hamad Ali	M	23	G	2	2	1	3
Halima Moh'd Rashid	F	19	G	1	3	2	4
Khadija Moh'dJaffar	F	20	G	4	3	4	2
SubiraJuma	F	22	G	1	3	2	3
Ali mohammedAmmeir	M	54	G	3	3	4	4
Amina Mohammed Hussein	F	20	G	2	3	2	3
Mustafa Rashid Juma	M	43	G	2	3	2	1
BimkubwaIssaNassor	F	21	G	2	2	3	2
Robert Ramadhan	M	45	G	3	3	2	4
Salma Mbarouk Omar	F	21	G	1	3	1	3
Munira Ali Ame	F	22	G	2	1	4	1
MfaumeJumanne	M	56	G	3	2	4	2
Salum Ally Salum	M	30	G	2	2	2	3
Mohammed JumaBakari	M	26	M	4	3	4	4
Edward Joseph	M	33	M	3	2	4	3
Ibrahim Hamad Ali	M	23	M	2	3	3	4
Halima Moh'd Rashid	F	19	M	2	4	4	4
Khadija Moh'dJaffar	F	20	M	2	4	3	4
SubiraJuma	F	22	M	3	4	3	4
Ali mohammedAmmeir	M	54	M	4	3	3	4
Amina Mohammed Hussein	F	20	M	4	4	4	4
Mustafa Rashid Juma	M	43	M	4	4	3	4
BimkubwaIssaNassor	F	21	M	3	3	4	4
Robert Ramadhan	M	45	M	4	4	4	4
Salma Mbarouk Omar	F	21	M	4	3	3	4
Munira Ali Ame	F	22	M	4	3	3	3
MfaumeJumanne	M	56	M	4	3	4	4

Salum Ally Salum	M	30	M	3	3	3	4
Mohammed JumaBakari	M	26	B	4	2	2	2
Edward Joseph	M	33	B	1	3	1	2
Ibrahim Hamad Ali	M	23	B	3	3	2	3
Halima Moh'd Rashid	F	19	B	3	3	2	4
Khadija Moh'dJaffar	F	20	B	3	3	2	1
SubiraJuma	F	22	B	3	4	3	3
Ali mohammedAmmeir	M	54	B	3	2	2	3
Amina Mohammed Hussein	F	20	B	3	3	4	2
Mustafa Rashid Juma	M	43	B	2	2	2	3
BimkubwaIssaNassor	F	21	B	4	2	3	2
Robert Ramadhan	M	45	B	4	4	2	2
Salma Mbarouk Omar	F	21	B	3	2	3	2
Munira Ali Ame	F	22	B	2	2	3	2
MfaumeJumanne	M	56	B	2	3	3	1
Salum Ally Salum	M	30	B	2	2	2	3

10.6: Questionnaire for panel 2

Name of the respondent	Gender	Age	Meat	Pref	Recog
Juma Ali Khamis	M	45	B	0	yes
Juma Ali Khamis	M	45	M	1	No
AsmaJumaUssi	F	21	B	0	No
AsmaJumaUssi	F	21	M	1	No
Asalim Amour Ali	M	26	B	0	No
Asalim Amour Ali	M	26	M	1	No
Saada Khamis Mzee	F	22	B	1	Yes
Saada Khamis Mzee	F	22	M	0	Yes
AwenaFakihAbdalla	F	20	B	0	Yes
AwenaFakihAbdalla	F	20	M	1	No
Aisha Khamis Juma	F	20	B	0	Yes
Aisha Khamis Juma	F	20	M	1	No
Ramla A Hamad	F	20	B	0	Yes
Ramla A Hamad	F	20	M	1	Yes
Abubakar Hassan Kisoma	M	46	B	0	Yes
Abubakar Hassan Kisoma	M	46	M	1	No
TalibHammid Othman	M	23	B	1	Yes
TalibHammid Othman	M	23	M	0	No
MozaSeifAbdalla	F	21	B	0	Yes
MozaSeifAbdalla	F	21	M	1	Yes
Halima Khamis Juma	F	20	B	1	No
Halima Khamis Juma	F	20	M	0	No
Ali MwalimSoud	M	20	M	0	Yes
Ali MwalimSoud	M	20	M	1	No
Hassan Shamte Omar	M	28	B	0	No
Hassan Shamte Omar	M	28	M	1	Yes
HusnaYahyaIssa	F	25	B	0	No
HusnaYahyaIssa	F	25	M	1	No
Arafa Abdu Mwarab	F	22	B	0	Yes
Arafa Abdu Mwarab	F	22	M	1	No

10.7: Questionnaire for panel 3

Name of the respondent	Gender	Age	Meat	Pref	Recog.
SalimJuma Khamis	M	28	M	1	Yes
SalimJuma Khamis	M	28	G	0	Yes
BakarMasoudBakar	M	25	M	0	No
BakarMasoudBakar	M	25	G	1	No
Ismail Said Shamte	M	27	M	1	No
Ismail Said Shamte	M	27	G	0	No
Abdalla Said Saleh	M	25	M	0	Yes
Abdalla Said Saleh	M	25	G	1	No
Ali Kai Hamad	M	23	M	1	Yes
Ali Kai Hamad	M	23	G	0	No
ShafaaMoh'd Khamis	F	21	M	0	Yes
ShafaaMoh'd Khamis	F	21	G	1	Yes
FathiyaKhator Khamis	F	20	M	0	No
FathiyaKhator Khamis	F	20	G	1	No
MabroukSabourMachano	M	22	M	1	No
MabroukSabourMachano	M	22	G	0	No
Khamis Majaliwa	M	50	M	1	Yes
Khamis Majaliwa	M	50	G	0	No
Ally Issa Suleiman	M	30	M	1	Yes
Ally Issa Suleiman	M	30	G	0	No
Zuleikha Suleiman Hamad	F	20	M	0	Yes
Zuleikha Suleiman Hamad	F	20	G	1	Yes
Haji MussaAbeid	M	25	M	1	Yes
Haji MussaAbeid	M	25	G	0	No
Said Hassan	M	22	M	1	No
Said Hassan	M	22	G	0	No
ZahorSalumKombo	M	30	M	0	No
ZahorSalumKombo	M	30	G	1	No
Rashid Suleiman Hamad	M	21	M	0	Yes
Rashid Suleiman Hamad	M	20	G	1	No

10.4 Meat Preference and Recognition between Beef and goat Meat

Name of the respondent	Gender	Age	Meat	Pref	Recog
YussufSalumJuma	M	27	G	0	No
YussufSalumJuma	M	27	B	1	No
Sabra Suleiman Hamad	F	23	G	0	No
Sabra Suleiman Hamad	F	23	B	1	No
Mwanaharusi A Suleiman	F	21	G	1	No
Mwanaharusi A Suleiman	F	21	B	0	No
Ali UfuzoSalmin	M	23	G	1	No
Ali UfuzoSalmin	M	23	B	0	Yes
Abdalla Suleiman Hamad	M	26	G	0	No
Abdalla Suleiman Hamad	M	26	B	1	No
Nasra Ali Simba	F	21	G	0	Yes
Nasra Ali Simba	F	21	B	1	Yes
SalumJuma Khamis	M	37	G	0	No
SalumJuma Khamis	M	37	B	1	No
HusnaZubeirAme	F	20	G	0	No
HusnaZubeirAme	F	20	B	1	No
HusnaIddiHamad	F	22	G	0	No
HusnaIddiHamad	F	22	B	1	No
Suleiman Hamad Said	M	52	G	0	No
Suleiman Hamad Said	M	52	B	1	No
AbdallaMussa	M	29	G	0	No
AbdallaMussa	M	29	B	1	Yes
Moh'd Ally Moh'd	M	51	G	0	No
Moh'd Ally Moh'd	M	51	B	1	No
IssaAbdallaAme	M	20	G	1	No
IssaAbdallaAme	M	20	B	0	No
Naima Issa Hassan	F	21	G	0	Yes
Naima Issa Hassan	F	21	B	1	No
Faki Ali	M	37	G	1	Yes
Faki Ali	M	37	B	0	No