EFFECT OF *CHROMOLAENA ODORATA* LEAF MEAL ON THE PERFORMANCE OF SMALL EAST AFRICAN GOATS

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

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ABSTRACT

A 90 days study was conducted to investigate the effect of *Chromolaena odorata* leaf meal as protein supplement on the growth performance, carcass characteristics and meat quality of Small East African (SEA) goats. Sixteen entire male goats aged 12 to 15 months with mean initial weight of 13.10 ± 0.72 kg were randomly allocated to four dietary treatments in a completely randomized design. Four dietary treatments D1, D2, D3 and D4 were formulated with inclusion of *Chromolaena odorata* leaf meal at 0%, 5.0%, 10.0% and 15.0% levels, respectively. The diets had isocaloric and isonitrogenous ranging from 10.14 to 11.57 ME (MJ/Kg DM) and 15.39 to 16.61% crude protein (CP), respectively. *Chromolaena odorata* leaf meal had CP ranging from 13 to 24%, gross energy from 2.61 to 3.15 kcal/g, calcium 0.98 to 1.14% and phosphorus from 0.19 to 0.29%. The average dry matter intake values were 378.86 g/day, 379.29 g/day, 343.38 g/day and 368.31 g/day for D1, D2, D3 and D4, respectively. Growth rates were significantly ($p<0.0001$) influenced by diets. Growth rate values were 35.28 g/day, 54.18 g/day, 27.78 g/day and 25.00 g/d for D1, D2, D3 and D4, respectively. Goats supplemented with D2 had the highest feed conversion efficiency requiring 7.0 g DM of feed to produce one gram of weight gain. The diet did not significantly ($p>0.05$) influence the carcass characteristics, non carcass components and meat quality of SEA goats. Goats supplemented with D1 and D2 had relatively heavier carcass and tissue weight. It can be concluded that *Chromolaena odorata* leaf meal has nutritional profile similar to ingredients used in formulation of livestock feeds hence could be incorporated in goats` diet. The optimum level of inclusion should not exceed 5% for better growth performance of SEA goats.

DECLARATION

I, JAMES KAWED SHAO, do hereby declare to the Senate of the Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

_____ _____

JAMES KAWED SHAO **Date**

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The above declaration confirmed:

_____ _____

Prof. Mtengeti E. J. **Date**

(Supervisor)

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This work is dedicated to my wife Loveness Kauwed Mrosso and our daughter Emmy James. Apart from loneliness faced, she was responsive. Her patience and prayers during my absence enabled me in undertaking my postgraduate studies.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADF	Acid Detergent Fibre
AFO	Agricultural Field Officer
CCIAM	Climate Change Impact Adaptation and Mitigation
COLM	*Chromolaena odorata* Leaf Meal
CP	Crude Protein
DASP	Department of Animal Science and Production
DM	Dry Matter
DP	Dressing Percentage
EE	Ether Extract
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
GLM	General Linear Model
IVDMD	*In Vitro* Dry Matter Digestibility
IVOMD	*In Vitro* Organic Matter Digestibility
Kg	Kilogram
km	Kilometre
LFO	Livestock Field Officer
ME	Metabolisable Energy
min	Minute
MJ	Mega Joule
mm	Millimetre
NDF	Neutral Detergent Fibre
NRC	National Research Council

^{o}C	Degree Celsius
OM	Organic Matter
pH	Hydrogen ion concentration (Measure of Acidity or Alkalinity)
ppm	Parts per million
Rev	Revolution
SAS	Statistical Analysis System
SEA	Small East African
SEDEREC	Serengeti Development Research and Environmental Conservation
SEM	Standard Error of the Mean
SUA	Sokoine University of Agriculture
UDSM	University of Dar es salaam
WEO/VEO	Ward/Village Executive Officer

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Chromolaena odorata is an invasive weed native to Central America. The weed is reported to be a major agronomic problem in many tropical countries such as India, Australia, Pacific islands, Southern Asia, South Africa, Central and Western Africa (Lina and Ephrime, 2011). The weed has also been reported to be common in south-western Kenya and eastern Victoria Lake of Tanzania (Zachariades *et al.,* 2009). In Tanzania the weed is present in some villages of Serengeti district in Mara region. *Chromolaena odorata* is classified as a species of Asteraceae family with a common name Siam weed. In Lake Victoria zone in Tanzania the weed has been given a local name "*Amacha-bhongo or Matogoro*" meaning sprouting recently.

It is not known how the weed came in Mara region; however, some villagers in Serengeti district believe that the weed came with water along river Mara from Sudan and Kenya. Other villagers believe that the weed was brought by livestock traders from Kenya. The weed can be spread by wind, human activity or grazing livestock.

The control measures of *Chromolaena odorata* such as hand-pulling, slashing and uprooting the plant, frequent hoeing and the use of herbicides are inefficient and not cost-effective as they are highly labour intensive (Zachariades *et al.,* 2009). Biological control is considered to be the most appropriate method in decreasing impact of the weed in farming activities (Hoevers and M`boob, 1993). *Pareuchaetes pseudoinsulata* (moth) is reported to decrease *Chromolaena odorata* population in Sri-Lanka, the Marianas, India, Ghana and Sumatra (Zachariades *et al.,* 2009). However, the population of moth declines

after 1-2 years and the weed recover (Zachariades *et al.,* 2009). Evaluations on progress made by several researchers revealed that the problem of *Chromolaena odorata* remain unsolved and suggest ways of putting it in beneficial uses (Bamikole *et al.,* 2004). *Chromolaena odorata* has been used in various parts of the world for medicinal and nutritional purposes (Asomugha *et al.,* 2013). However, the weed is unpalatable and is suspected to cause death to domestic animal when ingested (Zachariades *et al.,* 2009; Lina and Ephrime, 2011). The rejection of *Chromolaena odorata* leaves as a feeding material for livestock can be reduced by some pre-treatments such as sun-drying, grinding and mixing it with other feedstuffs that makes it acceptable to livestock making the weed potential source of protein supplement to livestock (Apori, 2000; Aro *et al.,* 2009).

Effects of toxic substance contained in most plants including *Chromolaena odorata* may be seen when levels of inclusion in animal feeds are high. The assessment of nutritive value showed that the *Chromolaena odorata* has a good potential for feeding livestock due to its high crude protein content (Apori *et al.,* 2000). Therefore the need of including *Chromolaena odorata* leaf meal in ruminants' ration as a source of protein is important in order to investigate its feeding potential.

Domestic animals such as goats can also be used to control weeds. Goats can reduce noxious weeds, bring back native grasses and prevent fires through fuel load reduction (Sandra, 2007). Poor nutrition rate is among the factors which hinder goats' productivity. Some studies have reported that proper management practices together with concentrates supplementation to provide protein, energy, minerals and vitamins according to their requirements can improve performance to the desired level of production (Kabir *et al.,* 2004). The primary goal of raising SEA goats in Tanzania is meat production (Mushi *et al.,* 2009). Goat meat is preferred to mutton due to its deliciousness and low fat content

as compared to mutton (Chenyambuga *et al.,* 2004). Goat meat is evaluated as of high quality or low by looking at the amount and distribution of fat in relation to lean meat. Carcass characteristics may be affected by breed, sex, age, body size and condition, type of feed and level of supplementation. Little information is available in supplementing *Chromolaena odorata* leaf meal to ruminants. The present study investigated the use of *Chromolaena odorata* leaf meal as supplement on the performance of small East African goats.

1.2 Problem Statement and Justification

Chromolaena odorata plants have been reported to invade some villages of Serengeti District since 2009. The plant is unpalatable to grazing animals due to presence of odour in fresh foliage. Several problems including decline of desirable pastures for domestic and wild animals in the grazing area, deteriorating health of animals and declining crop productivity due to smothering of other plant species by this invasive weed has been reported by Lina and Ephrime (2011). It is difficult to control the weed because it forms tuber like undergrowth which recovers aggressively when the weed is burnt or slashed. The weed also produces a lot of seeds which are easily dispersed by wind and grazing animals. The only possible means of controlling the weed is through mechanical removal and chemical treatment which involves frequent hoeing and uprooting the plant species and the use of herbicides. These control measures of *Chromolaena odorata* are inefficient and not cost-effective as they are highly labour intensive. Herbicides can be used but are expensive, hazardous to human and livestock with negative environmental impact (Zachariades *et al.,* 2009).

Biological control is considered to be the most appropriate method in decreasing impact of the weed in farming activities. It has been reported elsewhere that the negative response

for livestock consuming *Chromolaena odorata* is not related to its energy or protein value. The weed has been found to be a good source of protein in poultry when proper inclusion level is established. Therefore it was worthy to investigate the possibility of including *Chromolaena odorata* leaf meal as protein supplement in SEA goats' ration using growth performance, carcass characteristics and meat quality. This study could also lead to a positive contribution in the control of *Chromolaena odorata* invasive weed in Serengeti district.

1.3 Objectives of the Study

1.3.1 General objective

To investigate the growth performance, carcass characteristics and meat quality of SEA goats under *Chromolaena odorata* leaf meal as protein supplement.

1.3.2 Specific objectives

i. To evaluate the chemical composition of *Chromolaena odorata* plant.
ii. To asses the growth performance of SEA goat supplemented with *Chromolaena odorata* leaf meal.
iii. To assess carcass characteristics, meat pH, cooking loss and meat tenderness of SEA goats supplemented with *Chromolaena odorata* leaf meal.

In this study it was hypothesized that;

Null hypothesis (H_0)

The inclusion of *Chromolaena odorata* leaf meal in SEA goats' diets improves their performance and carcass characteristics.

Alternative hypothesis (Ha)

The inclusion of *Chromolaena odorata* leaf meal in SEA goats' diets does neither improve their performance nor carcass characteristics.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Overview of *Chromolaena odorata* Plant

Chromolaena odorata is an invasive weed native to Central America (Zachariades *et al.,* 2009). It is classified as a species of Asteraceae family with a common name Siam weed. The weed is present in some villages of Serengeti district in Mara- Tanzania where it has been given a local name "*Amacha-bhongo or Matogoro*" meaning sprouting recently (Plate 1).

The weed has been reported to be a major agronomic problem in many tropical countries such as India, Australia, Pacific islands, Southern Asia, South Africa, Central and Western Africa (Lina and Ephrime, 2011). The weed was first reported in year 2009 to invade eastern parts of lake Victoria zone in Tanzania (Zachariades *et al.,* 2009). It also grows in grazing areas along the mountain, open land and along roadsides of some villages of Serengeti District in Mara region. Farmers and livestock keepers' face problems with this weed as it grows aggressively, forms shrubs and smother other plant species (Plate 2).

Plate 1: *Chromolaena odorata* plant

Plate 2: *Chromolaena odorata* shrub

2.2.1 Distribution of *Chromolaena odorata*

Chromolaena odorata is widely distributed in many tropical countries frequently well-known as native to Central and South America but it has been introduced in many other tropical countries. The geographical distribution of *Chromolaena odorata* is known to be limited to regions within 30° N and 30° S latitudes in areas with a rainfall of 500 – 1500 mm and temperature ranges from 20°C to 37°C (Zachariades *et al.,* 2009). The weed is present in eastern Lake Zone of Tanzania in particular Mara region covering some parts of Butiama and Serengeti districts. The weed invasiveness attributes include its ability to thrive in a wide variety of soils, short juvenile stage and flowering in dry season, prolific seed production and strong ability to re-sprout after burning during land preparation (Lina and Ephrime, 2011). The allelopathic properties of the weed aid it in gaining dominance in vegetation and in replacing other plants species (Zachariades *et al.,* 2009).

2.2.2 Impact of *Chromolaena odorata* on the environment and farming activities

In invaded areas, different uses of *Chromolaena odorata* has been documented, mostly being improvement of soil fertility by decomposing foliage (Apori, 2000). However, in heavily infested areas, the weed competes with other plants and crops and become a threat to other plant species. *Chromolaena odorata* causes severe shortage of pasture in grazing lands. Livestock avoid invaded areas and overgraze non-infected lands. *Chromolaena odorata* is regarded as poisonous to animals and thus not recommended as a livestock feed. This is due to high nitrate level contained in the forage which is converted to nitrite in the rumen and absorbed, join with haemoglobin to form met-haemoglobin which cannot perform the function of haemoglobin and probably cause tissue anoxia hence death of animal (Aro *et al.,* 2009). However, some studies show its benefits in low concentrations, such as up to 5% inclusion level for egg-laying chickens which also improved yolk colour (Fasuyi *et al*., 2005).

Chromolaena odorata is a serious weed in all types of perennial crops thus increases costs of production, reduces total area used for cultivation and competes for nutrients with other plants.

During dry seasons the abundance of *Chromolaena odorata* increases fire hazard to the surrounding villages and natural vegetation (Hoevers and M`boob, 1993). This is due to presence of volatile oils in stems and leaves. It has also been reported to burn even when green in the growing season (Macdonald, 1983).

2.2.3 *Chromolaena odorata* control methods

2.2.3.1 Mechanical control

Chromolaena odorata seedling and young plants in a moist soil can be removed by hand-pulling, hoeing, slashing and uprooting the plant. These activities have to be repeated every 2 - 3 months because of *Chromolaena odorata* rapid re-growth (Zachariades and Goodall, 2002).

2.2.3.2 Chemical control

Chromolaena odorata is most susceptible to chemical control especially at the beginning of the rainy season. It is recommended to apply herbicides (Table 1) to young shoots after slashing (Nick, 2007).

Table 1: Herbicides used to control *Chromolaena odorata* in crop fields

Herbicide	Crop
Metribuzin	Yams and Cassava
Oxyfluoren	Cassava
Cyanazine + Atrazube or Atrazine + Terbutryn	Maize
Dipropetrin	Groundnuts and Cotton

Source: Nick (2007)

2.2.3.3 Biological control of *Chromolaena odorata*

Biological control is considered by researchers to be good means of controlling *Chromolaena odorata* as the use of herbicides is uneconomical with negative impact to environment (Hoevers and M`boob, 1993). *Pareuchaetes pseudoinsulata* (moth) was selected as first agent for trial in West Africa and has been widely released in South and South - East Asia and the Pacific (Zachariades *et al.,* 2009). *Pareuchaetes pseudoinsulata* did not build up in sufficient numbers to have any beneficial impact. However, in West Africa, *Paraeuchaetes pseudoinsulata* has been established and there is an ongoing programme in South Africa (Kluge and Zachariades, 2006).

2.2.4 Nutritional composition of *Chromolaena odorata*

Chromolaena odorata leaves are good source of crude protein (Table 2). The leaves are also a rich source of mineral elements such as Calcium (Ca), Sodium (Na), Potassium (K), Iron (Fe), Manganese (Mn), Zinc (Zn), Cupper (Cu), Phosphorus (P), and Magnesium (Mg) (Kigigha and Zige, 2013).

Similar chemical composition was reported by Fasuyi *et al*. (2005). Other studies indicated slightly different nutritive value of *Chromolaena odorata* leaf meal as reported

by Nwinuka *et al.* (2009). The use of *Chromolaena odorata* in livestock production faces challenges of rejection by animals making it abundant in grazing areas. A study by Apori *et al.* (2000) found the weed to be a good source of protein in poultry at 5% level of inclusion in the diet. It has been reported to be unpalatable and may cause death when ingested by domestic animals (Zachariades *et al.,* 2009; Lina and Ephrime, 2011).

Table 2: Proximate composition of *Chromolaena odorata* leaf meal

Nutrient	Percentage composition (%)
Dry matter	87.4
Crude protein	18.7
Crude fibre	11.7
Ether extract	1.01
Ash	3.63
Nitrogen free extractives	65.0
Gross energy, kcal/g	3.73

Source: Aro *et al.* (2009)

The weed is also not used by livestock due to presence of bad odour in the fresh foliage. The negative response for livestock consuming *Chromolaena odorata* is not related to its energy or protein value (Apori *et al.,* 2000). The rejection of *Chromolaena odorata* leaves as a feeding material for livestock can be reduced by some pre-treatments such as sun-drying, grinding and mixing it with other feedstuffs that makes it acceptable to animals making the weed potential source of protein supplement to livestock (Apori, 2000; Aro *et al.,* 2009).

2.3 Small ruminants' Production in Tanzania

2.3.1 Overview

In Tanzania SEA goats are mainly raised for meat production. Livestock statistics indicated that by 2010/2011 there were 15.2 million goats and 6.4 million sheep which contributed 22% of total meat production in Tanzania (MLFD, 2011). About 90% of this population is composed of indigenous type which is raised on natural pastures which are qualitatively poor hence low productivity (MLFD, 2011). The response can be reflected from the performance such as growth rate, level of production and reproduction. Feeding has showed that goats can attain desired level of production when fed according to their requirements (Mushi *et al.,* 2009; Mekasha *et al*., 2010).

2.3.2 Small ruminants feeding

Goats are characterised by having unique feeding habits of trees (backs and twigs) and therefore they are likely to be raised in a variety of environments. They have ability to tolerate forage and water shortage during dry season hence can be raised in arid and semi arid areas. Their small body size contributes to their wide distribution and easy management (Mlela, 2012).

On counteracting protein shortage many studies conducted revealed that utilization of trees legumes and pods as an alternative source of protein supplement in feeding goats is gaining popularity. Available browse can serve as a supplement and sustain animal performance in pastures with declining herbage quality. Supplementing goats with trees has been observed to improve body weight and general health (Moyo *et al.,* 2014). Browse (leaves and twigs) contain high levels of protein and phosphorous during growing season than grasses (Sandra, 2007). Browses are rich in nutrients, although some of them are unpalatable due to high lignin, silica and essential oils. They often contain high levels of

plant toxins and anti-nutritive factors (Sandra, 2007). Most tropical browse species used as animal feeds contain large amount of phenolic compounds mainly tannins and other secondary compounds (Ben Salem *et al.*, 2005). The existence of tannin in the feeds could reduce their nutritional value because tanning may bind feed proteins making them unavailable to ruminal micro-organisms (Mueller-Harvey, 2005; Do Thi Thanh Van, 2006). However, a low level of tannin will improve nitrogen utilization by ruminants since much tannin can alter the site of protein digestion and thereby improve amino acid absorption (Perez-Maldonado and Norton, 1996). The ability of goats to tolerate toxins allows them to feed on a diet high in polyphenols without reducing their performance as long as the nutrient requirements are met (Papachristou *et al*., 2005; Yusuf *et al.*, 2014).

Chromolaena odorata can be used as protein supplement to goats as they can feed on a wide range of multipurpose trees and shrubs through incorporating it in their diet. The limitations of odour and other ant nutritive factors in the fresh foliage can be reduced by some pre-treatments such as sun-drying, grinding and mixing it with other feedstuffs and establishing inclusion level in the diet that can be tolerated so as to make it acceptable to livestock (Apori, 2000; Aro *et al.,* 2009). Generally goats in the tropics have lower growth rate. The average daily weight gain for small indigenous goats is reported to be 25 - 44 g (Banda *et al.,* 1990) and large indigenous goats can grow at 54 to 80 g per day while exotic/temperate breeds may grow at 150 to 250 g per day (Gebrelul *et al.,* 1994).

2.4 Factors Influencing Goats' Performance

2.4.1 Adaptive feature of goats

Indigenous goats have developed special adaptive feature which enable them to survive in areas with repeatedly incidence of drought. Feeding behaviour is one of adaptive feature that enable goats to feed on trees and shrubs left untouched by other domestic animals.

Feeds that contain high level of tannin are poorly utilized by other ruminants although efficiently utilized by goats. Goats can feed on high tannin browse while sheep and cattle under similar conditions can not feed on high tannin browse (Mlela, 2012).

2.4.2 Environmental factors

In Tanzania goats are kept under varying agro-ecological zones. Goats perform better in highlands and semi arid zone due to presence of trees and shrubs which are the sources of protein. A study by Safari *et al.* (2004) indicated that weight changes of SEA goats is influenced by genotype, season and zone where gaining was inferior in the wet season for animals in humid and highland zones but superior for animals in semiarid zones.

2.4.3 Climatic factors

Weather conditions such as ambient temperature, humidity, soil fertility and moisture are climatic factors which indirectly affect animal production. They affect animals especially ruminants which are largely dependent on forage. High ambient temperature depress voluntary feed intake. For instance when temperature is elevated to 35^0C, voluntary feed intake is also depressed. In general dry matter intake (DMI) is negatively correlated to high ambient temperature. Soil fertility and moisture enable plant growth thus affecting quantity and quality of available nutrients (Mlela, 2012).

2.4.4 Diseases

The tropical environments are characterized by erratic rainfall, high relative humidity and temperature which favour occurrence of pests and parasitic diseases. These diseases account for the recorded high mortality rates resulting in reduced livestock productivity. Diseases which hinder goat productivity are parasitic, bacteria and viral. They may be caused by poor disease surveillance programmes.

Poor infrastructure and economic condition of livestock keepers have been low due to these diseases (Kahi *et al.,* 2006).

2.4.5 Social economic factors

In spite of increasing population size and demand for goat meat the production system is constrained by poor breeding policies, poor infrastructure, inadequate veterinary and extension services. Apart from conflicts between farmers and livestock keepers in Tanzania, poor infrastructure, inadequacy veterinary and extension services has also been a serious issue in animal management hence affect their performance.

2.4.6 Nutritional factors

In Tanzania SEA goats are kept mainly for meat production, live bank and social status. Poor nutrition is among the factors which hinder their productivity. This situation can be improved by proper management practices together with feeding concentrates which provide energy, dietary fibre, protein, minerals and vitamins required by the goat to attain the desired level of performance. Some studies have reported that concentrates supplementation is important for optimizing live weight gain and increase level of production (Kabir *et al.,* 2004).

2.4.6.1 Energy requirements

Energy is important feed component obtained from carbohydrate and fat. All carbohydrate contains similar ratio of carbon, hydrogen and oxygen hence considered to have approximately equal amount of gross energy 17.5 MJ/Kg DM. Digestible part of this energy is used in animal while indigestible part is excreted in faeces. Energy which is not used for metabolic processes is lost in urine and methane while metabolic processes lose energy as heat. Energy is required by any living organism for different physiological

functions including maintenance, production and reproduction (Luo *et al.,* 2004). The requirements of energy in animals vary according to breed, age, sex, physiological status, level of production and climatic conditions (Table 3). Excess energy supplied in the diet above maintenance is used for production (McDonald *et al.,* 2002). Insufficient energy supply in goats ration will reduce weight gain and may lead to abortions during 90 to 110 days of pregnancy (Hossain *et al*., 2003). Goats' diets are high in cellulose which is digested by rumen microorganism to yield volatile fatty acids. Half of the goat diet should be provided in form of hay or grass pasture to avoid concentrates related problems. According to Mamoon (2008) goats' diet should contain crude fibre of at least 12%.

Table 3: Energy requirements of goats according to different systems

Energy, MJ/day	NRC	Devendra and McLeroy	Langston University System	Mandal *et al*., 2004
Maintenance, 40kg	8.4	6.6	6.7	
Maintenance + late pregnancy	14.3	14.3	11.2	
Maintenance 40kg + lactation, 2 kg/day, 3.5% fat	18.6	15.7	17.8	
Maintenance 20kg + growth 50 g/day	6.5	5.5	5.6	5.5
Maintenance 20kg + growth 100 g/day	8.0	7.3	7.0	6.7

Source: Luo *et al.* (2004).

2.4.6.2 Dietary fibre requirements

Dietary fibre is rarely stated in the feeding table as essential nutrient required to ruminants. The fibre fraction of a food has the greatest influence on digestibility, and both the quantity and quality of the fibre are important. Deficiency of rumen-degradable nitrogen or sulphur may restrict microbial protein synthesis and thus reduce fibre digestibility (Mamoon, 2008). An excess of dietary lipid will also inhibit the activity of rumen microorganisms to digest fibre which is a primary source of energy for ruminants

as it end up in production of acetate rather than propionate from starch fermentation (McDonald *et al.,* 2010). It also causes extensive regurgitation for rumination and plentiful salivation for rumen buffering.

2.4.6.3 Protein requirements

Proteins are biological compounds which contain carbon, hydrogen, oxygen, nitrogen and sulphur. It is required in the animal for growth and development, repair of worn out cells and many other physiological functions (Table 4). It is an expensive nutrient in feeding hence limiting maximum productivity. Protein can be of plant or animal origin, plant source being less expensive. Protein is digested in the rumen into amino acids which is absorbed in small intestine. Protein supplementation to ruminants increases rumen microbial activity that influences rate of degradability and passage (McDonald *et al.,* 2010). Supplementing SEA goats (indigenous goats) with different protein levels did not significantly influence slaughter and carcass weight (Chenyambuga *et al.,* 2004). However, protein deficiencies will reduce feed intake, rumen function and retard foetal development.

Table 4: Protein requirements of goats according to different systems

CP g/day	NRC	Devendra and McLeroy	Langston University System	Mandal *et al.*, 2004
Maintenance, 40kg	77	48	48	
Maintenance + late pregnancy	159	139	123	
Maintenance 40kg + lactation, 2 kg/day, 3.5% fat	213	205	245	
Maintenance 20kg + growth 50 g/day	50	53	62	77
Maintenance 20kg + growth 100 g/day	74	71	82	100

Source: Luo *et al*. (2004)

2.4.6.4 Vitamins

Vitamins are organic compounds which are required by animal body in small amount for stimulation and proper functioning of physiological systems. Vitamins can be grouped into fat-soluble vitamins (A, D, E, and K) and water-soluble Vitamins (B- Complex vitamins and Vitamin C). In practical feeding of goats vitamin A and D is available to animals provided that they have free access to green pasture. Vitamins B- Complex can be synthesized by rumen microorganisms. Fat soluble vitamins should be supplied in the diet. Vitamins are used as coenzymes in cellular metabolism (Fuller *et al.,* 2004). Vitamins are required by animals for normal vision, growth and development of different tissues and enable animals to resist diseases.

2.4.6.5 Minerals

Minerals are inorganic substances which have to be included in the diet. They are of two major classes as per requirement in the animal body. This includes those required in large amount on percentage basis (macro minerals) such as calcium, phosphorus, sodium, potassium, chlorine, sulphur and magnesium (Table 5). Micro minerals are required in small quantity (parts per million) in the diet. They include iron, copper, cobalt, manganese, zinc, iodine, selenium etc. Minerals are involved in the formation of body skeleton; activate enzymes and other metabolic functions such as carriers of proteins, regulation of digestion, respiration, water balance, muscle reaction, nerve transmission, pH balance and protection against diseases (Fuller *et al.,* 2004).

Table 5: Acceptable quantity of macro and micro-minerals in a goat's diet

Macro minerals	Percentage (%)	Micro-minerals	Parts per million (ppm)
Calcium (Ca)	0.3 - 0.8	Iron (Fe)	50 - 1000
Phosphorus (P)	0.25 - 0.4	Copper (Cu)	10 - 80
Sodium (Na)	0.2	Cobalt (Co)	0.1 - 10
Potassium (K)	0.8 - 2.0	Zinc (Zn)	40 - 500
Chloride (Cl)	0.2	Manganese (Mn)	0.1 - 3
Sulphur (S)	0.2 - 0.32	Selenium (Se)	0.1 - 3
Magnesium (Mg)	0.18 - 0.4	Iodine (I)	0.5 - 50

Source: Mamoon (2008)

2.4.6.6 Water

Water is important nutrient required by animals for all biological reactions. Goats can get water through drinking, feeding and metabolic water from nutrient oxidation in the body. Adequate drinking water should be provided for effective digestion of feed by microorganisms in the rumen. Water should be provided *ad-libitum* to the goats. Normally the amount of water to be supplied to goat is four times the amount of dry matter consumed (Peacock, 1996). However, goats are well adapted to dry environment due to their low water turnover rate as compared to sheep.

2.5 Voluntary Feed Intake

Voluntary feed intake is the weight of feed eaten by an animal or group of animals in a given period of time during which they have free access to it (McDonald *et al.,* 2010). Animals differ in ability of digesting different feed materials. They should be given feeds according to the rate of passage and digestion in the gastro intestinal tract (G.I.T). Voluntary feed intake determines microbial protein synthesis in the rumen for ruminants. The amount of feed an animal can ingest is a result of animal and feed related factors such as species, sex, age and physiological conditions like lactation, pregnancy, growth rate, composition and type of food eaten.

Composition of the diet influences the amount and rate of digestion and passage of roughages. Intake in ruminants depends on capacity (fill) of the rumen to accommodate bulky feeds consumed until the fermentation of carbohydrates and protein are done and feed material digested to release volatile fatty acids. The quantity of digesta may determine whether the animal to ingests more food or not (McDonald *et al.,* 2010).

Feeding high energy feedstuffs has a negative associative effect on the degree of utilization of roughage in ruminants. For instance one of the primary species responsible for the digestion of roughages is cellulolytic bacteria which produce acetate as end product of digestion of roughages. Acetate is a relatively weak acid. The primary end product of fermentation of high energy feedstuffs is propionate which is relatively strong acid. The strong acid tends to lower pH of the rumen, normal rumen pH 6.0 - 7.0 (McDonald *et al.,* 2010). Low pH has a negative effect on the microorganisms responsible for digestion of roughages. Thus incorporation of high energy or high non-fibrous carbohydrate in ruminant ration decreases the utilization of roughages (Fuller *et al.,* 2004).

The extent to which cellulose is digested in the rumen depends on the degree of lignifications of the plant material. As plant mature fibre increases, protein and energy decrease, digestibility decreases and feed intake decrease. Foods that are low in fibre are equally well digested by both ruminants and non-ruminants, but feeds high in fibre are better digested by ruminants (McDonald *et al.,* 2010). Forages with a high content of cell walls (or neutral detergent fibre) are digested slowly, low in digestibility and promotes low intakes. Reducing particle size of forages by grinding may reduce the digestibility of the fibre by 20% and of the dry matter as a whole by 5 – 15% while increasing passage rate and food intake (Mamoon, 2008). Disrupting the cell walls of forages by chemical treatment increases rate of digestion and rate of passage hence increased utilization of

nutrients as well as voluntary feed intake. The key to improvements in the utilisation of roughages is supplementation. Supplementing a deficient nutrient in a diet will improve intake (McDonald *et al.,* 2010). Increase in intake is associated with protein supplementation and is generally attributed to increasing rumen microbial activity and consequently rate of passage. Variety of species of forage that differ in acceptability in a free choice situation with comparable digestibility may give different intakes when they are the sole feed (Fuller *et al.,* 2004).

2.6 Carcass Characteristics of SEA Goats

A carcass weight is part of slaughtered animal which remain after bleeding, skinning, evisceration and removal of head, feet and genitals. Goat meat is evaluated as of high quality or low by looking at the amount and distribution of fat in relation to lean (Chenyambuga *et al.,* 2004; Mushi *et al.,* 2009). However, meat sellers pay more attention to carcass weight, dressing percentage and carcass composition (Chenyambuga *et al.,* 2004). Generally carcass characteristics may be affected by breed, sex, age, level of protein supplementation, weight at slaughter, pre-slaughter handling of animals, method of dressing and gut fill.

2.6.1 Dressing percentage

Dressing percentage is the proportion of carcass weight to the live weight at slaughter. The dressing percentage of SEA goats compare well with other breeds (Chenyambuga *et al.,* 2004). It ranges between 36.6 to 49.8% in Indian breeds (Saha *et al.,* 2001) and 38.3 to 52.1% in Saanen breed (Coloer-Rocher *et al.,* 1992). A study on crossbred goats in Tanzania indicated that the dressing percentage ranged from 33% through 57% (Mushi *et al.,* 2009) while Assenga (1997) found dressing percentage (DP) to range between 39 to 43%. The value agrees to that reported by Mlela (2012) who found dressing percentage

(DP) in crossbred goats to be 41.59 to 42.11%. Under natural grazing conditions with no supplementation dressing percentage (DP) of 31 to 40% has been reported (Mekasha *et al*., 2010).

2.6.2 Non carcass component

Non carcass components are the head, liver, heart, lungs, intestines, spleen, tongue, skin, feet, testes, cheeks, blood and fat of slaughtered animal. Some authors consider diaphragm, kidney, pelvic fat and tail as non carcass component while others consider them as part of carcass (Chenyambuga *et al.,* 2004). In tropic countries including Tanzania these non carcass components of slaughtered animals are edible and contribute to the overall supply of animal protein (Assenga, 1997).

2.7 Parameter Indicative to Meat Quality

2.7.1 Carcass composition

Carcass composition based on physical dissection refers to the proportion of muscle, bone and fat. Fat is deposited at an increasing rate and lean at decreasing rates (Hadja, 2007). Fat is known to be late maturing tissue which is variable in the body and increases at high level of nutrition. The proportion of lean and bone in the carcasses do not differ significantly but the percentage of fat in the carcasses differs significantly between different levels of protein supplementation (Chenyambuga *et al.,* 2004). A study by Mushi *et al*. (2009) in cross bred SEA goats showed that carcass composition ranged from 68.0% to 73.0% lean meat, 13.30% to 17.21% fat and 6.0% to 18.5% bone. The carcass composition ranging from 58.95% to 60.48% lean meat, 13.30% to 17.21% fat and 23.84% to 26.35% has also been reported by Mekasha *et al*. (2010) for lean meat, fat and bone, respectively. Carcass composition varies depending on the species, age and live weight of the animals at slaughter.

2.7.2 Meat tenderness

Meat tenderness appears to be the most important sensory characteristic and major determinant of eating quality of meat which can be evaluated by mechanical devices or a taste panel. Usually younger animals produce tender meat while older animals produce tough meat (Purslow, 2005). The process of producing quality meat is complex and is influenced by many interacting factors (Mushi *et al.,* 2006). Several studies report that meat tenderness is influenced by connective tissue, intramuscular fat, sarcomere length and post-mortem proteolysis (Mushi *et al.,* 2006). If the connective tissue do not change at post-mortem significantly to the extent that can influence tenderization that meat is thought to be tough (Purslow, 2005). Factors affecting meat tenderness include breed, nutrition, age, and muscle location (Mushi *et al.,* 2006).

2.7.3 Meat pH

Meat quality can be determined by meat pH. The ultimate pH is determined 24 hours post-slaughter, using a pH meter. Good quality meat usually has a pH of 5.5 – 5.7 (Ekiz *et al*., 2012). The muscle of a living animal has a pH of 6.8 to 7.4 (Toshio *et al*., 1997). The extent to which pH is lowered after slaughter depends on the amount of pre-slaughter muscle glycogen reserves in animals. After slaughter anaerobic glycolysis takes place where energy metabolism in muscle breaks down glycogen to produce pyruvate which is reduced to lactate by the NADH thus lactic acid is formed (Fuller *et al*., 2004). Increase in lactic acid is responsible for lowering meat pH to the normal acceptable value of around 5.6. Both high and low pH will affect meat characteristics such as appearance, tenderness, flavour and water holding capacity (Maltin *et al*., 2003).

2.7.4 Cooking loss

Cooking meat is a process of heating beef at sufficiently high temperatures that denatures proteins and makes it less tough and easy to consume (Garcia-Segovia *et al*., 2006). It can be achieved either by boiling or by roasting as reported by Jama *et al.* (2008). Cooking loss which is one of the meat qualities refers to the reduction in weight of meat in major components such as thawing, dripping and evaporation which occur during the cooking process. The lower cooking loss is associated with juiciness of the meat. Percentage Cooking loss as described by Ding *et al*. (2010) = [(weight before cooking – weight after cooking) ÷ weight before cooking] × 100. It is generally regarded that cooking loss is among meat qualities which influence eating quality for the sensory perception of meat by consumers (Ablikim *et al*., 2016).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Overview

Two experiments were carried out at Sokoine University of Agriculture (SUA) to examine effect of *Chromolaena odorata* leaf meal as protein supplement on the growth performance and carcass characteristics of SEA goats. Experiment one involved feed intake and growth study conducted in November 2014 to March 2015 at Department of Animal Science and Production (DASP) dairy goat unit (Magadu Farm). Experiment two was on the determination of *in vitro* digestibility of *Chromolaena odorata* leaf meal and dietary treatments samples. Laboratory analysis to determine nutritional chemical composition of *Chromolaena odorata* leaf meal, individual feed ingredients and feed samples were carried out at DASP, animal nutrition laboratory. The effect of the four dietary treatments on killing out carcass characteristics, physical carcass composition and meat quality was also investigated in this study.

3.2 Description of the Study Area

A study was conducted at Sokoine University of Agriculture (SUA) to investigate performance of SEA goats under different levels of *Chromolaena odorata* leaf meal supplementation. The leaves were obtained from one of the most invaded village of Serengeti District in Mara region. The village is located between 1^{o} to 41^{o} S and 16^{o} to 34^{o} E about 60 km from Musoma town and elevation of about 1300 - 1341 m above sea level, while SUA is located between 6^{o} to 7^{o} S and 37^{o} to 38^{o} E about 3 km from Morogoro town and lies on the western slopes of the Uluguru mountains at an elevation of about 500 - 600 m above sea level.

3.3 Source of Feeding Materials

Chromolaena odorata leaves with immature twigs were picked at flowering stage and they were collected from mostly invaded village in Serengeti district. They were dried for twenty one days under shade, transported to SUA half by private car and another half by public transport. They were milled to get leaf meal which was used in formulating supplementary diet. Other feeding materials used in formulating the supplementary diets included soybean meal, cotton seed cake, maize meal, maize bran, rice polishing, sugarcane molasses, minerals i.e. limestone, salt and vitamin premixes which were purchased from Agro-vets shop in Morogoro Municipality.

3.4 Dietary Formulation and Sample Collection

Four dietary treatments (D1, D2, D3 and D4) were formulated; D2, D3 and D4 comprised of different inclusion levels of *Chromolaena odorata* leaf meal that were 5.0%, 10.0% and 15.0%, respectively while D1 was a control diet without *Chromolaena odorata* leaf meal (Table 6). Feed samples for both individual ingredients and compounded diets were taken for proximate analysis.

Table 6: Physical composition of the dietary treatments

Feed ingredients	Dietary treatments percentage composition (%)			
	D1	D2	D3	D4
Maize bran	35	35	35	35
Maize meal	16	16	16	16
Rice polishing	23	23	20.5	20.5
Sugarcane molasses	1.0	1.0	1.0	1.0
Soybean meal	5.5	5.5	6	8
Cotton Seed Cake	15	10	7	0
COLM	0	5	10	15
Limestone	2.0	2.0	2.0	2.0
DCP	1.5	1.5	1.5	1.5
Vitamin-Mineral Premix	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Total (%)	100	100	100	100

COLM = *Chromolaena odorata* Leaf Meal, DCP = Di-calcium phosphate, D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, D1 to D4 = dietary treatments

3.5 Experimental Animals and Design

The number of goats needed in this study was obtained by using formula (1).

$$n = (t^2 \times cv^2)/d^2 \quad \text{.....} \quad (1)$$

Where n = Minimum number of goats required in the experiment

t = Confidence interval for 95%, selected alpha level of 0.025 in each tail = 1.96

cv = Coefficient of variation in feeding goats, for this case 10%

d = Acceptable margin of error for mean being estimated to be 5%

$n = (1.96^2 \times 0.1^2)/0.05^2$

$= (3.8416 \times 0.01)/0.0025$

$= 15.4 \approx 16$ goats.

Twenty four SEA goats (entire males) aged 12 - 15 months were purchased from livestock keeper at Ubena Zomozi village in Bagamoyo district. The animals were brought at Department of Animal Science and Production Dairy goat unit, Magadu Farm (SUA).

The animals were identified by plastic ear tags and blocked by weight and assigned to the respective treatment at random. Four groups of six animals were formed (three animals in replication one and three animals in replication two) receiving the different dietary treatments namely D1, D2, D3 and D4, respectively.

3.6 Experiment 1: Feed Intake and Growth Study

3.6.1 Management of experimental animals

The animals were identified by ear tagging, drenched with broad a spectrum antihelminthic i.e. albendazole 10% once per experimental time and sprayed with dominix acaricide once weekly to control internal and external parasites, respectively.

A mixture of *Heteropogon contutus, Hyparemia rufa and Urochloa mozambiensis* based hay was used as a basal diet. Experimental goats were provided with 200 g/goat/day of dietary treatment which was gradually increased as the goats became acclimatized to the diet. This amount was offered once daily at 09:00 hour. Adoption period was 10 days prior to data collection. Clean water was offered *ad-libitum* served in plastic containers changed everyday for 90 days of experiment.

3.6.2 Feed intakes and live weight gain recording

Animals were group fed with three animals per pen. Intake for hay and supplementary diet and refusals collected from each allowance for each treatment were recorded on daily bases. Overall dry matter intake was obtained by subtracting refusals collected from the amount of hay offered to animals in each pen in addition to the amount of supplementary diet consumed on daily bases. Average intake was obtained by subtracting refusals from the amount offered divided by number of animal in each pen. Mean initial and final weight

was obtained by weighing experimental goats for three consecutive days after overnight fasting in the morning prior to feeding at the commencement and at the end of experiment, respectively.

3.7 Experiment 2: *In vitro* Digestibility

The two steps procedure according to Tilley and Terry (1963) was used for determination of *in vitro* dry matter (IVDMD) and organic matter digestibility (IVOMD) of *Chromolaena odorata* leaf meal and feed samples.

In vitro dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) were determined by equations (1) and (2).

$$\text{Percentage IVDMD} = \frac{\text{(DM (feed) – (DM (residue) – DM (blank))}}{\text{DM (feed sample)}} \text{ X } 100 \quad \text{……...….. (1)}$$

$$\text{Percentage IVOMD} = \frac{\text{(OM (feed) – (OM (residue) – OM (blank))}}{\text{OM (feed sample)}} \text{ X } 100 \quad \text{…….... (2)}$$

Where,

OM (feed sample) = DM (feed sample) – Ash (feed sample)

OM (sample residue) = DM (sample residue) – Ash (sample residue)

OM (blank) = DM (blank) – Ash (blank)

DM = Dry matter

OM = Organic matter

3.8 Laboratory Chemical Analyses of Feeds

3.8.1 Proximate analysis of *Chromolaena odorata* leaf meal, feed ingredient and experimental diets

Proximate analysis method/procedure developed in Germany was used to determine dry matter (DM), ash, crude protein (CP), crude fibre (CF), nitrogen free extract (NFE) and ether extract (EE) of *Chromolaena odorata* leaf meal and other feedstuffs (AOAC, 2002).

3.8.2 Neutral detergent fibre (NDF) and acid detergent fibre (ADF)

Detergent fibre analysis developed by Van Soest (1967) designed to separate plant tissue into cell wall (NDF) and constituents and cell contents was used due to shortcoming of the proximate analysis (Crude fibre) with missing hemicelluloses, part of lignin and insoluble ash which is supposed to be in fibrous material, as well as Nitrogen free extract (soluble carbohydrate) with excess hemicelluloses, part of lignin and insoluble ash. Insoluble fibre in feed was determined as Neutral Detergent Fibre (NDF). Neutral detergent solution recovers its main components cellulose, hemicelluloses and lignin. As the residue remaining from NDF i.e. an acidified solution was added to determine Acid Detergent Fibre (Van Soest, 1991).

3.9 Carcass Characteristics

3.9.1 Evaluation of killing out characteristics

After 90 days of the experimental period, goats were fasted overnight (16 hours) only drinking water was provided and then weighed to obtain slaughter live weight. Slaughtering was performed where the head were removed at the atlanto-occipital joint, fore and hind feet removed at the carpal and tarsal joint, respectively. Slaughtered animal was hanged from achille tendon shortly for proper and efficient bleeding. Skinning was done there after and non-carcass component were removed, weighed and recorded. The

guts were striped and emptied. Weight of gut was subtracted from slaughter weight to get empty body weight (EBW) and weight of gut content was added to the overnight weight loss to get the gut fill.

Carcasses were weighed to obtain hot carcass weight (HCW) and then split longitudinally into two halves from caudal part to the first cervical vertebrae cutting along the median exposing the spinal cord. The *Longissimus dorsi* muscle from the right carcasses were removed for cooking losses and meat tenderness evaluation while the remaining part of the right carcasses were disposed for human consumption. The left side carcasses were weighed and stored in the refrigerator at 4^0C for 24 hours. After overnight storage, the left half carcasses were re-weighed to obtain cold carcass weight (CCW). The pH and temperature was taken and recorded at 45 minutes 6 hours and 24 hours post-mortem. Carcasses were stored in the freezer (-25^0C) for carcass composition determination.

3.10 Evaluation of Meat Quality

3.10.1 Meat pH

The carcass pH and temperatures was measured in 45 minutes, 6 hours and 24 hours post-mortem using a portable digital pH meter (knick- portamess 910) and meat thermometer. The pH meter was calibrated at room temperature of 28^0C in standard buffer solution for pH range of 4.0 and pH 7.0. The electrode and thermometer were inserted into *biceps femoris* muscles of the left half-carcasses and the readings recorded. Six hours post-mortem before measurement calibration of pH meter was resumed at room temperature (28^0C). Carcasses were then refrigerated at 4^0C for 24 hours. Prior to pH and temperature measurement calibration of pH meter at 4^0C was done and probed on the same muscle. All values of pH and temperature were recorded.

3.10.2 Cooking loss

Evaluation of percentage cooking loss was done for *longissimus dorsi* muscle dissected from the right side of the carcasses 24 hours at 4^0C post-mortem. The *longissimus dorsi* muscle measuring 8cm long from right side carcass of each animal was weighed (W1) and vacuum packed in plastic bags. Packed muscle samples were then cooked in a thermostatically controlled water bath set at 72^0C for 45 minutes. The cooked muscle samples were then removed from water bath and were cooled under running tap water for 2 hours. They were then stored in a refrigerator at 4^0C and removed after 24 hours unpacked from plastic bags, blot dried and weighed (W2). The difference between (W1) and (W2) were recorded as (W3). The percentage cooking loss was estimated as per equation 3.

Percentage cooking loss = (W3 /W1) *100..... (3)

3.10.3 Meat tenderness (Warner Bratzler Shear force)

Warner Bratzler Shear force (WBSF) values were determined by shearing cubes of cooked muscle samples which were used for measurements of cooking loss. Three sub samples from each cooked muscle sample measuring 1 x 1 cm and 3 cm long was incised parallel to the muscle fibres. These sub samples were sheared with Warner Bratzler Shear Force (WBSF) blade attached to Zwick/Roell (Z2.5, German) instrument set at a cross head speed of 110 mm/min fitted with inverted V- blade positioned perpendicular to muscle fibre. The average of three samples measured was considered to be WBSF read value in Newton (N).

3.11 Physical Carcass Composition

The left side carcasses were jointed into seven standard joints i.e. neck, ribs, breast, loin, chump, hind leg and fore leg as reported by Hozza *et al.* (2014). The joints were weighed

and recorded. Each cut was dissected with scalpel blades to separate lean, fat and bone weighed separately and recorded for estimation of percentage lean, fat and bone in the carcass.

3.12 Statistical Data Analysis

3.12.1 Growth and feed conversion efficiency

Initial body weights were taken as covariate to take care of initial differences in body weights. General Linear Model (Proc GLM) of SAS (2002) was used to analyze data for the effect of *Chromolaena odorata* leaf meal according to statistical model (1).

$Yij = \mu + Di + b(Xij - \sum X/n) + \varepsilon ij$ …… (1)

Where,

Yij = Response

μ = General mean

Di = Effect of dietary treatment

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

Xij = Initial body weight of individual animal

∑X/n= Mean of initial body weight in the experiment.

εij = Random error

3.12.2 Killing out and physical carcass characteristics

The difference between least squares means of killing out and physical carcass characteristics for each treatment was compared by probability of difference (PDIFF) of the GLM procedure of SAS (2002). Statistical model (2) was used.

$Yij = \mu + Di + b(Xij - X) + \varepsilon ij$ ……...…… (2)

Where,

Yij = Carcass characteristics of j^{th} animal of i^{th} treatment

μ = General mean

Di = Effect of i^{th} treatment

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

Xij = slaughter weight of individual animal

X = Mean slaughter weight of experimental animals

εij = Residue effect to each animal.

3.12.3 Evaluation of meat quality

3.12.3.1 Cooking loss, meat tenderness and pH

Data on cooking loss, meat tenderness and pH meat were analyzed by General Linear Model (Proc GLM) of SAS (2002) for the effect of dietary treatment on meat quality. Statistical model (3) was used.

Yij = μ + Di + εij ……..……...……. (3)

Where,

Yij = Response

μ = General mean

Di = Effect of i^{th} treatment

εij = Random error to each animal

CHAPTER FOUR

4.0 RESULTS

4.1 General Observations

Generally the experiment was carried out as it was planned. Twenty four animals were placed in four blocks containing six animals; group fed with three animals per pen each block receiving different dietary treatment. These animals were totally confined in eight pens. At week seven of experiment animal number 41 receiving dietary treatment one (D1), 25 (D3) and 44 (D4) in replication two was observed to be off the feeds (low appetite), dull with labored breathing, thick nasal discharge, profuse diarrhea, and high body temperature ($40 – 41^0$C). All experimental animals were treated with oxtetracycline antibiotics (OTC 10%) and dexamethasone, they responded positively. However, three animals mentioned above and other two animals 76 (D3), 70 (D4) in replication one died. The ill health and death of goats observed was caused by *Peste des Petitis Ruminants* (PPR) disease outbreak as it was confirmed to occur at Magadu farm. The data which was collected from these five animals and other three animals 78 (D1), 73 (D2) in replication one and 46 (D2) in replication two were excluded from analysis. This chapter reflects findings of experiments to answer objectives listed in chapter one subsection 1.3.2.

4.2 Laboratory Evaluation of Feedstuffs

4.2.1 Proximate analysis of *Chromolaena odorata* leaf meal

The mean value of chemical composition of *Chromolaena odorata* leaves before flowering and at flowering are presented in Table 7. Before flowering, *Chromolaena odorata* had relatively higher crude protein (CP) and gross energy contents (24.35% and 3.15 kcal/g, respectively) than at flowering (13.61% and 2.61 kcal/g, respectively). Ether extract (EE) in *Chromolaena odorata* at flowering (2.81%) was higher compared to

Chromolaena odorata before flowering (2.19%). *Chromolaena odorata* at flowering had higher crude fibre (28.35%) as compared to *Chromolaena odorata* before flowering (14.65%). Calcium and Phosphorus contents were observed to be 1.14% and 0.19% in *Chromolaena odorata* before flowering and 0.98% and 0.29% at flowering. Both *in vitro* dry matter and organic matter digestibility in *Chromolaena odorata* before flowering were higher 69.45% and 68.04% as compared to 50.08% and 49.35% at flowering, respectively.

Table 7: Proximate composition and *In vitro* digestibility of *Chromolaena odorata* leaf meal

Nutritional component	Percentage composition (%)	
	C. odorata before flowering	*C. odorata* At flowering
DM	90.49	92.59
Ash	12.11	10.40
CP	24.35	13.61
CF	14.65	28.35
EE	2.19	2.81
NFE	37.19	37.43
GE (kcal/g)	3.15	2.61
Ca	1.14	0.98
P	0.19	0.29
In vitro digestibility		
IVDMD	69.45	50.08
IVOMD	68.04	49.35

Values are means of duplicate determination, GE = Gross energy, IVDMD = *In vitro* dry matter digestibility, IVOMD = *In vitro* organic matter digestibility, *C. odorata* = *Chromolaena odorata*

4.2.2 Nutritive value of feed ingredients and experimental diets

The nutritive values of feedstuff ingredients and experimental diets are shown in Tables 8 and 9, respectively. Maize meal with 13.03 ME (MJ/Kg DM) was used as main source of energy. *Chromolaena odorata* leaf meal (13.61% CP) was used to replace cotton seed

cake (28.22% CP). Soybean meal (37.46% CP) was used as alternative source of protein. Hay with very low CP (3.41 %) and energy (1.87 MJ/kg DM), was used as a basal diet for SEA goats. Diet D2 had slightly lower EE than other diets. The difference in CF, NFE and ADF contents was observed in experimental diets. Nutrient Detergent fibre in diet D1 and D2 was higher as compared to diets D3 and D4.

Energy in diet D2 and D4 was slightly higher than energy in diet D1 and D3. *In vitro* dry matter digestibility (IVDMD) for diet D1and D4 was slightly lower than IVDMD D2 and D3. *In vitro* organic matter digestibility (IVOMD) of diet D2 and D3 was slightly higher than IVOMD in diets D1 and D4.

Table 8: Chemical composition of feed ingredient used in the study

Feedstuffs	Percentage composition (%)						
	DM	Ash	CP	EE	CF	NFE	ME (MJ/Kg DM)
Maize meal	87.70	5.82	8.30	3.71	2.68	67.19	13.03
Maize bran	89.57	5.87	8.38	3.79	5.33	66.33	12.52
Rice polishing	91.05	7.33	7.82	1.18	2.89	71.83	12.84
Soybean meal	89.30	6.45	37.46	1.67	5.94	37.78	12.43
Cotton seed cake	90.12	5.96	28.22	11.64	19.77	24.53	9.76
COLM	92.59	10.40	13.61	2.81	28.35	37.42	5.08
Hay	94.58	7.56	3.41	0.76	39.48	43.37	1.87

Values are means of duplicate determination, COLM = *Chromolaena odorata* leaf meal, ME (MJ/Kg DM) = Metabolizable energy, NFE = Nitrogen free extract

Table 9: Chemical composition and *in vitro* digestibility of experimental diets

Nutritional Component	Dietary Treatment			
	Percentage composition (%)			
	D1	D2	D3	D4
DM	97.13	96.13	95.75	97.29
OM	88.49	88.55	86.35	87.03
Ash	11.51	11.48	13.65	12.97
CP	15.9	16.61	16.36	15.39
EE	7.58	7.21	7.67	7.58
CF	16.36	12.91	14.69	11.12
NFE	45.73	47.92	43.39	50.25
NDF	35.32	31.85	30.93	30.78
ADF	9.31	7.85	7.04	6.94
Ca	1.21	1.24	1.63	1.06
P	0.60	0.52	0.62	0.45
ME (MJ/Kg DM)	10.16	11.03	10.14	11.57
In vitro Digestibility				
IVDMD	59.78	71.01	71.49	67.69
IVOMD	60.88	72.02	72.79	68.94

Note: values are means of duplicate determination, ME MJ/Kg = Metabolisable energy, D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal, Ca = Calcium, P = Phosphorus, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, IVDMD = *In vitro* dry matter digestibility, IVOMD = *In vitro* organic matter digestibility

4.3 Effect of *Chromolaena odorata* leaf meal on dry matter intake

The average daily feed intake as fed and dry matter intake of hay (roughage) and concentrates are presented in Table 10. The dry matter intake of supplementary experimental diet D1 and D2 was slightly higher than dry matter intake of diet D3 and D4. The average dry matter intake for concentrate ranged from 224.48 g/day in D3 to 249.64 g/day in D1. Hay dry matter intake by SEA goats supplemented with D4 was slightly higher than supplementary diets. The relatively lower value of hay intake was observed in

SEA goats supplemented with D3. The highest value of total dry matter intake (379.29 g/day) was observed in SEA goats supplemented with D2 while the lowest value (343.38 g/day) was observed in SEA goats supplemented with D3.

Table 10: Average daily feed intake

Component	Average daily feed intake (g/day)			
	D1	D2	D3	D4
As fed concentrates	266.99	265.32	242.05	250.01
As fed hay (roughages)	136.65	131.36	125.82	143.61
Total as fed concentrates	403.65	396.68	367.87	393.63
Dry matter intake (concentrates)	249.64	246.06	224.38	232.48
Hay dry matter intake	129.25	124.23	119.00	135.85
Total dry matter intake	378.86	379.29	343.38	368.31

Note: D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal

4.4 Effect of *Chromolaena odorata* Leaf Meal on Weight Gain of SEA Goats

The least square means of SEA goats` performance are presented in Table 11. The final weights of SEA goats in D1 and D2 (after 90 days) were significantly ($p<0.05$) higher than those of D3 and D4. The experimental animals supplemented with D2 had significant ($p<0.05$) highest average daily weight gain (54.18 g/day) followed by D1 (35.28 g/day) where as D3 and D4 had lowest daily weight gains (27.78 and 25.00 g/day, respectively) that did not differ significantly ($p>0.05$). Feed conversion efficiency in SEA goats supplemented with D1 (0.10) and D2 (0.15) did not differ but were significantly ($p<0.05$) higher than that of goats under D3 (0.08) and D4 (0.07) diets. Feed conversion ratio of SEA goats supplemented with experimental diets D1 and D2 were significantly lower than for the goats in diets D3 and D4 ($p<0.05$).

Table 11: Least square means and SEM of SEA goat's growth performance during growth study

Parameter	SEA goats performance					
	D1	D2	D3	D4	SE	*P*-value
Final weight (kg)	17.00[b]	18.38[b]	14.88[a]	15.25[a]	± 0.81	0.0331
Weight gain (kg)	3.18[b]	4.88[a]	2.5[c]	2.25[c]	± 0.25	<.0001
Growth rate (g/day)	35.28[b]	54.18[a]	27.78[c]	25.00[c]	± 2.73	<.0001
Feed conversion efficiency	0.10[b]	0.15[b]	0.08[a]	0.07[a]	± 0.01	0.0001
Feed conversion ratio	10.87[a]	6.95[a]	12.56[b]	14.90[b]	± 0.80	0.0001

Note: [abc]L.S means within rows without common superscript differ significantly ($p < 0.05$). D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal

4.5 Effect of *Chromolaena odorata* Leaf Meal on Killing out and Non-carcass Components, Carcass Characteristics, Physical Carcass Composition, Meat pH, Cooking Loss and Meat Tenderness of SEA Goats

Carcass and edible non-carcass components weights are presented in Table 12. The experimental diets did not influence significantly ($p>0.05$) any carcass component. The dressing percentage of experimental SEA goats ranged from 40.21 in D1 to 42.10% in D2. Generally SEA goats supplemented with experimental diets D1 and D2 had numerically heavier carcass weight and fat values compared to those supplemented with D3 and D4.

The carcass joints presented in Table 13 shows numerically higher weight values for neck in D1, D2 and D3 as compared to D4. Ribs in D1 and D2 were numerically higher weight than in D3 and D4. Physical carcass composition (Table 14) shows percentage of lean meat from side carcass which ranged from 58.95 to 60.48%, fat 13.30 to 17.21% and bones 23.84 to 26.35%. Lean tissue was numerically higher in D3 (60.48%) and lower in D1 (58.95%) and the fat was relatively higher in D1 (17.21%) and lower in D4 (13.30%). The percentage of bones ranged from 23.84 to 26.35%. Numerically lower bone

percentage was observed in D1 (23.84%) and slightly higher in D4 (26.35%). The ratio of lean to fat was observed to be rather lower in D1 (3.61) and comparatively higher in D4 (4.56) while lean to bone ratio was slightly lower in D4 (2.31) than in D1 (2.49). Lean plus fat to bone ratio was observed to be slightly higher in D1 (3.22) and lower in D4 (2.82).

Meat pH, cooking loss and meat tenderness of SEA goats supplemented with four experimental diets are presented in Table 15. At 45 minutes post slaughter the meat pH was observed to be rather higher in D1 (6.71) at 34.5^0C and lower in D2 (6.42) at 35.5^0C. After 24 hours post slaughter pH was slightly higher in D4 (5.73) at 3.5^0C and lower in D3 (5.56) at 7.0^0C. The cooking loss and shear force ranged from 24.61 to 28.05% and 35.08 to 39.66 N, respectively.

Table 12: Least square means for killing out characteristics and edible non-carcass components

Parameter	Dietary treatment					
	D1	D2	D3	D4	SEM	*P*-value
Slaughter weight (kg)	16.96[b]	18.04[c]	14.86[a]	14.82[a]	± 0.81	0.0361
Empty body weight (kg)	14.49	14.72	12.36	12.95	± 0.87	0.2106
Carcass wt (kg)	7.23	7.38	6.10	6.05	± 0.49	0.1525
Dressing (%)	42.10	40.21	40.94	40.50	± 1.44	0.8045
Edible non-carcass component (kg)						
Head	1.01[b]	1.11[b]	0.88[a]	0.97[a]	± 0.05	0.0382
Pluck	0.26	0.26	0.24	0.23	± 0.02	0.5108
Gut (empty)	1.63	1.56	1.59	1.50	± 0.19	0.9682
Liver	0.28	0.30	0.27	0.25	± 0.02	0.2340
Kidney	0.05	0.05	0.05	0.05	± 0.001	0.1402
Spleen	0.03	0.02	0.02	0.02	± 0.002	0.7837
Gut fat	0.26	0.30	0.22	0.25	± 0.059	0.8204
Hind feet	0.21	0.23	0.18	0.20	± 0.012	0.1195
Fore feet	0.231	0.25	0.19	0.22	± 0.014	0.1111
Tail	0.02	0.03	0.02	0.02	± 0.002	0.0660

Note: [abc]L.S means within rows with the same superscript are not significantly different ($p>0.05$) D1 = 0% COLM, D2 = 5%COLM, D3 = 10%COLM, D4 = 15%COLM, COLM =*Chromolaena odorata* Leaf Meal

Table 13: Least square means for effect of dietary treatment on left half carcass and joints weights

Parameter	Dietary Treatment					
	D1	D2	D3	D4	SE	*P*- value
Left Hot carcass (kg)	3.59	3.75	3.04	3.10	± 0.27	0.2084
Left Cold carcass (kg)	3.42	3.64	2.95	2.96	± 0.25	0.1909
Left Cold carcass joints (kg)						
Neck	0.32	0.34	0.31	0.26	± 0.04	0.6229
Ribs	0.62	0.60	0.49	0.48	± 0.05	0.1562
Breast	0.29	0.29	0.23	0.20	± 0.03	0.1468
Loin	0.33	0.34	0.29	0.29	± 0.04	0.6422
Chump	0.32	0.35	0.23	0.28	± 0.04	0.1390
Hind leg	0.76	0.79	0.66	0.68	± 0.06	0.4775
Fore leg	0.70	0.75	0.61	0.63	± 0.05	0.2799

D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal

Table 14: Least square means of physical carcass composition (left cold carcass)

Parameter	Dietary Treatment					
	D1	D2	D3	D4	SE	*P*-value
Lean (kg)	1.93	2.00	1.66	1.67	± 0.15	0.2742
Fat (kg)	0.57	0.51	0.39	0.38	± 0.06	0.1163
Bone (kg)	0.78	0.83	0.69	0.72	± 0.05	0.2179
Carcass tissue						
as percentage (%) of carcass weight						
Lean	58.95	59.87	60.48	60.36	± 1.08	0.7486
Fat	17.21	15.34	14.03	13.30	± 1.36	0.2434
Bone	23.84	24.79	25.49	26.35	± 0.95	0.3366
Carcass tissue ratios						
Lean : Fat	3.61	4.11	4.32	4.56	± 0.41	0.4317
Lean : Bone	2.49	2.42	2.38	2.31	± 0.11	0.6720
Lean + Fat : Bone	3.22	3.05	2.94	2.82	± 0.15	0.3434

D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal

Table 15: Least square means for meat quality by dietary treatment

Variable	Dietary treatment					
	D1	D2	D3	D4	SE	*P*-value
pH						
45 minutes	6.71	6.42	6.52	6.51	± 0.08	0.1837
6 hours	5.80	5.63	5.69	5.62	± 0.08	0.5031
24 hours	5.67	5.65	5.56	5.73	± 0.04	0.1385
Temperature (^{0}C)						
45 minutes	34.50	35.50	34.25	32.00	± 1.13	0.2995
6 hours	26.50	27.50	26.50	27.50	± 0.50	0.3813
24 hours	4.50	8.00	7.00	3.50	± 0.94	0.0759
Cooking loss percentage (*l.d*)	25.65	24.80	28.05	24.61	± 1.77	0.5185
Shear force (*l.d*) (N)	35.08	33.14	39.66	31.66	± 3.95	0.5314

L.d = *Longissimuss dorsi* muscle, N = Newton, D1 = 0% COLM, D2 = 5% COLM, D3 = 10% COLM, D4 = 15% COLM, COLM = *Chromolaena odorata* Leaf Meal

CHAPTER FIVE

5.0 DISCUSSION

5.1 General Observations

The main objective of this study was to investigate on the effect of *Chromolaena odorata* leaf meal as protein supplement on the growth performance and carcass characteristics of SEA goats. It was hypothesized that the inclusion of *Chromolaena odorata* leaf meal in SEA goats' diets improves their performance in term of live weight gain, carcass composition and meat quality. The ill health and death of goats observed at week seven of experiment was caused by *Peste des Petitis Ruminants* (PPR) disease outbreak as it was confirmed to occur at Magadu farm.

5.2 Chemical composition of *Chromolaena odorata* Leaf Meal, other Feedstuffs and Dietary Treatments

The chemical composition of *Chromolaena odorata* leaves before flowering indicated nutritional profiles which were comparable to the reported values by Aro *et al.* (2009), Nwinuka *et al*. (2009). The CP content of 24.35% for *Chromolaena odorata* before flowering obtained in this study conform to the one reported by Nwinuka *et al*. (2009). Higher CP value (29.76%) was reported by Bamikole *et al.* (2004). The CP (13.6%) value at flowering was used in the formulation of experimental diets, was slightly lower than other reported values (18.67%, 16.2% and 18.7%) by Fasuyi *et al.* (2005), Igboh *et al*. (2009) and Aro *et al*. (2009), respectively. These differences might be due to environmental factors such as temperature, sunlight, soil moisture and fertility and stage of growth during sample collection. Higher *In vitro* dry matter digestibility of *Chromolaena odorata* before flowering was possibly due to high level of CP, low fibre content and stage of plant maturity. The provision of protein may enhance the activity of the rumen

microorganisms and improve digestibility of poor quality feedstuffs (McDonald *et al.,* 2010). The gross energy content of *Chromolaena odorata* 2.61 kcal/g at flowering is also lower than 3.73 kcal/g reported by Aro *et al.* (2009) but slightly higher than the value (2.20 kcal/g) reported by Nwinuka *et al.* (2009). Ether extracts (2.81%) and crude fibre (28.35%) at flowering were higher than before flowering 2.19% (EE) and 14.65% (CF) due to plant maturity. As plant mature crude protein and energy decreases while crude fibre increases. *Chromolaena odorata* was found to have 1.14% Ca and 0.19% P before flowering while at flowering Ca content decreased to 0.98% and P increased to 0.29%. Mineral content of *Chromolaena odorata* conformed to the amount of minerals contained in the formulated diets. This indicates that *Chromolaena* odorata is a rich source of minerals as reported by Nwinuka *et al*. (2009). The nutrient profile of *Chromolaena odorata* leaf meal is similar to standard concentrates and thus can be used as ingredient in formulating animal feeds (Bamikole *et al.,* 2004). However, bio-availability may differ due to presence of ant nutritional factors. Therefore *Chromolaena odorata* can be used not only as feed ingredient in formulating livestock feeds but also as mineral source.

The CP contents of experimental diets were approximately similar. A study on SEA goats by Chenyambuga *et al.* (2004) indicated that varying crude protein beyond goats` requirements does not improve their performance. The NDF and ADF in all experimental diets were decreasing as the amount of cotton seed cake was replaced with *Chromolaena odorata* leaf meal. Neutral Detergent Fibre is an estimate of the cell wall fraction of forages and mixed feeds. It is used to measure the amount of cell wall in feeds (Fuller *et al.,* 2004). In vitro dry matter digestibilities of experimental diets D2 and D3 were numerically higher than D1. On the other hand ether extract (EE) in D1, D3 and D4 was slightly higher than in D2. The lower digestibility in D1 could be due to high level of

cotton seed cake which might have increased the amount of indigestible fibre in the diet. The CP content of D1 was also slightly lower than the other diets.

5.3 Feed Intake

The dry matter intake (concentrates) was higher in D1 (249.64 g/day) and D2 (246.06 g/day) than in D3 (224.38 g/day) and D4 (232.48 g/day). Lower intake in D3 and D4 could be due diet composition i.e. increased level of *Chromolaena odorata* leaf meal which releases unpleasant odour to feeding animals.

The age of goats at the beginning of the experiment could also influence the dry matter intake. In a study by Shirima *et al.* (2014) it was observed that dry matter intake as percentage of body weight was significantly higher in older than younger lambs, thus the amount of feed required for a kilogram gain increased with age of the entry to the experimental diet.

5.4 Weight Gain and Feed Conversion of SEA Goats

The average weight gain of SEA goats varied with experimental diets. The highest value of weight gain (54.18 g/day) was recorded in SEA goats supplemented with D2 (5% *Chromolaena odorata* leaf meal) and the lowest weight gain (25.0 g/day) in SEA goats supplemented with D4 (15% *Chromolaena odorata* leaf meal). Increasing level of *Chromolaena odorata* leaf meal in the diet from 5 to 10% decreased weight gain of SEA goats by 50%. This was observed in SEA goats supplemented with D3 (10% *Chromolaena odorata* leaf meal) with weight gain of 27.78 g/day. Feed conversion efficiency of D2 (0.15) was nearly double that of D4 (0.07). Low weight gain in D3 and D4 is not related to energy or protein levels since these levels were nearly the same in all four diets. Same results have been reported by Apori *et al.* (2000). This could be due to ant-nutritional

factors which may lower the absorption of digested materials in the small intestine. This finding suggests inclusion of only 5% *Chromolaena odorata* leaf meal to be used in formulation of diets for SEA goats for better growth performance.

5.5 Carcass Characteristics

5.5.1 Killing out characteristics and edible non-carcass components

Slaughter weight, carcass weight and edible non-carcass components in goats fed dietary treatments D1 and D2 were numerically higher than for goats fed higher ration of dietary treatments D3 and D4. This is an indication that diets D1 and D2 were efficiently utilized as it is also expressed by lower values of feed conversion ratio. At the level of 5% *Chromolaena odorata* leaf meal, slaughter weight and carcass weight were 1.08 kg and 0.15 kg respectively above the control diet. Additional *Chromolaena odorata* leaf meal to 10% however, lowered slaughter weight and carcass weight by 2.1 kg and 1.13 kg respectively as compared to the control diet. Currently *Chromolaena odorata* leaves is not used for feeding livestock especially goats. However, *Chromolaena odorata* leaf meal fed with other feeding materials may give higher slaughter weight. Therefore it is worthy to use *Chromolaena odorata* leaf meal up to only 5% of feed when supplementing goats in Serengeti district.

5.5.2 Physical carcass composition

Carcass dressing percentage determines amount and value of meat and therefore is an important measure of assessing performance of meat producing animals. The dressing percentage and carcass tissue ratio between four treatments did not differ significantly. The values for dressing percentage observed in SEA goats fed experimental diets were within the expected range of 33% through 57% as reported for crossbred goats in Tanzania (Mushi *et al.,* 2009). The dressing percentage observed in this study was comparable to

41.59% and 42.11% as observed by Mlela (2012) in crossbred goats. Slightly higher dressing percentage 42.10% was observed in goats fed dietary treatment D1. However, dressing percentage ranging from 31 to 40% under natural grazing conditions with no supplementation for goats have been reported by Mekasha *et al.* (2010).

The carcass composition ranged from 58.95% to 60.48% lean meat, 13.30% to 17.21% fat and 23.84% to 26.35% bone. These values were lower for lean, higher for bone and in agreement with fat values to those reported by Mushi *et al*. (2009) in cross bred SEA goats (68 - 73%, 13.30 – 17.21% and 6.0 – 18.5%), respectively. In the current study diets D1 and D2 had lower bone percentage, lower ratio of lean to fat and lower lean to bone ratio. However, most people currently prefer lean meat due to health problems associated with large amount of fat in the meat. Therefore the value of goat meat with optimum fat distribution depends on consumer`s preference.

5.5.3 Meat quality of SEA goats

At 45 minutes post slaughter the meat pH for all treatment was above 6.0 and at 24 hours post slaughter the meat pH was above 5.5 for all treatment, ranging between 5.56 – 5.73 and temperature ranged from 3.5 – 8.0^0C. A difference in temperature was caused by the difference in the carcass fat between different treatments. The pH values were within the acceptable range of pH 5.5 – 5.7 as reported by Ekiz *et al*. (2012). In the current study pH values indicate that ante-mortem glycogen reserves were high as a result an in build up of lactic acid, which causes a drop in pH of the meat. If the animal's glycogen is depleted before slaughter, the pH may not drop quickly enough after slaughter because of insufficient lactic acid production. In this case the meat will be dark, firm, and dry (DFD) making meat more susceptible to spoilage microorganisms (Adzitey and Nurul, 2011).

The cooking loss of *longissimuss dorsi* muscle dissected from right carcasses ranged from 24.61% (D4) to 28.05% (D3). Lower cooking loss is associated with juiciness of meat which suggests high water holding capacity in the muscle. Therefore dietary treatments had insignificant influence on cooking loss.

Shear force and cooking loss of goat meat of the same treatment (D3) was observed to be higher (Table 15). As water was retained in the muscle the meat turns out to be tender. In general meat with shear force (WBSF) values exceeding 55 N is considered as tough (Abdullah and Musallam, 2007). The shear force values obtained from the current study considers that meat from experimental animals was tender.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Basing on the finding from this study of the effect of *Chromolaena odorata* leaf meal as protein supplement on the growth performance of SEA goats, the following conclusions can be made:-

i. *Chromolaena odorata* leaf meal has potential nutritional profile similar to some ingredients used in formulating livestock feeds hence could be incorporated in SEA goat`s ration and contributing in the control of the weed where it is widely found.

ii. The optimum level of inclusion of *Chromolaena odorata* leaf meal as protein supplement in SEA goats` ration formulation should not exceed 5% in order to attain higher growth rates.

iii. Feeding *Chromolaena odorata* leaf meal has no observable pathological effect on carcass, non carcass components and meat quality even though further detailed research is necessary to investigate real cause of declining feed intake with increased levels of *Chromolaena odorata* leaf meal in the diet.

6.2 Recommendations

i. Preparation of *Chromolaena odorata* leaf meal should be at immature stage of the plant growth i.e. before seed set so as to avoid the risks of dispersal of the weed to areas which is not invaded and also take advantage of higher nutritive value that decline with plant maturity.

ii. Study on the effect of *Chromolaena odorata* leaf meal on milk production and quality and the performance of other livestock species is required for immediate realization of its benefit to a wider use in livestock production.

iii. Using *Chromolaena odorata* leaf meal as livestock feed could not itself provide suitable means of control of the weed on grazing and cropping lands. Only small amount of *Chromolaena odorata* leaf meal is required for livestock as compared to its coverage in vast grazing and agricultural lands in Serengeti District. Therefore integrated efforts from villagers, government and all environmental stakeholders should be made in controlling this invasive weed.

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APPENDICES

Appendix 1: ANOVA Table summary for the effect of *C. odorata* on growth performance of SEA goats

Dependent Variable: Final weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	31.62500000	10.54166667	4.06	0.0331
Error	12	31.12500000	2.59375000		
Corrected Total	15	62.75000000			

R-Square	Coeff Var	Root MSE	FNWT Mean
0.503984	9.835190	1.610512	16.37500

Dependent Variable: Weight gain

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	16.79500000	5.59833333	23.13	<.0001
Error	12	2.90500000	0.24208333		
Corrected Total	15	19.70000000			

R-Square	Coeff Var	Root MSE	WTGAIN Mean
0.852538	15.37561	0.492020	3.200000

Dependent Variable: Growth rate

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2073.604350	691.201450	23.12	<.0001
Error	12	358.719250	29.893271		
Corrected Total	15	2432.323600			

R-Square	Coeff Var	Root MSE	WTGAINg Mean
0.852520	15.37751	5.467474	35.55500

Dependent Variable: Feed conversion ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.01386875	0.00462292	20.74	<.0001
Error	12	0.00267500	0.00022292		
Corrected Total	15	0.01654375			

R-Square	Coeff Var	Root MSE	FCR Mean
0.838308	15.41202	0.014930	0.096875

Dependent Variable: Feed conversion efficiency

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	135.0225250	45.0075083	17.56	0.0001
Error	12	30.7544500	2.5628708		
Corrected Total	15	165.7769750			

R-Square	Coeff Var	Root MSE	FCE Mean
0.814483	14.13439	1.600897	11.32625

Dependent Variable: Average dry matter intake concentrates per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1664.712200	554.904067	4.27	0.0286
Error	12	1558.377800	129.864817		
Corrected Total	15	3223.090000			

R-Square	Coeff Var	Root MSE	DMCOId Mean
0.516496	4.785347	11.39582	238.1400

Dependent Variable: Average dry matter intake roughage hay per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	618.634275	206.211425	0.64	0.6028
Error	12	3856.640700	321.386725		

Corrected Total	15	4475.274975		

R-Square	Coeff Var	Root MSE	DMROId Mean
0.138234	14.10748	17.92726	127.0763

Dependent Variable: Average total dry matter intake per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2796.81852	932.27284	1.27	0.3295
Error	12	8825.52668	735.46056		
Corrected Total	15	11622.34519			

R-Square	Coeff Var	Root MSE	TDMId Mean
0.240641	7.425579	27.11938	365.2156

Dependent Variable: Average as fed concentrates per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1752.925275	584.308425	3.90	0.0370
Error	12	1795.639300	149.636608		
Corrected Total	15	3548.564575			

R-Square	Coeff Var	Root MSE	ASFEDCO Mean
0.493982	4.776658	12.23260	256.0913

Dependent Variable: Average as fed roughage hay per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	691.599569	230.533190	0.64	0.6028
Error	12	4311.370075	359.280840		
Corrected Total	15	5002.969644			

R-Square	Coeff Var	Root MSE	ASFEDRO Mean
0.138238	14.10760	18.95470	134.3581

Dependent Variable: Average total as fed concentrates + roughage hay per goat/day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2932.08590	977.36197	1.18	0.3596
Error	12	9970.89000	830.90750		
Corrected Total	15	12902.97590			

R-Square	Coeff Var	Root MSE	TASFED Mean
0.227241	7.382579	28.82547	390.4525

Appendix 2: ANOVA Table summary for the effect of *C. odorata* on carcass and edible non-carcass components of SEA goats

Dependent Variable: Slaughter body weight (kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	30.65346875	10.21782292	3.94	0.0361
Error	12	31.13442500	2.59453542		
Corrected Total	15	61.78789375			

R-Square	Coeff Var	Root MSE	SBWT Mean
0.496108	9.961001	1.610756	16.17063

Dependent Variable: Carcass weight (kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6.12825000	2.04275000	2.11	0.1525
Error	12	11.62265000	0.96855417		
Corrected Total	15	17.75090000			

R-Square	Coeff Var	Root MSE	CWT Mean
0.345236	14.71628	0.984151	6.687500

Dependent Variable: Gut (kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.18285000	1.06095000	4.52	0.0242
Error	12	2.81475000	0.23456250		
Corrected Total	15	5.99760000			

R-Square	Coeff Var	Root MSE	Gut Mean
0.530687	11.01972	0.484317	4.395000

Dependent Variable: Empty gut (kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.03666875	0.01222292	0.08	0.9682
Error	12	1.77622500	0.14801875		
Corrected Total	15	1.81289375			

R-Square	Coeff Var	Root MSE	Empgut Mean
0.020227	24.49547	0.384732	1.570625

Dependent Variable: Empty body weight (kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	16.01665000	5.33888333	1.75	0.2106
Error	12	36.66265000	3.05522083		
Corrected Total	15	52.67930000			

R-Square	Coeff Var	Root MSE	Emptybwt Mean
0.304041	12.82641	1.747919	13.62750

Dependent Variable: Dressing percentage

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	8.2443571	2.7481190	0.33	0.8045
Error	12	100.2127605	8.3510634		

Corrected Total	15	108.4571176		

R-Square	Coeff Var	Root MSE	Dp Mean
0.076015	7.059142	2.889821	40.93728

Dependent Variable: Head (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	109116.1875	36372.0625	3.86	0.0382
Error	12	113047.7500	9420.6458		
Corrected Total	15	222163.9375			

R-Square	Coeff Var	Root MSE	Hd Mean
0.491152	9.778730	97.06001	992.5625

Dependent Variable: Pluck (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2542.25000	847.41667	0.81	0.5108
Error	12	12503.50000	1041.95833		
Corrected Total	15	15045.75000			

R-Square	Coeff Var	Root MSE	Pluck Mean
0.168968	13.07519	32.27938	246.8750

Dependent Variable: Liver (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	5843.50000	1947.83333	1.63	0.2340
Error	12	14318.50000	1193.20833		
Corrected Total	15	20162.00000			

R-Square	Coeff Var	Root MSE	Lv Mean
0.289827	12.53824	34.54285	275.5000

Dependent Variable: Kidney (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	75.2500000	25.0833333	2.21	0.1402
Error	12	136.5000000	11.3750000		
Corrected Total	15	211.7500000			

R-Square	Coeff Var	Root MSE	Kdn Mean
0.355372	6.629355	3.372684	50.8750

Dependent Variable: Spleen (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	19.2500000	6.4166667	0.36	0.7837
Error	12	214.5000000	17.8750000		
Corrected Total	15	233.7500000			

R-Square	Coeff Var	Root MSE	Spln Mean
0.082353	18.68678	4.227884	22.62500

Dependent Variable: Gut fat (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	12711.1875	4237.0625	0.31	0.8204
Error	12	165974.7500	13831.2292		
Corrected Total	15	178685.9375			

R-Square	Coeff Var	Root MSE	Gutfat Mean
0.071137	45.30941	117.6062	259.5625

Dependent Variable: Hind feet (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	4315.68750	1438.56250	2.39	0.1195

Error	12	7214.75000	601.22917
Corrected Total	15	11530.43750	

R-Square	Coeff Var	Root MSE	Hfet Mean
0.374287	11.85614	24.51997	206.8125

Dependent Variable: Fore feet (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	5501.18750	1833.72917	2.48	0.1111
Error	12	8878.75000	739.89583		
Corrected Total	15	14379.93750			

R-Square	Coeff Var	Root MSE	Ffet Mean
0.382560	12.22862	27.20103	222.4375

Dependent Variable: Tail (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	204.2500000	68.0833333	3.12	0.0660
Error	12	261.5000000	21.7916667		
Corrected Total	15	465.7500000			

R-Square	Coeff Var	Root MSE	Tail Mean
0.438540	22.36242	4.668155	20.87500