

**EFFECT OF CONCENTRATE SUPPLEMENTATION ON FATTENING  
PERFORMANCE AND QUALITY OF CARCASS AND MEAT OF CROSSBRED  
AND SMALL EAST AFRICAN GOATS**

**FOR REFERENCE  
ONLY**

**BY**

**WILLIAM ABDI HOZZA**



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

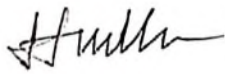
**2011**

**ABSTRACT**

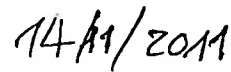
Forty eight castrated goats (24 Small East African x Norwegian crossbreds and 24 Small East African), 18 months old with average body weight of 16.7 kg were used to evaluate effect of genotype and concentrate supplementation levels on fattening, quality of carcass and meat and ultimately economics of fattening. Goats were randomly allocated into three diets varying in concentrate levels in a 2 x 3 factorial arrangement fed for 84 days. The concentrate levels were; no access to concentrate (T0), 66 % access to *ad libitum* concentrate allowance (T1) and 100 % access to *ad libitum* concentrate allowance (T2). In addition to the supplement goats were grazed, fed hay and drinking water. Diet had significant ( $P<0.01$ ) effects on total DM intake. T2 goats had 145 and 110 g higher ( $P<0.05$ ) total DM intake than T0 and T1 goats respectively. T0 goats were 3.3 kg and 2.6 kg lower ( $P<0.05$ ) in final BWT than those in T2 and T1 respectively. Supplemented goats had significantly ( $P<0.05$ ) higher daily gain, body condition score, better feed conversion efficiency, dressing percentage and EUROP scores for conformation than T0 goats. Diet had a significant effect ( $P<0.001$ ) on all killing out parameters. Increasing level of concentrate increased ( $P<0.05$ ) fatness and DM of the meat and decreased ( $P<0.05$ ) water in meat, without affecting that of ash, protein and chemical fat. Although thawing loss for LD muscle increased ( $P<0.05$ ) with ageing, cooking loss and WBSF improved ( $P<0.05$ ) with ageing. The lowest WBSF values were recorded for *M. Psoas major* and *Infraspinatus*. Among supplemented goats the cost of 1 kg gain under T1 was Tsh 213 cheaper than T2. It was concluded that goats should be grazed and supplemented with 400 g of concentrate for satisfactory fattening performance, meat quality and higher economic return of the enterprise.

**DECLARATION**

I, WILLIAM ABDI HOZZA, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.



William Abdi Hozza  
(MSc. Candidate)

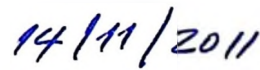


Date

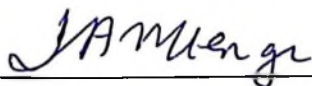
**The above declaration is confirmed**



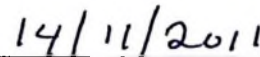
Prof. Kifaro, G.C.  
(Supervisor)



Date



Prof. Mtenga, L.A.  
(Supervisor)



Date

**COPY RIGHT**

No part of this dissertation may be reproduced, stored in any retrieval system or transmitted in any form or by any means, without written prior permission of the author or Sokoine University of Agriculture in that behalf.

## ACKNOWLEDGEMENTS

My most heartfelt thanks go to my supervisor Prof. Kifaro, G.C. for his guidance, sound advice, his encouragement at all stages of my work. His excellent teaching and constructive criticism and comments from the proposal writing to end of this work are highly appreciated. This work was co-supervised by Prof. Mtenga, L.A. who equally provided me with the much needed intellectual, technical and moral support at different stages of the study.

My thanks and appreciations also go to the German Academic Exchange Service (DAAD) for giving me scholarship which enabled me to undertake this study. Also thanks (DAAD) for short term research scholarship in Georg-August University Gottingen German under supervision of hosting Prof. Wicke, M. at the latter part of my study is also highly appreciated.

I would like to express my gratitude to Prof Katule, A.M. and Zabron, N. for their guidance during data analysis and my special gratitude goes to Dr. Mushi, D. for data analysis, technical and moral support especially during slaughter operation.

I would also like to thank PANTIL Project No 020 for partly funding this work during data collection. Thanks to all members of the academic staff, friends, colleagues in the Department of Animal Science and Production (DASP), who made my course work possible and for their constructive criticisms and good suggestions to this research.

My thanks are due to extension officers of Gairo and SUA Mr. Mchomvu, Y. and Faustine, C. and Mrs. Samia, R. for their great assistance in the initial preparation and data collection,

Laboratory Technicians Mr. Muffui, G. Allute, D. and Ahmad, H. for their laboratory analytical work. Very special thanks go out to Mr. Mvungi, K. for providing the animal structures in which the experiment was conducted.

Finally, I would like to thank my family members for their moral support throughout my studies. Last but not least I would like to thank the Sokoine University of Agriculture management for granting me the study leave, without which the study would not have been possible.

Most of all, I am thankful to God for all the blessings and success that I have received in my life.

## DEDICATION

This dissertation is dedicated to my parents: my father the late Mr. Hozza, A. and my mother Matulo and to my wife Leah and our children Anna and Abigail.

## TABLE OF CONTENTS

<b>ABSTRACT</b> .....	<b>ii</b>
<b>DECLARATION</b> .....	<b>iii</b>
<b>COPY RIGHT</b> .....	<b>iv</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>v</b>
<b>DEDICATION</b> .....	<b>vii</b>
<b>TABLE OF CONTENTS</b> .....	<b>viii</b>
<b>LIST OF TABLES</b> .....	<b>xii</b>
<b>LIST OF APPENDICES</b> .....	<b>xv</b>
<b>LIST OF ABBREVIATIONS</b> .....	<b>xvi</b>
<b>CHAPTER ONE</b> .....	<b>1</b>
<b>1.0 INTRODUCTION</b> .....	<b>1</b>
1.1 Background Information .....	1
1.2 Objective .....	3
1.2.1 Overall objective .....	3
1.2.2 Specific objectives were .....	3
<b>CHAPTER TWO</b> .....	<b>4</b>
<b>2.0 LITERATURE REVIEW</b> .....	<b>4</b>
2.1 Overview .....	4
2.1.1 The role of goats in Tanzania.....	4
2.1.2 Social and economic importance of goats .....	5
2.1.3 Demand for goat meat.....	6
2.1.4 Meat quality .....	6
2.1.4.1 Tenderness .....	7
2.1.4.2 Post-mortem conditions .....	8

2.1.4.3	Water in meat.....	9
2.1.4.4	Fat in chevon.....	10
2.2	Factors Affecting Growth, Carcass and Meat Quality.....	11
2.2.1	Fattening .....	11
2.2.2	Genotype.....	11
2.2.3	Nutrition.....	12
2.3	Non-Carcass Components.....	13
2.4	Economics of Concentrate Supplementation on Chevon Production .....	15
<b>CHAPTER THREE.....</b>		<b>17</b>
3.0	<b>MATERIALS AND METHODS.....</b>	<b>17</b>
3.1	Study Area .....	17
3.2	Experimental Design and Dietary Treatments.....	17
3.3	Source of Experimental Animals.....	18
3.4	Management of Experimental Animals .....	18
3.4.1	Feeds and feeding of the experimental animals.....	18
3.4.2	Housing.....	20
3.4.3	Disease control.....	20
3.5	Body Weight and Linear Body Measurements.....	20
3.6	Sampling and Chemical Analyses of Feeds.....	21
3.7	Slaughter Procedure and Slaughter Data .....	22
3.8	Measurements on Carcasses .....	23
3.9	Muscle Physico-Chemical Properties .....	23
3.10	Chemical Composition of Minced Meat.....	24
3.11	Economic Analysis of Fattening.....	25
3.12	Data Handling and Statistical Analyses.....	25

<b>CHAPTER FOUR</b> .....	<b>28</b>
<b>4.0 RESULTS</b> .....	<b>28</b>
4.1 Chemical Composition of Feeds.....	28
4.2 Feed Intake.....	29
4.3 Growth Performance.....	30
4.4 Linear Body and Carcass Measurements.....	31
4.5 Killing out Characteristics .....	32
4.6 Non Edible Offal Components (NEOC).....	33
4.7 Edible Offal Components (EOC).....	34
4.8 Fat Depots.....	36
4.9 Carcass Physical Compositions .....	37
4.10 Carcass Chemical Compositions.....	39
4.11.1 Temperature of carcasses.....	40
4.11.2 pH of carcasses .....	41
4.11.3 Thawing loss, cooking loss and WBSF of aged <i>M. Longissimus dorsi</i> (LD).....	43
4.11.4 Muscle physical properties .....	45
4.12 Economic Analysis of Goat Fattening.....	47
 <b>CHAPTER FIVE</b> .....	 <b>49</b>
<b>5.0 DISCUSSION</b> .....	<b>49</b>
5.1 Chemical Composition of Feeds.....	49
5.2 Feed Intake.....	49
5.3 Growth Performance.....	50
5.4 Linear Body and Carcass Measurements.....	53
5.5 Killing-Out Characteristics .....	53

5.6	Non Edible Offal Components (NEOC).....	55
5.7	Edible Offal Components (EOC).....	56
5.9	Carcass Physical Composition.....	58
5.10	Carcass Chemical Composition .....	59
5.11	Muscle Physico-Chemical Properties .....	60
5.11.1	Temperature and pH of carcasses .....	60
5.11.2	Effect of breed and diet on muscle physico-chemical properties .....	60
5.11.3	Effect of muscle type on meat physico-chemical properties .....	61
5.12	Economic Analysis of Goat Fattening .....	63
<b>CHAPTER SIX .....</b>		<b>65</b>
<b>6.0 CONCLUSIONS AND RECOMMENDATIONS.....</b>		<b>65</b>
6.1	Conclusions.....	65
6.2	Recommendations.....	66
<b>REFERENCES.....</b>		<b>67</b>
<b>APPENDICES.....</b>		<b>89</b>

## LIST OF TABLES

Table 1:	Goat products and services .....	5
Table 2:	Components and factors of meat quality .....	7
Table 3:	Data on killing out characteristics of goat carcasses in Tanzania.....	15
Table 4:	Combination layout of the experiment .....	18
Table 5:	Chemical composition of feeds and feed ingredients used (g/kg DM).....	28
Table 6:	Feed intakes and DM intake (% live weight) of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	29
Table 7:	Growth performance of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	31
Table 8:	Linear body and carcass measurement of castrated SEA x N and SEA goats under different levels of concentrate supplementation.....	32
Table 9:	Killing out characteristics of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	33
Table 10:	Non edible offal components of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	34
Table 11:	Edible offal components of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	35
Table 12:	Fat depots and their percentages of total fat depots of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	37
Table 13:	Carcass physical compositions of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	38
Table 14:	Carcass chemical compositions of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	39

Table 15: Muscle physical properties of castrated SEA x N and SEA goats under different levels of concentrate supplementation .....	46
Table 16: Effect of diets on economics of fattening .....	48

**LIST OF FIGURES**

Figure 1:	Post-mortem temperature decline in SEA x N crossbreds and SEA goat carcasses.....	40
Figure 2:	Post-mortem temperature decline in goat carcasses fed T0, T1 and T2 diets.....	41
Figure 3:	Post-mortem pH decline in SEA X N crossbreds and SEA goat carcasses....	42
Figure 4:	Post-mortem pH decline in goat carcasses fed T0, T1 and T2 diets.....	43
Figure 5:	Effect of ageing LD muscle on thawing and cooking loss .....	44
Figure 6:	Effect of ageing LD muscle on Warner-Bratzler shear forces WBSF (N). ....	44

**LIST OF APPENDICES**

Appendix 1: ANOVA Tables for feed intake .....	89
Appendix 2: ANOVA Tables for growth parameters.....	91
Appendix 3: ANOVA Tables for linear body and carcass measurements (cm).....	93
Appendix 4: ANOVA Tables for killing-out characteristics .....	95
Appendix 5: ANOVA Tables for non-edible offal components.....	97
Appendix 6: ANOVA Tables for edible offal components .....	100
Appendix 7: ANOVA Tables for fat depots .....	103
Appendix 8: ANOVA Tables for carcass physico-composition.....	107
Appendix 9: ANOVA Tables for carcass chemical composition .....	110
Appendix 10: ANOVA Tables for aged LD muscle.....	112
Appendix 11: ANOVA Tables for muscle physico-chemical properties .....	113

**LIST OF ABBREVIATIONS**

±SE	-	Standard Error
°C	-	Degree Celsius
ADF	-	Acid detergent fibre
ADG	-	Average Daily Gain
ANOVA	-	Analysis of Variance
AOAC	-	Association of Official Analytical Chemists
BCS	-	Body Condition Score
BL	-	Body Length
BWT	-	Body Weight
CCPP	-	Contageous-Caprine Pleuropneumonia
CD	-	Carcass Depth
CF	-	Crude Fibre
CL	-	Carcass Length
cm	-	Centimetre
CP	-	Crude Protein
d	-	Day
DAAD	-	<i>Deutscher Akademischer Austausch Dienst</i>
DASP	-	Department of Animal Science and Production
DM	-	Dry Matter
DP	-	Dressing Percentage
EBW	-	Empty Body Weight
EE	-	Ether Extracts
EOC	-	Edible Offal Component
FAO	-	Food and Agriculture Organization

FCR	-	Feed Conversion Ratio
g	-	Gram
GDP	-	Gross Domestic Product
GIT	-	Gastro Intestinal Tract
GLM	-	General Linear Model
GR	-	Gross Return
h	-	Hour
HCW	-	Hot Carcass Weight
HG	-	Heart Girth
HLC	-	Hind Leg Circumference
HLL	-	Hind Leg Length
HR	-	Height at Rump
HW	-	Height at Withers
INVDMD	-	<i>In-Vitro</i> dry Matter Digestibility
INVOMD	-	<i>In-Vitro</i> Organic Matter Digestibility
kg	-	Kilogram
LD	-	<i>Longissimus dorsi</i>
m	-	Metre
MAFS	-	Ministry of Agriculture and Foods Security
ME	-	Metabolisable Energy
MFI	-	Myofibril Index
MJ	-	Mega Joule
mm	-	Millimetres
MLDF	-	Ministry of Livestock Development and Fisheries
NA	-	Not Available

NDF	-	Neutral Detergent Fibre
NEOC	-	Non Edible Offal Components
NFE	-	Nitrogen Free Extract
NR	-	Net Return
NRS	-	Net Return Due to Supplementation
PANTIL	-	Programme for Agricultural and Natural Resources Transformation for Improved Livelihood
PDIFF	-	Probability levels for difference between LSmeans
pH	-	Hydrogen ion concentration
pHu	-	Ultimate pH
PM	-	Post-Mortem
PRC	-	Pasture Research Centre
R <sup>2</sup>	-	Coefficient of Determination
SAS	-	Statistical Analytical System
SEA x N	-	Small East African and Norwegian dairy goat crossbred
SUA	-	Sokoine University of Agriculture
SWT	-	Slaughter Weight
T0	-	Treatment Zero
T1	-	Treatment One
T2	-	Treatment Two
TEP	-	Total Edible Proportion
Tsh	-	Tanzania Shillings
UNESCO	-	United Nations Educational Scientific and Cultural Organization
USD	-	United States of America Dollar
TVC	-	Total Variable Cost

- WBSF - Warner -Bratzler Shear Force
- WHO - World Health Organization

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background Information

Small ruminants play an important role in almost all farming systems in the tropics and sub tropics. Like other ruminants, goats are particularly well suited to utilize poor quality roughages and adapt to many types of management systems. Moreover, goats have various attributes that make them better suited to small scale producers. These include their small size, short generation interval, high prolificacy, better ability to eat a wide range of feedstuffs, low feed requirements and relatively low capital requirement. Njombe (1993) observed that although small ruminants are basically multipurpose animals they are mainly kept for meat production in Tanzania. Latest estimates show that Tanzania has 13.7 million goats (MLDF, 2010) of which most of these are found in the traditional livestock sector under extensive pasture driven systems.

Despite having large livestock numbers, Tanzania is still insufficiently supplied with animal protein. Low carcass weight and yield from goats limits potential for export as well as the availability of meat to fulfil the increased domestic demand for meat from small ruminants. Due to poor muscle development, such carcasses have poor conformation and quality, which results in low prices given in the competitive market. Therefore smallholders require improved management in many aspects of goat production in order to improve the productivity of this specie on a sustainable basis. One of the needed improvements is the formation of planned business oriented fattening program. The fattening program will improve the body weight, body condition, carcass conformation and quality making these carcasses more competitive in local and export market.

Genetic factors and levels of feeding are probably the most important factors influencing growth and thus meat production. Experiences from inland of Tanzania have shown that low quality and quantity of pastures is so common such that minimum nutrient requirements for maintenance and production of animals can not be met (Kakengi *et al.*, 1999). Hence animals take over 2 years to reach slaughter weight of 20 kg with daily growth rates of less than 21 g/d and often produce low quality carcass (Mtenga and Shoo, 1990; Mushi *et al.*, 2004). Roughage alone is not sufficient to support optimal growth due to low levels of protein and energy (Sebsibe and Muthur, 2000). Kochapakdee *et al.* (1994) have reported the importance of concentrate supplementation in growth and productivity of sheep and goats in a pasture based grazing. They also reported that grazing alone may not be sufficient for optimizing live weight gain. Concentrate supplementation besides having high feeding value, improves the utilization of roughages fed with them.

Some goat producers in Tanzania offer some level of supplementation to their animals. At the same time commercial concentrates are increasingly costly, and on farm mixes of agro-industrial by-products are seasonal in their availability and are often inconsistent in formulation. Grains are expensive and highly valued as human food in Tanzania and currently can not be used as source of concentrate for ruminants. However, there are a number of agricultural and agro-industrial by-products that can be used as supplements. Agro-industrial by-products are the by-products from the primary processing of crops such as milling by-products, oilseed cakes from mechanical oil extracting small-scale industries, molasses and occasional surplus grain or grain damaged during processing. The use of industrial and farm by-products however, would save grain not only for human consumption, but can also be used more efficiently in feeding monogastric animals such as pigs and poultry.

Modifying the traditional production systems through improved feeding, therefore improves the eating quality of goat meat (Arsenos *et al.*, 2002). This is true for crossbreds as well as for local Tanzanian goat kids (Mushi *et al.*, 2009). Concentrate supplementation reduces age to slaughter, increases carcass quality and increases meat output thereby improving access to animal protein and income to households in the traditional sector (Mtenga and Kitanyi, 1990). Data from on station experimentation with animals fed on low quality roughage show improved performance and satisfactory fattening performance for both Small East African (SEA) and crossbred goats when they are supplemented with concentrate feeds (Hango *et al.*, 2007; Mushi *et al.*, 2009; Safari *et al.*, 2009). However how these animals will perform on fattening dietary regime under farm conditions in Tanzania is yet to be documented. This being the case, replicability of on-station results along with demonstration to farmers how fattening is done, the end results and the economics of it should be done under farm condition.

## **1.2 Objectives**

### **1.2.1 Overall objective**

To study the effect of concentrate supplementation on fattening performance and quality of carcass and meat of SEA x N and Small East African goats and ultimately to study the economics of fattening under rural farm condition.

### **1.2.2 Specific objectives were**

- i) To assess the effect of concentrate supplementation and genotype on dry matter intake, feed efficiency and growth performance of goats under farm condition.
- ii) To evaluate the effect of on-farm concentrate supplementation and genotype on fattening performance, carcass characteristics, non carcass components and meat quality of goats.
- iii) To evaluate the economic feasibility of fattening goats under farm conditions.

## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1 Overview

In Tanzania, Small East African goats are the main goat breed kept for meat production. In order to improve performance of indigenous goats, a crossbreeding programme was initiated in 1988 in the high agricultural potential areas of the Uluguru highlands. This was done by crossing SEA with Norwegian dairy goats. The resulting crosses from this programme had faster growth rates and higher milk yields (Mtenga *et al.*, 1998). Further, in 1999, resultant crosses were introduced in smallholder farms in Gairo; a semi arid area in Tanzania. The available F1 male crosses are not used for breeding purposes and could be used for meat production.

##### 2.1.1 The role of goats in Tanzania

In the tropics goats are ideal livestock types for the improvement of the livelihood of the rural households (Kusina and Kusina, 2001). In Tanzania, as in many African countries, goats play a number of roles ranging from nutritional, sociological to economic roles. For example, goat meat represents an important source of animal proteins in rural areas and its meat is rated highly for tenderness and juiciness when compared with mutton (Babiker *et al.*, 1985). Lwelamira *et al.* (1999) also reported that the majority of farmers in Tanzania use sheep and goats as a source of income and food. Table 1 shows the goat products and services offered to small scale farmers.

**Table 1: Goat products and services**

<b>Products</b>	<b>Services</b>
Meat (raw, cooked blood, soup)	Cash income
Milk (fresh, sour, yoghurt, butter, cheese)	Security
Skin (clothes, water/grain containers, tents, thongs, etc)	Gifts
Hair (cashmere, mohair, coarse hairs tents, wigs fish lures)	Loans
Horns	Religious rituals
Bones	Judicial rule
Manure (crop, fish)	Pleasure
	Pack transport
	Draught power
	Medicines
	Control of bush
	Encroachment
	Guiding sheep

Source: Peacock (2005)

### 2.1.2 Social and economic importance of goats

Socially, goats have a number of roles to play (Ajala, 1995): (i) they are used to pay dowry, (ii) in ceremonies, parties and festive celebrations, goat meat is served because of its tenderness and good taste, preferred to that of cattle, (iii) a goat can be offered as a present to a relative, to honour an important visitor, friend or for thanking somebody in appreciation for his/her good deeds (iv) in some tribes goats are slaughtered during certain traditional rituals or reconciliation following disputes.

The economic importance of goats for smallholders in developing countries as a source of animal protein and income is on the increase (Atti *et al.*, 2004; Mahgoub *et al.*, 2005a). The livestock sub-sector provides about 30% of the Agricultural GDP and livelihood to an estimated 1 745 776 households. Out of sub-sectors contribution to GDP, about 40% originates from beef, 30% from milk and another 30% from poultry and small stock production (UNESCO, 2010). Their current contribution is not commensurate with the potential capacity for higher levels of production.

### **2.1.3 Demand for goat meat**

Melewas *et al.* (2004) has reported that there has been export of live sheep and goats to the Persian Gulf countries, Madagascar and Comoro. Such open market provides opportunities for commercialisation of the smallholder production system. Thus, increasing the contribution of the sub-sector towards poverty reduction, household food security and the national economy. Meat from small ruminants accounts for about 30 % of the meat consumed in Africa (Reed *et al.*, 1988) whereas 23 % of meat consumed in the Tanzania comes from small ruminants (Mtenga *et al.*, 2004). Goat meat is preferred to mutton and ranks second to beef in sales and consumption. About 60 % of the world population, that live in the developing countries is estimated to be suffering from animal protein deficiency (Attah *et al.*, 2006). In Tanzania, there is no taboo preventing its consumption in the country and most people of any religion eat goat meat. A similar opinion has also been reported by Casey (1992), that there are virtually no religious or cultural taboos against goat meat consumption and thus goats are readily acceptable to societies in which eating beef, pork or other meat types are prohibited. It is most likely that with this high demand of small ruminants, the current low productivity can not meet the market demand.

### **2.1.4 Meat quality**

Perceptions of meat quality vary among countries, between ethnic groups within countries, between age groups of all ethnicity and also over time (Dhanda *et al.*, 1999a). Quality is defined as the consumer acceptance or preference of a food or food product. Traditionally, meat quality is either eating quality or processing quality, therefore quality is directly associated with usage and is a multifaceted concept (Webb *et al.*, 2005). The properties of meat are determined by several factors spanning from the conception of the animal to the consumption of the meat (Hofmann, 1994). Meat quality also characterizes the composition and safety of a food product. Each of these characteristics are dependent on

factors that are directly linked with the animal (breed, age, sex) and factors external to the animal (diet, weather and harvest procedure) that are indicated by the term “environmental factors”. The quality factors may be presented in groups that are closely related and determined component of meat quality (Table 2).

**Table 2: Components and factors of meat quality**

<b>Component</b>	<b>Meat quality factors</b>
Yields and gross composition	Ratio of fat to lean Muscle size
Appearance and technical characteristics	Colour and water holding capacity of lean Fat texture and colour Marbling (Intramuscular fat) Chemical composition of lean
Palatability	Texture and tenderness Juiciness Flavour Aroma
Wholesomeness	Nutritional quality Chemical safety Microbial safety Acceptable animal husbandry

**Source: Hofmann (1994)**

#### **2.1.4.1 Tenderness**

Tenderness is defined as the easiness of mastication, which involves the initial ease of penetration by the teeth, the ease with which the meat breaks into fragments and the amount of residue remaining after mastication (Lawrie, 1998). There are two main components of meat tenderness myofibrillar (muscle) and connective tissue (collagen). The degree of tenderness can be related to three categories of protein in muscle (Sarcoplasmic, myofibrillar and stromal), those of the connective tissue (collagen, elastin and reticulin), of the myofibril (actin, myosin and tropomyosin) and of the sarcoplasm (sarcoplasmic protein and sarcoplasmic reticulum).

The connective tissues, which are present in all muscles in the epimysial, perimysial, and endomysial components surrounding the muscle fibres, lead to strength of muscle but now make it tough. The strength of connective tissues is derived from its collagen fibres. The resilience depends on the elastic fibres in the intercellular matrix. The connective tissues can be divided into two main categories; - loose and dense (regular or irregular) connective tissues based on density and organization of fibre bundles. The dense connective tissues that are very common in tendons are much tougher than the loose ones. The increase in cross-linking associated an expansion of dense connective tissues and the insolubility of collagen increase with age, therefore affect muscle tenderness. Thus, when considering collagen content, its types, and cross-linking, younger animals will produce more tender meats than will older animals. The toughness of meat decreases during post-mortem (PM) storage and is termed as tenderisation. The PM tenderisation is due to the enzymatic activity of calpain, which break down the structural protein within the muscle fibres and consequently weakens the myofibrillar matrix (Koochmaraie, 1996). The rate and extent of PM proteolysis depends on the temperature and pH of the meat (Koochmaraie, 1992).

#### **2.1.4.2 Post-mortem conditions**

Conversion of muscle to meat – The stoppage of blood circulation at slaughter initiates a complex series of changes in muscular tissue which may be described in two phases. In the first phase, rigor mortis develops during which muscles become inextensible and attain maximum toughness (Lawrie, 1998; Warriss, 2000). The major events accompanying rigor development are glycolysis and the denaturation of some proteins, of which the proteolytic enzymes are of particular interest. The second phase known as conditioning is characterised by a gradual improvement in tenderness during post-mortem storage, which is largely attributed to the activity of the calpains and other proteolytic enzymes, which break down the structural proteins within muscle fibres and consequently weakens the

myofibrillar matrix (Lawrie, 1998; Warriss, 2000). The contractile system of muscles is another factor that contributes to meat tenderness. The contraction makes the Z discs closer to each other and increases density of filaments, therefore reduces chewing ability. After slaughter, but before the rigor mortis, it is still able for filaments to slide over each other. However, after rigor mortis, the two types of filaments become fixed and hence meat toughness.

Glycolysis continues in the tissues of animals following harvest until the glycogen substrate is exhausted or autolysis of glycolytic enzymes renders glycolysis inoperable. Acidic glycolytic end products accumulate in tissues and the pH declines. Ultimate pH values for goat muscles range from 5.55 to 6.33 (Webb *et al.*, 2005). Muscle glycogen concentrations are reduced in stressed or excitable animals reducing the potential for a favourable pH decline from living tissue of 7.0 to post-mortem muscle of 5.8 (Muir *et al.*, 1998). Simela *et al.* (2004) indicated that the tenderness and colour properties of chevon, from indigenous South African goats, were highly dependent on post-mortem pH and temperature. Carcasses chilled slowly resulted in a faster pH decline, which improved the tenderness. Temperature, carcass size and fat cover may influence meat tenderness because muscles in larger and fatter carcasses are slower to cool thus prolonging post-mortem proteolysis.

#### **2.1.4.3 Water in meat**

Fresh meat contains about 75 % water at slaughter (Offer and Trinick, 1983) and some of this water is lost post-slaughter in one of the three ways. First are evaporative losses, which occur during carcass chilling and from the surface of cuts on display. Evaporative losses during chilling are probably the first water losses to have an impact on the appeal of chevon because the carcasses are relatively lean and have a high surface area to volume ratio. The losses tend to be higher for smaller than the larger carcasses. In Zimbabwe

chilling losses from goats that were less than 35 kg were about 3 % while the losses from heavier goats were only 2.3 % (Simela *et al.*, 2000). Second is drip loss which occurs from cut surfaces of meat. High drip loss is undesirable because it detracts from the appeals of the meat, and valuable proteins and flavour compounds are lost in the exudates (Lawrie, 1998). Cooking is a process of heating meat at sufficiently high temperatures that denatures proteins and makes the meat less tough and easy to consume (Garcia-Segovia *et al.*, 2006). It can be achieved either by boiling or roasting (Shilton *et al.*, 2002).

Cooking loss, which is one of the meat quality parameters, refers to the reduction in weight of meat during the cooking process (Vasanthi *et al.*, 2006). Cooking losses not only reduce the size of the meat but also result in reduced succulence, loss of flavour and loss of essential minerals, including iron and zinc as well as B vitamins. The increased loss of such nutrients deteriorates the meat nutritional quality and lowers its purchase (Pearson and Gillett, 1988). Thawing loss refers to the loss of fluid in meat resulting from the formation of exudates following freezing and thawing.

#### **2.1.4.4 Fat in chevon**

Development of fat in goat occurs very late and only reaches appreciable levels when the animals are near or at their mature body weight (Owen *et al.*, 1983). The fat content is highly variable and is influenced by such factors as age, sex, body weight and growth rate. Most of the fat is deposited in the viscera rather than carcass depots (Kirton, 1988). Typically, goat carcasses have about 60 % dissectible lean and 5 % to 14 % dissectible fat (Norman, 1991). Despite the trend towards reduced consumption of animal fats, fat on the carcass is extremely important for a number of reasons. The amount, distribution, colour and texture of the fat all have a bearing on carcass grading and price. Thus, animals with high degree of fatness regardless of size and weight fetch a premium price in most tropical

countries (Thatcher and Gaunt, 1992). The demand for quality meat is growing due to expanding markets composed of tourism, mining industries, expatriates as well as increased income and purchasing power of the society (Mushi *et al.*, 2006).

## **2.2 Factors Affecting Growth, Carcass and Meat Quality**

### **2.2.1 Fattening**

Live weight has been one of the determinants of the commercial value of an animal (Assenga, 1997). Slaughtering goats at heavier live weights can possibly be advantageous for producers based on greater profits from meat sales and for consumers by supplying mature meat with improved quality (Manfredini *et al.*, 1988). Mtenga *et al.* (1984) found that slaughter weight for goats in Tanzania ranged from 11 - 40 kg. Higher live weights lead to significant increases in dressing percentage (DP). Generally, fattening of an animal improves the animal body weight, body condition, carcass conformation and quality.

Body condition score (BCS) reflects subcutaneous fat depots and muscular development and coverage of the ribs. According to Rae (2002) BCS is a subjective measure of nutrient reserve. A numerical score is used as an indication of the body reserve and hence, nutritional status of the animal. The score relies on physical appraisal of the quantity of the subcutaneous fat cover under the skin on the hipbone, tail head area, gluteal muscle, spinous process and the lower rib cage (Peacock, 1996; Steele, 1999). For market purposes, BCS enables farmers to maximize returns by selling goats at peak condition (Honhold *et al.*, 1989).

### **2.2.2 Genotype**

Generally animals of large breeds grow at a faster rate than smaller breeds and have higher pre-slaughter live weights and carcass weight than those of smaller breeds at a similar age.

The post weaning growth of indigenous Malawi goats was reported to be 40 g/d (Kirk *et al.*, 1994) whereas the Black Bengal at the age of 9 - 12 months was 23 g/d (Husain *et al.*, 1996). Mushi *et al.* (2009) reported that the average daily gain (ADG) for *ad-libitum* concentrate allowance of Norwegian x SEA crossbred goats was 95.7 g/d. However, SEA goats under similar dietary regime grew at 49.5 g/d (Safari *et al.*, 2009). Dressing-out percentage (based on empty body weight) of goats ranged between 53 and 57 %, with the Dhofari goats having the highest values (Kadim *et al.*, 2003). In another study, Mahgoub *et al.* (2005b) reported that Batina goats grew faster (96 g/d) and reached higher body weight of 27 kg than Dhofari goats. Goat breeds differ in the age at which the fattening stage begins and they probably differ also in the weight at which fat is deposited during the fattening phase. Some breeds begin to fatten at lower weights while others at heavier weights. Breeds differ in the rate at which fat is deposited during the fattening stages.

In addition, breed effect on meat quality is associated with differences in muscle distribution, muscle physical and biochemical properties in the carcass (Notter *et al.*, 1991; Santos-Silva *et al.*, 2002; Dawson *et al.*, 2002). Carcasses of the same weight produced from different goat breeds had different proportions and distribution of muscle, fat and bone (Gibb *et al.*, 1993; Dhanda *et al.*, 1999b). Genotype also affects the carcass characteristics and the internal fat depots significantly (Sebsibe *et al.*, 2007) as well as cooking loss (Dhanda *et al.*, 1999a; Dhanda *et al.* 2003). In their work, Dhanda *et al.* (2003) reported cooking loss values that ranged from 23.2 – 35.4 % for Boer x Feral and Boer x Angora.

### **2.2.3 Nutrition**

Nutritional treatment, especially dietary energy and protein, are the major and most important environmental factors affecting live weight gain and meat production in goats.

In tropical countries like Tanzania where extensive grazing system is mainly practiced, the growth rate and consequently meat production of animals fluctuate because of the seasonality of forage availability and quality. According to Mtenga and Kitalyi (1990), the performance of East African goats in Tanzania under varying levels of concentrate supplementation ranged between 23 – 63 g/d. Shahjalal *et al.* (1997) reported that growth rate of grazing Black Bengal goats can improved under conditions of increased protein supplementation. When crude protein levels of 10, 13 and 16 % were compared in the local Tunisian goats, the diet containing medium level of 13 % CP was found to have the highest (105 g/d) growth rate (Atti *et al.*, 2004).

On the other hand, the eating quality of meat can be affected by feeding strategy and composition of a diet. Low energy grass or forage diets give rise to less tender meat compared with higher energy diets fed *ad libitum* (Kristensen *et al.*, 2002). Moreover, adjusting energy levels in a diet in order to produce high quality goat carcasses could be beneficial to goat producers especially if they satisfy consumer desire by altering carcass composition and the quality of meat (Abdullah and Musallam, 2007). Animals fed on diets with higher energy contents produce significantly higher weights of dissected lean tissue and fat in the carcass in comparison to those on low energy diets (Shahjalal *et al.*, 1992). Carcass fat contents were highest for the group fed the lowest 10 % hay level (Hatendi *et al.*, 1990).

### **2.3 Non-Carcass Components**

In the temperate and subtropics the components of value in the slaughtered goats is the carcass and skin. However in the tropics, a great value is also attached to the non- carcass edible components. These include the liver, kidneys, heart, tongue, brain, cheeks, intestines, lungs, spleen, blood, fat and even the skin (Kirton, 1988) although the type of edible non-

carcass components may vary from country and place to place. For example, the Chagga and Meru of Tanzania prepare blood into a delicious dish called “Kisusiyo” that is liked by most members of the community. Similarly, fresh blood can be collected from live animals and mixed with fresh milk and the mixture termed “Mlaso” is given to lactating women to promote milk yield. The Chagga of Tanzania also prepares porridge from green bananas known as “Mtori” and is best served with internal offal. The testicles and the brain are also favourite to children among the Chagga and Meru of Tanzania.

Moreover, the Kikuyu tribe of Kenya are found of a sausage like dish is made from blood and large intestines called “Mutura”. In Nigeria, the skin from slaughtered goats and sheep is not removed, but instead the hair is scalded after burning and the meat is eaten together with the skin (Aduku *et al.*, 1991).

In Table 3, various data on killing out characteristics of different goat breeds in Tanzania are presented by different authors. The effect of breed on carcass characteristics of goats has not been extensively studied in Tanzania. Few studies have been done to compare the carcass characteristics of different strains of SEA goats. In a survey to assess the carcass characteristics of local goats in three regions of Tanzania (Madubi, 1997), it was found that average slaughter weight (SWT) and carcass weight range from 19.7 to 22.7 kg and from 10.4 to 11.0 kg, respectively. Dressing percentage (DP) ranged from 46.8 to 52.3 %. The three strains of SEA goats studied (i.e. Ugogo, Newala and Ujiji) did not differ significantly in terms of reported carcass characteristics. In another study by Malole (2002), a sample of goats from the Ugogo, Newala and Ujiji were brought to Sokoine University of Agriculture (SUA) and managed in the same environment. The kids born were monitored and slaughtered at the same age (23 months) for carcass evaluation. In that study, the effect of breed was not significant on SWT and empty body weight (EBW). However, the effect

of strains was significant on carcass weight and DP. The Ugogo goats had higher carcass weight (13.6 kg) and DP (49.3 %) relatively better than the other two strains.

**Table 3: Data on killing out characteristics of goat carcasses in Tanzania**

Breeds	SWT	HCW	EBW	DP	Authors
Ugogo strain	19.7±0.84	10.4±0.63	NA	49.3± 0.01	Madubi, 1997
	25.14	13.63 <sup>b</sup>	21.41	49.28 <sup>b</sup>	Malole, 2002
Ujiji strain	21.3±1.77	11.0±0.74	NA	52.3±0.02	Madubi, 1997
	19.19	9.73 <sup>a</sup>	15.27	44.72 <sup>a</sup>	Malole, 2002
Newala strain	22.7±2.59	10.7±0.41	NA	46.8±0.01	Madubi, 1997
	21.17	9.82 <sup>a</sup>	16.74	45.53 <sup>a</sup>	Malole, 2002
SEA	20.50	8.57	16.97	42.27	Assenga, 1997
	12.74±0.28	NA	na	45.87±0.8	Mushi, 2004
	19.67	9.09	16.79	46.15	Hango, 2005
	24.0±1.10	10.1±0.6	17.5±1.0	57.3±1.0	Safari <i>et al.</i> ,2009
Crossbreed	25.3±1.1	12.8±0.5	22.3±1.0	57.3±0.7	Mushi <i>et al.</i> , 2009

SWT = Slaughter weight; HCW = Hot carcass weight; EBW = Empty body weight; DP = Dressing percentage; SEA = Small East African goats; NA = information not available

#### 2.4 Economics of Concentrate Supplementation on Chevon Production

Goat production under traditional production system does not satisfy the high demand of goat meat despite the fact that there is a big export potential if quality goat meat is produced. The feeding regime for fattening depends on concentrate feeding but fattening goats is not common practice in Tanzania. Economic analysis of the goat feedlot has shown that the level of concentrate on offer affects the total concentrate and hay consumed as well as their costs (Hango, 2005).

According to partial budget analysis, Somali goats managed under semi-intensive system returned a higher profit margin than the goats managed under extensive system (Legesse *et*

*al.*, 2005). On the other hand, goats under higher level of supplementation had the highest (Tshs 10 372.33) revenue as compared to 5 572.07 and 8 597.35 on the other diets (Hango, 2005). When trends for total revenue were related to gain on carcass and non carcass components (Hango, 2005), in general terms, therefore, the objectives of meat production enterprises which are to produce meat efficiently and under profits that are based on market forces need to be put in consideration.

## CHAPTER THREE

### 3.0 MATERIALS AND METHODS

#### 3.1 Study Area

This study was carried out in Gairo division of Kilosa district, Morogoro region, Tanzania. The division lies along the foot of Ukaguru Mountains, covering almost the entire north of Ukaguru agro-ecological zone. The altitude of the division ranges between 1076 – 1631 m above sea level on the margins of the Dodoma semi-arid region. It has very unreliable rainfall with the distribution varying every year. On the average, the north of Gairo receives 600 – 800 mm of rain whereas the hills receive 800 – 1 000 mm of rain annually.

#### 3.2 Experimental Design and Dietary Treatments

The study adopted a 2 x 3 factorial experimental design involving two breeds and three dietary treatments as shown in Table 4. The breeds studied were SEA x N crossbreds and Small East African goats (SEA) and all the goats were castrates. The three dietary treatments were T0 where animals were fed with hay only without any concentrate supplementation and treatments T1 and T2 where goats were fed 66 % of *ad lib* concentrate intake and *ad libitum* concentrate allowing 20 % refusal respectively besides been offered hay and water *ad libitum*. In this experiment, 24 castrated SEA x N crossbreds and 24 SEA goats were assigned randomly to the three feeding regimes, thus having eight animals per dietary treatment.

**Table 4: Combination layout of the experiment**

		Breed	
		B1	B2
Diet	T0	B1T0	B2T0
	T1	B1T1	B2T1
	T2	B1T2	B2T2

B1T0= SEA x N Crossbred goats grazing + hay supplementation; B2T0= SEA goats grazing + hay supplementation; B1T1= SEA x N crossbred goats grazing + hay supplementation + 66 % of *ad libitum* concentrate; B2T1= SEA grazing + hay supplementation + 66 % of *ad libitum* concentrate; B1T2= SEA x N crossbred goats grazing + hay supplementation + 100 % of *ad libitum* concentrate; B2T2= SEA grazing + hay supplementation + 100 % of *ad libitum* concentrate.

### 3.3 Source of Experimental Animals

The SEA castrated male goats used in the study were purchased from Msingisi local livestock market while SEA x N crossbreds castrate goats were obtained from farmers with dairy goats in Gairo and Msingisi villages. The experimental goats purchased were around 18 months old with mean body weight of  $16.7 \pm 0.54$  kg. These goats were then transported to a farm owned by one of goat keepers in Gairo where the experiment was conducted. Metal ear tags were used to identify the experimental animals.

### 3.4 Management of Experimental Animals

#### 3.4.1 Feeds and feeding of the experimental animals

The experiment started on 2 November, 2010 and lasted for 84 days (12 weeks). Prior to the commencement of the experiment, the experimental premises, feeding troughs and drinking accessories were cleaned. The concentrate supplement consisted of 70 % maize bran, 28 % sunflower seedcake, 1.3 % lime, 0.5 % mineral-vitamins mixture and 0.2 % table salt. All the concentrate ingredients were obtained from Gairo and the prices of these feed ingredients were Tshs 200, 150, 200, 4000 and 500 per kg for maize bran, sunflower

seed cake, lime, mineral-vitamins mixture and table/common salt respectively. Thus the price of concentrate was Tshs 198 per kg. The grass hay used in the study which was predominantly composed of *Cenchrus ciliaris* was obtained from Pasture Research Centre (PRC) Kongwa and costed about Tshs 87 per kg air dry matter.

Before onset of the experiment the chemical compositions of hay, sward and concentrate and its ingredients were determined at the Department of Animal Science and Production (DASP) laboratory (Table 5). Animals were allowed 14 days of acclimatization before the trial began. During the acclimatization period the T0 group was group fed hay *ad libitum* and the T1 and T2 group received 200 g of concentrate per goat per day plus hay *ad libitum*. The animals were grazed on pastures around the farm from 1000 to 1200 h after which they were brought back to their group feeding pens. Drinking water and hay was provided *ad libitum* but there was no drinking water provided during grazing period. The amounts of hay and concentrate on offer as well as all refusals were weighed daily. The average concentrate intake for goats under T2 diet was determined at weekly interval to estimate amount to be offered for T1 group.

Feeding of concentrates was done twice a day in two equal portions at 0830 h in the morning before grazing and in the afternoon at 0230 h. During data collection period the animals were provided with weighed amount of hay *ad libitum*. Goats were group fed where feed refusals of concentrate and hay were collected, weighed and recorded at 0800 h every day before feeding new rations. Following death of three goats (two = SEA x N crossbreds and one = SEA) caused by Orf disease before the end of the experiment, goats that remained were 13, 16 and 16 in T0, T1 and T2 respectively.

### 3.4.2 Housing

The animals were kept under roof in 12 raised slatted floor pens made up of simple timber for ease of handling and cleanness. The raised slatted floor pens measured 4 x 4 m and each held 4 goats. The pens were roofed with corrugated iron sheets except for T0 goats which were roofed with thatch grass a common practice by most pastoralists. Each pen had two feeding troughs for concentrate and hay as well as a bucket for drinking water.

### 3.4.3 Disease control

Animals were dewormed prior to commencement of the experiment using a broad spectrum anthelmintic (Ivermectin super). Ectoparasites were controlled by spraying the goats using a knapsack sprayer with an acaricide (Titfix) after every two weeks. Ox-tetracycline (OTC) 20 % was administered to all goats to control Contagious Caprine Pleural Pneumonia (CPPP) before onset of the experiment.

### 3.5 Body Weight and Linear Body Measurements

The initial body weights were taken at the start of the experiment. The animals were weighed for three consecutive days and the average was taken as the initial body weight. Similarly, the final body weight was taken as the average weight of three days weights at the end of the experiment. Growth data of goats were taken once in a fortnight from day one to day 84 when the experiment was terminated. Goats were weighed before the morning feeding. Growth rates or body weight changes of goats were computed as;-

$$\text{Average daily gain (ADG)} = \frac{\text{Final weight} - \text{Initial weight}}{84 \text{ days}}$$

Linear body measurements for individual goats were taken before slaughter as follow;

**Body length (BL):** Body length was measured using a tape-measure, as the distance from the occipital protuberance to the base of the tail.

**Height at withers (HW):** A flat platform was used upon which the animal was placed. The height at withers was measured as the distance from the surface of the platform to the withers using a measuring stick.

**Heart girth (HG):** The heart girth was measured with a tape-measure by taking the circumference of the chest behind the forelegs.

**Rump height (HR):** The rump height was measured as a distance from the surface of the platform to the rump using a measuring stick.

### 3.6 Sampling and Chemical Analyses of Feeds

Chemical analyses of feeds was done at the DASP laboratory to determine dry matter (DM), ash, crude protein (CP), ether extract (EE) and crude fibre (CF) according to AOAC (2000). The neutral detergent fibre (NDF), acid detergent fibre (ADF), *in vitro* dry matter (INVDM) and *in vitro* organic matter (INVOM) of various feed ingredients were determined according to the procedure of Van Soest *et al.* (1991). Sampling of pastures was done from ten sampling sites within the main grazing areas of approximately eight hectares using 0.5 m metallic quadrant that was randomly dropped in the sampling sites. The samples obtained were weighed and dried in an oven at 70 °C. The air dried feed samples taken for chemical analyses were ground to pass through a 1mm screen. Nitrogen free extracts (NFE) was calculated as follow;  $NFE = 100 - (\text{Moisture \%} + \text{CP \%} + \text{CF \%} + \text{EE \%} + \text{Ash \%})$ . Metabolisable energy contents of feeds were estimated from their chemical composition following the equation of MAFF (1975);-

$$ME \text{ (MJ/kg DM)} = 0.012CP + 0.031EE + 0.005CF + 0.014NFE$$



### 3.7 Slaughter Procedure and Slaughter Data

All the animals were transported to SUA at the end of experiment. The animals were weighed a day before slaughter, fasted for 16 h but with access to drinking water, reweighed and slaughtered in the halal method (Kadim, 2003). Fasting loss was computed as the difference between final body weight and slaughter weight (SWT). Animals were slaughtered for four consecutive days, with one animal from each pen, thus making two animals from each dietary treatment per day. The goats were slaughtered by severing the carotid arteries and jugular veins on both sides of the neck using a sharp knife. The slaughtered goat was bled by hanging it from hind legs. Following slaughter, the blood from each animal was collected separately in a plastic container and weighed. After skinning and evisceration, hot carcass weight was recorded. The gastro intestinal tract (GIT) was weighed when full and empty after removing GIT contents. Empty body weight (EBW) was calculated by subtracting the weight of the GIT contents from the fasted body weight. The hot carcass was composed of the body after removing the skin, head at the atlanto-occipital joint and fore feet (at the carpal-metacarpal joint), hind feet (at the tarsal-metatarsal joint) and visceral organs.

The hocks, head and skin were weighed as they were excised. Following evisceration, weight of internal visceral organs; - (kidney, liver and gall bladder, spleen, testes and spermatic cords, heart, lungs and trachea and diaphragm) were taken. Internal fat depots;- (kidney, pelvic, omental, mesenteric, heart and scrotal fat) were weighed. Carcasses (with kidneys, and pelvic fat) were weighed immediately after slaughter to get hot carcass weight (HCW) and scored for conformation and fatness based on EUROP classification system for goats (Kosum *et al.*, 2003; Johansen *et al.*, 2006). Carcasses were classified for conformation (scale from E = excellent to P = poor) and fatness (scale from 1 = none or low fat cover to 5 = entire carcass covered with fat). Each of the five classes for

conformation and fatness were divided into three subclasses; -, 0, or + to form 15 grades, Grade 1 is P- for conformation class and 1- for fat class. Grade 15 is E+ for conformation class and 5+ for fat class. The total edible proportion (TEP) was the SWT minus GIT contents and non edible offal components.

### 3.8 Measurements on Carcasses

A special hand meat saw was used to split carcasses into two halves longitudinally through the median plane. Various linear measurements were taken on the right half-carcasses to determine carcass conformation; internal carcass length (CL), carcass depth (CD), hind leg length (HLL), and hind leg circumference (HLC). A digital thermometer and portable pH-meter (Knick-portamess 910, Germany) were used to measure temperature and pH of meat at 45 min, 6 h post-mortem (PM) and 24 h after being chilled at 0°C (PM), at the same point on the geometric centre of *M. Gluteobiceps* of the right half- carcasses.

### 3.9 Muscle Physico-Chemical Properties

Ten muscles namely;- *Semimembranosus*, *Semitendinosus*, *Gluteobiceps*, *Vastus lateralis*, *Rectus abdominis*, *Longissimus dorsi*, *Psoas major*, *Supraspinatus*, *Infraspinatus* and *Triceps brachii* were excised from the left half of carcasses 6 h PM. Further *M. Longissimus dorsi* (LD) was split into 3 blocks measuring approx. 7 cm long. The three blocks of LD were assigned to samples for 0, 6 and 9 days ageing and stored in PVC bags. The muscles were weighed before being stored in a fridge set at 4°C overnight. These muscles were then shifted to a freezer set at – 25°C till further analyses. The LD samples for ageing remained in the fridge for 6 and 9 days respectively before being shifted to the freezer. The remaining parts of the left half-carcasses were dissected into muscle, fat and bone to estimate the carcass physical composition. Total weight of muscle included weights of the ten muscles sampled at 6 h PM. Thereafter, muscle and fat tissues were

thoroughly mixed together; minced (5 mm sieve) and three sub-samples were taken for chemical analyses.

The ten muscles were weighed and thawed at 4 °C overnight before analyses. Muscles were then blotted dry with paper towel and weighed. The muscles in the water - tight vacuum packed bags were boiled in thermostatically controlled water bath (Fisher scientific, Pittsburgh, PA) set at 75°C. Raw and cooked weights were recorded. Following cooking for 60 min the meat samples were cooled down in ice water for 60 min. Percentage thawing and cooking loss were calculated as follow;-

- Thawing loss = [(Weight before thawing – weight after thawing) / weight before thawing] \* 100.
- Cooking loss = [(Weight of raw meat after thawing - weight of cooked meat) / weight of raw meat after thawing] \* 100.

Cubes measuring 1 x 1 cm, 2 cm long were prepared from each muscle for Warner-Bratzler shear forces (WBSF) assessment. Preparation of each cube was done in a way that muscle fibre direction was parallel to the cube length. The WBSF blade, with a triangular slot cutting edge, attached to Zwick/Rorll (22.5, German) instrument was used to determine the force (N/cm<sup>2</sup>) required to shear through a muscle cube at right angle to the muscle fibre direction. The Zwick was set with 1 KN load cell, with a cross head speed of 100 mm /min. The average shear force of cubes per muscle sample was considered as a peak force for a particular muscle (Abdullah and Musallam, 2007).

### **3.10 Chemical Composition of Minced Meat**

Water content was determined by weight loss of 3 g of minced meat dried for 48 h in a 104 °C oven according to AOAC (2000). Ash content was determined by further ashing

the dried samples in a 600 °C muffle furnace for 6 h. Total lipid content (g fat/100 g sample) was estimated in 5 g samples after a 6 - cycle extraction with petroleum ether in a soxhlet apparatus. Crude protein content was determined using a 1 g sample following the Kjeldahl method as described in the AOAC (2000).

### **3.11 Economic Analysis of Fattening**

The mean value of feed intake, carcass yield and edible offal and skin for each pen was used to estimate feed costs and revenue from experimental goats. The weight of hay and concentrate consumed were recorded from which the costs of hay and concentrate were calculated, thus total cost of feeds was obtained. Then, costs of production based on feed costs from different feeding regimes were calculated. The prices of both carcass and edible offal per kg were assumed to be the prices in the normal butchereries. Meat was assumed to be sold at Tshs 5000 and 6000 per kg for un-supplemented and supplemented goats respectively based on prices of between 2 to 5 USD a kilo of fresh meat (Safari *et al.*, 2009). The price for supplemented goat carcasses was based on 80 % of the premium price. Also edible offal and goat skin were sold at Tshs 2000 and 1500 respectively as a market price for all animals. Finally, the returns from each feeding regime were computed and net revenue over non-concentrate supplemented (T0) goats were derived.

### **3.12 Data Handling and Statistical Analyses**

The mean value from each pen for daily dry matter intake and feed conversion ratio (FCR) was used in the ANOVA. The experimental data were analyzed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS, 2002) 9.2 version, in a 2 X 3 factorial arrangement with genotype (SEA x N crossbreds and SEA) and feeding regime (T0, T1 & T2) as main effects. The initial body weight was used as a covariate to compare feed intake, FCR and growth adjusted for differences in initial body weight at the

beginning of experiment (Model 1). A second model was used for carcass characteristics & meat quality and slaughter weight was used as covariate. Each individual animal served as an experimental unit for all the parameters assessed. Further, in the analysis of muscle physico-chemical properties fixed effects included genotype, feeding regime, muscle type and their interactions. However, interaction effect was not significant ( $P>0.05$ ); hence only the effects of the main factors are reported and discussed in the present study. In all the analyses, when differences between means were significant in the ANOVA, they were separated by PDIFF statement at  $P<0.05$ . The following models were used.

**a) Feed intake and FCR**

$$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + b(X_{ijk} - \sum x/n) + e_{ijk} \dots \dots \dots \text{(Model 1)}$$

Where;-

- $Y_{ijk}$  = Response of  $k^{\text{th}}$  pen of  $i^{\text{th}}$  genotype from  $j^{\text{th}}$  diet
- $\mu$  = Overall mean
- $A_i$  = Effect of  $i^{\text{th}}$  genotype
- $B_j$  = Effect of  $j^{\text{th}}$  diet level
- $(AB)_{ij}$  = Effect associated with the interaction of  $i^{\text{th}}$  genotype and  $j^{\text{th}}$  diet
- $b$  = Regression of  $Y_{ijk}$  on  $X_{ijk}$
- $X_{ijk}$  = The record of the initial live weight of individual goat
- $\sum x/n$  = Mean initial live weight of each pen
- $e_{ijk}$  = The random error specific to each pen.

**b) Linear measurement, killing out characteristics, non carcass components, fat depots and carcass physical composition**

$$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + b(X_{ijk} - \sum x/n) + e_{ijk} \dots \dots \dots \text{(Model 2)}$$

Where;-

$Y_{ijk}$	=	Response of $k^{\text{th}}$ goat of $i^{\text{th}}$ genotype from $j^{\text{th}}$ diet
$\mu$	=	Overall mean
$A_i$	=	Effect of $i^{\text{th}}$ genotype
$B_j$	=	Effect of $j^{\text{th}}$ diet level
$(AB)_{ij}$	=	Effect associated with the interaction of $i^{\text{th}}$ genotype and $j^{\text{th}}$ diet
$b$	=	Regression of $Y_{ijk}$ on $X_{ijk}$
$X_{ijk}$	=	The record of the initial live weight of individual goat
$\Sigma x/n$	=	Overall mean of slaughter weight
$e_{ijk}$	=	The random error specific to each individual

### c) Muscle physico-chemical properties

$$Y_{ijk} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{ik} + (BC)_{jk} + (ABC)_{ijk} + e_{ijk} \dots \dots \dots \text{(Model 3)}$$

Where;

$Y_{ijk}$	=	Response of the $k^{\text{th}}$ muscle belonging to a goat of $i^{\text{th}}$ genotype fed the $j^{\text{th}}$ diet
$\mu$	=	Overall mean
$A_i$	=	Effect of $i^{\text{th}}$ genotype
$B_j$	=	Effect of $j^{\text{th}}$ diet
$C_k$	=	Effect of $k^{\text{th}}$ muscle
$(AB)_{ij}$	=	Effect of associated with the interaction of $i^{\text{th}}$ genotype and $j^{\text{th}}$ diet
$(AC)_{ik}$	=	Effect of associated with the interaction of $i^{\text{th}}$ genotype and $k^{\text{th}}$ muscle
$(BC)_{jk}$	=	Effect associated with the interaction of $j^{\text{th}}$ diet level and $k^{\text{th}}$ muscle
$(ABC)_{ijk}$	=	Effect associated with the interaction of $i^{\text{th}}$ genotype, $j^{\text{th}}$ diet and $k^{\text{th}}$ muscle
$e_{ijk}$	=	The random error specific to each muscle.

## CHAPTER FOUR

### 4.0 RESULTS

#### 4.1 Chemical Composition of Feeds

The composition and nutritive value of diets used in the present study are shown in Table 5. The feeds and feed ingredients used had almost similar dry matter (DM) and organic matter contents. The content of ash in the sward was twice the amount observed in maize bran and sunflower cake. The concentrate offered was of high quality as indicated by the crude protein (CP) concentration. The highest CP content was observed in sunflower seed cake while the lowest CP was seen in the maize bran but high nitrogen free extract (NFE) compared other feed ingredients. The grass hay and sward had lower and similar amount of ether extract (EE). On the other hand; the higher NDF and ADF were accompanied by lower IVDMD, IVOMD and ME in grass hay and sward.

**Table 5: Chemical composition of feeds and feed ingredients used (g/kg DM)**

Component	Concentrate	Maize bran	Sunflower cake	Hay	Sward
Dry matter	944.5	899.0	961.2	956.7	947.8
Organic matter	923.7	931.7	957.3	951.4	913.8
Ash	72.1	40.4	41.0	46.5	81.7
Crude protein	143.7	104.1	233.8	41.0	106.9
Ether extracts	91.1	68.1	28.1	5.5	6.6
Crude fibre	141.9	65.0	292.5	359.1	268.3
NFE	495.7	626.3	365.8	504.6	484.3
NDF	410.6	399.4	495.9	791.4	662.7
ADF	170.8	121.0	338.2	481.5	365.8
IVDMD	540	693	450	404	391
IVOMD	553	755	442	411	373
ME (MJ/kg DM)	12.2	12.9	10.3	9.5	9.6

NFE=Nitrogen free extracts; ADF=Acid detergent fibre; INDMD=*In-vitro* dry matter digestibility; INOMD=*In-vitro* organic matter digestibility; ME=Metabolisable energy; MJ=Mega joules, DM=Dry matter.

## 4.2 Feed Intake

Breed had a significant ( $P<0.001$ ) effect on DM intake of concentrate and its ME (Appendix 1). The DM intake of concentrate and its ME for SEA x N crossbred goats were significantly higher ( $P<0.05$ ) than SEA goats (Table 6). Diet had significant ( $P<0.001$ ) effects on DM and ME intake of concentrate and grass hay, total ME intake and total DM intake ( $P<0.01$ ). The T2 goats had a higher ( $P<0.05$ ) DM intake of concentrate (536 g/d) and 183 g higher than T1 goats. Overall mean for total DM intake was 521.5 g/d. Similarly, T2 goats had higher ( $P<0.05$ ) total DM intake and ME intake from concentrate. The DM intake of grass hay and its ME declined ( $P<0.05$ ) as the amount of concentrate increased. Total DM intake for dietary treatments in the present study ranged between 2.7 % and 3.2 % of body weight.

**Table 6: Feed intakes and DM intake (% live weight) of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Feed intake (g DM/d)</b>					
Concentrate	302.7±0.0 <sup>a</sup>	290.1±0.0 <sup>b</sup>	-	352.9±0.0 <sup>b</sup>	536.3±0.0 <sup>a</sup>
Hay	240.9±16	209.3±16	461.8±19 <sup>a</sup>	143.5±19 <sup>b</sup>	70.1±19 <sup>c</sup>
Total	543.6±16	499.4±16	461.8±19 <sup>b</sup>	496.3±19 <sup>b</sup>	606.3±19 <sup>a</sup>
<b>Metabolisable energy</b>					
MJ, ME/d					
Concentrate	3.7±0.0 <sup>a</sup>	3.5±0.0 <sup>b</sup>	-	4.3±0.0 <sup>b</sup>	6.5±0.0 <sup>a</sup>
Hay	2.3±0.2	2.0±0.2	4.4±0.2 <sup>a</sup>	1.4±0.2 <sup>b</sup>	0.7±0.2 <sup>c</sup>
Total	6.0±0.2	5.5±0.2	4.4±0.2 <sup>c</sup>	5.7±0.2 <sup>b</sup>	7.2±0.2 <sup>a</sup>
Intake (% BWT)	2.9±0.1	2.8±0.1	2.7±0.1	2.7±0.1	3.2±0.1

<sup>abc</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; BWT= Body weight.

### 4.3 Growth Performance

The castrated goats of the two genotypes did not show any significant differences ( $P>0.05$ ) for all growth traits studied (Table 7). The corresponding ANOVA Tables are shown in Appendix 2. The dietary effects were highly significant ( $P<0.001$ ) on final body weight (BWT), slaughter weight (SWT), weight gains, body condition score (BCS) and on feed conversion ratio ( $P<0.01$ ). The T0 goats had a lower ( $P<0.05$ ) final BWT, SWT, total weight gain, ADG and BCS than the supplemented goats although there was no significant difference ( $P>0.05$ ) on the above traits among concentrate supplemented goats (T1 and T2).

The overall mean final BWT for SEA x N and SEA goats was 19.8 kg. T0 goats were 3.3 kg and 2.6 kg lower ( $P<0.05$ ) in final BWT than those in T2 and T1 respectively. The total weight gains for T1 and T2 goats were 2.6 and 3.4 kg heavier ( $P<0.05$ ) than T0 goats. Fasting loss decreased ( $P<0.05$ ) as level of concentrate increased and *ad libitum* concentrate fed goats had a lowest fasting loss. BCS for supplemented goats were greater than 3 units and higher ( $P<0.05$ ) than that of goats fed T0, which were “thin” (2 units). The efficiency of feed utilization (FCR) improved ( $P<0.05$ ) with concentrate supplementation and supplemented goats had better FCR which were about three-fold more efficient than goats under T0.

**Table 7: Growth performance of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Body weight (kg)</b>					
Initial	16.8±0.5	16.6±0.5	16.7±0.7	16.8±0.6	16.5±0.6
Final	19.9±0.5	19.4±0.4	17.7±0.6 <sup>b</sup>	20.3±0.5 <sup>a</sup>	21.0±0.5 <sup>a</sup>
Slaughter	18.8±0.5	18.3±0.4	16.6±0.6 <sup>b</sup>	19.1±0.5 <sup>a</sup>	20.0±0.5 <sup>a</sup>
Total gain	3.3±0.5	2.8±0.4	1.0±0.6 <sup>b</sup>	3.6±0.5 <sup>a</sup>	4.4±0.5 <sup>a</sup>
ADG (g/d)	39.0±5.5	32.8±5.3	12.4±7.1 <sup>b</sup>	43.0±6.5 <sup>a</sup>	52.1±6.4 <sup>a</sup>
Fasting loss (%)	5.4±0.3	5.8±0.3	6.0±0.3 <sup>a</sup>	5.9±0.3 <sup>a</sup>	4.9±0.3 <sup>b</sup>
BCS (1-5)	2.8±0.1	2.9±0.1	1.7±0.2 <sup>b</sup>	3.3±0.2 <sup>a</sup>	3.4±0.2 <sup>a</sup>
FCR	17.6±2.7	24.3±2.7	39.5±3.2 <sup>a</sup>	11.6±3.3 <sup>b</sup>	11.7±3.3 <sup>b</sup>

<sup>ab</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; BCS=Body condition score; FCR= Feed conversion ratio.

#### 4.4 Linear Body and Carcass Measurements

There was no significant ( $P>0.05$ ) effect of either genotype or diet on the linear body and carcass measurements except hind leg circumference (cm) which was highly ( $P<0.001$ ) affected by dietary regime (Appendix 3). Hind leg circumference of goats fed three different dietary regimes increased with concentrate level in the diet (Table 8). Concentrate supplemented goats displayed comparable values for hind leg circumference (cm), but all were greater ( $P<0.05$ ) than that of non-supplemented goats.

**Table 8: Linear body and carcass measurement of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Linear body measurements (cm)</b>					
Body length	52.3±0.6	50.7±0.6	52.2±0.8	51.1±0.7	51.3±0.7
Heart girth	61.8±0.4	63.0±0.4	62.8±0.6	62.3±0.5	62.1±0.5
Height at wither	55.5±0.5	56.4±0.5	56.1±0.8	55.8±0.6	55.9±0.6
Height at rump	56.5±0.5	57.6±0.5	57.7±0.7	56.8±0.6	56.7±0.6
<b>Linear carcass measurements (cm)</b>					
Carcass length	51.4±0.3	50.5±0.3	50.8±0.5	51.1±0.4	51.0±0.4
Carcass depth	23.3±0.4	22.9±0.4	23.3±0.5	23.1±0.4	22.9±0.5
Hind leg length	35.5±0.6	36.8±0.6	37.9±0.9	35.4±0.7	35.3±0.8
Hind leg circumference	28.6±0.4	29.3±0.4	26.9±0.5 <sup>b</sup>	29.7±0.4 <sup>a</sup>	30.2±0.5 <sup>a</sup>

<sup>ab</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate.

#### 4.5 Killing out Characteristics

Genotype had a significant ( $P<0.05$ ) effect on hot carcass weight and dressing percentage (Appendix 4). The SEA goats had higher ( $P<0.05$ ) hot carcass weight, true and commercial dressing percentages than the crossbreds (Table 9). The overall mean for true DP was 54.0 %, but genotype affected the true DP (53.3 and 54.5 %) and commercial DP (41.6 and 43.3 %). Most killing out characteristics increased with concentrate supplementation level except full GIT which followed a reverse order. Diet had a significant effect ( $P<0.001$ ) on all killing out parameters and commercial DP at ( $P<0.01$ ).

Though supplemented goats were comparable in EBW and hot carcass weight, T2 goats were 0.4 and 2.3 kg heavier in EBW and had 0.3 and 1.5 kg heavier hot carcass weight than T1 and T0 respectively. Non-supplemented goats had lowest ( $P<0.05$ ) values for all

killing out characteristics except full GIT. Diet affected the DP that ranged from 52.7 - 54.9 % and 37.2 - 45.7 % on EBW and SWT basis respectively. No significant difference was observed for all killing out characteristics among supplemented goats except fatness score of the carcasses increased ( $P<0.05$ ) with level of concentrate supplementation.

**Table 9: Killing out characteristics of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Weight in (kg)</b>					
EBW	14.6±0.1	14.9±0.1	13.4±0. <sup>b</sup>	15.3±0.2 <sup>a</sup>	15.7±0.2 <sup>a</sup>
Hot carcass	7.9±0.1 <sup>b</sup>	8.2±0.1 <sup>a</sup>	7.1±0.1 <sup>b</sup>	8.3±0.1 <sup>a</sup>	8.6±0.1 <sup>a</sup>
<b>Dressing percentage (DP)</b>					
True	53.3±0.3 <sup>b</sup>	54.5±0.3 <sup>a</sup>	52.7±0.5 <sup>b</sup>	54.1±0.4 <sup>a</sup>	54.9±0.4 <sup>a</sup>
Commercial	41.6±0.5 <sup>b</sup>	43.3±0.5 <sup>a</sup>	37.2±0.7 <sup>b</sup>	44.3±0.6 <sup>a</sup>	45.7±0.6 <sup>a</sup>
Full GIT (kg)	5.6±0.2	5.3±0.2	6.7±0.2 <sup>a</sup>	5.0±0.2 <sup>b</sup>	4.6±0.2 <sup>b</sup>
<b>EUROP grading(1-15 points)</b>					
Conformation	5.6±0.3	5.6±0.3	3.5±0.4 <sup>b</sup>	6.2±0.3 <sup>a</sup>	7.0±0.4 <sup>a</sup>
Fatness	5.7±0.5	5.8±0.5	2.6±0.7 <sup>c</sup>	6.2±0.6 <sup>b</sup>	8.5±0.6 <sup>a</sup>

<sup>abc</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; EBW= Empty body weight GIT= Gastro intestinal tract; True dressing percentage= Hot carcass x 100/EBW; Commercial dressing percentage= Hot carcass weight x 100/Slaughter body weight.

#### 4.6 Non Edible Offal Components (NEOC)

The SEA goats had 20 g heavier ( $P<0.05$ ) testes than SEA x N crossbreds (Table 10). The castrated goats fed three different diets did not show significant differences ( $P>0.05$ ) in NEOC except in weights of gastro-intestinal (GIT) contents and its weight as percentage of SWT ( $P<0.001$ ). GIT contents and weights as percentage of SWT declined ( $P<0.05$ ) with

concentrate supplementation. *Ad libitum* fed goats (T2) and those under medium level of concentrate supplementation (T1) had comparable weight of GIT contents but T0 goats were 1.9 and 2.3 kg heavier ( $P<0.05$ ) than those of T1 and T2 goats, respectively. Similarly, when GIT contents were expressed as percent of SWT, T0 goats were 11.8 and 12.9 % higher ( $P<0.05$ ) than those of T1 and T2 goats, respectively. When total NEOC was analyzed as percentage of SWT, there were no significant differences ( $P>0.05$ ) among genotypes and feeding regimes.

**Table 10: Non edible offal components of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Weights (kg)</b>					
Blood	0.71±0.02	0.73±0.02	0.67±0.03	0.74±0.02	0.73±0.02
Hock	0.51±0.01	0.53±0.01	0.52±0.01	0.52±0.01	0.52±0.01
Head	1.24±0.02	1.20±0.02	1.26±0.02	1.20±0.02	1.19±0.02
Skin	1.27±0.04	1.28±0.04	1.18±0.05	1.31±0.04	1.33±0.04
Testes	0.05±0.01 <sup>b</sup>	0.07±0.01 <sup>a</sup>	0.07±0.01	0.06±0.01	0.05±0.01
Total NEOC	3.78±0.05	3.80±0.05	3.70±0.08	3.84±0.06	3.83±0.06
<b>GIT Contents</b>					
Weight (kg)	4.06±0.15	3.81±0.15	5.33±0.21 <sup>a</sup>	3.40±0.17 <sup>b</sup>	3.07±0.18 <sup>b</sup>
As % SWT	22.12±0.81	21.02±0.79	29.81±1.13 <sup>a</sup>	18.00±0.94 <sup>b</sup>	16.89±0.97 <sup>b</sup>
Total NEOC % SWT	20.37±0.28	20.39±0.27	19.84±0.39	20.74±0.33	20.56±0.34

<sup>ab</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; NEOC=Non edible offal components; SWT= Slaughter weight.

#### 4.7 Edible Offal Components (EOC)

Genotype significantly ( $P<0.05$ ) affected the weight of lungs and not on other EOC (Appendix 6). The SEA x N crossbred goats had 22 g heavier ( $P<0.05$ ) weight of lungs

than SEA goats (Table 11). Diet significantly affected most of EOC except weights of heart, lungs, kidney and diaphragm. Dietary effect was highly significant ( $P<0.001$ ) on spleen, total EOC and total edible portion (TEP) and their weights as percentages of slaughter weight (SWT). Diets were also noted to affect significantly ( $P<0.01$ ) the weights of liver, weight of empty GIT and weights EOC as percentage of TEP ( $P<0.05$ ). Concentrate supplementation promoted heavier ( $P<0.05$ ) spleen, liver, total EOC and TEP and their percentages of SWT. The weight of empty GIT increased ( $P<0.05$ ) with concentrate supplementation in a curvilinear fashion but decreased ( $P<0.05$ ) total EOC as percentage of TEP.

**Table 11: Edible offal components of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Weights (g)</b>					
Heart	90.3±25.74	124.4±25.15	69.2±36.03	148.6±30.03	101.3±30.99
Lungs	213.4±7.54 <sup>a</sup>	191.7±7.37 <sup>b</sup>	187.8±10.56	217.6±8.80	202.3±9.08
Spleen	33.4±2.06	36.0±2.01	25.2±2.88 <sup>b</sup>	36.6±2.40 <sup>a</sup>	42.3±2.48 <sup>a</sup>
Kidney	58.6±2.62	59.0±2.56	54.2±3.66	59.9±3.05	62.3±3.15
Diaphragm	52.4±1.68	53.1±1.65	53.0±2.36	52.5±1.96	52.7±2.03
Liver	280.5±8.63	269.1±8.43	241.1±12.07 <sup>b</sup>	292.1±10.06 <sup>a</sup>	291.1±10.38 <sup>a</sup>
<b>Weights (kg)</b>					
Empty GIT	1.5±0.03	1.5±0.03	1.4±0.04 <sup>b</sup>	1.6±0.03 <sup>a</sup>	1.5±0.03 <sup>ab</sup>
Total EOC	2.3±0.04	2.2±0.04	2.0±0.06 <sup>b</sup>	2.4±0.05 <sup>a</sup>	2.3±0.05 <sup>a</sup>
<b>Total edible offal component (EOC)</b>					
As % SWT	12.1±0.23	11.8±0.23	10.9±0.33 <sup>b</sup>	12.8±0.27 <sup>a</sup>	12.2±0.28 <sup>a</sup>
As % TEP	21.4±0.45	20.4±0.44	22.1±0.63 <sup>a</sup>	20.9±0.53 <sup>ab</sup>	19.7±0.54 <sup>b</sup>
TEP (kg)	10.8±0.13	11.1±0.12	9.7±0.18 <sup>b</sup>	11.4±0.15 <sup>a</sup>	11.8±0.15 <sup>a</sup>
TEP as % SWT	57.5±0.69	58.7±0.67	50.3±0.97 <sup>b</sup>	61.3±0.80 <sup>a</sup>	62.8±0.83 <sup>a</sup>

<sup>ab</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; GIT= Gastro intestinal tract; EOC= Edible offal components; TEP= Total edible proportion; SWT= Slaughter weight.

When goats were fed with medium levels of concentrates, the weight of empty GIT was significantly ( $P<0.05$ ) higher than non-supplemented goats (Table 11). However, increasing level of concentrate supplementation did not affect ( $P>0.05$ ) weight of most EOC and weights of total EOC as percentage of SWT. On the other hand, concentrate supplemented goats had higher ( $P<0.05$ ) values for above mentioned traits except non-supplemented goats which had a higher ( $P<0.05$ ) EOC when it was expressed as percentage of TEP than *ad libitum* concentrate fed goats.

#### 4.8 Fat Depots

Mesenteric fat as a percent of total fat depots was significantly ( $P<0.01$ ) affected by genotype (Appendix 7) and SEA x N goats had a higher (12.1 %,  $P<0.05$ ) value than SEA goats (4.3 %, Table 12). However, weights of other fat depots and their weights as percent of total fat depots did not differ ( $P>0.05$ ) between genotypes. The overall mean for total fat depots was 0.5 kg (Appendix 8.4). Dietary treatments had highly significant influences on weights of all fat depots ( $P<0.001$ ), on weight of mesenteric fat ( $P<0.01$ ) and on weight of heart fat ( $P<0.05$ ). Proportions of different fat depots were not significantly ( $P>0.05$ ) affected by diets except when weights of kidney and pelvic fat were expressed as percent of total depots were highly ( $P<0.001$ ) affected by diets. T0 goats had lowest ( $P<0.05$ ) weights of kidney, pelvic and omental fat. Goats fed T2 diet had heaviest ( $P<0.05$ ) weights for all fat depots except kidney and pelvic fat which were comparable among concentrate supplemented goats. On the other hand, levels of concentrate on offer increased ( $P<0.05$ ) weight of omental and total fat depots when expressed as percent of slaughter weight in a linear pattern.

**Table 12: Fat depots and their percentages of total fat depots of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Weights (g)</b>					
Kidney fat	68.0±9.10	67.4±8.89	26.2±12.74 <sup>b</sup>	76.26±10.62 <sup>a</sup>	100.6±10.96 <sup>a</sup>
Pelvic fat	63.4±9.52	72.3±9.30	18.4±13.32 <sup>b</sup>	78.1±11.10 <sup>a</sup>	107.0±11.46 <sup>a</sup>
Mesenteric fat	42.6±5.37	30.9±5.24	21.1±7.51 <sup>b</sup>	32.4±6.26 <sup>b</sup>	56.7±6.46 <sup>a</sup>
Omental fat	188.1±26.62	230.7±26.01	92.3±37.26 <sup>c</sup>	215.5±31.05 <sup>b</sup>	320.4±32.05 <sup>a</sup>
Heart fat	16.0±4.18	20.5±4.08	7.3±5.85 <sup>b</sup>	16.2±4.87 <sup>b</sup>	31.2±5.03 <sup>a</sup>
Scrotal fat	41.5±6.01	46.4±5.88	19.9±8.42 <sup>b</sup>	40.6±7.01 <sup>b</sup>	71.3±7.24 <sup>a</sup>
<b>Fat depots as % total depots</b>					
Kidney fat	13.4±1.21	10.0±1.18	1.6±1.69 <sup>b</sup>	18.2±1.41 <sup>a</sup>	15.2±1.46 <sup>a</sup>
Pelvic fat	13.0±1.34	11.7±1.31	0.9±1.87 <sup>b</sup>	19.2±1.56 <sup>a</sup>	16.9±1.61 <sup>a</sup>
Mesenteric fat	12.1±1.80 <sup>a</sup>	4.3±1.76 <sup>b</sup>	7.5±2.52	7.9±2.10	9.1±2.17
Omental fat	34.3±4.89	40.6±4.78	26.2±6.85	41.8±5.71	44.2±5.89
Heart fat	2.8±0.84	2.7±0.82	0.8±1.18	3.4±0.98	4.1±1.01
Scrotal fat	13.4±3.17	7.0±3.09	10.5±4.43	9.4±3.69	10.6±3.81
Fat depots % SWT	2.1±0.23	2.3±0.23	0.7±0.33 <sup>c</sup>	2.3±0.27 <sup>b</sup>	3.4±0.28 <sup>a</sup>

<sup>abc</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N = Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; SWT= Slaughter weight.

#### 4.9 Carcass Physical Compositions

There was no significant ( $P>0.05$ ) effect of genotypes on weights of carcass tissues and their physical composition. ANOVA Tables for three carcass tissues are shown in Appendix 8. Based on dietary treatments, the mean proportions of the various carcass tissues ranged from 64 - 67, 3 - 15, 21 - 30 % for muscle, fat and bone respectively (Table 13). Dietary treatment had a significant effect ( $P<0.001$ ) on tissue composition except weight of bone (kg) and proportion of muscle in the half carcasses. The weight of dissected carcass fat, fat as percent of half carcass, total fat depot, total fat and its weights as percent of slaughter weight increased ( $P<0.05$ ) with concentrate supplementation in a linear pattern. Total fat, however, were significantly different among the dietary groups

and *ad libitum* fed goats (T2) were 1.6 and 0.8 kg heavier ( $P<0.05$ ) in total fat than those of goats fed T0 and T1 respectively. As expected, goats fed T2 had heaviest ( $P<0.05$ ) weights of all fats and lowest ( $P<0.05$ ) proportion of bone followed by T1 and T0. On the other hand, all goats had similar weights of bone but the proportion of bone decreased ( $P<0.05$ ) with increasing carcass fat.

**Table 13: Carcass physical compositions of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Carcass tissue weights</b>					
<b>from half carcass (kg)</b>					
Muscle	2.4±0.06	2.5±0.06	2.1±0.08 <sup>b</sup>	2.5±0.07 <sup>a</sup>	2.7±0.07 <sup>a</sup>
Fat	0.4±0.04	0.4±0.04	0.1±0.06 <sup>c</sup>	0.4±0.05 <sup>b</sup>	0.7±0.05 <sup>a</sup>
Bone	0.9±0.03	0.9±0.03	0.9±0.04	0.9±0.03	0.9±0.03
Total fat depots	0.4±0.05	0.5±0.05	0.2±0.07 <sup>c</sup>	0.5±0.06 <sup>b</sup>	0.7±0.06 <sup>a</sup>
Total fat	1.3±0.11	1.2±0.10	0.4±0.15 <sup>c</sup>	1.2±0.12 <sup>b</sup>	2.0±0.13 <sup>a</sup>
<b>Carcass physical composition (%)</b>					
Muscle	65.3±0.77	66.4±0.75	66.8±1.07	66.7±0.89	63.9±0.92
Fat	9.8±0.62	8.4±0.61	3.0±0.87 <sup>c</sup>	9.6±0.73 <sup>b</sup>	14.7±0.75 <sup>a</sup>
Bone	25.0±0.63	25.2±0.62	30.1±0.89 <sup>a</sup>	23.7±0.74 <sup>b</sup>	21.4±0.76 <sup>c</sup>
<b>As % Total fat</b>					
Carcass fat	70.8±2.36	73.1±2.30	85.2±3.30 <sup>a</sup>	64.7±2.75 <sup>b</sup>	65.9±2.84 <sup>b</sup>
Depots	29.2±2.36	26.9±2.30	14.8±3.30 <sup>b</sup>	35.3±2.75 <sup>a</sup>	34.1±2.84 <sup>a</sup>
Total fat % SWT	6.5±0.61	5.8±0.59	1.5±0.85 <sup>c</sup>	6.3±0.71 <sup>b</sup>	10.6±0.73 <sup>a</sup>

<sup>abc</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N= Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate; SWT= Slaughter weight.

The mean proportions of different groups of fat as a percent of total fat tissue in goats fed different diets ranged from 15 - 35 % and 65 - 85 % for fat depots and carcass fat

(Table 13). Whereas diet had a significant effect on tissues; there was no significant ( $P>0.05$ ) differences in weight of muscle, proportion of total fat depots and carcass fat as percent of total fat among concentrate supplemented goats. However, concentrate supplementation increased ( $P<0.05$ ) proportion of total fat depot but reduced ( $P<0.05$ ) carcass fat when expressed as percent of total fat.

#### 4.10 Carcass Chemical Compositions

The DM (32.3 - 32.8), moisture (67.2 - 62.7), ash (3.5 - 3.6), protein (20.4 - 20.8) and fat (5.3 - 6.0) % were not significantly ( $P>0.05$ ) affected by genotypes (Table 14). Respective ANOVA Tables are shown in Appendix 9. On the other hand, dietary effect on percent DM, moisture, ash, protein and fat in the minced meat was highly significant ( $P<0.001$ ). Concentrate supplemented goats had similar values for ash, protein and fat contents; lower ( $P<0.05$ ) values for ash and protein but higher ( $P<0.05$ ) value for fat content than non-supplemented goats (T0). Generally, increasing levels of concentrates increased ( $P<0.05$ ) DM of the meat but decreased ( $P<0.05$ ) content of water in the meat.

**Table 14: Carcass chemical compositions of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

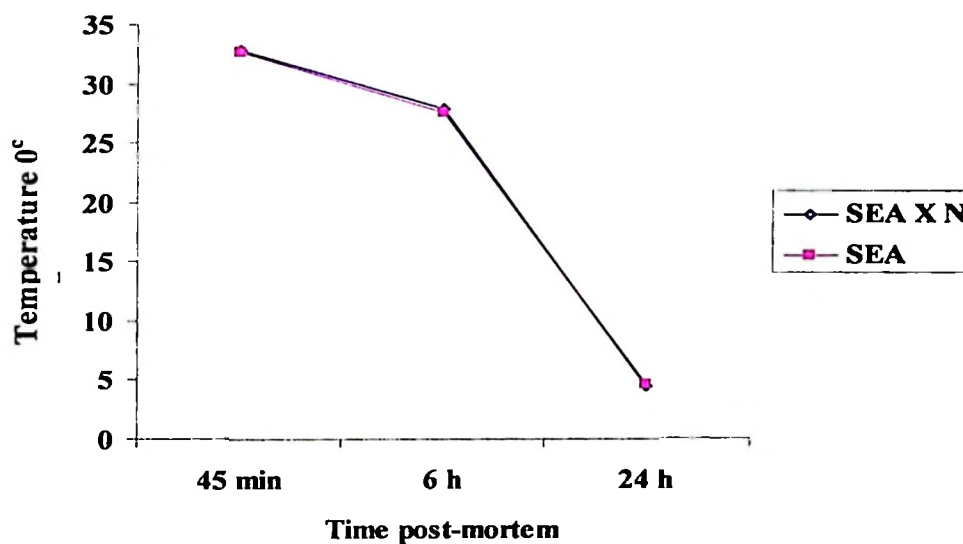
Variable	Genotype		Diet		
	SEA x N	SEA	T0	T1	T2
<b>Percentages</b>					
Dry matter	32.8±0.78	32.3±0.76	27.1±1.09 <sup>c</sup>	33.9±0.91 <sup>b</sup>	36.6±0.94 <sup>a</sup>
Moisture	67.2±0.78	67.7±0.76	72.9±1.09 <sup>a</sup>	66.1±0.91 <sup>b</sup>	63.4±0.94 <sup>c</sup>
Ash	3.6±0.13	3.5±0.13	4.4±0.19 <sup>a</sup>	3.3±0.16 <sup>b</sup>	3.0±0.16 <sup>b</sup>
Protein	20.4±0.34	20.8±0.34	22.2±0.48 <sup>a</sup>	20.2±0.40 <sup>b</sup>	19.3±0.41 <sup>b</sup>
Fat	6.0±0.70	5.3±0.69	2.3±0.98 <sup>b</sup>	6.2±0.82 <sup>a</sup>	8.4±0.85 <sup>a</sup>

<sup>abc</sup> Within breed and diet in the same row, least squares means with a common superscript are not significantly different ( $P>0.05$ ); SEA x N= Small East African x Norwegian goats; SEA= Small East African goats; T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate.

## 4.11 Muscle Physico-Chemical Properties

### 4.11.1 Temperature of carcasses

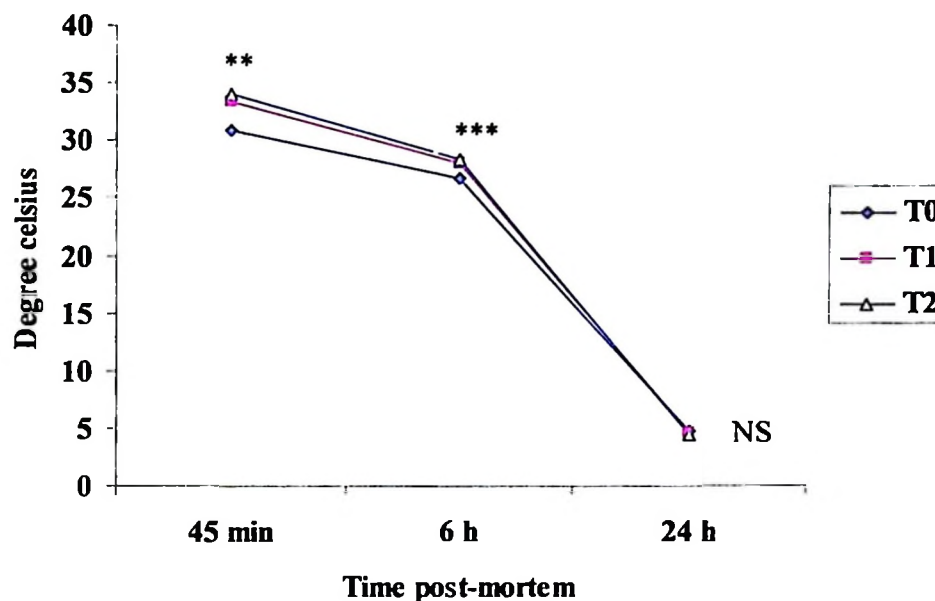
Muscle temperature was independent ( $P>0.05$ ) of breed effect during post-mortem (PM) temperature decline (Fig. 1). However, temperature of carcasses declined faster for both genotypes after the sixth hour than 45 min PM. The 24 h temperatures of the carcasses were 4.7 and 4.5°C for SEA and SEA x N goats respectively.



**Figure 1: Post-mortem temperature decline in SEA x N crossbreds and SEA goat carcasses**

SEA x N= Small East African x Norwegian goats; SEA= Small East African goats.

Differences in temperature between carcasses from goats fed different levels of concentrates were significant at 45 min ( $P<0.01$ ) and 6 h ( $P<0.001$ ) but carcass temperature measured at 24 h PM did not differ between dietary treatments (Fig. 2). Carcass temperature for goats fed T0 was lower ( $P<0.05$ ) up to 6 h PM. Similar to what was observed under breed effect, carcass temperature for carcasses fed three different diets declined faster after 6 h than after 45 min PM.



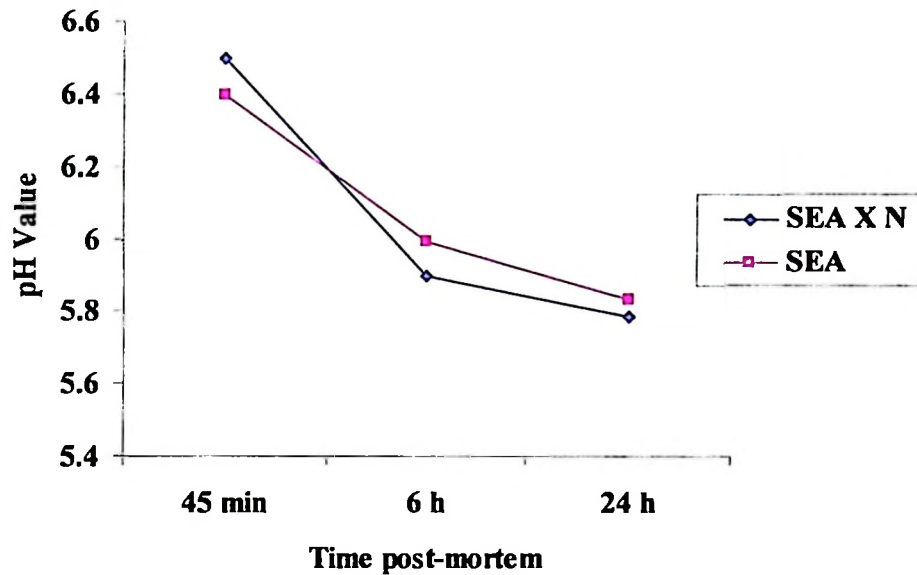
**Figure 2: Post-mortem temperature decline in goat carcasses fed T0, T1 and T2 diets**

Significance: - NS = Not significant; \*\* =  $P < 0.01$ ; \*\*\* =  $P < 0.001$ .

T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate.

#### 4.11.2 pH of carcasses

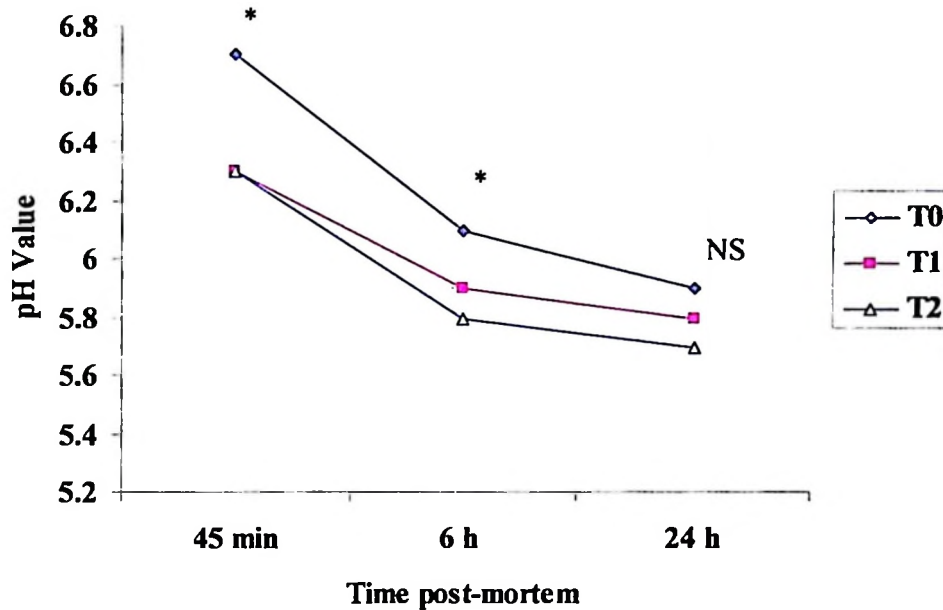
Carcass pH measured 45 min, 6 h and 24 h PM was not significantly ( $P > 0.05$ ) affected by genotype (Fig. 3). The 24 h PM carcass pH were 5.79 and 5.84 for SEA x N and SEA goats respectively. On the other hand, pH of carcasses measured 45 min PM was slightly higher for SEA x N crossbred but the decline was faster and resulted into numerically lower ultimate pH (pHu) than that of SEA goats.



**Figure 3: Post-mortem pH decline in SEA X N crossbreeds and SEA goat carcasses**

SEA x N= Small East African x Norwegian goats; SEA= Small East African goats.

The effect of diet on pH decline at different times PM was significant ( $P < 0.05$ ) at 45 min and 6 h (Fig. 4). Ultimate pH measured at 24 h PM did not differ between dietary treatments. Decline in muscle pH-values was faster in the first 6 h PM while the decline was almost levelled afterward. On the other hand, muscle pH for T2 goats was lower ( $P < 0.05$ ) at 45 min and 6 h PM than that of goats fed T0. The pH values for T1 and T2 goats were below 6 after 6 h PM while that of T0 goats remained above 6.



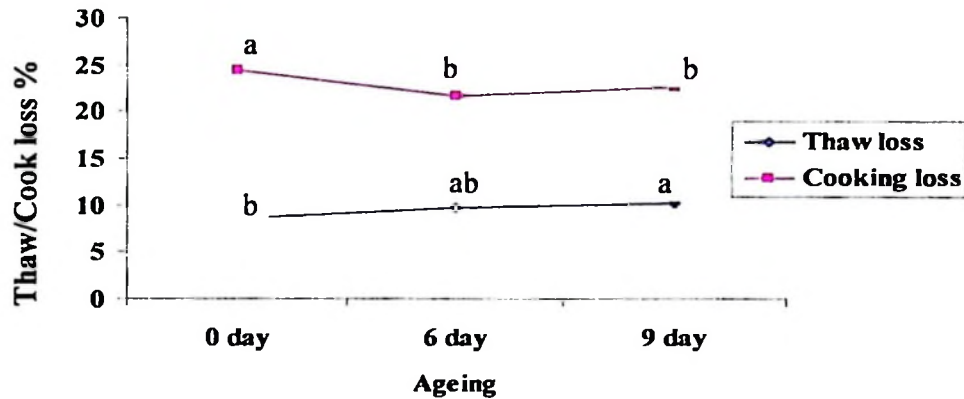
**Figure 4: Post-mortem pH decline in goat carcasses fed T0, T1 and T2 diets**

Significance: - NS = Not significant; \* =  $P < 0.05$ .

T0= Grazing + hay supplementation; T1= Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2= Grazing + hay supplementation + 100 % of *ad libitum* concentrate.

#### 4.11.3 Thawing loss, cooking loss and WBSF of aged *M. Longissimus dorsi* (LD)

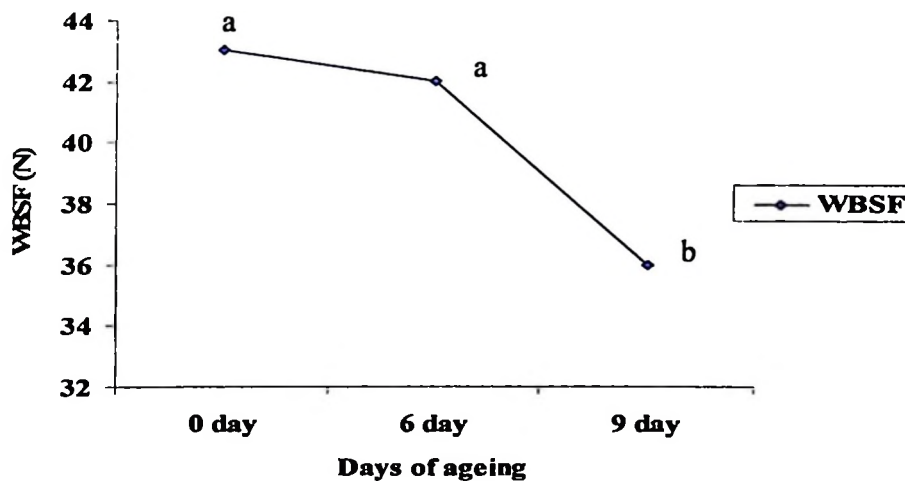
Although thawing loss for *M. Longissimus dorsi* (LD) increased ( $P < 0.05$ ) with ageing, cooking loss for LD muscle decreased ( $P < 0.01$ ) with ageing (Appendix 10). The LD muscle aged for 9 days had higher ( $P < 0.05$ ) thawing loss than non-aged (Fig. 5). On the other hand, non-aged LD muscle had higher ( $P < 0.05$ ) cooking loss than loss obtained when LD muscle was aged. For the aged LD samples ranking order observed for thawing loss was; - LD-9D > LD-0D = LD-6D, cooking loss; - LD-0D > LD-6D = LD-9D.



**Figure 5: Effect of ageing LD muscle on thawing and cooking loss**

<sup>ab</sup> within trait in the same line ageing days with common superscript are not significantly different ( $P>0.05$ ).

Warner-Bratzler shear forces (WBSF) values for cooked LD muscle decreased ( $P<0.001$ ) with ageing (Appendix 10). Ageing of LD muscle for 9 days resulted into significantly lower ( $P<0.05$ ) WBSF than values at 0 and 6 days of ageing which displayed comparable values (Fig. 6). The faster decline in WBSF values was obtained after 6 days of ageing. Ranking order for WBSF was; - LD-0D=LD-6D>LD-9D.



**Figure 6: Effect of ageing LD muscle on Warner-Bratzler shear forces WBSF (N).**

<sup>ab</sup> Within the line ageing days with common superscript are not significantly different ( $P>0.05$ ).

#### 4.11.4 Muscle physical properties

Table 15 shows least squares means and standard errors for data on muscle physical properties. Appendix 11 shows the detailed ANOVA Tables for these parameters. There was no significant ( $P>0.05$ ) effect of genotype on muscle physical properties except on thawing loss ( $P<0.01$ ). SEA goats had higher ( $P<0.05$ ) thawing loss than SEA x N crossbred goats. On the other hand, thawing loss was not affected by dietary regimes. T1 goats had higher ( $P<0.05$ ) cooking loss compared to the other groups. Shear force decreased ( $P<0.05$ ) with concentrate supplementation, whereby T0 had higher ( $P<0.05$ ) shear force than goats fed *ad libitum* concentrate (T2).

There were significant differences among muscles with respect to thawing loss, cooking loss and WBSF (Table 15). Of the muscles analysed without ageing, *M. Semimembranosus* and *Longissimus dorsi* (LD) had similar and highest ( $P<0.05$ ) thawing loss followed by *M. Psoas major*, while *M. Rectus abdominis* had the lowest ( $P<0.05$ ) values for thawing losses followed by *M. Triceps branchii*. On the other hand, *M. Supraspinatus* and *Semimembranosus* had statistically similar and highest ( $P<0.05$ ) values for cooking loss, followed by *M. Vastus lateralis*. Cooking loss was lowest for *M. Rectus abdominis*. On the other hand, *M. Gluteobiceps* and *Semimembranosus* had similar and highest values for WBSF, followed by *Vastus lateralis* and *Triceps branchii*. The lowest ( $P<0.05$ ) shear force values were recorded for *M. Psoas major* and *Infraspinatus* followed by LD muscle.

**Table 15: Muscle physical properties of castrated SEA x N and SEA goats under different levels of concentrate supplementation**

Variable	Thawing loss %	Cooking loss %	Shear force (N)
<b>Genotypes</b>			
SEA x N	5.77±0.16 <sup>b</sup>	25.69±0.29	47.40±0.55
SEA	6.36±0.15 <sup>a</sup>	25.33±0.28	47.94±0.52
<b>Diets</b>			
T0	5.96±0.20	25.17±0.37 <sup>b</sup>	49.32±0.69 <sup>a</sup>
T1	5.97±0.18	26.28±0.33 <sup>a</sup>	47.54±0.62 <sup>ab</sup>
T2	6.26±0.18	25.09±0.34 <sup>b</sup>	46.15±0.64 <sup>b</sup>
<b>Muscles</b>			
LD – 0D	8.61±0.37 <sup>b</sup>	24.35±0.69 <sup>d</sup>	42.97±1.31 <sup>d</sup>
LD – 6D	9.76±0.37 <sup>ab</sup>	21.76±0.69 <sup>c</sup>	42.00±1.31 <sup>d</sup>
LD – 9D	10.26±0.37 <sup>a</sup>	22.77±0.69 <sup>dc</sup>	36.34±1.31 <sup>c</sup>
<i>Psoas major</i>	6.97±0.37 <sup>c</sup>	28.80±0.69 <sup>c</sup>	34.96±1.31 <sup>c</sup>
<i>Rectus abdominis</i>	1.05±0.37 <sup>b</sup>	5.54±0.69 <sup>f</sup>	NA
<i>Triceps branchii</i>	3.62±0.37 <sup>f</sup>	27.97±0.69 <sup>c</sup>	54.90±1.31 <sup>b</sup>
<i>Infraspinatus</i>	4.06±0.37 <sup>cf</sup>	24.79±0.69 <sup>d</sup>	36.36±1.31 <sup>c</sup>
<i>Supraspinatus</i>	5.62±0.37 <sup>d</sup>	32.09±0.69 <sup>a</sup>	48.87±1.31 <sup>c</sup>
<i>Semimembranosus</i>	8.98±0.37 <sup>b</sup>	31.30±0.69 <sup>ab</sup>	65.56±1.31 <sup>a</sup>
<i>Semitendinosus</i>	3.87±0.37 <sup>cf</sup>	28.54±0.69 <sup>c</sup>	47.18±1.31 <sup>c</sup>
<i>Vastus lateralis</i>	4.86±0.37 <sup>dc</sup>	29.53±0.69 <sup>bc</sup>	58.20±1.31 <sup>b</sup>
<i>Gluteobiceps</i>	5.13±0.37 <sup>d</sup>	28.71±0.69 <sup>c</sup>	66.66±1.31 <sup>a</sup>
<b>Significance:</b>			
Genotype (G)	**	NS	NS
Diet (D)	NS	*	**
Muscle (M)	***	***	***
G*D	***	***	NS
G*M	NS	NS	NS
D*M	***	*	NS
G*D*M	NS	NS	NS

<sup>abcdefg</sup> Between genotype, diet and muscle within column, least squares means with a common superscript are not significantly different (P>0.05) Significance;- NS= Not significant; \*= P <0.05; \*\*= P <0.01;\*\*\*= P <0.001; NA= Not analysed; LD-0D= *longissimus dorsi* unaged; LD-6D= *longissimus dorsi* aged for 6 days; LD-9D= *longissimus dorsi* aged for 9 days; G= Genotype; D= Diet and M= Muscle.

#### **4.12 Economic Analysis of Goat Fattening**

Table 16 shows how the economics of goat fattening was assessed. Cost of concentrate and total feed costs increased with concentrate supplementation. In this experiment goats fed T2 had higher costs of concentrate. The cost of grass hay declined with concentrate allowance. Non-supplemented goats had higher cost of grass hay but lowest total feed cost of Tsh. 3512 and it was almost half of the costs incurred on medium level of supplementation.

On the other hand, revenue collected from carcasses, edible offal and its gross return increased with concentrate supplementation. Non-supplemented goats had lower revenue from edible offal, carcass and its gross return. The cost of gain (Tsh/kg gain) for non-supplemented goats (T0) was Tsh. 3512 and higher than those offered concentrate. For goats fed medium concentrate supplementation (T1), the cost of gain was Tsh. 2018 which was Tsh. 213 cheaper than goats fed T2. The highest net return due to supplementation was Tsh. 19 745 under goats fed T2 and Tsh. 1443 more than that of T1 goats.

**Table 16: Effect of diets on economics of fattening**

Variable	Diet		
	T0	T1	T2
<b>Feed costs per animal (Tsh)</b>			
Concentrate/day	-	73.98	112.42
Hay/day/animal	41.81	12.51	7.09
Total cost 84 days	3 512.17	7 264.40	10 039.01
<b>Yields (kg)/animal</b>			
Carcass	6.06	8.56	9.28
Edible offal	1.89	2.41	2.36
Skin	1	1	1
<b>Revenue (Tsh/animal)</b>			
Carcass	30 318.75	51 337.50	55 662.50
Edible offal	3 788.33	4 823.75	4 716.67
Skin	1 500.00	1 500.00	1 500.00
Gross return	35 607.08	57 661.25	61 879.17
Net return	32 094.91	50 396.85	51 840.16
Cost of gain (Tsh/kg gain)	3 512.17	2 017.89	2 230.89
NRS	-	18 301.94	19 745.24

T0 = Grazing + hay supplementation; T1 = Grazing + hay supplementation + 66 % of *ad libitum* concentrate; T2 = Grazing + hay supplementation + 100 % of *ad libitum* concentrate; NRS = Net return due to supplementation; Prices of feeds in (Tsh/kg):- Concentrate 198 and Hay 87; Revenue (Tsh/kg) T0 = 5 000, T1 & T2 = 6 000 for carcass and 2 000/= for edible offal.

## CHAPTER FIVE

### 5.0 DISCUSSION

#### 5.1 Chemical Composition of Feeds

The high CP and low fibre level of the sunflower seed cakes indicating their potential as protein supplements in ruminants' nutrition, especially where nitrogen is considered as a constraint to production. Oil seedcakes have reputation to bear reasonable amounts of both rumen degradable protein and by-pass protein (Meissner, 1999). On the other hand, the low CP and high fibre content in grass hay are indication of their limitation as livestock feed. Therefore feeding grass hay alone would not be adequate to support optimum goat production and thus must be supplemented. A low level of CP in a feed depressed DM intake (McDowell, 1996). Overall, digestibility values of concentrate are quite encouraging. It proves that the concentrate was highly digestible (>50 % apparent digestibility) and thus available to the microbes for conversion into energy for production and growth of the animals. The CP, CF, NDF and ME values of concentrates were slightly lower than those reported in previous studies (Mushi *et al.*, 2009; Safari *et al.*, 2009). The low CP and high NDF of the grass hay than the sward indicates that it was low quality hay. The ME value of 12.2 MJ/kg DM of concentrate was similar to 12.4 MJ/kg DM reported by Hango *et al.* (2007). Energy content in the concentrate feed used in this study was above the minimum recommended level of 3.7 - 7.3 MJ/kg DM for diets of ruminants (Abate, 1980).

#### 5.2 Feed Intake

The higher concentrate DM and ME intake for SEA x N crossbred compared to SEA goats can be explained by the superior growth potential of the crossbreds. Concentrate supplementation reduced forage DM intake but increased total energy intake. For T1 and T2 goats, grass hay DM intake declined from T0 by 0.32 and 0.39 kg respectively.

Correspondingly total dry matter intake increased by 0.03 and 0.14 kg. The observed similarity in total DM intake for T0 and T1 groups despite their differences in dietary regime probably is due to higher forage intake of 462 g/d in the former to compensate for the low energy content in their diet. Daily total ME intake for T0 goats 4.4 MJ/kg DM was below the recommended value of 5.78 MJ/kg DM (Langston University, 2000). Physical fill of the gut due to retarded rumen fermentation arising from deficiency of nutrients for rumen micro-organism could be the limiting factor for the amount of hay consumed by T0 goats resulting in overall lower total energy intake compared to supplemented goats. The total daily DM intake of goats fed different levels of concentrate ranged between 2.7 and 3.2 on percent body weight basis and these intakes were within the range reported for Ethiopian indigenous goats fed grain-less diet (Sebsibe, 2006).

### 5.3 Growth Performance

The higher SWT of 19 and 20 kg for T1 and T2 goats respectively was probably due to better body development with higher total feed intake. Lack of significant effect of level of concentrate on SWT in the present investigation may be attributed to similarity in growth rates. The observed SWT of goats fed three different diets ranged from 17 to 20 kg which is in agreement with previous reports on SEA goats (Mtenga *et al.*, 1984) who reported highest SWT of 20 kg. Also SWT is within the range reported by Melaku and Betsha (2008) who found SWT ranging from 16.6 – 24.7 kg for Somali goats fed hay *ad libitum* and other groups supplemented with graded levels of peanut cake and wheat bran mixture. However, higher SWT (31.4 - 37.6) kg was reported for South African indigenous goats (Simela, 2005). Likewise, Liméa *et al.* (2009) reported higher SWT of 22.5 - 23.6 kg for indigenous Caribbean goats under varying nutritional densities. The South African indigenous goats are considered as a large goat breed hence higher SWT than weight obtained in both SEA x N and SEA goats used in the present study.

Average daily gain (ADG) is a significant factor in assessing growth rates in most food animal species. In the present study, goat's ADG increased progressively with the increasing nutritional density of the diet. The growth rate of 12 g/d observed for the T0 (goats fed on grass alone) was lower than 20 - 25 g/d that have been reported by Ayo (2002) for Tanzania goats. This could be explained by the use of wastes brewer's yeast which is an excellent source of important minerals, vitamins and protein for goats fed low quality hay. SEA goats with 33 g/d were similar to 32 g/d reported for same SEA goats supplemented with leguminous proteins (Ntakwendela *et al.*, 2002). The growth rate of 43 - 52 g/d for supplemented goats correspond with 29.2 - 50.5g/d reported by Hango *et al.* (2007) and 35.8 - 49.5 by Safari *et al.* (2009) with SEA goats under feedlot system. A Similar ADG of 44.7 g/d was also reported in Somali goats fed basal diet of hay and supplemented with 400 g DM/d of wheat bran and peanut mixture on DM basis (Melaku and Betsha, 2008). The daily gain observed from T1 goats (43 g/d) was similar to those of other tropical breeds of Batina 44 g/d (Kadim *et al.*, 2003) and Indian goats 40g/d (Sen *et al.*, 2004). The growth rates reported in Table 7 were within the range of 23 - 63 g/d reported for Tanzania East African goats by Mtenga and Kitalyi (1990).

The observed similarity and high value for final BWT, ADG, total gain and BCS among supplemented goats was probably due to similar feed utilization efficiency. However, weight gains were lower compared with those reported for other temperate breeds of 90 - 103 g/d (Ryan *et al.*, 2007) and 132 g/d (Ahuya *et al.*, 2009). Mushi *et al.* (2009) observed higher ADG of 74.5 and 95.7 g/d for goats fed 66 % of *ad libitum* concentrate and 100 % of *ad libitum* concentrate respectively for SEA x N crossbred goats under feedlot system. These differences in growth rate among studies could be attributed to differences in the age of animals and energy concentrations of the diets.

Contrary to other previous works which showed that goats maintained entirely on grass hay generally experienced weight loss that ranged from -23.6 to -30.2 g/d (Melaku and Betsha 2008; Mushi *et al.*, 2009; Safari *et al.*, 2009), in this experiment there were daily gains of 12 g/d when non-supplemented goats were allowed to graze on natural pasture. The weight loss from previous studies could be attributed to total confinement of the animals. Total confinement of goats might have caused the poor feed intake. Goats are naturally browsers, and selecting nutritious parts of browse plants. Generally, the significant increases in daily gains due to supplementation from the present study are in line with other previous findings (Ebro *et al.*, 1998; Atti *et al.*, 2004). The total body weight gain of 3.6 - 4.4 kg for supplemented goats was similar to the range of 2 to 4 kg reported by Melaku and Betsha (2008) and Safari *et al.* (2009). However, values in this study were lower than 3.5 - 8.6 kg reported for SEA x N crossbred goats (Mushi *et al.*, 2009) and 9.3 - 10.7 kg in Norduz male kids (Daskiran *et al.*, 2010). The variation could be due to differences in breed and duration of experiment.

For small ruminants, live weight shrinkage increases with fasting duration peaking at 7 % after 21 h of fasting and depending on the nutritional status of animals. Such shrinkage is attributed to the reduction in gut contents (Diaz *et al.*, 2002). In the present study, goats fed *ad libitum* concentrate had significantly lower fasting loss than T1 and T0 goats. Fasting loss in this experiment ranged from 5 - 6 % and are in range of 4 - 11 % reported in the stall-fed goats (Sebsibe and Mathur, 2000; Sebsibe, 2007). The superiority of supplemented goats in BCS was probably contributed by high intake of nutrients which results into higher ADG. The increase in BCS with increased levels of supplementation agrees with Nsoso *et al.* (2003) who reported a strong association between BCS and weight change. As the BCS increased weight also increased, whereas when BCS decreased weight also decreased. The BCS for supplemented goats that ranged from 3.3 - 3.4 resemble those

values of 3.3 - 3.9 (Hango *et al.*, 2007) and 2.4 - 3.8 (Cam *et al.*, 2010) for supplemented goats. However, values obtained for BCS were higher compared with 1.0 - 2.5 reported by Lapenga *et al.* (2009) for Mubende goats fed elephant grass *ad libitum* in Uganda.

#### **5.4 Linear Body and Carcass Measurements**

Linear body measurements in the present study are lower than previous findings reported for Red Sokoto goats (Moruppa and Ngere, 1986; Khan *et al.*, 2006). The highest values for body length (52 cm) and heart girth (63 cm) in the present study were lower than 64 and 68 cm respectively reported for the 18 months male goats with 25 kg body weight (Khan *et al.*, 2006). These variations may be due to differences in genetic makeup of the goats, nutrition and final body weight. Linear carcass measurements indirectly help to determine carcass conformation; they are dependent on genotype, sex and feeding regimen (inducing different growth patterns). Thus, comparisons of absolute values between studies are difficult. Hind leg circumference of goats under T2 was greater by 3.3 cm than those under T0 goats. Most carcass measurements in the present study were similar to those from similar carcass weights (Mushi *et al.*, 2009; Safari *et al.*, 2009; Alexandre *et al.*, 2010) but slightly longer carcasses than 46 cm found by Mourad *et al.* (2001). The overall mean carcass length of 51 cm was a bit shorter than 65 and 73 cm reported for Arsi-bale and Borana respectively fed for 90 days (Dadi *et al.*, 2005) and 64 cm for Norduz male kids managed under semi-intensive production system (Daskiran *et al.*, 2010).

#### **5.5 Killing-Out Characteristics**

In the current study, concentrate fed goats had higher values for EBW, HCW, DP and carcass conformation score than the forage fed ones whereas their full GIT was reversed. The heavier full GIT from goats maintained under T0 were probably due to high forage intake in attempt to compensate for the differences in energy contents in the grass hay. The

higher SWT in T1 and T2 goats also resulted into higher EBW, HCW, DP and conformation score but lower weight of full GIT. The HCW in the present study were 8.3 and 8.6 kg for goats under T1 and T2 respectively and similar to 9.3 kg reported for indigenous Caribbean goats fed tropical forage without supplementation (Liméa *et al.*, 2009). Results of HCW for T0 goats of 7.1 kg agree to range of 5.9 - 7.1 kg for non-supplemented Black Bengal goats (Asaduzzman *et al.*, 2009).

Dressing percentage (DP) is an important parameter for assessing meat production potential in meat animals, and it is influenced by age, sex and plane nutrition (Devendra and Burns, 1983). The DP observed in this study ranged from 53 - 55 and 37 - 46 % for true DP and commercial DP, respectively. The superior DP found in heavier goats is associated with relatively higher proportions of fat in the carcass and lower proportions of digester due to less intake of forage. These findings correspond with reports of indigenous Tswana goats (Nsoso *et al.*, 2004), Borana and Arsi-Bale goats (Dadi *et al.*, 2005) and Creole kids under varying feeding regimes (Alexandre *et al.*, 2009). Moreover, the trend for DP to increase with level of concentrate supplementation agrees with similar studies (Melaku and Betsha, 2008; Liméa *et al.*, 2009) which reported increased DP with concentrate supplementation in the diet.

Lack of significant differences on DP as a percent EBW among goats that fed on concentrate-based diet is in line with results of Hango *et al.* (2007) who did not find differences between different feeding regimes for this trait in SEA goats. The DP as percent EBW observed in this study is relatively higher than those values ranged from 41.5 - 43.7 % reported by Das *et al.* (2000), Abedin *et al.* (2005) and Asaduzzman *et al.* (2009) for Black Bengal goats. The DP (based on EBW) of the goats in the present study was similar to 50 - 52 % reported for kids fed sunflower oil supplemented diet (Marinova *et al.*,

2001) and 51 – 54 % for male goats of six genotypes (Dhanda *et al.*, 2003). Differences in DP for SEA x N crossbred and SEA observed in the present study agrees with previous work reported significant difference between various goat breeds for DP based on full body weight (Dhanda *et al.*, 2003). On the contrary, Johnson *et al.* (1995) and Gonewardene *et al.* (1998) did not find significant difference in DP between different goat breeds. Generally breed difference in DP or lack of them are influenced by degree of gut fill at slaughter (Van Niekerk and Casey, 1988). However, literature reports indicated that DP in goats varies between 38 - 56 % depending on breed, sex, age, weight and conformation (El Hag and El Shargi, 1996).

EUROP classification system for carcasses based on conformation and fatness reflects the amount of flesh (meat) in relation to bone and the amount of visible fat on the carcasses (Johansen *et al.*, 2006). Therefore conformation is an important visual criterion that has bearing on the perceived market value of a carcass. The higher scores for conformation in supplemented animals can be associated with concentrate allowance which resulted into higher energy intake for muscle development. The carcass fatness increases with energy intake in a linear fashion.

#### **5.6 Non Edible Offal Components (NEOC)**

Traditionally blood, head, skin, hocks and testes were considered as NEOC and cannot be found in the butcheries for market. In the present study, all of the weights of these components did not differ between diets. Goats maintained under T0 had the lowest weight of total NEOC. In another study, Liméa *et al.* (2009) found differences on weight of NEOC for Caribbean goats under varying nutritional densities. This difference was probably due to differences in SWT for these two experiments. When NEOC was expressed as percent of SWT there was no significant effect of neither breed nor diet. It

was difficult to make comparisons with most of the literature because of the different genotypes, rearing systems, age and SWT. Results on the GIT contents as percent BWT observed in this study of 21 and 22 % for SEA and SEA x N are similar to Shahjalal *et al.* (2000) who found gut fill to be 20 - 22 % of BWT. The relatively higher weight of the GIT contents in goats fed hay is associated with their high intake of hay which is bulky in nature.

### 5.7 Edible Offal Components (EOC)

Depending on the cultural context, the offal may be considered as waste materials or delicacies that can command an interesting price such as in Tanzania. The main observations on EOC of this study fell within conclusions of Atti *et al.* (2004) who reported that diet influenced visceral organs mass. The weight of kidney and heart were not affected by the diet and these results are in line with growing Baladi kids (Haddad, 2005) and indigenous Caribbean goats under varying nutritional densities (Liméa *et al.*, 2009). On the other hand, the lighter liver weight in T0 would be in accordance with a decreasing plane of nutrition, eliciting reduced metabolic rate and mass of metabolically active tissue, such as liver (Atti *et al.*, 2004; Almeida *et al.*, 2006). In the current study, the supplemented goats had heavier total EOC weights than non-supplemented.

Total edible proportion (TEP) is another important trait which could be a more useful criterion for evaluating yields of breed or production practices. The TEP as % SWT were 50, 61 and 63 % for T0, T1 and T2 goats respectively. Results from supplemented goats agree with the report of Sebsibe *et al.* (2007) on three Ethiopian goat breeds as 64, 61 and 62 % of SWT for Afar, Central highland goat (CHG) and Long eared Somali (LES) goats respectively. Likewise Asaduzzman *et al.* (2009) observed similar TEP (64 and 62 % of SWT) for Black Bengal and crossbred goats respectively. Further, findings from

supplemented goats are in line with those of Legese and Abede (2008) and Abedin *et al.* (2005) who found a similar range for TEP 58 - 63 % of SWT for Somali and Arsi-Bale goats kept under intensive, semi-intensive and extensive systems. The lower TEP observed under T0 goats was primarily due to their lower proportion of edible offal components.

In this study, the TEP recorded for supplemented goats were 61 and 63 % of SWT of which nearly 17 % was contribution of edible offals. In countries where edible offal is eaten like in Tanzania, DP that excludes edible offal reduces the relative contribution of goat meat to the national meat supply. Moreover edible offal components are an important part of the goat farmer's economies. That is why studies aiming at the development of the local meat sector which equally take into account the cultural habits of the consumers such as these in Africa and elsewhere are encouraged (Aduku *et al.*, 1991; Riley *et al.*, 1989).

### **5.8 Fat Depots**

In general, the trends for fat depots accumulation showed that increasing amount of concentrate in the diet increased fat deposition. The observed highest weight of kidney and omental fat in the present study were 0.1 kg and 0.3 kg which agrees with the range of 0.02 - 0.2 kg and 0.03 - 0.4 kg for kidney and omental fat respectively reported by Lapenga *et al.* (2009). Furthermore, our findings on kidney and omental fat for supplemented goats were higher compared to those reported by Alexandre *et al.* (2009), heavier scrotal and pelvic fat than weight reported by Tadesse (2007). However, Daskiran *et al.* (2010) reported higher omental fat of 0.91 kg for Norduz male goats under semi intensive system and three times more for our heavier 0.32 kg omental fat recorded on goats fed T2. The difference in the fat depots reported by different workers can mainly be ascribed to level of feeding, age at fattening and breed characteristics.

When considering individual fat depot as percent of total fat depots, omental fat for T2 was 320 g and represent nearly half of the total fat depots. Comparison with other tropical breeds, such as Arsi-Bale (Dadi *et al.*, 2005) at similar BWT indicated that goats in our study had higher accumulation of all fat depots but less than the highest value reported by the same authors for Borana goats with 23 - 30 kg BWT.

### 5.9 Carcass Physical Composition

Muscle and especially fat deposition depends on nutrient utilization (Atti *et al.*, 2004). The observed heavier weights of muscle and fat on carcasses of concentrate supplemented goats compared to non-supplemented ones is chiefly due to heavier carcasses in the former than in the latter. Muscle, fat and bone are usually used in the appraisal of carcass composition and any change in the proportion of one of the components will influence the others. More fat was deposited in the carcasses of goats fed with higher level of concentrate T2 and the increase was statistically significant. In the present study, T2 goats were fatter with lower bone weights when expressed as a proportion of half carcass weight. These findings are explained by the lower carcass weight of non-supplemented goats where the weight of bones accounted for a significant proportion. Results from the present study support those of SEA goats (Hango *et al.*, 2007; Safari *et al.*, 2009). The observed proportion of bone and fat in the present study of 21 - 32 % and 3 - 15 %, respectively are within the range reported for SEA x N crossbred goats (Mushi *et al.*, 2009).

The proportion of fat increased with concentrate supplementation in the diet. This result agrees with Somali goats fed hay with graded levels of pea nut cake and wheat bran mixture (Melaku and Betsha, 2008). Malole (2002) recorded higher (68 - 70 %) lean than that found in this study. Mushi (2004) reported lower range of lean (56 - 63 %) for SEA goats. Lean meat percentages have varied from 64 - 67 % which is higher than those

reported for Boer and SEA x N goats by Webb *et al.* (2005) and Mushi *et al.* (2009) respectively. However this is in agreement with findings from Borana and Arsi-Bale goats under different durations of feedlot management (Dadi *et al.*, 2005). But that of fat is higher than those reported by the same authors for Arsi-Bale (3.1 %) and Borana (5.6 %) for 90 days feeding experiment.

#### 5.10 Carcass Chemical Composition

Dry matter (DM) and fat of minced meat increased with concentrate on offer and body carcass weight while that of moisture contents, ash and protein followed the reverse order. Hatendi *et al.* (1992) also reported a decline in moisture contents of goat meat with increasing weight. The protein content of goat carcass was significantly affected by dietary treatments and did not differ between genotypes. However Tshabalala *et al.* (2003) found significant effects of genotype on the protein of South African goats. The protein values observed from this study ranged from 19 - 22 % which were comparable to the report of young goats of Majorera breed (Arquello *et al.*, 2005).

The observed higher levels of fatness in carcasses for supplemented goats are due to higher intake of energy. These findings agree with various reports comparing effects of dietary energy density on carcass composition (Santos-Silva *et al.*, 2002; Diaz *et al.*, 2002). Our findings differ with those from previous studies where by dietary effect did not have significant influence on the chemical composition of Egyptian goats (El-Gallad *et al.*, 1988) and Majorera goats (Arquello *et al.*, 2005). The higher chemically determined fat in minced meat from concentrate supplemented goats basically is the cause for its lower proportion of water, protein and ash than non-supplemented goats. Juiciness of meat is directly related to the intramuscular fat and moisture contents of the meat (Cross *et al.*,

1986) but water remaining in the cooked product is the major contributor to the sensation of juiciness during eating (Forrest *et al.*, 1975).

## **5.11 Muscle Physico-Chemical Properties**

### **5.11.1 Temperature and pH of carcasses**

Better meat quality, especially meat tenderness, is linked to the rate of pH and musculature temperature fall with time post-mortem. The ultimate pH values were 5.76 and 5.86 for SEA x N and SEA goats, respectively. Ultimate pH ranging from 5.49 - 5.86 in goats were recorded and considered normal (Arquello *et al.*, 2005; Pratiwi *et al.*, 2007). In the present study, the difference in carcass temperature and pH decline between animals in different dietary regimes could be a result of variation in their fat cover. Similarly Abdullah and Musallam (2007) observed differences on carcass temperature and pH decline between castrated and intact male goats with different levels of fat cover. However the presence of dietary effect on muscle temperature and pH decline is in disagreement with Abdullah and Musallam (2007). The pH recorded after 24 h PM for supplemented goats in the current study 5.7 - 5.8 was, however, within the normal range reported for goats. The observed higher pH 5.9 for T0 goats may have been due to lower glycogen reserves caused by inadequate nutrition. Although Abdullah and Musallam (2007) found that different energy diets fed to kids did not affect muscle temperature and pH values, probably due to the differences in make-up of feeds and energy levels between the studies.

### **5.11.2 Effect of breed and diet on muscle physico-chemical properties**

Thawing loss differed between genotypes and not diets, with higher losses on SEA goats than SEA x N crossbreds. The values for cooking loss in the present study were slightly lower than 32 - 33 % by Simela (2005) and 32 - 51 % by Dhanda *et al.* (1999a). Babiker *et al.* (1990) and Johnson *et al.* (1995) also reported higher values of 30 - 36 %. However,

considering the similarity in ultimate pH between diet groups, the observed differences in cooking loss agree with Dhanda *et al.* (2003) and Pratiwi *et al.* (2007) but is in disagreement with findings on crossbred goats (Mushi *et al.*, 2009) and SEA goats (Safari *et al.*, 2009). As expected, higher tenderness for supplemented goats is associated with its higher values for intra-muscular fat. Trend for tenderness coincide with findings that meat from concentrate supplemented goats will be juicier than that from non-supplemented ones because of high fat content of muscle in the former than in the latter, especially intramuscular fat (Sanudo *et al.* , 2000).

The decrease in cooking loss as ageing increased was as expected since enzymatic reactions by endogenous enzymes, such as collagenase progresses at faster rates as ageing increases. The collagenase enzymes disintegrate the myofibrillar proteins and connective tissue thereby improving water holding capacity by proteins (den Hertog-Meischke *et al.*, 1998; Bruce *et al.*, 2003). The LD muscle progressively increased tenderness throughout the PM ageing period of 9 days. Therefore, lower shear force values may have been attained with extended ageing. This appears contradictory to the findings from Mushi *et al.* (2009) that major part of PM tenderisation of chevon occurred within 6 days of ageing after which increases in tenderness was minimal.

### **5.11.3 Effect of muscle type on meat physico-chemical properties**

On the other hand, the observed variation in thawing and cooking loss for individual muscles studied correspond with Pratiwi *et al.* (2007) that cooking losses are different for muscles taken from different anatomical regions. Further, the observed similarity in percentage cooking loss between *M. Triceps branchii* and *Vastus lateralis* is in agreement with Feral and SEA x N crossbred goats (Pratiwi *et al.*, 2007; Mushi *et al.*, 2009). The differences in thawing and cooking losses in the current study and those reported by other

authors may be attributed to several factors such as differences in ageing, marbling, cooking methods, temperature and duration (Yu *et al.*, 2005). For example, boiling samples in polythene bags in a water bath (Babiker *et al.*, 1990; Dhanda *et al.*, 1999a) which was a similar cooking method used in the current study generally yields higher losses than oven cooking (Smith *et al.*, 1976; SchÖnfeld *et al.*, 1993).

Overall, meat with Warner-Bratzler shear force values (WBSF) that exceed 55 N would be considered as objectionably tough by a trained sensory panel and by consumers (Abdullah and Musallam 2007). Therefore, WBSF values obtained in the present study (46.2 - 49.3N) between genotypes and dietary regimes can be considered to be of acceptable tenderness. Although all diet groups produced tender meat, supplemented goats with higher level of concentrate had more tender meat than non-supplemented goats. Meat tenderness increased with higher dietary energy intake and consequently carcass fatness (Wood *et al.*, 1999). Abdullah and Musallam (2007) noted that an increased amount of subcutaneous and intermuscular fat prevents carcasses from drying out during hanging and from the impact of rates of cooling on carcasses (Kannan *et al.*, 2006).

Results from the present study indicated that *M. Gluteobiceps* (66N), *M. Semimembranosus* (65N) and *M. Vastus lateralis* (58N) were regarded as objectionably tough whereas the rest fall in the tender range (WBSF<55N). The lower shear force values recorded for *M. Psoas major* and *Infraspinatus* in the present study coincide with findings by Keith *et al.* (1985), Safari *et al.* (2009) and Mushi *et al.* (2009). However, variation of individual goats muscle on WBSF values may be associated with their content and structure (degree of cross-links of collagen fibres) of connective tissue due to differential involvement in physical activities.

### 5.12 Economic Analysis of Goat Fattening

Based on current market prices for the key feed ingredients (Maize bran, sunflower seed cakes, lime, minerals/vitamins mixture and table salts), the cost of supplementary feeds per animal over the 84 days were Tsh. 3512, 7264 and 10 003 for T0, T1 and T2 respectively. The total feed cost in T1 goats was twice than that of T0 goats. The highest feed cost observed under *ad libitum* concentrate supplementation (T2) was Tshs. 2775 and 6527 more than cost of T1 and T0 goats respectively. The difference in total feed costs is attributed to differences on intake of concentrate and hay. The higher the concentrate intake, the higher the total feed costs and vice versa. On the other hand cost of hay in T0 was significant higher than supplemented goats and was three times more than cost observed under T1. Although daily total feed cost was lower in non-supplemented group, the lower carcass and edible offal yields rendered this system costly and less economical.

It was obvious that animals under T1 and T2 systems had effectively utilised both provision of the supplement and the opportunity to select. Therefore, combining grazing with concentrate supplementation is potentially more profitable than forage fed goats without supplementation. This was attributed to the higher growth rates and final body weights of supplemented goats than those under grazing without supplementation. Meanwhile, Legesse *et al.* (2005) reported that net returns from Arsi-Bale goats managed extensively and intensively were negative. Bhatt *et al.* (1991) reported a similar economic trend for Black Bengal x Beetal half bred kids managed under three feeding systems. However, the trend of gains for carcass that increased with levels of supplementation coincides with SEA goats under feedlot system reported by Hango (2005). Despite the differences in profits reported in this study and those of Hango (2005) it is still evident that profit increased with levels of concentrate supplementation.

Supplemented goats had higher and similar value for net return (NR) and this could be due to similar trend on body weight changes in respect to concentrate intake. Therefore, the trends in expected income from supplementary feeding were clear. The cost of one kg weight gain is important criterion that influences the economics of fattening. The supplement feed cost per kg of gain was therefore Tsh. 3512, 2 018 and 2 231 for T0, T1 and T2 respectively. On the other hand, goats under medium (T1) level of concentrate had similar net return due to supplementation with goats receiving the highest level of supplementation (T2), despite a lower DM intake (496 g/d) in the former compared to (606 g/d) in those supplemented with the highest level of concentrate. This could be attributed to the higher expenditure on supplementary feeds by T2 goats to produce total weight gain of 4.4 kg. Fattening resulted in heavier goats with improved body condition and hopefully bringing a better price when sales of animals are based on body weight in the market. The increased size and grade of the supplemented goat together with increase in the price per head will definitely offset the additional cost of feeding. Fattening goats is not a common practice in Tanzania. The current management practices of agro-pastoralists are one of very important factors that influence the adoption of fattening practice. Similarly, lack of proper fattening package found to be another limitation.

## CHAPTER SIX

### 6.0 CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 Conclusions

1. Although total DM intake, efficiency of feed utilisation and growth performance did not significantly differ between genotypes, SEA x N crossbred goats were slightly superior for these parameters. Total DM intake and FCR were depressed with increased intake of hay in the diet. Encouraging results from this on-farm goat fattening experiment have been obtained in terms of feed intake and growth performance on supplemented goats.
2. Genotype did not affect most of the carcass and meat quality traits but, SEA goats were slightly superior in hot carcass weight and dressing percentage and had higher thawing loss in the meat. Concentrate in the diet resulted in an improvement on carcass yield, TEP, carcass conformation, fatness and tenderness. The TEP recorded for supplemented goats ranged from 61 - 63 % of SWT of which nearly 17 % was contribution of edible offal. Results from this study emphasize the importance of considering yields of all edible offal items that can be used as food rather than simply basing on DP.
3. It was particularly interesting to note that it was cheaper to produce 1 kg gain under goats fed medium level of supplementation (T1). Therefore, combining grazing with medium level of concentrate supplementation is appropriate for goat fattening and potentially more profitable than other alternatives.

## 6.2 Recommendations

1. It is recommended to repeat this study using various energy and protein sources for making comparison under dry and wet seasons. Further, costs which were not recorded in this fattening operation such as housing, labour and others should be taken into account. This can give a clearer picture of the status of farm in the final analysis especially for people wish to fatten goats as commercial enterprises for the first time.
2. There should be deliberate policies to encourage well organized formal marketing of finished animals because this is where the success or failure of promoting goat fattening among small holders hinges.
3. There is need to establish modern meat processing factories which will stimulate demand for fattened animals with better pricing policies such as purchasing animals by weight as opposed to the current practice of pricing through visual assessment of weight.

## REFERENCES

- Abdullah, A.Y. and Musallam, H. (2007). Effect of different levels of energy on carcass composition and meat quality of male black goats kids. *Livestock Science* 107(1): 70 - 80.
- Abate, A. (1980). *In-vitro* estimation of energy content of some feeds commonly fed to livestock in Kenya. *East African Agricultural and Forestry Journal* 45(4): 255 - 260.
- Abedin, S.M.A.; Alam, M.R. and Faruque, M.O. (2005). Comparative carcass characteristics of ruminant species in Bangladesh. *Journal of Bangladesh Agricultural University* 3(2): 243 - 249.
- Aduku, A.O.; Aganga, A.A.; Okoh, N.P.; Ingawa, S.A. and Phillip, D.O.A. (1991). Contribution of offal to the gross value of goat carcasses in Nigeria. *Small Ruminant Research* 6: 179 - 184.
- Ahuya, C.O.; Ojangob, J.M.K.; Masic, R.O.; Peacock, C.P. and Okeyo, A.M. (2009). Performance of Toggenburg dairy goats in smallholder production systems of the eastern highlands of Kenya. *Small Ruminants Research* 83(1-3): 7 - 13.
- Ajala, A.A. (1995). Adoption of castration and socio-economic consequences for goat keepers of Southern Nigeria. *Small Ruminant Research* 16: 185 - 189.
- Almeida, A.M.; Schwalbach, L.M.; de Waal, H.O.; Greyling, P.C. and Cardoso, L.A. (2006). The effect of supplementation on productive performance of Boer goat bucks fed winter veld hay. *Tropical Animal Health and Production* 38: 443 - 449.

- Alexandre, G.; Arquet, R.; Gravillon, G.; Weisbcker, J.L. and Mandonnet, N. (2009). Carcass characteristics of Creole goat of Guadeloupe (FWI) as a function of pre-weaning performances and post-weaning management. *Livestock Research for Rural Development*. Volume 21, Article #57. Retrieved June 22, 2010, from <http://www.lrrd.org/lrrd21/4/alex21057.htm>.
- Alexandre, G.; Liméa, L.; Nepos, A.; Fleury, J.; Lallo, C. and Archimede. H. (2010). The offal components and carcass measurements of Creole kids of Guadeloupe under various feeding regimes. *Livestock Research for Rural Development*. Volume 22, Article #100. Retrieved June 4, 2010 from <http://www.lrrd.org/lrrd22/5/alex22100.htm>
- AOAC, (2000). Official methods of analysis, 17<sup>th</sup> ed. Association of Official Analytical Chemists, Alington, VA. 1298pp.
- Arsenos, G.; Banos, G.; Fortomaris, P.; Katsaounis, N.; Stramataris, C.; Tsaras, L. and Zygoyiannis, D. (2002). Eating quality of lamb meat: effect of breed, sex, degree of maturity and nutritional management. *Meat Science* 60: 379 - 387.
- Arguello, A.; Castro, N.; Capote, J.J. and Solomon, M. (2005). Effects of diet and live weight at slaughter on kid meat quality. *Meat Science* 70: 173 - 179.
- Asaduzzaman, M.; Alam, M.R.; Amin, M.R. and Faruque, M.O. (2009). Comparative study on carcass characteristics between Black Bengal and crossbred goats. *Journal of Bangladesh Agricultural University* 7(1): 87 - 90.

- Assenga, F.P. (1997). Performance and carcass characteristics of local sheep and goats of Mlali and Mkuyuni divisions of Morogoro District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 203pp.
- Attah, S.; Omojolla, A.B. and Adeschimwa, A.O.K. (2006). Yield and carcass composition of goats as affected by breed and slaughter weight. *World Applied Science Journal* 1(1): 8 - 11.
- Atti, N.; Rouissi, H. and Mahouachi, M. (2004). The effect of dietary crude protein level on growth, carcass and meat composition of male goat kids in Tunisia. *Small Ruminant Research* 54(1-2): 89 - 97.
- Ayo, E. (2002). The use of waste brewer's yeast as a protein supplement for growing Tanzania goats fed low quality hay. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 80pp.
- Babiker, S.A.; Maglad, M. and Koudoda, M, M. E. (1985). Effect of castration on performance and carcass characteristics of male Sudan desert goats. *World Review of Animal Production* 21(1): 11- 13.
- Babiker, S.A.; Khider, I.A. and Shafie, S.A. (1990). Chemical composition and quality attributes of goat meat and lamb. *Meat Science* 28: 273 - 277.
- Bhatt, A.S.; Singh, R.A.; Verma, S.K. and Gupta, B.S. (1991). Carcass traits and economics of meat production in kids under different management systems. *Indian Journal of Animal Science* 61(10): 1149 -1151.

- Bruce, H.L.; Stark, J.L. and Beiken, S.L. (2003). The effect of finishing diet and post-mortem ageing on the quality of *M. Longissimus thoracis* of electrically stimulated Brahman steers carcasses. *Meat Science* 67(2): 261 - 268.
- Cam, M.A.; Olfaz, M. and Soydan, E. (2010). Possibilities of using morphometrics characteristics as a tool for body weight prediction in Turkish hair goats (Kilkeci). *Asian Journal of Animal and Veterinary Advances* 5(1): 52 - 59.
- Casey, N.H. (1992). Goat meat in human nutrition. Pre: *Conference proceedings invited papers of the fifth international conferences on goats*. Indian council of Agricultural Research New Delhi. Volume 2, part II, 582 - 596.
- Cross, H.R.; Durland, P.R. and Seidman, S.C. (1986). Sensory qualities of meat. In: P.J Bechtel (ed.). *Muscle as Food. Food Science and Technology series*, Academic Press, New York, pp. 279 - 320.
- Dadi, H.; Woldu, T. and Lema, T. (2005). Comparison of carcass characteristics of Borana and Arsi-Bale goats under different durations of feedlot management. *Livestock Research for Rural Development*. Volume 17, Article #137. Retrieved April 4, 2010, from <http://www.lrrd.org/lrrd17/12/dadi17137>.
- Das, S.; Husain, S.S.; Hoque, M.A. and Amin, M.R. (2001). Association between body measurements and carcass characteristics of goats. *Bangladesh Journal of Animal Science* 30(1-2): 85 - 91.

- Daskiran, I.; Bingol, M. and Karaca, S. (2010). The effect of feeding system on fattening performance, slaughter characteristics of Norduz male kids. *Tropical Animal Health and Production*. DOI 10.1007/s11250 - 010 - 9577 - 3.
- Dawson, L.E.R.; Carson, A.F. and Moss, B.W. (2002). Effects of crossbred ewe genotype and ram genotype on lamb meat quality from the lowland sheep flock. *Journal of Agricultural Science* 139: 183 - 194.
- Den Hertog-Meischke, M.J.; Smulders, F.J.M. and Van Logtestijn, J.G. (1998). The effect of storage temperature on drip loss from fresh beef. *Journal of Science, Food and Agriculture* 78(4): 522 - 526.
- Devendra, C. and Burns, M. (1983). *Goat production in the Tropics, 2<sup>nd</sup> ed.* Commonwealth Agricultural Bureaux, Farnham Royal., UK. 183pp.
- Dhanda, J.S.; Taylor, D.G.; Murray, P.J. and McCosker, J.E. (1999a). The influence of goat genotype on the production of Capretto and Chevon carcasses. 2. Meat quality. *Meat Science* 52(4): 363 - 367.
- Dhanda, J.S.; Taylor, D.G.; McCosker, J.E. and Murray, P.J. (1999b). The influence of goat genotype on the production of Capretto and Chevon carcasses. 3. Dissected carcass compositions. *Meat Science* 52(4):369 - 374.
- Dhanda, J.S.; Taylor, D.G. and Murray, P.J. (2003). Growth, carcass and meat quality parameters of male goats: effects of genotype and live weight at slaughter. *Small Ruminant Research* 50(1-2): 57 - 66.

- Diaz, M.T.; Velasco, S.; Canque, V.; Lauzurica, S.; de Huidobro, F.R.; Perez, C.; Gonzalez, J. and Manzanares, C. (2002). Use of concentrate or pasture for fattening lambs and its effect on carcass and meat quality. *Small Ruminant Research* 43(3): 257 - 268.
- Ebro, A.; Sisay, A. and Alemu, T. (1998). Effect of supplementation of lablab (*Dolichus lablab*) for concentrate on growth rate and efficiency in post weaning goats. In: *Proceedings of 6<sup>th</sup> conference of Ethiopian Society of Animal production*, Addis Ababa, Ethiopia. pp. 264 - 268.
- El-Gallard, T.T.; Allam, S.M.; Gihad, E.A. and El-Bedawy, T.M. (1988). Effect of energy intake and roughage ratio on the performance of Egyptian Nubian (Zaraibi) kids from weaning to one year of age. *Small Ruminant Research* 1: 343 - 353.
- El Hag, M.G. and El Shargi, K.M. (1996). Feedlot performance and carcass characteristics of local (Dhofari) and exotic (cashmere) goats fed on high-fibre by products diet supplemented with fish sardine. *Asian-Australian Journal of Animal Science* 9: 389 - 396.
- Forrest, J.C.; Aberle, E.D.; Hedrick, H.B.; Judge, M.D. and Merkel, R.A. (1975). Meat as food. In: *Principles of Meat Science*. B.S. Schweigert (ed.) Freeman, Francisco, U.S.A. pp. 3-7.
- Garcia-Segovia, P.; Andres-Bello, A. and Martinez- monzo, J. (2006). Effect of cooking method on mechanical properties, colour and structure of beef muscle (*M. Pectoralis*). *Journal of Food Engineering* 80(3): 813 - 821.

- Gibb, M.J.; Cook, J.E.; Treacher, T.T. (1993). Performance of British Saanen, Boer x British Saanen and Anglo-Nubian castrated male kids from 8 weeks to slaughter at 28.33 or 38 kg live weight. *Animal Production* 57: 263 - 271.
- Goonewardene, L.A.; Day, P.A; Patrick, N.; Scheer, H.D and Suleiman, A. (1998). A preliminary evaluation of growth and carcass traits of Alpine and Boer goats crosses. *Canadian Journal of Animal Science* 78: 229 - 232.
- Haddad, S.G. (2005). Effect of dietary forage: concentrate ratio on growth performance and carcass characteristics of growing Baladi kids. *Small Ruminant Research* 57: 43 - 49.
- Hango, A. (2005). A pilot study on a goat feedlot production system. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 131pp.
- Hango, A.; Mtenga, L. A.; Kifaro, G.C.; Safari, J.; Mushi, D.E. and Muhikambele, V.R. M. (2007) A study on growth performance and carcass characteristics of Small East African goats under different feeding regimes. *Livestock Research for Rural Development*. Volume 19, Article #130. Retrieved April 5, 2010, from <http://www.lrrd.org/lrrd19/9/hang19130.htm>.
- Hatendi, P.R.; Smith, T.; Ndlovu, L. and Mutisi, C. (1990). Fattening mature indigenous (Matebele) goats. Effect on animals performance, body and carcass composition. [<http://www.fao/wirdocs/ilri/x5520b/x5520b00.htm/#contents>] site visited on 10/04/2010.

- Hatendi, P.R.; Smith, T.; Ndlovu, L. and Mutisi, C. (1992). Fattening mature indigenous (Matebele) goats. Effect on animals performance, body and carcass composition. In: *Small Ruminant Research and Development in Africa, Proceedings of the first biennial Conference of the African Small Ruminant Research Network*, ILCA, Kenya 10 - 14 December 1990. pp. 355 - 365.
- Hofmann, K. (1994). What is quality? Definition, measurement and evaluation of meat quality. *Meat Focus International* 3(2): 73 - 82.
- Honhold, N.; Petit, H. and Halliwell, R.W. (1989). A condition scoring scheme for small East African Goats in Zimbabwe. *Tropical Animal Health and Production* 21: 121 - 127.
- Hussain, S.S.; Harst, P. and Islam, A.B.M.M. (1996). Study on the growth performance of Black Bengal goats in different periods. *Small Ruminant Research* 21: 165 - 171.
- Johansen, J.; Aastveit, A.H.; Egelanddal, B.; Kvaal, K. and Roe, M. (2006). Validation of EUROP system for lamb classification in Norway: Repeatability and accuracy of visual assessment and prediction of lamb carcass composition. *Meat Science* 74(3): 497 - 509.
- Johnson, D.D.; McGowen, C.H.; Nurse, G. and Anous, M.R. (1995). Breed type and sex effects on carcass traits, composition and tenderness of young goats. *Small Ruminant Research* 17(1): 57 - 63.

- Kadim, I.T.; Mahgoub, O.; Al-Ajmi, D.S.; Al-Maqbaly, R.S.; Al-Saqri, N.M. and Ritchie, A. (2003). An evaluation of the growth, carcass and meat quality characteristics of Omani goat breeds. *Meat Science* 66(1): 203-210.
- Kakengi, A.M.; Shem, N.M. and Otsyina, P. (1999). Performance of grazing cattle in semi-arid tropics supplemented with *Leucaena leucocephala* leaf meal and its cost benefit analysis. In: *Proceedings of the 26<sup>th</sup> Scientific Conference of Tanzania Society of Animal Production*. (Edited by Mbagu, S.H.; Ndemanisho, E.E. and Kakengi, A.M.V.), 3 – 5 August 1999, Tengeru, Arusha, Tanzania. 26: 176 - 187.
- Kannan, G.; Gadiyaram, K.M.; Galipalli, S.; Carmichael, A.; Kouakou, B.; McMillin, .W. and Gelaye,S. (2006). Meat quality in goats as influenced by dietary protein and energy levels, and post-mortem aging. *Small Ruminant Research* 61(1): 45 - 52.
- Keith, F.K.M.; Vol, D.L.D.; Miles, R.S. and Bechtel, P.J. (1985). Chemical and sensory properties of thirteen major beef muscles. *Journal of Food Science* 50(4): 869 - 872.
- Khan, H.; Muhammad, F.; Ahmad, R.; Nawaz, G.; Rahimullah and Zubair, M. (2006). Relationship of body weight with linear body measurements in goats. *Journal of Agricultural and Biological Science* 1(3): 51 - 54.
- Kirk, J.A.; Cooper, R.A. and Kamwanga, L.A. (1994). Growth, carcass composition and its prediction in the indigenous Malawi goats. *Journal of Animal Science* 58(3): 480 (Abstract).

- Kirton, A.H. (1988). Characteristics of goat meat including quality and methods of slaughter. In: Goat Meat Production in Asia, In: *Proceedings of a workshop held in Tando Jam, Pakistan, 13-18 March 1988*, IDRC Ottawa, Canada, pp. 87 - 99.
- Kitalyi, A.J. (1982). Effects of supplementing low quality hay with different protein levels on growth performance of goats. Dissertation for Award of MSc Degree at University of Dar es Salaam, Tanzania. 157pp.
- Kochapakdee, S.W.; Pralokarn, S.; Laapetchara, A.S. and Norton, B.W. (1994). Grazing management studies with Thai goats. Productivity of female goats grazing newly established pasture with varying levels of supplementary feeding. *Asian-Australia Journal of Animal Science* 7: 289 - 293.
- Koohmaraie, M. (1992). Effect of pH, temperature and inhibitors of autolysis and catalytic of bovine skeletal muscle u-calpain. *Journal of Animal Science* 55:312 - 317.
- Koohmaraie, M. (1996). Biochemical factors regulating the toughening and tenderization process of meat. *Meat Science* 43: 193 - 209.
- Kosum, N.; Alcicec, A.; Taskin, T. and Onenc, A. (2003). Fattening performance and carcass characteristics of Saanen and Bornova male kids under an intensive management system. *Czech Journal of Animal Science* 48(9): 379 - 386.

- Kristensen, L.; Therkildsen, M.; Riis, B.; Sorensen, M.T.; Oksbjerg, N.; Purslow, P.P. and Ertbjerg, P. (2002). Dietary-induced changes of muscle growth rate in pigs: Effects on in vivo and post-mortem muscle proteolysis and meat quality. *Journal of Animal Science* 80(11): 2862 - 2871.
- Kusina, N.T. and Kusina, J. (2001). Goat marketing model for enhanced revenue generation by small holder farmers in Zimbabwe. In: *Proceedings of the Tanzania Society of Animal Production*. 28: 52 - 60.
- Langston University, (2000). Goat research extension. Goat ME Requirement calculator. <http://www2.luresext.edu/goats/research/me2.html>. Site visited on 15/5/2010.
- Lapenga, K.O.; Ebong, C. and Opuda- Asibo, J. (2009). Effect of feed supplements on weight gain and carcass characteristics of intact male Mubende goats fed elephant grass (*Pennisetum purpureum*) ad libitum in Uganda. *Journal of Animal and Veterinary Advances* 8(10): 2004 - 2005.
- Lawrie, R.A (1998). *Lawries Meat Science*. Pergamon Press pk. Headington Hill Hall, Oxford, England (6<sup>th</sup> edition) 336pp.
- Legesse, G.; Abebe, G. and Ergano, K. (2005). The economics of goats managed under different feeding systems. *Livestock Research for Rural development*. Volume 17, Article # 66. Retrived April 4, 2010 from <http://www.Irrd.org/Irrd17/6/lege17066.htm>.

- Legesse, G. and Abebe, G. (2008). The effect of breed type and feeding system on yields of edible and saleable components of Somali and Arsi-Bale goats. *Livestock Research for Rural Development*. Volume 20, Article #91 Retrieved March 20, 2010, from <http://www.lrrd.org/lrrd20/6/lege20091.htm>.
- Liméa, L.; Boval, M.; Mandonnet, N.; Garcia, G.; Archiméde, H. and Alexandre, G. (2009). Growth performance, carcass quality and non-carcass components of indigenous Caribbean goats under varying nutritional densities. *Journal of Animal Science* 87: 3770 - 3781.
- Lwelamira, J.; Muhikambele, V.R.M. and Mtenga, L.A. (1999). Potentials and constraints of small ruminant production in Gairo division. Tanzania Agricultural Research challenges for the 21<sup>st</sup> century. In: *Proceedings of fourth Annual Research Conference of the Faculty of Agriculture*, Sokoine University of Agriculture, Morogoro, Tanzania 17-19 November, 1999. pp. 42 - 47.
- Madubi, M. A. (1997). Physical characteristics of three strains of Small East African goats in Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 146pp.
- MAFF, (1975). Energy allowances and feeding systems for ruminants, Ministry Agriculture and Fisheries. *Food Technology Bulletin* Volume 33 (London).
- Mahgoub, O.; Kadim, I.T.; Al-saqry, N.M. and Al-Busaid, R.M. (2005a). Potential of Omani jebel Akhdar goat for meat production under feed lot conditions. *Small Ruminant Research* 56(1-3): 223 - 230.

- Mahgoub, O.; Lu, C.D.; Hameed, M.S.; Richie, A.; Al-Halhali, A.S. and Annamalai, K. (2005b). Performance of Omani goats fed diet containing various metabolizable energy densities. *Small Ruminants Research* 58: 175-180.
- Malole, J.L. (2002). Studies on growth rate, carcass quality and helminthiasis resistance of three strains of Tanzania local goats. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 115pp.
- Manfredini, M.; Massari, M.; Cavan, C. and Falaschin, A.F. (1988). Carcass characteristics of male Alpine kids slaughtered at different weights. *Small Ruminant Research* 1: 49 - 58.
- Marinova, P.; Banskaliieva, V.; Alexandrov, S.; Tzvetkova, V. and Stanchev, H. (2001). Carcass composition and meat quality of kids fed sunflower oil supplemented diet. *Small Ruminant Research* 42(3): 219 - 227.
- McDowell, L.R. (1996). Feeding minerals to cattle on pasture. *Animal and Feed science Technology* 60: 241 - 246.
- Meissner, H.H. (1999). Nutrient supplementation of the grazing animals. In: Taiton, N.M. (Ed.) veld management in South Africa University of Natal Press, Pietermaritzburg, pp. 334 - 354.
- Mellaku, S. and Betsha, S. (2008). Body weight and carcass characteristics of Somali goats fed hay supplemented with graded levels of peanut cake and wheat bran mixture. *Tropical Animal Health and Production* 40: 553 - 560.

- Melewas J.N; Rwezaula D.A; Kaduma I; and Bahari M. (2004). Policies for provision of efficient livestock services in Tanzania. In: *Proceedings of the 31<sup>st</sup> Scientific Conference of Tanzanian Society of Animal Production*, 31: 10 –19
- MLDF, (2010). Ministry of Livestock Development and Fisheries. Speech by the Minister of MLDF. Hon Dr. John Pombe Magufuli (MP), presenting to the National Assembly the proposal for the medium term plan and expenditure framework for the year 2010/2011, 102pp.
- Morrupa, S.M. and Ngere, L.O. (1986). Biometric studies on the Bornu white and Red Sokoto (Moradi) goats breeds. *Paper presented at the 11<sup>th</sup> Annual Conference of Nigerian Society for Animal Production*, Ahmadu Bello University, Shika-zaria, Nigeria. 23 – 27pp.
- Mourad, M.; Gbanamon, G. and Balde, I.B. (2001). Carcass characteristics of West African dwarf goats under extensive system. *Small Ruminant Research* 42(1): 81 - 85.
- Mtenga, L.A.; Mandari, G.C.H.; Kitalyi, A.J. and Sarwatt, S.V. (1984). Impact of past and current research on small ruminant production in Tanzania. In: *Proceedings of the 11<sup>th</sup> conference of Tanzania Society of Animal Production*. 11: 111-114.
- Mtenga, L.A. and Kitalyi, A.J. (1990). Performance and carcass composition of Tanzania goats fed *Chloris gayana* hay with supplements containing different levels of protein. *Small Ruminant Research* 3(1): 1 - 8.
- Mtenga, L.A. and Shoo, R.A. (1990). Growth rate, feed intake and feed utilization of Small East African goats supplemented with *Leucaena leucocephala*. *Small Ruminant Research* 3: 9 - 18.

- Mtenga, L.A.; Kiango, S.M.; Kifaro, G.C. and Muhikambebe, V.R.M. (1998). Performance of dairy goats in Mgeta Highlands, Tanzania In: *Food, Land and Livelihoods. Edition BSAS/KARI, BSAS*, Edinburg United Kingdom: 56 - 57.
- Mtenga, L.A.; Chenyambuga, S.W. and Kifaro, G.C. (2004). Carcass characteristics of indigenous goats in Tanzania. In: *Proceedings of the scientific conference of Tanzania Society of Animal Production, held at Kilimanjaro Crane Hotel - Moshi, 5<sup>th</sup>-7<sup>th</sup> October 2004*. Volume 31: 202-207.
- Muir, P. D.; Deaker, J.M. and Brown, M.D. (1998). Effects of forage and grain based feeding systems on beef quality: a review. *New Zealand Journal of Agriculture Research* 41: 623 - 635.
- Mushi, D.E. (2004). Studies on marketing of meat goats and carcass composition. A case study of Gairo auction markets. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 174pp.
- Mushi, D.E.; Mtenga, L.A.; Eik, L.O.; Safari, J. and Mwilawa, A.J. (2006). Some factors affecting the quality of meat from ruminants and their relevance to the Tanzania meat industry. In: *Proceedings of the 32 scientific conference of Tanzania Society of Animal Production*, 32: 109 - 124.
- Mushi, D.E.; Safari, J.; Mtenga, L.A.; Kifaro, G.C. and Eik, L.O. (2009). Effects of concentrate levels on fattening performance, carcass and meat quality attributes of Small East African x Norwegian crossbred goats fed low quality grass hay. *Livestock Science* 124 (1): 148.-155.

- Njombe, A.P. (1993). Small Ruminant production in Tanzania. Current trends in Livestock production. In: *Proceedings of the 20<sup>th</sup> scientific conference of the Tanzania Society of Animal Production* 20:130 - 145.
- Nsoso, S.J.; Aganga A.A.; Moganetsi, B.P. and Tshwenyane, S.O. (2003). Body weight, body condition score and heart girth in indigenous Tswana goats during the dry and wet seasons in southeast Botswana. *Livestock Research for Rural Development* 15(4), Retrieved July 7, 2010 from <http://www.lrrd.org/lrrd15/4/nsos154.htm>
- Nsoso, S.J.; Mannathoko, G.G.; Tadubana, T.T. and Malela, L. (2004). The effect of methods of castration on live weight, dressed percentage and linear body measurements of indigenous Tswana goats raised under semi-intensive management in Southeast Botswana. *Livestock Research for Rural Development*, Volume. 16, Art. #12. Retrieved July 7, 2010, from <http://www.lrrd.org/lrrd16/2/nsos1602.htm>.
- Ntakwendela, L.; Mtenga, L.A.; Pereka, A.E.; Chenyambuga, S.W.; Laswai, G.H.; Kimambo, A.E. and Muhikambile, V.R.M. (2002). Effect of substituting sunflower seed cake with *Acacia tortilis* pods as protein source in supplementary diets of SEA goats. *Tanzania Journal of Agricultural Sciences* 5(1): 39 - 48.
- Norman, G.A. (1991). *The potential of meat from the goat. Developments in Meat Science*. S. R .A Lawrie (ed) Elsevier Science Publishers Ltd. Essex, England, 89 - 157.

- Notter, D.R.; Kelly, R.F. and Berry, B.W. (1991). Effects of ewe breed and management system on efficiency of lamb production and meat characteristics. *Journal of Animal Science* 69(9): 3523 - 3532.
- Offer, G. and Trinick, J. (1983). On the mechanism of water holding capacity in meat: The swelling and shrinking of myofibrils. *Meat Science* 8 (4): 245 - 281.
- Owen, J.E.; Arias Cereceres, M.T.; Garcias macias, J.A. and Nunez, Gonzalez, F.A. (1983). Studies on the Criollo goat of Southern Mexico. Part I. The effect of body weight on body components and carcass development. *Meat Science* 9:199 - 204.
- Peacock, C. (1996). Improving goat production in the Tropics: *A manual for development works FARM-Africa and Ox farm*. United Kingdom and Ireland. 386pp.
- Peacock, C. (2005) Goats – A pathway out of poverty. *Small Ruminant Research* 60: 179 - 186.
- Pearson, A.M. and Gillett, T.A (1988). *Processed Meat*. 3<sup>rd</sup> edition. Aspen Publishers, Inc. Gaithersburg. pp. 210 – 212
- Pratiwi, N.M.W.; Murray, P.J. and Taylor D.G. (2007). Feral goats in Australia: a study on the quality and nutritive value of their meat. *Meat Science* 75(1): 68 - 177.
- Rae, D.O. (2002). Managing for profit: Nutritional priorities-cow age and body Condition.[<http://gnv.ifas.ufl.edu/animal/shortas/rae.htm>]. site visited on 2/5/2009.

- Reed, J.C.; Ebong, C.; Tanner, J.; Gebru, G. and Akalc, N.W. (1988). The nutritive value and use of feeds for fattening small ruminants in African Highlands. A perspective of ILCA research. *Small Ruminant Research Network Newsletter* 12: 10 – 27.
- Riley, R.R.; Savell, J. W.; Shelton, M. and Smith, G.C. (1989). Carcass and offal yields of sheep and goats as influenced by market class and breed. *Small Ruminant Research* 2: 265 - 272.
- Ryan, S.M.; Unruh, J.A.; Corrigan, M.E.; Drouillard, J.S. and Seyfert, M. (2007). Effect of concentrate level on carcass traits of Boer crossbred goats. *Small Ruminant Research* 53 (1-3): 67 – 76.
- Safari, J.; Mushi, D.E.; Mtenga, L.A.; Kifaro, G.C. and Eik, L.O. (2009). Effects of concentrate supplementation on carcass and meat quality attributes of feedlot finished Small East African goats. *Livestock Science* 125(2): 266 – 274.
- Santos-Silva, J.; Mendes, L.A. and Bessa, R.J.B. (2002). The effect of genotype, feeding system and slaughter weight on the quality of light lambs. Growth, carcass composition and meat quality. *Livestock Production Science* 76(1-2): 17 - 25.
- SAS, (2001). Stastical Analysis System. Users guide, Version 8.2. SAS Institute, INC, arry. NC.USA. 1028pp.
- Sanudo, C.; Alfonso, M.; Sanches, A. Delfa, R. and Teixeira, A. (2000).Carcass and meat quality in light lambs from different fat classes in the EU carcass classification systems. *Meat Science* 56(1): 89 - 94.

- SchÖnfeldt, H.C.; Naude, R.T.; Bok, W.; Van Heerden, S.M.; Sowden, L.E. and Boshoff, E. (1993). Cooking and juiciness related quality characteristics of goat and sheep meat. *Meat Science* 34: 381 - 394.
- Sebsibe, A. (2000). Effect of concentrate supplementation on carcass characteristics of stall-fed Barbari kids. *Indian Journal of Animal Nutrition* 17: 304 - 307.
- Sebsibe, A. and Mathur, M.M. (2000). Growth and carcass characteristics of Barbari kids as influenced by concentrate supplementation. In: *Proceedings of conference held at Debub University, Awassa, Ethiopia*. 10 to 12 November, 2000. 144 – 150pp.
- Sebsibe, A. (2006). Meat quality of selected Ethiopian goat genotypes under varying nutrition conditions. PhD Thesis, University of Pretoria, South Africa. 172pp.
- Sebsibe, A.; Casey, N.H.; van Niekerk, W.A.; Tegegne, A. and Coertze, R.J. (2007). Growth performance and carcass characteristics of three Ethiopian goat breeds fed grain less diets varying in concentrate to roughage ratios. *South Africa Journal of Animal Science* 37(4): 221 - 232.
- Sen, A.R.; Santra, A. and Karim, S.A. (2004). Carcass yield, composition and meat quality attributes of sheep and goats under semi arid conditions. *Meat Science* 66(4): 757 - 763.
- Shahjalal, M.; Galbraith, H. and Topps, J.H. (1992). The effect of changes in dietary protein and energy on growth, body composition and mohair fibre characteristics of British Angora goats. *Animal Production* 54: 405 - 412.

- Shahjalal, M.; Bishwas, A.M.; Tareque, A. (1997). Effect of feeding Sesbania leaves on growth and nutrient utilization in goats. *Bangladesh Journal of Animal science* 26: 117-123
- Shahjalal, M.; Bishwas, A.M.; Tareque, A. and Hoki, M.M. (2000). Growth and carcass characteristics of goats given diets varying in protein concentration and feeding level. *Asian-Australian Journal of Animal Science* 13: 613 - 618.
- Shilton, N.; Mallikarjunan, P. and Sheridan, P. (2002). Modelling of heat transfer and evaporative mass losses during the cooking of beef using far-infrared radiation. *Journal of Food Engineering* 80(3): 813 - 821.
- Smith, G.C.; Dutson, T.R.; Hostetler, R.L. and Carpenter, Z.L. (1976). Fatness, rate of chilling and tenderness of lambs. *Journal of Food Science* 41: 748 - 755.
- Steele, M. (1999). Goats. (Edited by Rene Coste and Antony, J.M). *The Tropical Agriculturist*. CTA, Macmillan publishers Ltd. 152pp.
- Simela, L.; Gumeda, S.; Ndlovu, L.R. and Sibanda, L.M. (2000). Handling losses of Matabele goats marketed through a commercial abattoir. In: *Improvement of market oriented Small Ruminant production systems and sustainable land use in semi arid regions of Southern Africa*. Project Ts3\*CT94-0312 Final Technical Report 147 - 156.

- Simela, L.; Webb, E.C. and Frylinck, L. (2004). Effect of sex, age, and pre-slaughter conditioning on pH, temperature, tenderness properties and colour of indigenous South African goats. *South African Journal of Animal Science* 34(1): 208 - 211.
- Simela, L. (2005). Meat characteristics and acceptability of chevon from South African indigenous goats. PhD Thesis University of Pretoria, South Africa. 274pp.
- Tadesse, M. (2007). The influence of age and feeding regimen on the carcass traits of Arsi-Bale goats. *Livestock Research for Rural Development*. Volume 19, Article # 47. Retrieved April 30, 2010, from <http://www.lrrd.org/lrrd19/4/tade19047.htm>.
- Thatcher, L.P. and Gaunt, G.M. (1992). Effects of growth path and post slaughter chilling regime on carcass composition and meat quality of ewe lambs. *Australian Journal of Agricultural Research* 43: 819 - 830.
- Tshabalala, P.A.; Strydom, P.E.; Webb, E.C. and De Kock, H.L. (2003). Meat quality of designated South African indigenous goats and sheep breeds. *Meat Science* 65: 563 - 570.
- UNESCO, (2010). *Report of National Commission of the United Republic of Tanzania*, pp. 166 - 170.
- Van Niekerk, W. and Casey, N.H. (1988). The Boer goat. II. Growth, nutrient requirements, carcass and meat quality. *Small Ruminant Research* 1: 355 - 368.

- Van soest, P.J.; Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, neutral detergent fibre and non starch polysaccharides in relation to animal nutrition. *Journal Dairy Science* 74(10): 3583 - 3597.
- Vasanthi, C.; Venkataramanujam, V. and Dushyanthan, K. (2006). Effect of cooking temperature and time on the physico-chemical, histological and sensory properties of female carabeef (Buffalo) meat. *Meat Science* 76(2): 274 - 280.
- Warris, P.D. (2000). *Meat Science*. An Introductory Text. CABI publishers, New York, USA. 310pp.
- Webb, E.C.; Casey, N. and Simela, L. (2005). Goat meat quality, *Small Ruminant Research* 60(1-2): 153 - 166.
- Wood, J.D.; Enser, M.; Fisher, A.V.; Nute, G.R.; Richardson, R.I. and Sheard, P.R. (1999). Manipulating meat quality and composition. In: *Proceedings of Nutrition Society* 58(2): 363 - 370.
- Yu, L.H.; Lee, E.S.; Jeong, J.Y.; Paik, H.D.; Choi, J.H. and Kim, C.J. 2005). Effects of thawing temperature on physico-chemical properties of pre-rigor frozen chicken breast and leg muscles. *Meat Science* 71(2): 375 - 382.

## APPENDICES

## Appendix 1: ANOVA Tables for feed intake

## 1.1 Dependent Variable: DM intake of concentrate

R-Square	Coeff Var	Root MSE	DMIC Mean
1.000000	0	0	296.3833

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	430.3944	430.3944	Infy	<.0001
Diet	2	579751.2736	289875.6368	Infy	<.0001
Breed*Diet	2	220.3956	110.1978	Infy	<.0001
SWT	1	0.0000	0.0000		

## 1.2 Dependent Variable: DM intake of hay

R-Square	Coeff Var	Root MSE	DMIH Mean
0.979204	16.98355	38.22869	225.0925

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	2683.2212	2683.2212	1.84	0.2334
Diet	2	342283.3734	171141.6867	117.11	<.0001
Breed*Diet	2	4079.1795	2039.5898	1.40	0.3299
SWT	1	4744.2058	4744.2058	3.25	0.1315

## 1.3 Dependent Variable: Total DM intake

R-Square	Coeff Var	Root MSE	TDMI Mean
0.893354	7.330889	38.22869	521.4742

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	5262.09502	5262.09502	3.60	0.1162
Diet	2	42794.6327	21397.31635	14.64	0.0081
Breed*Diet	2	2452.91041	1226.45521	0.84	0.485
SWT	1	4744.20579	4744.20579	3.25	0.1315

## 1.4 Dependent Variable: DM intake as percent of body weight

R-Square	Coeff Var	Root MSE	DMIBWT Mean
0.831952	7.622441	0.216985	2.846667

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.07768731	0.07768731	1.65	0.2552
Diet	2	0.56852271	0.28426135	6.04	0.0464
Breed*Diet	2	0.09449193	0.04724597	1.00	0.4301
SWT	1	0.27848648	0.27848648	5.91	0.0592

## 1.5 Dependent Variable: ME intake from concentrate

R-Square      Coeff Var      Root MSE      MEC Mean  
 1.000000      0                      0                      3.615

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.06604921	0.06604921	Infty	<.0001
Diet	2	86.23607989	43.11803995	Infty	<.0001
Breed*Diet	2	0.0332866	0.0166433	Infty	<.0001
SWT	1	0.000000	0.000000		

## 1.6 Dependent Variable: ME intake from hay

R-Square      Coeff Var      Root MSE      MEH Mean  
 0.979088      17.04266      0.364287      2.1375

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.23741744	0.23741744	1.79	0.2387
Diet	2	30.90705285	15.45352642	116.45	<.0001
Breed*Diet	2	0.37409977	0.18704989	1.41	0.327
SWT	1	0.43272572	0.43272572	3.26	0.1308

## 1.7 Dependent Variable: Total ME intake

R-Square      Coeff Var      Root MSE      TME Mean  
 0.96427      6.330835      0.364287      5.754167

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.56208535	0.56208535	4.24	0.0947
Diet	2	15.29429456	7.64714728	57.63	0.0004
Breed*Diet	2	0.18498809	0.09249404	0.70	0.5408
SWT	1	0.43272572	0.43272572	3.26	0.1308

## Appendix 2: ANOVA Tables for growth parameters

### 2.1 Dependent Variable: Initial body weight

R-Square      Coeff Var      Root MSE      BW1 Mean  
0.018593      15.30154      2.546755      16.64378

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.40647658	0.40647658	0.06	0.8036
Diet	2	0.85741913	0.42870956	0.07	0.9361
Breed*Diet	2	3.77481981	1.88740991	0.29	0.7491

### 2.2 Dependent Variable: Final body weight (kg)

R-Square      Coeff Var      Root MSE      FBWT Mean  
0.598805      10.79752      2.135821      19.78067

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.0146511	3.0146511	0.66	0.4213
Diet	2	84.819315	42.4096575	9.30	0.0005
Breed*Diet	2	12.228304	6.114152	1.34	0.2739
BW1	1	154.3183368	154.3183368	33.83	<.0001

### 2.3 Dependent Variable: Fasting loss (%)

R-Square      Coeff Var      Root MSE      Floss Mean  
0.30944      22.41052      1.24971      5.576444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	2.34584828	2.34584828	1.50	0.2279
Diet	2	10.80644801	5.403224	3.46	0.0417
Breed*Diet	2	4.05483461	2.02741731	1.30	0.2849
BW1	1	8.89173203	8.89173203	5.69	0.0221

### 2.4 Dependent Variable: Slaughter body weight (kg)

R-Square      Coeff Var      Root MSE      SWT Mean  
0.569335      11.3568      2.122181      18.68644

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.5687633	3.5687633	0.79	0.379
Diet	2	84.2364753	42.1182377	9.35	0.0005
Breed*Diet	2	3.2575644	6.6287822	1.47	0.2423
BW1	1	121.7922155	121.7922155	27.04	<.0001

## 2.5 Dependent Variable: Total weight gain (kg)

R-Square      Coeff Var      Root MSE      WTGain Mean  
0.397          68.07703      2.135652      3.137111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.01949008	3.01949008	0.66	0.4209
Diet	2	84.84383836	42.42191918	9.30	0.0005
Breed*Diet	2	12.21584521	6.10792261	1.34	0.2742
BW1	1	12.12504955	12.12504955	2.66	0.1113

## 2.6 Dependent Variable: Average daily gain (g/d)

R-Square      Coeff Var      Root MSE      ADG Mean  
0.396948      68.08375      25.42626      37.34556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	427.71524	427.71524	0.66	0.4211
Diet	2	12023.26243	6011.63121	9.30	0.0005
Breed*Diet	2	1731.60977	865.80489	1.34	0.2741
BW1	1	1718.27496	1718.27496	2.66	0.1113

## 2.7 Dependent Variable: Body condition score (BCS)

R-Square      Coeff Var      Root MSE      BCS Mean  
0.622272      22.41086      0.644088      2.874

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.12431461	0.12431461	0.30	0.5873
Diet	2	23.58511853	11.79255926	28.43	<.0001
Breed*Diet	2	1.42236193	0.71118097	1.71	0.1937
BW1	1	0.2086296	0.2086296	0.50	0.4826

## 2.8 Dependent Variable: Feed conversion efficiency (FCR)

R-Square      Coeff Var      Root MSE      FCR Mean  
0.917015      30.69445      6.428186      20.9425

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	118.814405	118.814405	2.88	0.1507
Diet	2	2067.01955	1033.509775	25.01	0.0025
Breed*Diet	2	65.794607	32.897303	0.80	0.501
BW1	1	51.922492	51.922492	1.26	0.3132

**Appendix 3: ANOVA Tables for linear body and carcass measurements (cm)****3.1 Dependent Variable: Body length (BL)**

R-Square	Coeff Var	Root MSE	BL Mean
0.625415	5.407672	2.781947	51.44444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	29.3443871	29.3443871	3.79	0.0589
Diet	2	7.3860004	3.6930002	0.48	0.6242
Breed*Diet	2	8.3594101	4.1797051	0.54	0.5871
SWT	1	341.224823	341.224823	44.09	<.0001

**3.2 Dependent Variable: Heart girth (HG)**

R-Square	Coeff Var	Root MSE	HG Mean
0.781226	3.110254	1.940335	62.38511

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	13.7218757	13.7218757	3.64	0.0638
Diet	2	2.7541856	1.3770928	0.37	0.6961
Breed*Diet	2	1.8723961	0.936198	0.25	0.7811
SWT	1	411.6248532	411.6248532	109.33	<.0001

**3.3 Dependent Variable: Height at wither (HW)**

R-Square	Coeff Var	Root MSE	HW Mean
0.403562	4.455166	2.49324	55.96289

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	8.0753305	8.0753305	1.30	0.2615
Diet	2	0.6595927	0.3297963	0.05	0.9484
Breed*Diet	2	2.0361702	1.0180851	0.16	0.8495
SWT	1	119.7156534	119.7156534	19.26	<.0001

**3.4 Dependent Variable: Height at rump (HR)**

R-Square	Coeff Var	Root MSE	HR Mean
0.471698	4.338879	2.474443	57.02956

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	12.8238648	12.8238648	2.09	0.156
Diet	2	7.0461324	3.5230662	0.58	0.5673
Breed*Diet	2	1.0374557	0.5187279	0.08	0.9189
SWT	1	175.8470682	175.8470682	28.72	<.0001

## 3.5 Dependent Variable: Carcass length (CL)

R-Square	Coeff Var	Root MSE	CL Mean
0.721392	2.971737	1.513935	50.94444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	9.0488874	9.0488874	3.95	0.0542
Diet	2	0.6304498	0.3152249	0.14	0.8719
Breed*Diet	2	5.6656418	2.8328209	1.24	0.302
SWT	1	149.698681	149.698681	65.31	<.0001

## 3.6 Dependent Variable: Carcass depth (CD)

R-Square	Coeff Var	Root MSE	CD Mean
0.413787	0.413787	1.776043	23.09267

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1.37758182	1.37758182	0.44	0.5127
Diet	2	1.08690268	0.54345134	0.17	0.8424
Breed*Diet	2	0.70990865	0.35495432	0.11	0.8939
SWT	1	64.92094414	64.92094414	20.58	<.0001

## 3.7 Dependent Variable: Hind leg length (HLL)

R-Square	Coeff Var	Root MSE	HLL Mean
0.433736	8.012751	2.891713	36.08889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	18.6645802	18.6645802	2.23	0.1434
Diet	2	48.0071113	24.0035557	2.87	0.069
Breed*Diet	2	70.2214626	35.1107313	4.20	0.0225
SWT	1	203.6933218	203.6933218	24.36	<.0001

## 3.8 Dependent Variable: Hind leg circumference (HLC)

R-Square	Coeff Var	Root MSE	HLC Mean
0.799713	5.992288	1.741319	29.05933

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	4.9239979	4.9239979	1.62	0.2103
Diet	2	71.1206408	35.5603204	11.73	0.0001
Breed*Diet	2	17.0051972	8.5025986	2.8	0.0731
SWT	1	154.4733816	154.4733816	50.94	<.0001

**Appendix 4: ANOVA Tables for killing-out characteristics**

## 4.1 Dependent Variable: Empty body weight kg (EBW)

R-Square	Coeff Var	Root MSE	EBW Mean
0.957889	4.641977	0.689788	14.85978

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.8447334	0.8447334	1.78	0.1907
Diet	2	33.4194812	16.7097406	35.12	<.0001
Breed*Diet	2	0.491073	0.2455365	0.52	0.601
SWT	1	198.9168134	198.9168134	418.06	<.0001

## 4.2 Dependent Variable: Hot carcass weight kg (HOCW)

R-Square	Coeff Var	Root MSE	HOCW Mean
0.95639	5.617888	0.454188	8.084667

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1.23254834	1.23254834	5.97	0.0193
Diet	2	13.69606449	6.84803225	33.20	<.0001
Breed*Diet	2	0.44473585	0.22236792	1.08	0.3505
SWT	1	83.79739024	83.79739024	406.22	<.0001

## 4.3 Dependent Variable: True DP (%)

R-Square	Coeff Var	Root MSE	TDP Mean
0.743244	2.790914	1.505692	53.94978

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	15.185572	15.185572	6.70	0.0136
Diet	2	27.3493465	13.6746733	6.03	0.0053
Breed*Diet	2	13.1299944	6.5649972	2.9	0.0675
SWT	1	100.5985982	100.5985982	44.37	<.0001

## 4.4 Dependent Variable: Commercial DP (%)

R-Square	Coeff Var	Root MSE	CDP Mean
0.831095	5.375368	2.298221	42.75467

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	31.3569979	31.3569979	5.94	0.0196
Diet	2	462.3321622	231.1660811	43.77	<.0001
Breed*Diet	2	14.5540164	7.2770082	1.38	0.2645
SWT	1	87.7191038	87.7191038	16.61	0.0002

## 4.5 Dependent Variable: Full GIT (kg)

R-Square      Coeff Var      Root MSE      FGIT Mean  
 0.63521      13.54694      0.72419      5.345778

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1.08648167	1.08648167	2.07	0.1582
Diet	2	29.12412024	14.56206012	27.77	<.0001
Breed*Diet	2	0.28223965	0.14111982	0.27	0.7655
SWT	1	15.62520929	15.62520929	29.79	<.0001

## 4.6 Dependent Variable: EUROP conformation score

R-Square      Coeff Var      Root MSE      CONF  
 0.769923      24.11381      1.377167      5.711111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00138447	0.00138447	0.00	0.9786
Diet	2	75.53115696	37.76557848	19.91	<.0001
Breed*Diet	2	1.24345798	0.62172899	0.33	0.7225
SWT	1	49.74514187	49.74514187	26.23	<.0001

## 4.7 Dependent Variable: EUROP fatness score

R-Square      Coeff Var      Root MSE      FATES  
 0.722512      39.37836      2.342312      Mean  
 5.948222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.2912268	0.2912268	0.05	0.819
Diet	2	199.0625987	99.5312994	18.14	<.0001
Breed*Diet	2	0.7753168	0.3876584	0.07	0.9319
SWT	1	99.3715387	99.3715387	18.11	0.0001

**Appendix 5: ANOVA Tables for non-edible offal components**

## 5.1 Dependent Variable: Blood (kg)

R-Square      Coeff Var      Root MSE      Blood Mean  
0.668223      12.39199      0.08914      0.719333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00460332	0.00460332	0.58	0.4513
Diet	2	0.03285601	0.016428	2.07	0.1405
Breed*Diet	2	0.00051496	0.00025748	0.03	0.9681
SWT	1	0.34374872	0.34374872	43.26	<.0001

## 5.2 Dependent Variable: Hock (kg)

R-Square      Coeff Var      Root MSE      Hock Mean  
0.785018      6.763408      0.035305      0.522

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00224042	0.00224042	1.8	0.188
Diet	2	0.00019594	0.00009797	0.08	0.9246
Breed*Diet	2	0.00502929	0.00251465	2.02	0.147
SWT	1	0.11776555	0.11776555	94.48	<.0001

## 5.3 Dependent Variable: Head (kg)

R-Square      Coeff Var      Root MSE      Head Mean  
0.723587      6.293555      0.076544      1.216222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.02255547	0.02255547	3.85	0.0571
Diet	2	0.02838092	0.01419046	2.42	0.1023
Breed*Diet	2	0.0141069	0.00705345	1.2	0.3112
SWT	1	0.47889834	0.47889834	81.74	<.0001

## 5.4 Dependent Variable: Skin (kg)

R-Square      Coeff Var      Root MSE      Skin Mean  
0.613139      13.42786      0.171369      1.276222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00075279	0.00075279	0.03	0.8738
Diet	2	0.14503551	0.07251776	2.47	0.0981
Breed*Diet	2	0.15048818	0.07524409	2.56	0.0904
SWT	1	0.73924637	0.73924637	25.17	<.0001

## 5.5 Dependent Variable: Testes (kg)

R-Square      Coeff Var      Root MSE      Testes Mean  
0.196921      47.80593      0.027834      0.058222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00408147	0.00408147	5.27	0.0273
Diet	2	0.00219146	0.00109573	1.41	0.2556
Breed*Diet	2	0.00071553	0.00035777	0.46	0.6336
SWT	1	0.00247994	0.00247994	3.20	0.0816

## 5.6 Dependent Variable: TNEOC (kg)

R-Square      Coeff Var      Root MSE      TNEOC Mean  
0.807701      6.55773      0.248757      3.793333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00580225	0.00580225	0.09	0.7611
Diet	2	0.13930908	0.06965454	1.13	0.3350
Breed*Diet	2	0.29337143	0.14668571	2.37	0.1071
SWT	1	6.17963791	6.17963791	99.87	<.0001

## 5.7 Dependent Variable: NEOC as a percent of slaughter weight

R-Square      Coeff Var      Root MSE      Neoc SW Mean  
0.331578      6.394397      1.304741      20.40444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00336369	0.00336369	0.00	0.9648
Diet	2	5.12911857	2.56455928	1.51	0.2346
Breed*Diet	2	6.23821825	3.11910913	1.83	0.1739
SWT	1	22.14083176	22.14083176	13.01	0.0009

## 5.8 Dependent Variable: GIT Contents (kg)

R-Square      Coeff Var      Root MSE      GCONT Mean  
0.651807      18.05143      0.693175      3.84

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.70591753	0.70591753	1.47	0.2330
Diet	2	32.50366824	16.25183412	33.82	<.0001
Breed*Diet	2	0.33070348	0.16535174	0.34	0.711
SWT	1	8.92239699	8.92239699	18.57	0.0001

## 5.9 Dependent Variable: GIT Contents as percent SWT

R-Square	Coeff Var	Root MSE	GTCSW Mean
0.741835	17.8541	3.752415	21.01711

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	13.146563	13.146563	0.93	0.3400
Diet	2	1124.707267	562.353634	39.94	<.0001
Breed*Diet	2	8.274521	4.137261	0.29	0.7471
SWT	1	4.835995	4.835995	0.34	0.5613

**Appendix 6: ANOVA Tables for edible offal components**

## 6.1 Dependent Variable: Heart (g)

R-Square	Coeff Var	Root MSE	Heart Mean
0.145309	109.927	119.3808	108.6

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	11199.28831	11199.28831	0.79	0.3809
Diet	2	42674.40666	21337.20333	1.50	0.2367
Breed*Diet	2	27181.73369	13590.86684	0.95	0.3944
SWT	1	7039.72519	7039.72519	0.49	0.4865

## 6.2 Dependent Variable: Lungs (g)

R-Square	Coeff Var	Root MSE	Lungs Mean
0.523396	17.20981	34.98182	203.2667

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	5154.37638	5154.37638	4.21	0.0471
Diet	2	5731.39761	2865.6988	2.34	0.1099
Breed*Diet	2	1413.81506	706.90753	0.58	0.5661
SWT	1	17872.65881	17872.65881	14.61	0.0005

## 6.3 Dependent Variable: Spleen (g)

R-Square	Coeff Var	Root MSE	Spleen Mean
0.600727	27.00349	9.559235	35.4

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	71.963446	71.963446	0.79	0.3804
Diet	2	1683.27784	841.63892	9.21	0.0005
Breed*Diet	2	96.216136	48.108068	0.53	0.5949
SWT	1	1048.331251	1048.331251	11.47	0.0017

## 6.4 Dependent Variable: Kidney (g)

R-Square	Coeff Var	Root MSE	Kidney Mean
0.120944	20.5271	12.1338	59.11111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	2.1821369	2.1821369	0.01	0.9037
Diet	2	383.2179134	191.6089567	1.30	0.2840
Breed*Diet	2	173.4082894	86.7041447	0.59	0.5599
SWT	1	10.0601796	10.0601796	0.07	0.7952

## 6.5 Dependent Variable: Diaphragm (g)

R-Square      Coeff Var      Root MSE      Diaphragm Mean  
0.524147      14.8132      7.811492      52.73333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	4.712001	4.712001	0.08	0.7826
Diet	2	1.277776	0.638888	0.01	0.9896
Breed*Diet	2	18.141015	9.070508	0.15	0.8624
SWT	1	1925.566337	1925.566337	31.56	<.0001

## 6.6 Dependent Variable: Liver (g)

R-Square      Coeff Var      Root MSE      Liver Mean  
0.757172      14.44358      40.00231      276.9556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1418.89057	1418.89057	0.89	0.3523
Diet	2	18839.41085	9419.70543	5.89	0.0059
Breed*Diet	2	11651.35438	5825.67719	3.64	0.0358
SWT	1	69619.55712	69619.55712	43.51	<.0001

## 6.7 Dependent Variable: Empty GIT (kg)

R-Square      Coeff Var      Root MSE      EGIT Mean  
0.776175      7.967132      0.119861      1.504444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.05079512	0.05079512	3.54	0.0677
Diet	2	0.12887335	0.06443667	4.49	0.0178
Breed*Diet	2	0.02493328	0.01246664	0.87	0.4281
SWT	1	0.91579249	0.91579249	63.74	<.0001

## 6.8 Dependent Variable: Total EOC (kg)

R-Square      Coeff Var      Root MSE      TEOC Mean  
0.777342      8.3202      0.186372      2.24

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.03912389	0.03912389	1.13	0.2953
Diet	2	0.71279145	0.35639573	10.26	0.0003
Breed*Diet	2	0.04454506	0.02227253	0.64	0.5323
SWT	1	1.74591463	1.74591463	50.26	<.0001

## 6.9 Dependent Variable: Total EOC as percent of SWT

R-Square      Coeff Var      Root MSE      TEOCSW Mean  
0.398807      8.9613      1.080335      12.05556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.93047997	0.93047997	0.80	0.3775
Diet	2	21.46162297	10.73081148	9.19	0.0006
Breed*Diet	2	0.91569648	0.45784824	0.39	0.6782
SWT	1	17.68749289	17.68749289	15.15	0.0004

## 6.10 Dependent Variable: EOC as percent of Total edible portion (TEP)

R-Square      Coeff Var      Root MSE      EOCTEP Mean  
0.577362      10.07054      2.094002      20.79333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	10.65094659	10.65094659	2.43	0.1274
Diet	2	34.40783157	17.20391578	3.92	0.0282
Breed*Diet	2	1.53957316	0.76978658	0.18	0.8397
SWT	1	94.0964395	94.0964395	21.46	<.0001

## 6.11 Dependent Variable: Total edible portion kg (TEP)

R-Square      Coeff Var      Root MSE      TEP Mean  
0.956765      5.35869      0.5931      11.068

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.7417824	0.7417824	2.11	0.1547
Diet	2	29.4777856	14.7388928	41.90	<.0001
Breed*Diet	2	0.5691114	0.2845557	0.81	0.4529
SWT	1	133.9050833	133.9050833	380.66	<.0001

## 6.12 Dependent Variable: TEP as percent slaughter weight % (TEPSW)

R-Square      Coeff Var      Root MSE      TEPSW Mean  
0.806483      5.452869      3.19812      58.65022

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	15.680077	15.680077	1.53	0.2232
Diet	2	1008.501275	504.250637	49.30	<.0001
Breed*Diet	2	14.209893	7.104946	0.69	0.5055
SWT	1	45.924937	45.924937	4.49	0.0407

**Appendix 7: ANOVA Tables for fat depots**

## 7.1 Dependent Variable: Kidney fat (g)

R-Square	Coeff Var	Root MSE	Kidney Mean
0.670528	59.86065	42.20841	70.51111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	4.23012	4.23012	0.00	0.9614
Diet	2	31968.69146	15984.34573	8.97	0.0006
Breed*Diet	2	7036.2792	3518.1396	1.97	0.1528
SWT	1	32933.97604	32933.97604	18.49	0.0001

## 7.2 Dependent Variable: Pelvic fat (g)

R-Square	Coeff Var	Root MSE	Pelvic Mean
0.605287	62.08392	44.14856	71.11111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	856.9751	856.9751	0.44	0.5113
Diet	2	45302.20708	22651.10354	11.62	0.0001
Breed*Diet	2	4882.18904	2441.09452	1.25	0.2973
SWT	1	13184.3639	13184.3639	6.76	0.0132

## 7.3 Dependent Variable: Mesenteric fat (g)

R-Square	Coeff Var	Root MSE	Messent Mean
0.59062	66.16317	24.89205	37.62222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1483.805104	1483.805104	2.39	0.1300
Diet	2	8241.263976	4120.631988	6.65	0.0033
Breed*Diet	2	110.596769	55.298384	0.09	0.9148
SWT	1	9017.531394	9017.531394	14.55	0.0005

## 7.4 Dependent Variable: Omental fat (g)

R-Square	Coeff Var	Root MSE	Omental Mean
0.725379	56.74748	123.4573	217.5556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	19761.88	19761.88	1.30	0.2620
Diet	2	299320.7326	149660.3663	9.82	0.0004
Breed*Diet	2	66629.0579	33314.529	2.19	0.1263
SWT	1	441807.4266	441807.4266	28.99	<.0001

## 7.5 Dependent Variable: Heart fat (g)

R-Square      Coeff Var      Root MSE      Heart Mean  
0.442584      102.2306      19.37837      18.95556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	219.003126	219.003126	0.58	0.4498
Diet	2	3565.036993	1782.518496	4.75	0.0144
Breed*Diet	2	394.334864	197.167432	0.53	0.5958
SWT	1	2311.397548	2311.397548	6.16	0.0176

## 7.6 Dependent Variable: Scrotal fat (g)

R-Square      Coeff Var      Root MSE      Scrotal Mean  
0.639044      61.31322      27.8907      45.48889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	262.088	262.088	0.34	0.5650
Diet	2	16071.92732	8035.96366	10.33	0.0003
Breed*Diet	2	678.17897	339.08949	0.44	0.6499
SWT	1	12861.34094	12861.34094	16.53	0.0002

## 7.7 Dependent Variable: Kidney as percent of total fat depots

R-Square      Coeff Var      Root MSE      KidP Mean  
0.644977      45.65517      5.610513      12.28889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	129.586968	129.586968	4.12	0.0495
Diet	2	1801.281878	900.640939	28.61	<.0001
Breed*Diet	2	81.269426	40.634713	1.29	0.2868
SWT	1	42.049728	42.049728	1.34	0.255

## 7.8 Dependent Variable: Pelvic fat as percent of total fat depots

R-Square      Coeff Var      Root MSE      PelP Mean  
0.626252      47.58823      6.20762      13.04444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	20.879355	20.879355	0.54	0.4662
Diet	2	2239.708874	1119.854437	29.06	<.0001
Breed*Diet	2	103.309977	51.654988	1.34	0.2738
SWT	1	163.02036	163.02036	4.23	0.0466

## 7.9 Dependent Variable: Mesenteric fat as percent of total fat depots

R-Square      Coeff Var      Root MSE      MesP Mean  
0.270449      103.831      8.352627      8.044444

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	655.8346217	655.8346217	9.40	0.0040
Diet	2	18.2392677	9.1196339	0.13	0.8779
Breed*Diet	2	417.9256387	208.9628194	3.00	0.062
SWT	1	29.960673	29.960673	0.43	0.5162

## 7.10 Dependent Variable: Omental fat as percent of total fat depots

R-Square      Coeff Var      Root MSE      OmeP Mean  
0.209045      59.22715      22.69058      38.31111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	428.524334	428.524334	0.83	0.3674
Diet	2	2084.784739	1042.39237	2.02	0.146
Breed*Diet	2	213.003459	106.501729	0.21	0.814
SWT	1	674.149467	674.149467	1.31	0.2597

## 7.11 Dependent Variable: Heart fat as percent of total fat depots

R-Square      Coeff Var      Root MSE      HeartP Mean  
0.157367      134.8546      3.8958      2.888889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.09301016	0.09301016	0.01	0.9380
Diet	2	63.74617317	31.87308659	2.10	0.1364
Breed*Diet	2	15.47452075	7.73726037	0.51	0.6047
SWT	1	0.63932873	0.63932873	0.04	0.8385

## 7.12 Dependent Variable: Scrotal fat as percent of total fat depots

R-Square      Coeff Var      Root MSE      ScroP Mean  
0.163117      148.1954      14.68781      9.911111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	449.772712	449.772712	2.08	0.1570
Diet	2	13.383025	6.691512	0.03	0.9695
Breed*Diet	2	1266.617608	633.308804	2.94	0.0652
SWT	1	2.026181	2.026181	0.01	0.9233

## 7.13 Dependent Variable: Total fat depots as percent of SWT

R-Square	Coeff Var	Root MSE	TDepSW Mean
0.725891	47.98652	1.084495	2.26

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.46278853	0.46278853	0.39	0.5342
Diet	2	41.42916594	20.71458297	17.61	<.0001
Breed*Diet	2	3.71494446	1.85747223	1.58	0.2193
SWT	1	19.02841863	19.02841863	16.18	0.0003

**Appendix 8: ANOVA Tables for carcass physico-composition**

## 8.1 Dependent Variable: Muscle (kg)

R-Square	Coeff Var	Root MSE	Muscle Mean
0.847139	10.72418	0.265698	2.477556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.0143664	0.0143664	0.20	0.6545
Diet	2	1.6859711	0.84298555	11.94	<.0001
Breed*Diet	2	0.07083464	0.03541732	0.50	0.6095
SWT	1	6.55301085	6.55301085	92.83	<.0001

## 8.2 Dependent Variable: Fat (kg)

R-Square	Coeff Var	Root MSE	Fat Mean
0.673934	47.31694	0.191686	0.405111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.04401415	0.04401415	1.20	0.2806
Diet	2	1.70465583	0.85232792	23.20	<.0001
Breed*Diet	2	0.02485752	0.01242876	0.34	0.7151
SWT	1	0.13408922	0.13408922	3.65	0.0637

## 8.3 Dependent Variable: Bone (kg)

R-Square	Coeff Var	Root MSE	Bone Mean
0.296521	14.12612	0.125942	0.891556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.00089714	0.00089714	0.06	0.8133
Diet	2	0.00391663	0.00195832	0.12	0.8842
Breed*Diet	2	0.00326102	0.00163051	0.10	0.9026
SWT	1	0.2072742	0.2072742	13.07	0.0009

## 8.4 Dependent Variable: Total fat depots (kg)

R-Square	Coeff Var	Root MSE	TDEP Mean
0.743707	50.14689	0.231344	0.461333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.02549115	0.02549115	0.48	0.4943
Diet	2	1.4490973	0.72454865	13.54	<.0001
Breed*Diet	2	0.18071124	0.09035562	1.69	0.1984
SWT	1	1.48120374	1.48120374	27.68	<.0001

## 8.5 Dependent Variable: Total fat (kg)

R-Square      Coeff Var      Root MSE      TFAT Mean  
0.779883      38.29194      0.487074      1.272000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.06476175	0.06476175	0.27	0.6044
Diet	2	14.54570318	7.27285159	30.66	<.0001
Breed*Diet	2	0.07719565	0.03859782	0.16	0.8504
SWT	1	3.82316137	3.82316137	16.12	0.0003

## 8.6 Dependent Variable: Muscle as percent of half carcass weight (%)

R-Square      Coeff Var      Root MSE      MTissue Mean  
0.225215      5.397567      3.548588      65.74422

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	14.05899038	14.05899038	1.12	0.2974
Diet	2	74.61679244	37.30839622	2.96	0.0637
Breed*Diet	2	12.60538407	6.30269203	0.50	0.6102
SWT	1	59.19256098	59.19256098	4.70	0.0365

## 8.7 Dependent Variable: Fat as percent of half carcass weight (%)

R-Square      Coeff Var      Root MSE      FTissue Mean  
0.784221      30.38477      2.888781      9.507333

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	20.1681446	20.1681446	2.42	0.1283
Diet	2	776.3138137	388.1569069	46.51	<.0001
Breed*Diet	2	7.6600014	3.8300007	0.46	0.6354
SWT	1	15.5721937	15.5721937	1.87	0.18

## 8.8 Dependent Variable: Bone as percent of half carcass weight (%)

R-Square      Coeff Var      Root MSE      BTissue Mean  
0.761986      11.89641      2.944441      24.75067

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.5525108	0.5525108	0.06	0.8021
Diet	2	448.1528668	224.0764334	25.85	<.0001
Breed*Diet	2	7.1059596	3.5529798	0.41	0.6667
SWT	1	135.5455622	135.5455622	15.63	0.0003

## 8.9 Dependent Variable: Carcass fat as percent of total fat (%)

R-Square      Coeff Var      Root MSE      DETFAT Mean  
0.605720      15.35586      10.92999      71.17800

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	59.527909	59.527909	0.50	0.4846
Diet	2	2935.566369	1467.783184	12.29	<.0001
Breed*Diet	2	716.315717	358.157859	3.00	0.0618
SWT	1	505.603812	505.603812	4.23	0.0466

## 8.10 Dependent Variable: Depot fat as percent of total body fat (%)

R-Square      Coeff Var      Root MSE      CFTFAT Mean  
0.605720      37.92240      10.92999      28.82200

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	59.527909	59.527909	0.50	0.4846
Diet	2	2935.566369	1467.783184	12.29	<.0001
Breed*Diet	2	716.315717	358.157859	3.00	0.0618
SWT	1	505.603812	505.603812	4.23	0.0466

## 8.11 Dependent Variable: Total fat as percent of SWT (%)

R-Square      Coeff Var      Root MSE      TFSWT Mean  
0.700236      43.73165      2.821372      6.451556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	6.6235638	6.6235638	0.83	0.3674
Diet	2	472.7051353	236.3525676	29.69	<.0001
Breed*Diet	2	0.4585236	0.2292618	0.03	0.9716
SWT	1	13.1241016	13.1241016	1.65	0.2069

**Appendix 9: ANOVA Tables for carcass chemical composition**

## 9.1 Dependent Variable: Dry matter % (DM)

R-Square      Coeff Var      Root MSE      DM Mean  
0.702157      10.99702      3.61704      32.89111

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.2539358	3.2539358	0.25	0.6209
Diet	2	533.2682181	266.634109	20.38	<.0001
Breed*Diet	2	46.837915	23.4189575	1.79	0.1807
SWT	1	98.837984	98.837984	7.55	0.0091

## 9.2 Dependent Variable: Moisture %

R-Square      Coeff Var      Root MSE      Moisture Mean  
0.702157      5.389808      3.61704      67.10889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.2539358	3.2539358	0.25	0.6209
Diet	2	533.2682181	266.634109	20.38	<.0001
Breed*Diet	2	46.837915	23.4189575	1.79	0.1807
SWT	1	98.837984	98.837984	7.55	0.0091

## 9.2 Dependent Variable: Ash %

R-Square      Coeff Var      Root MSE      Ash Mean  
0.65437      17.64893      0.619478      3.51

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.01322565	0.01322565	0.03	0.8537
Diet	2	12.82038425	6.41019213	16.7	<.0001
Breed*Diet	2	3.34551601	1.67275801	4.36	0.0198
SWT	1	1.24107251	1.24107251	3.23	0.0801

## 9.4 Dependent Variable: Crude protein % (CP)

R-Square      Coeff Var      Root MSE      CP Mean  
0.476236      7.778426      1.594975      20.50511

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	1.12484485	1.12484485	0.44	0.5101
Diet	2	48.36303535	24.18151767	9.51	0.0004
Breed*Diet	2	8.07221116	4.03610558	1.59	0.2179
SWT	1	2.34521002	2.34521002	0.92	0.3431

## 9.5 Dependent Variable: Ether extracts % (EE)

R-Square	Coeff Var	Root MSE	EE Mean
0.58353	55.85075	3.258085	5.833556

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	5.0483958	5.0483958	0.48	0.4946
Diet	2	208.2650163	104.1325082	9.81	0.0004
Breed*Diet	2	12.10879	6.054395	0.57	0.5701
SWT	1	95.5266387	95.5266387	9.00	0.0047

## Appendix 10: ANOVA Tables for aged LD muscle

### 10.1 Dependent Variable: Thawing loss (%)

R-Square      Coeff Var      Root MSE      TLoss Mean  
0.227179      30.22796      2.901678      9.599318

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	3.00195255	3.00195255	0.36	0.5516
Diet	2	74.5174649	37.25873245	4.43	0.0141
Ageing	2	62.31826448	31.15913224	3.70	0.0277
Breed*Diet	2	41.3199059	20.65995295	2.45	0.0905
Breed*Ageing	2	1.28721573	0.64360786	0.08	0.9265
Diet*Ageing	4	36.71382731	9.17845683	1.09	0.3649
Breed*Diet*Ageing	4	75.2980513	18.82451283	2.24	0.0695

### 10.2 Dependent Variable: Cooking loss (%)

R-Square      Coeff Var      Root MSE      Closs  
0.30488      15.60014      3.601636      23.0872

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	10.980026	10.980026	0.85	0.3595
Diet	2	356.7926934	178.3963467	13.75	<.0001
Ageing	2	148.4657653	74.2328826	5.72	0.0043
Breed*Diet	2	4.6208796	2.3104398	0.18	0.8371
Breed*Ageing	2	24.7031435	12.3515718	0.95	0.3889
Diet*Ageing	4	47.7761603	11.9440401	0.92	0.4545
Breed*Diet*Ageing	4	80.1255213	20.0313803	1.54	0.1942

### 10.3 Dependent Variable: Shear force value (Fmax)

R-Square      Coeff Var      Root MSE      Fmax Mean  
0.198593      18.04844      7.299649      40.44477

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	0.205413	0.205413	0.00	0.9506
Diet	2	12.759105	6.379552	0.12	0.8873
Ageing	2	1116.070305	558.035153	10.47	<.0001
Breed*Diet	2	44.665277	22.332638	0.42	0.6586
Breed*Ageing	2	140.348442	70.174221	1.32	0.272
Diet*Ageing	4	47.743252	11.935813	0.22	0.9245
Breed*Diet*Ageing	4	97.141195	24.285299	0.46	0.768

## Appendix 11: ANOVA Tables for muscle physico-chemical properties

### 11.1 Dependent Variable: Thawing loss (%)

R-Square      Coeff Var      Root MSE      TLoss Mean  
0.63194      40.1284      2.445408      6.093958

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	45.336506	45.336506	7.58	0.0061
Diet	2	9.802856	4.901428	0.82	0.4412
Muscle	11	3895.922328	354.174757	59.23	<.0001
Breed*Diet	2	108.930415	54.465207	9.11	0.0001
Breed*Muscle	11	23.176113	2.106919	0.35	0.9728
Diet*Muscle	22	323.868397	14.721291	2.46	0.0003
Breed*Diet*Muscle	22	204.394814	9.290673	1.55	0.0530

### 11.2 Dependent Variable: Cooking loss (%)

R-Square      Coeff Var      Root MSE      CLoss Mean  
0.732283      17.86002      4.565901      25.56492

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	17.44552	17.44552	0.84	0.3608
Diet	2	161.49735	80.74868	3.87	0.0215
Muscle	11	23986.47303	2180.58846	104.6	<.0001
Breed*Diet	2	420.6057	210.30285	10.09	<.0001
Breed*Muscle	11	203.31473	18.48316	0.89	0.5535
Diet*Muscle	22	795.80037	36.17274	1.74	0.0211
Breed*Diet*Muscle	22	449.68873	20.4404	0.98	0.488

### 11.3 Dependent Variable: Shear force value (Fmax)

R-Square      Coeff Var      Root MSE      Fmax Mean  
0.659249      18.10548      8.619512      47.6072

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Breed	1	36.83351	36.83351	0.50	0.4817
Diet	2	838.41332	419.20666	5.64	0.0038
Muscle	11	61368.57793	5578.96163	75.09	<.0001
Breed*Diet	2	70.57376	35.28688	0.47	0.6222
Breed*Muscle	11	606.23474	55.11225	0.74	0.6983
Diet*Muscle	22	1271.59162	57.79962	0.78	0.7540
Breed*Diet*Muscle	22	500.93546	22.76979	0.31	0.9992