DETERMINATION OF THE OPTIMAL LEVEL OF INCLUSION OF CHICKPEA (*CICER ARIETINUM L.*) SEED WASTE IN THE DIETS OF GROWING RABBITS

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ABSTRACT

Studies to determine the optimal level of chickpea seed waste (*Cicer arietinum L.*) inclusion in the diets for growing rabbits were carried out using two experiments. In Experiment 1, 24 male rabbits were allocated to four dietary treatments in a completely randomized design to evaluate nutrients digestibility and nitrogen balance of diets containing different levels of chickpea seed waste (CSW). Diet T_0 was a control, formulated to meet nutrient requirements of growing rabbits, where as treatments T_{18}, T_{32} and T_{47} consisted of 18, 32 and 47 percent, respectively CSW substituting sunflower seed cake (SSC) in the control diet. In Experiment 2, 64 growing rabbits (32 males and 32 females) were allocated to the four dietary treatments in a completely randomized block design to evaluate the effect of CSW on growth performance of growing rabbits. Weekly feed intake and weight gain were recorded and feed conversion efficiency (FCE) derived. Chemical analysis of the CSW, compounded diets and faecal samples was performed and digestibility values determined. The crude protein and crude fibre contents (g/kg DM) of CSW were 162 and 304, respectively. Inclusion of CSW in the diets (T_0 to T_{47}) decreased ($P<0.05$) dry matter and crude protein digestibility (g/kg DM) from 620 to 413 and 720 to 334, respectively, but had no affect ($P>0.05$) on nitrogen retained (0.29 g/d) and nitrogen utilisation (0.25 g/d). Dry matter intake (g/d) increased ($P<0.05$) from 58.8 to 62.0 and protein intake decreased from 11.7 to 8.9. Similarly, growth rates from 16.3 to 13.3 and FCE from 25.1 to 19.9 percent. Feed cost was reduced from 31.8 to 19.2 percent and gross margin per rabbit increased from 23.5 to 26.0 percent. This implies that the optimal level of inclusion of CSW could be lower than the levels tested in the present study.

Further studies are recommended on the substitution based on the protein contents in the two ingredients.

DECLARATION

I, **CHRISPIN MLIGO NDALWISE**, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has never been submitted for a degree award in any other institution.

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Professor G. H. Laswai

(Supervisor) **Date**

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DEDICATION

To the almighty God: “To him be the glory”.

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ABBREVIATIONS

AOAC	Association Of Analytical Chemists
˚C	Degree celcious
CDB	Chickpea dehulling by-products
CF	Crude fibre
CFD	Crude fibre digestibility
CP	Crude protein
CPD	Crude protein digestibility
CPS	Chickpea pre-screening waste
CRBD	Completely randomized block design
CRD	Completely randomized design
CSW	Chickpea seed waste
DASP	Department of Animal Science and Production
DCP	Digestible crude protein
DE	Digestible energy
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
EBW	Empty body weight
EE	Ether extract
EED	Ether extract digestibility
FCE	Feed conversion efficiency
FM	Fish meal
FW	Final weight
G	Gram
GIT	Gastrointestinal tract

GM	Gross margin
GR	Growth rate
HCW	Hot carcass weight
Kcal	Kilo calorie
Kg	Kilogram
MB	Maize bran
ME	Metabolizable energy
MEI	Metabolizable energy intake
MJ	Mega joule
N	Nitrogen
NIRS	Near Infrared Resonance Spectroscopy
OM	Organic matter
OMD	Organic matter digestibility
PI	Protein intake
SAS	Statistical Analysis System
SSC	Sunflower seed cake
SUA	Sokoine University of Agriculture
SW	Slaughter weight
T	Treatment
T. Shs.	Tanzania shillings
WG	Weight gain

Statistical abbreviations and symbols

*	Significant at 5% level of probability
**	Significant at 1% level of probability
***	Significant at 0.1% level of probability
"a, b, c, d"	Values in the same row bearing different superscript letters are significantly ($P<0.05$) different
µ	Overall mean
CV	Coefficient of variation
Df	Degree of freedom
E	Error term
NS	Not significant
SED	Standard error of mean difference
Sign.	Significance
B	Effects associated with rabbits
Y	Observation
A	Effect associated with level of chickpea seed waste

CHAPTER ONE

1.0 INTRODUCTION

Adequate balanced diet is one of the major concerns in livestock production. In developing countries, Tanzania inclusive, there is general lack of feeds formulated for meeting the nutritional demands of rabbits. Feeds which are commonly used by farmers to feed rabbits are gathered from various sources. Mgheni (1978) reported that rabbits are fed on feedstuffs ranging from concentrates, wild lettuce to kitchen left overs. The nutritional values of these materials vary depending on the type of feedstuffs and agro ecological zones, thus meeting requirements of rabbits for good performance is doubtful. In some cases, commercial feeds for poultry are fed to rabbits. Such feeds are characterized by high price due to the fact that the ingredients used in formulating poultry feeds are competitive with human foods and other livestock species. On the other hand, compounded diets for poultry have lower crude fibre content (<7%) than that (18%) required by rabbits (Foster and Smith, 2011).

Low crude fibre content in rabbit diets reduces the gastrointestinal tract motility and consequently impairing digestion process, the balance and function of the microflora, which aid digestion in the caecum and colon. This can lead to enteritis and possibly death of rabbit if harmful microbes develop (Leng, 2008). There is need therefore of developing appropriate feed formula for rabbits diets using appropriate ingredients. One of the potential ingredients is chickpea seed waste.

Chickpea seed waste is a by product resulting from chickpea processing and packaging industries. Chickpea seed waste contains about (g/kg DM) 901.7, 218 and

217 dry matter, crude protein and crude fibre respectively, and 10.76 MJ/kg DM metabolizable energy. The dry matter and organic matter digestibility values are reported to be 821 g/kg DM and 709.8 g/kg DM (Maheri-sis *et al*. 2007) Chickpea seed waste has a potential to be used as feedstuff in rabbit diets when considering its composition and production level.

The production of chickpea is showing an increasing trend. According to Bejiga and van der Maesen (2006), the world chickpea production was reported to be 7 million tons in 1999 and 7.9 million tons in 2003. The annual production from Sub-Saharan Africa was about 280,000 tons, whereby from Tanzania was about 25,000 tones. From 2006 to 2008 the average chickpea production in Tanzania was amounted to 30,000 tons (SPIA, 2011). This increase in production has necessitated investment in the pulse processing factories currently in Arusha, Moshi and Dar es salaam. These factories are producing large amount of chickpea seed waste. Chickpea seed waste at the market is sold at relatively low price as compared to other plant protein sources for animals. For example in 2011, chickpea seed waste was sold at 200 Tshs per kg at Dar es salaam processing factories, while sunflower seed cake and cotton seed cake were sold at 600 and 800 Tshs per kg, respectively in Morogoro urban input shops.

Chickpea seed waste has a potential to be used as feedstuff in rabbit diets. It is currently being used by livestock keepers to supplement dairy animals, although the economic level of mixing the material in the diets is not well known. In spite of using this by product in some livestock production farms, limited studies have been carried out on their nutritive value (Mousavi and Mirza, 2007). Chickpea seed waste has high crude fibre content, which could be well utilized by rabbits when performing hind gut fermentation. The fermentation which is performed by micro flora enables rabbits to obtain protein and energy from feeds with relatively high crude fibre content. Crude fibre levels would also prevent enteritis.

One of the limitations on the use of chickpea seed waste in livestock diets could be presence of antinutritional factors, such as trypsin and chymotrypsin inhibitors, which impair utilization of the available nutrients (Bampids *et al*. 2009). Neverthless, the authors reported that the antinutritional factors present in the chickpea seed waste are 30 to 40 times less than those present in soybeans. In addition, Luis *et al*. (1998) reported that chickpea seed waste contain relatively low amount of antinutritional factors and they appear to be well tolerated by monogastric animals.

Scarce information exists on the effects of chickpea seed waste and its optimal level of inclusion on the performance and the economic returns in the diets of growing rabbits. The aim of this study was to determine the optimum level of inclusion of chickpea seed waste in the diets on growth performance, slaughter characteristics and economic returns of growing rabbits.

The specific objectives of the study were:

i. To determine the chemical composition and *in vivo* nutrients digestibility of diets containing different levels of chickpea seed waste
ii. To determine the effect of chickpea seed waste inclusion in the diets of rabbits on the growth performance, feed efficiency and slaughter characteristics

iii. To carry out economic analysis of inclusion of chickpea seed waste in the diet of growing rabbits.

iv. To determine the optimum level of inclusion of chickpea seed waste in the diet of growing rabbits

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Rabbits have the ability to utilize feedstuffs which cannot be easily or utilized with much limitation by other monogastric animals and hence reduce feed competition between animals and humans. The feedstuffs for rabbits varies from forages, kitchen left overs to various agricultural processing by products. The low input system with minimum cost of production of rabbits (Cheeke, 1992) can be a means of overcoming the shortage of animal protein in developing countries including Tanzania.

Rabbits have an efficient monogastric mode of digestion, which is followed by fermentation of selected cellulose in the caecum (Leng, 2008). This unique digestive physiology allows them to utilize feedstuffs with relatively high crude fibre (CF) content. Chickpea seed waste being a by product of legume processing has a relatively high CF to be used by ordinary monogastric animals. The purpose of this review is to search information on the potential use of chickpea seed waste in the formulation of rabbit feeds in order to identify knowledge gaps, which need further research.

The information on the chemical composition and digestibility of chickpea seed waste is reviewed. The nutritional aspects, growth and slaughter characteristics of rabbits are also presented in this review.

2.2 Rabbit nutrition

Good nutrition is essential to all livestock to allow animal growth and attain its genetic potential. Well understanding of the rabbits digestive physiology is of paramount importance if they are to be provided with good nutrition. The focus of this part is to review the role of the digestive tract of rabbits in relation to feed utilization in meeting body nutrient demands. The digestive physiology, feed intake and nutrients requirement by growing rabbits are covered.

2.2.1 Digestive physiology of rabbits in relation to feed utilization

Rabbits are herbivorous monogastric animals, which are classified as hind gut fermentors. Fermentation in rabbits is facilitated by enlarged hind gut with well developed caecum and colon. The detailed digestive physiology of rabbits is given by Lebas *et al*. (1997), Carbano and Pique (1998), McNitt *et al*. (2000) and Leng (2008).

The feed consumed by rabbits goes directly into the stomach, which has an acidic medium. The feed is digested enzymatically in the stomach for few hours (3-6) before the contents are pushed into the small intestines. In the small intestines, enzymatic digestion continues by diluting the acidic contents from the stomach to alkaline due to the presence of bile followed by pancreatic juice. Finally, the digested nutrients are absorbed through the gut wall while the undigested materials are further pushed into the large intestine. At this stage the contents are sorted, the indigestible materials are expelled out into the colon as normal faeces, while the digestible materials are forced back by the aid of muscle movement moving in opposite direction into the caecum. In the caecum, fermentation by bacteria and protozoa takes place to produce useful products to rabbits. The useful products contain amino acids, nitrogen and urea, which are used by rabbit to make protein. Volatile fatty acids are absorbed across the caecal wall, while water soluble vitamins and amino acids are absorbed through consumption of soft pellets, a phenomenon known as caecotrophy. These pellets once consumed by rabbits they again follow the normal digestion processes.

The soft pellets (caecotropes) consists half of imperfectly broken down food residues and what is left of the gastric secretions, half of bacteria, high value proteins and water soluble vitamins (Lebas *et al*.,1997). Therefore, caecotrophy plays an important role in the rabbit nutrition and it does not occur as a response to nutrition imbalance but represents a specialized digestive strategy for the welfare of rabbits (Carbano and Pique, 1998).

The diet for rabbits should not contain highly digestible feeds, such as high amount of soluble carbohydrates (starch) to avoid formation of harmful micro organisms such as *Clostridium spiroforme, Endospous spp* and *Acuformis spp* in the caecum which may cause production of toxic substances, which may end up killing the rabbits (Irelbeck, 2001 and Leng, 2008). Therefore, the diet of rabbits should contain optimum amount of fibre, which will contribute to the proper functioning of the digestive system.

Animal and plant protein sources are the two sources of protein in the diets of rabbits. Animal protein sources are characterized by high concentration of protein. According to Leng (2008), high protein sources are not suitable for rabbits as they cause harmful microbes to develop in the lower gut leading to deaths. On the other hand, the common plant protein sources, which are mainly oil cakes have high amount of fat. High amount of fats reduce feed intake by rabbits and consequently result into reduced growth performance. Rabbits can obtain most of the required protein from agricultural by products (Cheeke, 1992). The common protein sources and their effect in growing rabbits are presented in Table 1.

Table 1: Protein sources for growing rabbits

Type of protein	Growth rate (g/day)	Source
Cotton seed cake	10.2	Mbanya *et al*. (2005)
Soya bean cake	11.7	Mbanya *et al*. (2005)
Fish meal	9.9	Biobaku *et al*. (2003)
Groundnut cake	9.02	Biobaku *et al*. (2003)
Trichanthera gigantean	16.8	Ubwe, (2002)
Morus alba	21.3	Maeda, (2000)
Alfalfa	38	UNESCO, (1996)
Commelina benghalensis	14.6	Swai, (1987)

Legume seeds processing by product could be alternative protein sources since they have low amount of crude fat and protein but high amount of crude fibre that are best utilized by rabbits. Therefore, further research is required to evaluate the potential of legume seeds processing by products as important protein sources to rabbits.

2.2.2 Nutrients intake by growing rabbits

Rabbits eat small amounts of feed in short time intervals in contrast to other animals, such as cattle which can eat large amount of feed at a time and rest to regurgitate before eating again (Ubwe, 2002). However, the consumption of solids and liquids fluctuates over a 24 hour period since much more solid and liquid feeds are consumed in the dark than in the light (Lebas *et al.*, 1986). High ambient temperatures raises body temperature and consequently decreases feed intake in order to reduce heat production associated with heat increment and metabolic heat to prevent excessive increase in body temperature. Feed intake by rabbits is reduced when the ambient temperature reaches 30˚C thus consequently leads to reduced growth performance (Lebas *et al*. 1986).

The intake of feed and water depends on the kind of feed, breed, age of rabbits, and stage of production. Rabbits prefer pelleted diets, therefore the intake is higher when they are fed to pelleted diets and low when they are fed meal diets. Large breeds such as New Zealand White have high intake relative to their body weights than small breeds (Pond *et al*., 1995). Feed intake per body weight is also influenced by age being lower and higher in young and adult rabbits, respectively. A study by Lebas *et al*. (1986) was 56 g/kgW$^{0.75}$ at 1 month old and 59 g/kgW$^{0.75}$ at 4 months old. Feed intakes of growing rabbits as reported by different authors are presented in Table 2

Table 2: Feed intake by growing rabbits

Intake (g DM/day)	**Sources**
63.9	Mbanya *et al*. (2005)
67.3	Ubwe, (2002)
75.5	Maeda, (2000)
82.3	Lugembe, (1996)
87.0	Swai, (1987)

Protein intake by rabbits depends on the availability and balance of amino acids in the diets. When the dietary protein is low the protein intake is also low. The amino acid profile of the dietary protein tends to influence the feed intake. Rabbits will eat more of the feed with well balanced amino acids both lysine and sulphur amino acids (Gidene, 2000).

The energy intake in rabbits depends on the dietary energy concentration. Fibre tends to lower the energy concentration of the diet. Therefore, the feed intake by rabbits tends to increase with increase of dietary fibre content. Adeniji and Lawa (2012) observed that inclusion of fibre in the diet from 0% to 40% increased feed intake from 64.4 g/day to 78.5 g/day respectively. Similarly, De Blas *et al*. (1981) found that dry matter intake (DMI) increased linearly by 2.97 g/day with each percentage unit increase in crude fibre. Low energy diets increase feed intake by rabbits and *vice versa* (Carbano *et al*. 2008). However, rabbits failed to increase intake more when dietary energy was less than 9.2 MJ/kg DM due to affection of gastric volume (Xiangmei, 2008) because the growing rabbit at this level of energy has to eat more than 113 g/day so as to meet the demand for growth. Therefore there is a need to research for feeds which will supply optimum amount of protein, energy and crude fibre for good growth response of rabbits.

2.2.3 Nutrients requirements of growing rabbits

The nutrients needed by rabbits for growth are mainly energy, protein, fibre, minerals and vitamins (Lebas, 1987). The nutrients requirements are summarized in Table 3 and the requirements of individual nutrients are described subsequently.

Table 3: Recommended nutrient requirements (g/kg as fed) for growing rabbits

Nutrient (g/kg)	Sources			
	Lebas, (2004)	Lebas *et al*. (1997)	Lebas, (1988)	Lebas, (1987)
DE (MJ/kg)	10.7	10.7	11.3	10.5
Fat	25-40	30-40	50	30
CP	160-170	170	180	160
DCP	120-130	120	-	-
CF	-	-	140	140

DE-Digestible energy, CP-Crude protein, DCP-Digestible crude protein, CF-Crude fibre

2.2.3.1 Energy

Energy is required for organic synthesis, metabolism, maintenance and growth and the chief sources are carbohydrates and fats. Protein becomes a source of energy after deamination when it is supplied in excess of the animal's requirement (Lebas *et al*., 1986). The energy requirement for growing rabbits has been found to range from 9.2-13.0 MJDE/kg (Lebas, 2004) and (Partridge, 1989). However, the growing rabbit can adjust its voluntary feed intake in response to changes in the energy density in the diet (Partridge, 1989 and McNitt *et al*., 2000). Fats can be added in the diet so as to raise the energy concentration and help absorption of fat soluble vitamins. The recommended dietary level of fat is 20-50 g/kg (Amy, 2010) although Christ (1999) reported that up to 90 g fat/kg can be added. Despite the importance of energy on the performance of rabbits, high starch diets are not suitable because they tend to be partially digested in small intestines due to rapid transit time, thus allowing much microbial cell yield in the caecum. If toxin producing microbes are in residence high level of starch may lead to enteritis and possible death of rabbits (Leng, 2008).

The common energy sources used to feed rabbits in Tanzania are maize bran and rice polishing. These materials have high competition with other livestock species. Also, with respect to rabbits requirements the materials have low amount of crude fibre that are 74.8 g/kg DM and 112.6 g/kg DM of maize bran and rice polishing, respectively (Laswai *et al*. 2002). Therefore, there is need to have other alternative feed source with relative high crude fibre to combine with these resources when compounding diet suitable for rabbits.

2.2.3.2 Protein

Protein is required in large amount for the synthesis of body tissues and fluids such, as muscle tissues, cell membrane, hormones and enzymes (Swai, 1987). The protein requirement of rabbits ranges from 160-220 g/kgDM (Carbano *et al*., 2008; Lebas, 2004 and Lebas *et al.*, 1997). The amounts vary depending on the production status where it is highest during reproduction stage followed by growing period. According to Yassein *et al*. (2011) the rate at which rabbit grows is affected by the amount of protein in the diet, the growth is negatively affected when the dietary crude protein becomes less than 160g/kg DM. The type of protein also affects growth of rabbits, for example under similar environments Maeda (2000); Ubwe (2002) and Swai (1987) reported the growth rate of 22.3 g/day, 18.2 g/day and 12 g/day using *Morus alba*, *Trichanthera gigantean* and *Commelina benghalensis* respectively, when they were used as protein sources for growing rabbits. The variation in growth rate could possibly be due to variation in protein quality in terms of amino acids and digestibility. Rabbits are sensitive to amino acids (Lebas, 1987 and McNitt *et al*. 2000). The sensitivity to amino acid varies with age. Young growing rabbits are more sensitive than adult and the requirement for amino acid by growing rabbits is 6.8g/kg for lysine and 6.4g/kg for sulphur amino acids (Gidenne, 2000). Energy: protein ratio is a measure of optimal dietary level of protein for growth. The ratio of energy to protein in the diet is important as it has a direct effect on the intake by rabbits. When the level of energy in the diet is high feed intake is reduced, thus reducing protein intake and consequently growth rate. Energy: Protein ratio is more reliable unit as it has higher and direct impact on body nitrogen and energy retention than crude fibre, which is inversely related with digestible energy (Carbano *et al*. 2008). A recommended ratio of energy: protein for optimal growth rate according to Lebas *et al*. (1986) was 56:1 metabolizable energy (MJ) to protein (kg).

The common protein sources in Tanzania which are currently being used to compound rabbit diets are divided into two groups, namely animal protein and plant proteins. The animal protein sources include fish meal and blood meal, while plant sources include are sunflower seed cake and cotton seed cake. Animal proteins are characterized by high protein concentration. High protein level is incompletely digested in the upper tract due to overwhelming of enzyme system thus, allowing protein to enter lower tract where may cause a detrimental microbes population change which may lead to high death rates in rabbits (Leng, 2008). The plant sources are mainly oil cakes, which sometimes have high amount of fat. High amount of lipids are responsible for reducing feed intake by rabbits, hence limit their use in diets of rabbits. (Pascual *et al*. 1998 and Leng, 2008). In addition, the relatively high price and competition with other livestock species limit their use in rabbit diets. There is a need to find alternative sources of protein, which could be best utilized by rabbits. Apart from oil cakes, various leaf meals have been used as protein supplements in rabbit diet including *Trichanthera gigantea* (Ubwe, 2002); *Morus alba* (Maeda, 2000); *Crotalaria ochraleuca* (Lugembe, 1996); *Commelina benghalensis* (Swai, 1987) and *Medicago sativa*. Various agricultural processing products need also to be evaluated for their use in rabbit diets since they might contain valuable protein.

2.2.3.3 Fibre

Rabbits require dietary insoluble fibre for maintaining gut health, stimulating gut motility, reducing fur chewing and preventing enteritis. Low fibre diets result into gut hypomotility, reduced caecotrope formation and prolonged retention time in the gut (Irelbeck, 2001). Rabbits therefore need a minimum dietary fibre level ranging from 200-250 g/kg DM to maintain gut health (Leng, 2008 and Meredith, 2011). High dietary crude fibre, greater than 250 g/kg DM result into lower growth rate because the animal cannot increase intake sufficiently to meet its energy needs (Gidenne, 2000). Also high amount of fibre in the diet may cause some of the nutrients to be unavailable to rabbit because of high passage of digesta in the gut, thus reducing digestion time (Leng, 2008).

The available sources of fibre in rabbit diets in Tanzania are diverse and they include leaf meals such as *Morus alba*, *Comelina benghalensis*, *Leucaena leucocephala*, Wild lettuce, *Amaranthus spp,* different types of vegetables forages, brewers waste, and various kitchen left overs such as peelings from bananas, cassava and potatoes. Most of these materials are succulent and their ability to meet rabbit needs for better performance is doubtful. Rabbits can perform better when fed high quality fibre (Cheeke, 1992). Chickpea seed waste being a byproduct from legume seed processing could be used as an alternative source of fibre in the diet of rabbits because it has a relatively high crude fibre that could meet the nutritional demand of fibre for rabbits.

2.2.3.4 Minerals

There are two categories of minerals, the macro minerals and micro minerals. Macro minerals are required in large quantities, thus grams per day while micro minerals are required in small amounts or milligrams per day. The macro minerals include calcium, phosphorus, sodium, magnesium and potassium and the micro minerals include copper, zinc, manganese, iron, iodine, selenium and cobalt. Requirements for minerals to rabbits have been well documented by Lebas *et al*. (1997, 1986), Lebas (1987), McNitt *et al*. (2000) and Amy (2010). Calcium and phosphorus are major component of the skeletal system. Calcium plays a key role in organic processes such as heart function, muscle contraction and coagulation and equilibrium of the blood. Phosphorus is involved in energy metabolism. The recommended dietary ratio of calcium and phosphorus is 1.5:1 to 2:1 (Amy, 2010). Magnesium is involved in transmission of nerve impulses and as co-factor for many enzymes. Its documented requirement ranges from 0.3-3 g/kg diet. Sodium, potassium and chloride are important for acid base regulation of the blood. Additionally potassium is a cofactor for several enzymes. Copper is involved in iron and energy metabolism as well as collagen and hair formation. Dietary recommendations range from 5-30ppm with higher levels suggested for breeding does and fur production. Zinc function as cofactor for various enzymes and cell division process. Manganese is a co-enzyme in amino acid metabolism and cartilage formation. Iron is a major component of pigment haemoglobin and enzymes involved in oxygen transport and energy metabolism. Iodine is a component of thyroid hormones that regulate energy metabolism. Cobalt is involved in the structural make up of vitamin B_{12}. It is important for the hind gut bacteria for they require it for synthesis of vitamin $B_{12.}$

Mineral premixes are the chief source of minerals in the diets of rabbits. Competitions with other species limit the use of commercially available minerals in the diets of rabbits. Chickpea seeds are well balanced in terms of minerals (Muehlbauer and Tulu, 1998). The use of chickpea seed waste in rabbit diet could supply the required minerals with low supplementation and reduce competition.

2.2.3.5 Vitamins

Vitamins are important in maintaining health of animals. The roles of vitamins in the body of animals are accomplished by various functions they perform. Vitamins A, D, E and K are fat soluble vitamins. They can be stored within the body in the liver and fat deposit if eaten in excess. Vitamin C and B are water soluble and are not stored in the body. When eaten in excess they are excreted through urine. They are not problematic to rabbits since they are synthesized in the caecum. The requirements of vitamins have been well documented by Amy (2010), Lebas (2004), McNitt *et al*. (2000) and Lebas *et al*. (1997).

Vitamin A is involved in vision, growth, and maintenance of body tissues. Its deficiency leads to retarded growth, blindness, lack of coordination, paralysis and drooping ears. Vitamin D is involved in calcium and phosphorus absorption and mobilization. Vitamin E is involved in prevention of cell oxidation and its function is close to selenium, thus deficiency of either selenium or vitamin E result into muscular dystrophy, infertility or foetal resorption. Vitamin K is essential for blood clotting deficiency leads into bleeding following a minor injury. The requirements of vitamins A, D and E are 6000 iu/kg, 1000 iu/kg and 50 ppm, respectively (Lebas, 2004). Rabbits obtain vitamins A, D and E from feeds especially green forages.

Some compounded vitamins used to supplement rabbits diets are available commercially at the livestock input shops, however they tend to be expensive and have high competition among other monogastric animals. Rabbits are hind gut fermentors. The bacteria in the caecum synthesize most of the required vitamins especially B complex group, vitamin C and vitamin K when fed with high quality cellulose and reduce competition for commercial vitamins.

2.3 Growth patterns in rabbits

The growth pattern in rabbits according to Pet (2010) shows a sigmoid curve. The live weight gain gradually increases to a peak and then levels off and start to decline, thus it is possible to calculate the age at which the most economic gain in terms of feeding is obtained. Growth in rabbits is affected by several factors, the major factor being genetic make up of the animal. Large breeds have faster growth rate and reach heavier final slaughter weight earlier than small breeds. Small, medium and large breeds attained the weight ranges of 1.4 – 2 kg, 4 – 5.4 kg, and 6.4 – 7.3 kg respectively at maturity stage. However these values may be affected by environmental factors (Lebas *et al*. 1997). The most important environmental factor is nutrition of the animal. Growth performance of rabbits fed different dietary protein levels are presented in Table 4.

Table 4: Growth performance of growing rabbits under different protein levels

Protein level (g/kg DM	Growth rate (g/day)	Source
110	14.6	Swai, (1987)
160	21.0	Maeda, (2000)
161	10.2	Mbanya *et al*. (2005)
209	9.02	Biobaku *et al*. (2003)
222	16.8	Ubwe, (2002)

High environmental temperatures affect feed intake by rabbits, which result into reduced growth performance. According to Lebas *et al*. (1986) high temperatures of about 30˚C causes reduction in feed intake by 30% and reduce growth performance by 17%. Rabbit growth is favored in temperate countries where they can grow faster due to increased feed intake and produce a carcass weight of 2kg in 8-10 weeks (UNESCO, 1996). In tropical countries growth rate of rabbits ranges from 9 to 22 g/day (Owen, 1981). The high growth rate starts at birth and continues exponentially until they reach the age of 10 weeks. During this stage, the young rabbits double their weight every week until when they reach about 0.45kg at 3 weeks old. After that rapid phase the growth rate begins to diminish until 10-12 weeks old (Swai, 1987). According to Swai (1987), the growth curve of animals can be manipulated by the level of feeding. High plane of nutrition favour rapid growth and vice versa. Apart from nutrition, growth rate can be improved through cross breeding (Lebas *et al*. 1986). Crossbreds tend to have higher performance as compared to parent stocks. Crossbreeding animals helps to combine favourable genes of the two parents on the offspring, hence better performance.

Rabbits must be protected from heat stress which affects the performance of animal through changing the intake. Good nutrition, well balanced diet with optimum protein requirements for rabbit is a key for manipulating the growth pattern of animal because the growth rate of animal varies with dietary protein level offered to animals. It is therefore, possible to manipulate the rate at which the animal can grow by practicing good nutritional management.

2.4 Sunflower seed cake as animal feed

2.4.1 Introduction

Sunflower seed cake is a residue obtained after the greater part of the oil has been extracted from sunflower seeds have crude protein and crude fibre ranging from 260-400 g/kg DM and 130-302 g/kg DM, respectively. The amounts of nutrients vary with degree of oil extracted or hulls removed (Jabar *et al*. 2009; Laswai *et al*. 2002 and Pistoia *et al*. 2002). The protein content of the cake is low when the is oil extracted without decortications and vice versa, also the crude fibre is higher in the cake from undecorticated seed than the decorticated seeds. According to Laswai *et al*. (2002), sunflower seed cake contains about (in g/kg DM) 944.9 dry matter, 321.7 crude protein, 301.8 crude fibre, 191.6 ether extract, 125.7 nitrogen free extracts, 26 calcium, 100 phosphorous and Metabolizable energy of 10.24 MJ/kg DM. Sunflower seed cake do not contain anti nutritional factors, such as those found in other major oil seeds (Hueze *et al*. 2012).

2.4.2 Utilization of sunflower seed cake by animals

Sunflower seed cake has relative high crude fibres, which limit the extent of use in monogastric animals because of their restricted capacity to digest fibre (NRI, 1995). Inclusion of sunflower seed cake up to 30% in sheep diet reduced ($p<0.05$) dry matter and protein digestibility from 63.7 to 54.5% and 72.6 to 59.4% respectively. It also decreased growth rate from 84.4 to 56.7 g/day (Sarwatt, 1992 and Ahamad *et al*. 2004). In broiler, sunflower seed cake has been found to improve the mean body weight by 12.1% (2212 g vs 1992 g) and lowered feed conversion ratio 2.88 against 2.52 of soy bean meal (Jacob *et al*. 1996). Rabbit has well developed digestive system unlike other monogastric (Leng, 2008) and therefore can make better use of sunflower seed cake with high crude fibre. The use of sunflower seed cake in high proportion in rabbit diet could result into poor meat quality in terms of fat deposition. Since sunflower seed cake contains high amount of fat 191.6 g/kg DM (Laswai *et al*. 2002) than the dietary recommended for growing rabbit of about 20-50 g/kg DM (Amy, 2010).

2.5 Chickpea seed waste as a potential feed for rabbits

2.5.1 Introduction

Chickpea seed waste is a byproduct resulting from chickpea processing and packaging industries, where two types of byproducts are produced, which are the chickpea packaging waste and chickpea processing waste. The chickpea packaging wastes (also known as chickpea prescreening waste or culled chickpea) is a mixture consisting of cracked, broken, fine and deformed chickpea together with impurities. The chickpea processing wastes (also known as chickpea dehulling byproduct or chickpea seed bran) is a mixture consisting of chickpea hulls, broken and ground chickpea and foreign materials (Maheri-sis *et al*., 2007). Chickpea seed waste is currently being used by livestock keepers to supplement dairy animals although the economic levels of mixing the material in the diets are not well known. Chickpea seed waste has high digestible crude fibre content, which could be well utilized by rabbits since they have hind gut fermentation. Fermentation which is performed by micro flora enables rabbits to obtain protein and energy from feeds with quality cellulose materials.

2.5.2 Chemical composition of chickpea seed waste

The chemical composition and feeding values of different types of chickpea seed waste are summarized in Table 5. The chemical composition varies between products. The CP and DM values for chickpea dehulling by product (CDB) obtained by Maheri-sis *et al*. (2007) were similar to those reported by Aghdam-shahriar *et al*. (2004) and Mousavi and Mirza (2007). The CF of CDB obtained by Maheri-sis *et al*. (2007) was higher than that obtained by Abdi and Danesh (2010). Evaluation by Ferdinand (2011) showed that chickpea seed waste (CSW) contain 185 and 289 g/kg DM crude protein and crude fibre, respectively. The difference could be due to different ratios of hulls in the waste obtained by different methods of sampling and precision of processing machines. Also the wide variations in chemical composition of chickpea seed waste could probably be due to different climatic condition, geographical distribution and chickpea varieties.

Table 5: Chemical composition (g/kg DM) and energy value of chickpea seed waste

CSW	DM	OM	CP	CF	EE	DDM	DOM	ME(MJ/kgDM)
CPS[1]	-	940.0	279.0	72.0	78.0	-	591.0	8.95
CDB[1]	-	927.0	44.0	178.0	87.0	-	421.0	6.5
CPS[2]	897.8	969.0	197.0	217.0	78.0	887.0	857.6	13.26
CDB[2]	901.7	921.2	218	263.0	31.0	821.0	709.8	10.76
CDB[3]	912.0	-	200.3	-	32.5	-	-	-
CDB[4]	915.0	-	200.0	-	20.0	-	-	-
CDB[5]	913.9	-	185.0	289.0	22.0	-	-	-

CPS-Chickpea prescreening waste, CDB-Chickpea dehulling by product

Source: Abdi and Danesh, (2010)[1], Maheri-sis et al. (2007)[2], Aghdam-shahriar et al. (2004)[3], Mousavi and Mirza (2007)[4], Ferdinand (2011)[5]

2.5.3 Nutrient digestibility

The extent at which the feed can be utilized by an animal depends on its degradability through the gastrointestinal tract. Highly digested feed will be utilized by animal at high proportion because less will be lost through faeces. Maheri-sis *et al*. (2007) found that the digestibility of dry matter using *in vitro* gas production at 96 hours of incubation were higher ($P<0.05$) than that of organic matter as shown in Table 5. On the other hand Abdi and Danesh (2010) reported that organic matter digestibility of chickpea pre-screening were higher (591 g/kg) than chickpea bran (421 g/kg) and ME (MJ/kg) values were 8.95 and 6.5, respectively.

The digestibility estimates (DDM and DOM in Table 5) of chickpea seed waste were done using *in vitro* gas production of the rumen liquor taken from ruminant animals. The findings can be used in formulating rabbits diet because they are pseudo ruminant. Despite rabbits being pseudo ruminant and therefore undergoes microbial fermentation similar to ruminants, performing separate feed evaluation using rabbits is necessary as there are some dissimilarities. For instance microbial fermentation in ruminant animals occurs at the upper part while in rabbits it occurs at the hind gut. Due to this variation there could be differences also in absorption of end products which might give wrong results when using the digestibility findings from ruminant animals and apply them directly to rabbits. There is need therefore to estimate digestibility of chickpea seed waste using rabbits.

2.5.4 Effect on Animal performance

The digestibility estimates of chickpea seed waste suggest that the material could give better performance when fed to animals. Abdi and Danesh (2010) suggested that the byproducts have a potential to be used as feed in ruminant rations. However, the authors proposed further studies to evaluate the effect of these by products in ruminant production. In addition, Maheri-sis *et al*. (2007) concluded that the by product could be used as a source of energy and protein in ruminant diets. Abdollahi and Yousefinejad (2008) suggested that up to 30 percent of chickpea seed waste can be included in chicken (broiler) diets. The growth rate of 14.6 g/day and feed conversion efficiency of 13% were observed by Ferdinand (2011) in rabbits using a diet which was compounded to contain 47.5% of chickpea seed waste and 47.5% of poultry grower marsh.

The feeding estimates of chickpea seed waste has been done using ruminant animals and little has been done using monogastric animals, rabbits inclusive. The gathered information shows that chickpea seed waste could be best utilized by rabbits due to their efficient mode of digestion which allow utilization of diets with high crude fibre contents.

2.6 Conclusion

In the tropics the growth rate of rabbits ranges from 9 to 22 g/d. The variation depends on the type and level of protein used to feed the rabbits where higher growth rates were observed when high quality protein feed materials was used. The review on chickpea seed waste has indicated that the material is a potential feedstuff in terms of nutritive value and could improve feed intake, feed conversion efficiency and reduce feed cost and competition, hence improve growth rates in growing rabbits. Nevertheless, there is limited information on the feeding value and optimal inclusion levels of chickpea seed waste in rabbit diets for enhancing growth performance, carcass characteristics and digestibility by the animals. Availability of such information could provide the best way of including chickpea seed waste in rabbit diets.

CHAPTER THREE

3.0 MATERIALS AND METHODS

Two experiments, involving digestibility and growth performance studies were conducted in order to evaluate the feeding value and optimum level of inclusion of chickpea seed waste in the diets of growing rabbits. The studies were carried out at Sokoine University of Agriculture (SUA) in the Rabbit Unit at the Department of Animal Science and Production (DASP) between March and July, 2012. The university is located between 6 and 7^{o} S and 37 and 38^{o} E and altitude of 500 to 600 m above sea level. The area receives an average annual rainfall of between 600 to 1000 mm and experiences day temperature ranging between 20 to 27 ˚C in coolest months (April to September) and 30 to 37 ˚C during the hottest months (October to March).

3.1 Experiment 1: Digestibility and nitrogen balance study

3.1.1 Experimental design and treatments

Twenty four (24) male rabbits were allocated randomly into four dietary treatments in a completely randomized design. The four diets were formulated to contain 0, 18, 32 and 47% chickpea seed waste substituting sunflower seed cake in treatments T_0, T_{18}, T_{32} and T_{47}, respectively.

3.1.2 Source of experimental animals

The 24 rabbits were crosses between California White and New Zealand White bred at the Department of Animal Science and Production (DASP). The age of the rabbits was between 4-5 months and had an average body weight of 2033.04 ± 72.5 g.

3.1.3 Nutrient sources of the experimental diets

The physical composition of the experimental diets is shown in Table 6. Treatment T_0 was a control diet formulated to meet rabbit requirements. The other three dietary treatments were based on 18 (T_{18}), 32 (T_{32}) and 47 (T_{47}) percent chickpea seed waste substituting sunflower seed cake in the control diet. Chickpea seed waste was bought from Dar es Salaam chickpea processing factory. Maize bran was purchased from the milling machines in Morogoro. Sunflower seed cake, fish meal, vitamin and mineral mix, limestone and salt were purchased from the livestock input shops in Morogoro. Mixing of the feed ingredients to compound diets was done manually on a covered floor using a spade.

Table 6: Physical composition of experimental diet (% as fed)

Ingredients	**Treatments**			
	T_0	**T_{18}**	**T_{32}**	**T_{47}**
Chickpea seed waste	0	18	32	47
Sun flower seed cake	48	30	16	0
Fish meal	2.5	2.5	2.5	2.5
Maize bran	47	47	47	47
Limestone	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
Vitamin and mineral Premix	0.5	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**
Calculated values (g/kgDM)				
CP	182.3	177.6	174.0	170.1
CF	181.1	174.1	170.0	170.0
ME (MJ/kgDM)	13.20	13.30	13.37	13.45

3.1.4 Feeding and management

Animals were kept in a house built with big wire meshed windows to provide good ventilation. The rabbits were kept in individual cages measuring 57 x 53 x 60cm.

Wire mesh sieves and polythene sheet were fastened underneath the cages for separating faeces and urine. A preliminary period of 7 days was adopted to familiarize the animals to the diet, experimental protocol and establish feed allowance. Feed and drinking water was provided daily into two separate concrete containers in each cage. The preliminary period was followed by seven days of data collection. Feeding allowance, which was established during preliminary period (120 g), was weighed daily into nylon bags and put into feeders twice a day at 1000h and 1600h. Clean drinking water was provided into concrete containers daily. During the collection period, faeces voided from each animal was collected daily at 0800 h, weighed and bulked in air tight nylon bags and preserved in a deep freezer. Feed remaining in the feeder was weighed and oven dried for DM determination and bulked for further analysis. Urine was collected and preserved under acid medium to avoid escape of nitrogen and stored in air tight bottles at room temperature. At the end of the collection period, the collected faeces for each animal was thoroughly mixed and 20% of fresh sample was taken for nitrogen determination. The remaining portion was used for determining DM after oven drying and ground to pass through 1mm sieve, bottled and stored for chemical analysis.

3.1.5 Calculation of digestibility values

Digestibility values were calculated by taking the proportion (on DM basis) of feed intake less faeces to feed intake times one hundred. Digestible nutrients were obtained by taking the difference between nutrient intake in feed and nutrient excreted in faeces.

Apparent digestibility (%) = (DM Intake-DM Faeces)/DM Intake)*100

3.1.6 Calculation of nitrogen utilization

Nitrogen utilization was calculated by first determining percentage of nitrogen in feed, faeces and urine by Kjeldahl method. Total nitrogen excreted was obtained by taking the summation of faecal and urine nitrogen. Total nitrogen absorbed was obtained by taking the difference between nitrogen intake in feed less faecal nitrogen. Total nitrogen retained was obtained by taking the difference between nitrogen intake in feed less the total nitrogen excreted.

3.1.7 Chemical and data analysis

The chemical composition of chickpea seed waste, sunflower, maize bran, experimental diets and dry faeces were estimated using Near Infrared Reflectance Spectroscopy (NIRS, 1997). Metabolizable energy contents of the diets were estimated directly from Near Infrared Reflectance Spectroscopy (NIRS, 1997) readings. Two millilitres (2mls) of urine and 0.25 g of fresh faeces were taken from the total collection of each animal for nitrogen determination using Kjeldahl method according to standard methods of AOAC (1995).

The collected and derived data were analyzed using Statistical Analysis System (SAS, 2004) according to the following model;

$Y_{ij} = \mu + \alpha i + E_{ij}$

Where,

Y_{ij} = Record of the j^{th} rabbit belonging to the i^{th} treatment

αi = Effects due to ith treatment

E_{ij} = Error term

μ = General mean

Treatment means were compared using the method of Least Square Difference (LSD) according to SAS (2004). The optimal level of chickpea seed waste inclusion was obtained by using regression analysis according to the model outlined by Snedcor and Cochran (1989).

$Y_{ijk} = a + b_1× + b_2×^2 + e_{ijk}$

Where,

Y_{ijk} = Dependent variable (Digestibility)

b_1 and b_2 = Regression coefficients (CSW levels)

× = Independent variables (DM, CP, CF and EE)

e_{ijk} = The random error.

3.2 Experiment 2: Growth performance study

3.2.1 Experimental design and treatments

Sixty four (64) growing rabbits, males (32) and females (32) were randomly allocated into the four dietary treatments used in Experiment 1 in a completely randomized block design (CRBD). The animals were blocked by sex.

3.2.2 Source of experimental animals

The parent stock, crosses of California White and New Zealand White rabbits present in the Rabbit Unit at the Department of Animal Science and Production (DASP) were bred by bucks of the same breeds to produce rabbit weaners used in the study. After kindling, the does were allowed to nurse the kits for 42 days after which they were sexed and weaned. After weaning males and females were caged separately and fed on normal ration compounded using maize bran, sunflower seed cake, fish meal, *Moringa oleifera*, salt and limestone available in the unit. The animals were allocated randomly to the four dietary treatments at the age of 70±10 days with initial body weight of 693.6 ± 53.02 g.

3.2.3 Management and feeding of experimental animals

The rabbits were kept in a house with big windows fastened with wire mesh to ensure good ventilation. The animals were kept in individual cages measuring 57 x 53 x 60cm. The cages were identified by rabbit treatment and replicate number. The individual initial body weights of the experimental rabbits recorded by weighing them using a digital weighing scale before allocating them to the experimental diet. This was followed by weekly weighing for a period of ten weeks. The weighing was done during the morning hours after withholding feed for two hours to reduce the effect of gut fill on live weight gain. The weekly feed allowance for each individual rabbit was weighted using a digital balance and kept in separate own bags. Rabbits were fed individually in all treatments in *ad lib* bases. Feeding was done twice per day at 0800 h and 1500 h. Refusals were collected once per week, oven dried and weighed. Weekly feed intake was obtained by taking the difference between weekly allowance and weekly refusal on dry matter basis. Drinking water was supplied on *ad libitum* basis.

3.2.5 Slaughter procedure and characteristics

Thirty two (32) rabbits, 4 males and 4 females per treatment were selected randomly for slaughter. The animals were slaughtered at the 75th day of the experiment. They were weighed just before slaughter to get the slaughter weight. Before slaughter, both feed and water was withheld for two hours. Animals were slaughtered by dislocating the neck and bleeding by severing the jugular veins and carotid arteries using a sharp knife. The skin was then pulled out and feet separated between the metacarpus and carpus and between metatarsal and tarsus for the fore and hind feet, respectively. Evisceration was done by slitting the abdominal wall of the skinned animal longitudinally using a sharp knife. The total GIT was weighed when full and when emptied. The weight of gut contents was obtained by taking the difference between full and empty gut. Other related non carcass components were placed together, to have head (head, skin, feet and tail), pluck (oesophagus, lungs, liver and spleen), total internal fat (kidney fat and GIT fat), kidney and reproductive organs.

3.2.6 Derived parameters

The derived parameters were feed intake, growth rate and feed conversion efficiency. Feed intake was computed as the difference between the weekly feed allowance to the animal and the weekly refusal on dry matter basis. Growth rate was computed as the ratio between total weight gained and growth period. Feed conversion efficiency was obtained as the ratio between average daily weight gain and average daily feed intake. Dressing percentage was obtained as ratio of hot carcass and slaughter weight. Carcass and non carcass components were expressed as proportions to slaughter weight. Energy intake was calculated by multiplying the dietary energy concentration in megejoule per kg and individual feed intake on dry matter basis.

3.2.7 Data analysis

Data obtained were analyzed using Statistical Analysis System (SAS, 2004) according to the following model;

$Y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk}$

Where,

Y_{ijk} = Response of the k^{th} rabbit belonging to i^{th} dietary treatment and j^{th} sex

μ = general mean

α_i = Effect of i^{th} dietary treatment

β_j = Effect of j^{th} sex

$\alpha\beta_{ij}$= Interaction of i^{th} diet and j^{th} sex

e_{ijk} = Random error effect specific to each individual

Treatment means were compared using the method of Least Square Difference (LSD) according to SAS (2004). The optimal level of chickpea seed waste inclusion was obtained as described in Experiment 1.

3.2.8 Gross margin analysis

The costs of feeding were computed by multiplying the total amount of feeds used by each rabbit for the whole experimental period with the price per unit feed. The price of feed was taken as the total prices of feed ingredients used in compounding the diets. The return was taken as the value of animals at slaughter. Gross Margin (GM) was computed as the difference between the return and the cost of feeding the animal to slaughter. The data was analyzed statistically using the above model.

CHAPTER FOUR

4.0 RESULTS

4.1 Experiment 1: Digestibility and nitrogen balance

Animals selected for this study were in good health prior to the start up to the end of the experiment.

4.1.1 Chemical composition

The chemical composition of chickpea seed waste (CSW), feed ingredients used in formulating the experimental diets and the compounded diets used in the experiments is shown in Table 7. The values of crude protein and ether extract of chickpea seed waste were lower whereas crude fibre content was higher than those of sunflower seed cake. Fish meal had the highest amount of crude protein but lowest amount of crude fibre. Maize bran had the lowest amount of crude protein. The amount of ether extract was highest in sunflower seed cake, maize bran, and fish meal and lowest in chickpea seed waste. The crude protein, ether extract and energy contents of the diets decreased with increasing levels of chickpea seed waste in the diet. However, the energy contents for treatments T_0 and T_{18} were similar also treatments T_{32} and T_{47}. Crude fibre increased with increasing the levels of chickpea seed waste in the diets.

Table 7: Chemical composition of chickpea seed waste (CSW), sunflower seed cake (SSC), maize bran (MB), fish meal (FM) and compounded diets

Ingredient/diet	Composition (g/kg DM)				ME(MJ/kgDM)
	DM	**CP**	**CF**	**EE**	
CSW	852	162	304	19	7.0
SSC	862	241	243	126	7.7
MB	822	106	73	117	10.3
FM	882	490	21	90	13.3
Compounded diets					
T_O	881	199	164	130	9.8
T_{18}	874	182	166	119	9.7
T_{32}	862	162	196	89	9.3
T_{47}	861	148	202	71	9.0

4.1.2 Effect of dietary treatments on the nutrient digestibility and nitrogen utilization by rabbits

The Least Square Mean (LSM) of apparent dry matter (DMD), crude protein (CPD), crude fibre (CFD) and ether extract (EED) digestibility coefficients of the experimental diets by rabbits are shown in Table 8. The individual rabbit values of feed intake, wet and dry faeces, urine and their chemical compositions, digestible nutrients and digestibility coefficients are shown in Appendix Tables 1, 2, 3, 4, 5, 6 and 7. The summary of analysis of variance for dietary effect on digestibility coefficients is given in Appendix Table 8.

The mean digestibility of crude protein (CPD) decreased with level of inclusion of chickpea seed waste. The mean values of treatments T_0 and T_{18} were not significantly (P>0.05) different but were higher (P<0.05) than those of treatments T_{32} and T_{47}. The mean crude protein digestibility in treatments T_{32} and T_{47} were also similar (P>0.05). The mean values of crude fibre (CFD) digestibility and ether extract (EED) digestibility were not significantly (P>0.05) different between treatments.

Table 8: Effect of dietary treatments on nutrient digestibility (% DM) by rabbits (LSM)

Component	Treatment				SED	Sign
	T_0	**T_{18}**	**T_{32}**	**T_{47}**		
DMD	62.0^a	53.8^a	42.5^b	41.3^b	2.8	***
CPD	72.0^a	55.6^a	39.8^b	33.4^b	3.2	***
CFD	30.2	46.7	36.0	40.7	8.6	NS
EED	80.1	77.1	75.2	77.0	4.2	NS

** P<0.05, ***, P<0.001*
Values in the same row bearing same superscript letters are not significantly different (P>0.05)
NS-Not significant
SED-Standard error of the mean difference
Sign-Significance level

The relationship between chickpea seed waste inclusion level and crude protein digestibility (Figure 1) followed curvilinear relationship;

$Y=73.85 - 0.63\times - 0.006\times^2$, $R^2 = 89.5$ where Y= Crude protein digestibility, $\times$ and $\times^2$ = Chickpea seed waste inclusion levels in the diet, R^2 = Coefficient of determination

Using the curve for CPD values, it showed decreased protein digestibility with increased levels of chickpea seed waste in the diet.

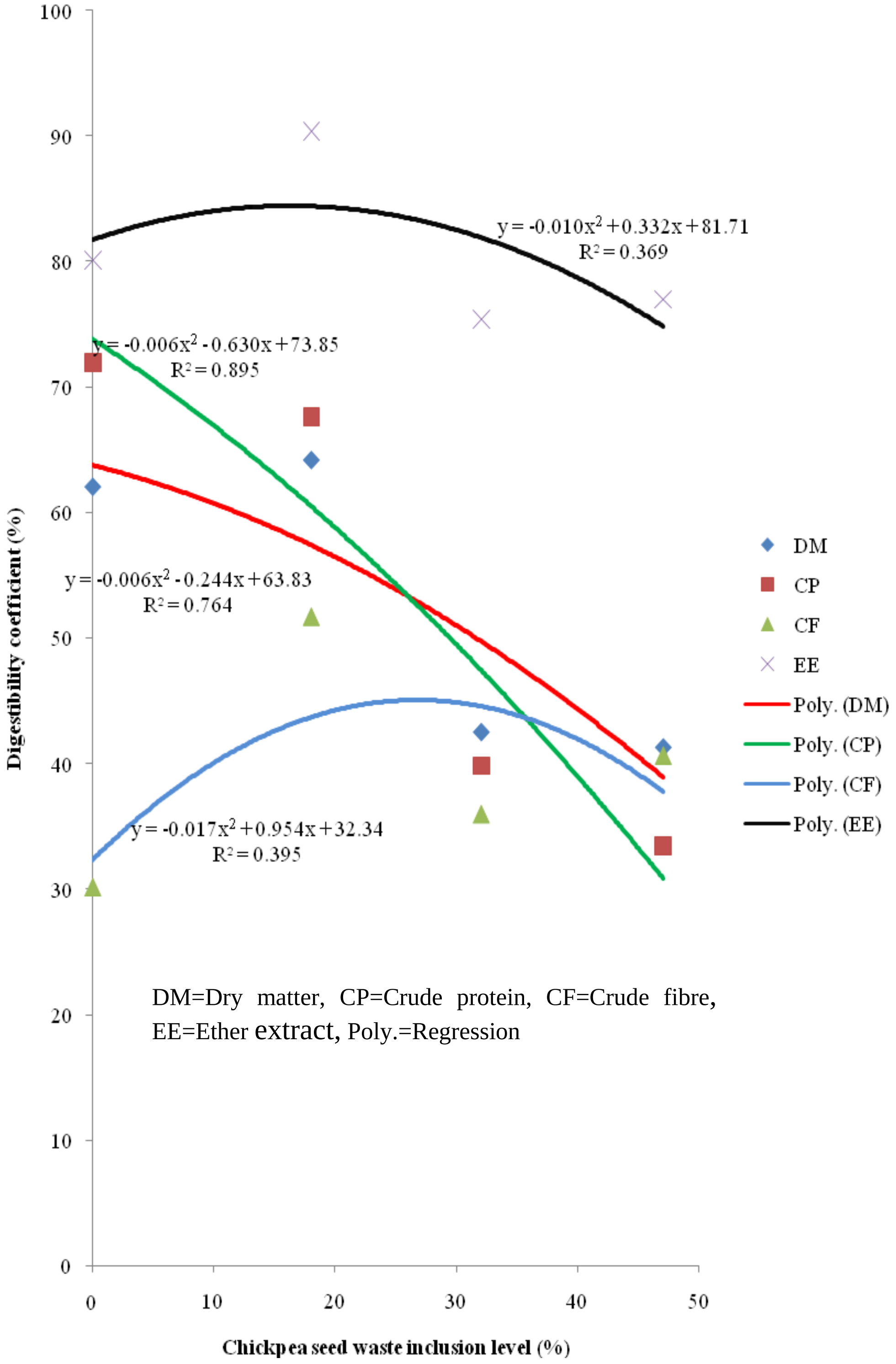

Figure 1: The relationship between chickpea seed waste inclusion levels and digestibility of dry matter, crude protein, crude fibre and ether extract.

The Least Square Mean (LSM) values of nitrogen utilization as influenced by the dietary treatments are shown in Table 9. The individual values and summaries of the analysis of variance to test the effects of dietary treatment on the nitrogen utilization are given in Appendix Tables 9 and 10, respectively.

The mean values of nitrogen intake decreased ($P<0.05$) with increasing levels of chickpea seed waste in the diets. Treatment T_{32} had the highest ($P<0.05$) faecal nitrogen content followed by treatments T_{18}, T_{47} and lowest in T_0. The mean urinary nitrogen content in treatments T_0 and T_{18} were similar ($P>0.05$) and higher ($P<0.05$) than those of treatments T_{32} and T_{47}. The mean values of urinary nitrogen in treatments T_{32} and T_{47} were similar ($P>0.05$). The mean total nitrogen excreted in treatments T_0 and T_{18} were not significantly ($P>0.05$) different but were higher ($P<0.05$) than those of treatments T_{32} and T_{47}. There were no significance ($P>0.05$) difference in nitrogen retention and efficiencies of nitrogen utilization between treatments. However the data shows that nitrogen retained was similar in T_0 and T_{32} and higher than T_{18} and T_{47} which also were similar. Nitrogen efficiencies were highest in $T_{32.}$

Table 9: Effect of dietary treatments on nitrogen utilisation by rabbits (LSM)

Parameter (g/day)	Treatment				SED	Sign
	T_0	T_{18}	T_{32}	T_{47}		
N-intake	2.83[a]	2.60[b]	2.29[c]	2.10[d]	0.1	***
Faecal N	1.21[d]	1.36[b]	1.44[a]	1.26[c]	0.02	***
Urinary N	1.21[a]	1.06[a]	0.44[b]	0.68[b]	0.13	**
Total N excreted	2.42[a]	2.42[a]	1.88[b]	1.94[b]	0.13	*
N-absorbed	1.63[a]	1.24[b]	0.85[c]	0.84[c]	0.1	***
Total N retained	0.42	0.18	0.41	0.16	0.15	NS
N-retained/N-intake	0.14	0.07	0.17	0.07	0.06	NS
N-retained/N-absorbed	0.24	0.15	0.41	0.18	0.18	NS

, P<0.05; **, P<0.01;*, P<0.001*
Values in the same row bearing same superscript letters are not significantly different (P>0.05)
NS-Not significant
SED-Standard error of the mean difference
Sign-Significance level

The mean total nitrogen excreted in treatments T_{32} and T_{47} was similar (P>0.05). It was noted that the trend for faecal nitrogen was similar to that of dry matter intake pattern. The highest dry matter intake was observed in treatment T_{32} similarly T_{32} had the highest faecal nitrogen. The mean nitrogen absorbed was relatively high (P<0.05) in treatment T_0 followed by treatments T_{18} where as the values for T_{32} and T_{47} were similar (P>0.05) and lowest.

4.2 Experiment 2: Growth performance study

4.2.1 Health of the experimental animals

The health condition of the experimental animals was good throughout the study.

4.2.2 Effects of dietary treatments on the feed dry matter and nutrient intake

The least square mean (LSM) values of dietary effects on dry matter, energy and protein intake are shown in Table 10. The individual animal values of feed intake by rabbits are shown in Appendix Table 13. The summary of analyses of variance is shown in Appendix Table 14.

The values for dry matter intake increased ($P<0.05$) with increasing levels of chickpea seed waste in the diets, the highest level was observed in T_{32} and decreased in T_{47}. The mean energy intake for T_0, T_{18} and T_{32} did not differ significantly ($P>0.05$) and were higher ($P<0.05$) than that of Treatment $T_{47.}$ The mean values of protein intake decreased ($P<0.05$) with increasing levels of chickpea seed waste in the diets. Treatment T_0 had the highest ($P<0.05$) protein intake, where as treatments T_{18} and T_{32} had similar value ($P>0.05$). The sex of the animal had no influence on all the parameters measured, hence the analysis are not presented.

Table 10: Effects of treatment on feed intake (DMI), energy intake (MEI), protein intake (PI), weight gained (WG) final weight (FW), growth rate (GR) and feed conversion efficiency (FCE) (LSM)

Parameter	Treatment				SED	Sign
	T_0	T_{18}	T_{32}	T_{47}		
DMI (g/day)	58.8^c	60.9^b	62.0^a	60.2^b	0.82	*
MEI (MJ/day)	5.8^a	5.8^a	5.8^a	5.4^b	0.09	*
PI(g/day)	11.7^a	10.4^b	9.5^{bc}	8.9^c	0.04	***
IW (g)	701.4	621.2	723.8	728.0		
FW(g)	1833.6^{ab}	1852.7^a	1719.1^b	1623.3^b	47.0	*
WG (g)	1440.1^a	1159.1^a	1025.5^{ab}	929.8^b	46.8	**
GR (g/day)	16.3^a	16.6^a	14.7^{ab}	13.3^b	0.67	**
FCE (%)	25.1^a	24.5^a	21.2^b	19.9^b	0.9	***

, P<0.05; **, P<0.01;*, P<0.001*
Values in the same row bearing same superscripts letters are not significantly different (P>0.05)
NS-Not significant
SED-Standard error of the mean difference
Sign-Significance level

4.2.3 Growth performance

The effects of treatment on growth performance of rabbits are also shown in Table 10. The individual values of liveweight and growth rate of rabbits are presented in

Appendix Tables 11 and 12, respectively. The rabbits in treatment T_{47} despite of having relatively higher initial weight as compared to the other three treatments showed the lowest gains from the start of the experiment to the end. Rabbits on treatments T_0, T_{18} and T_{32} showed similar growth patterns where Treatment T_0 showed relatively higher gains (Figure 2).

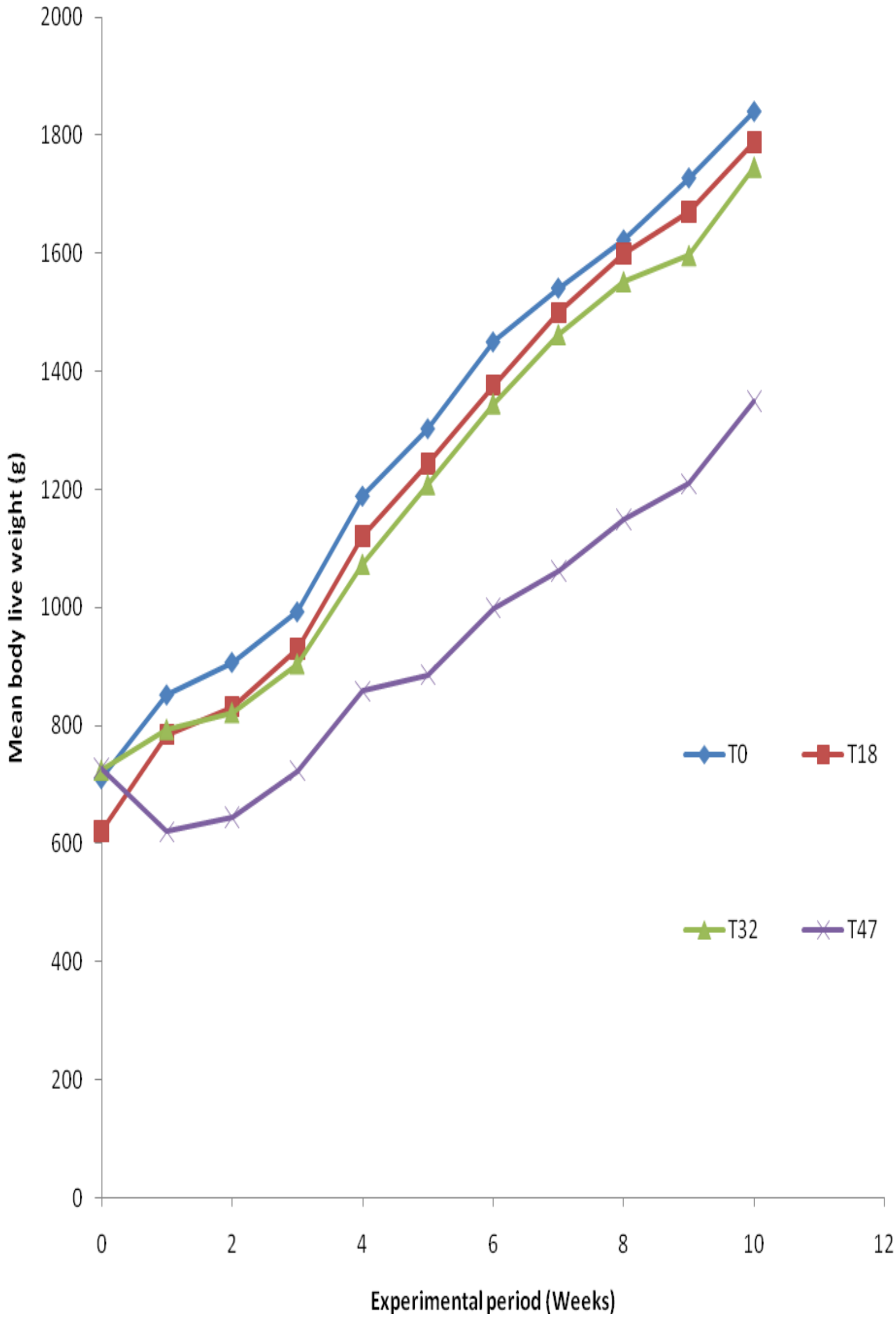

Figure 2: Growth curves for rabbits as affected by the four dietary treatments

The mean value of final weight of rabbits on treatments T_0 and T_{18} were similar ($P>0.05$) but differed ($P<0.05$) from those on treatments T_{32} and T_{47}. The mean values for growth rate and weight gained during the experimental period decreased with increased level of chickpea seed waste in the diets.

The mean value of feed conversion efficiency in rabbits on treatments T_0 and T_{18} did not differ ($P>0.05$) but were higher ($P<0.05$) than the means of those on treatments T_{32} and T_{47}. The mean total weight gain was lowest ($P<0.05$) for rabbits on treatment T_{47} followed by T_{32} and the highest for those on treatment T_{18}. The sex had no effect ($P>0.05$) and there were no interaction ($P>0.05$) effect between diet and sex in all parameters tested.

The relationship between chickpea seed waste inclusion level and DMI, FCE and GR are shown in Figure 3. The relationship followed curvilinear relationship;
$Y=16.40 + 0.025x - 0.002x^2$ ($R^2 = 0.93$), where Y = growth rate (g/day), X = chickpea seed waste inclusion level in the diet (%), R^2 = coefficient of determination.

In determining the optimal level of inclusion of chickpea seed waste, the curve for growth rate showed a decreased trend, implying that chickpea seed waste had a detrimental effect on the performance of the rabbits.

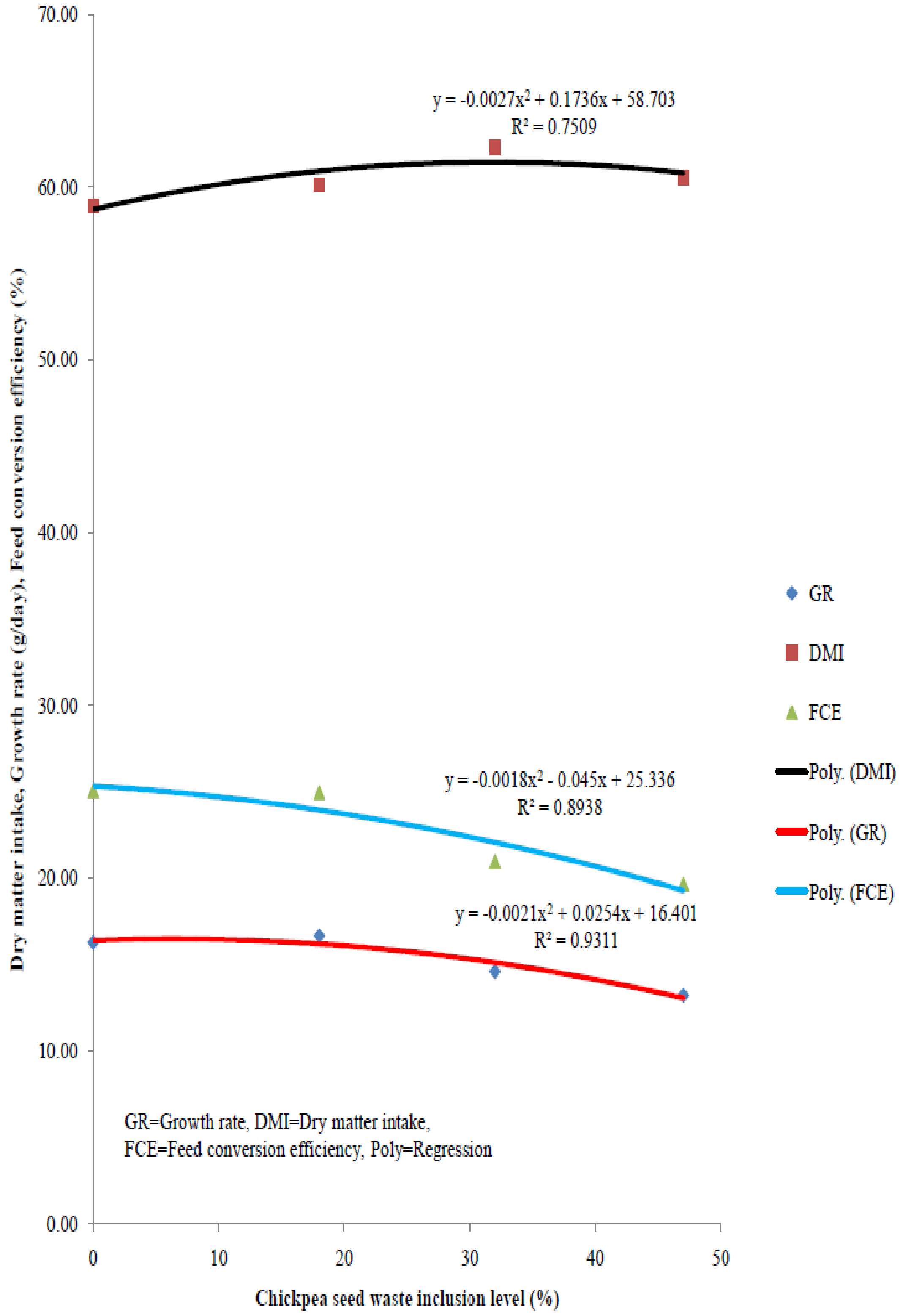

Figure 3: Relationship between chickpea seed waste inclusion level and dry matter intake, growth rate and feed conversion efficiency of the rabbits.

4.2.4 Slaughter characteristics

The mean dietary effect on slaughter characteristics of the rabbits are shown in Table 11. The individual values and their analysis of variance are shown in Appendix Tables 15 and 16, respectively. The mean slaughter weight and empty body weight did not differ (P>0.05) between treatments. The mean values of hot carcass weight decreased (P>0.05) with increased levels of chickpea seed waste in the diets. The mean values for rabbits on treatments T_0 and T_{18} were similar (P>0.05) and were higher than those of treatments T_{32} and T_{47}. Mean empty body weight as percentage of live weight, hot carcass as percentage of empty body weight and dressing percentage were not different (P>0.05) between treatments. Sex had no effect (P>0.05) on the parameters measured.

Table 11: Effect of treatment on slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW) and dressing percentage of rabbits (LSM)

Component	Treatment				SED	Sign
	T_0	**T_{18}**	**T_{32}**	**T_{47}**		
SW (g)	1849.5	1707.7	1673.8	1532.6	86.5	NS
EBW (g)	1373.3	1285.6	1304.8	1141.8	83.2	NS
EBW (% of SW)	73.9	74.9	78.1	74.5	2.2	NS
HCW (g)	944.3^a	837.8^a	794.8^b	730.0^b	48.1	*
HCW(% of EBW)	69.2	65.7	61.6	64.1	2.3	NS
Dressing (%)	50.9	49.0	47.4	47.7	0.9	NS

**, P<0.05*
Values in the same row bearing same superscripts letters are not significantly different (P>0.05)
NS-Not significant
SED-Standard error of the mean difference
Sign-Significance level

The mean effect of treatments on non carcass components is presented in Table 12. The individual absolute values of non carcass components and their summaries of analysis of variance to show the effects of treatment on non carcass components are presented in Appendix Tables 17 and 18, respectively. Non carcass components as a proportion of slaughter weight were neither affected by treatment nor sex of the animal.

Table 12: Effect of treatment on non carcass components of rabbits as proportion of slaughter weight (g) (LSM)

Component (g)	Treatment				SED	Sign.
	T_0	T_{18}	T_{32}	T_{47}		
SW	1849.5	1707.7	1673.8	1532.6	86.5	NS
Head	21.6	21.9	21.2	21.0	0.5	NS
Pluck	3.4	3.3	3.4	3.7	0.2	NS
GIT full	16.7	17.1	18.5	19.2	0.7	NS
GIT empty	6.9	6.8	7.1	7.9	0.4	NS
GIT contents	9.8	10.2	11.4	11.3	0.8	NS
Total internal fat	2.6	2.1	2.0	2.8	0.5	NS
Kidney	0.5	0.6	0.5	0.5	0.02	NS
Reproductive organ	0.3	0.3	0.3	0.3	0.03	NS

SW-Slaughter weight, GIT-Gastrointestinal tract, SED-Standard error of the difference, Sign-Significance level, NS-Not significance (P>0.05)

4.2.5 Economics of using chickpea seed waste in rabbit diets

The mean effects of treatment on the economic returns of using chickpea seed waste in rabbit diets are shown in Table 13. Individual values indicating parameters evaluated are presented in Appendix Table 19. The mean square and F-values obtained from analysis of variance are presented in Appendix Table 20.

Feed cost decreased ($P<0.05$) with increasing level of chickpea seed waste in the diets. Whereby the amount of feed consumed was highest ($P<0.05$) in treatment T_0 followed by treatments T_{32}, T_{18} and lowest for T_{47}. The cost of live rabbits was estimated at T. Shs. 6000 per rabbit. The mean cost of carcass per kilogram of treatments T_0 and T_{18} was similar ($P>0.05$) and higher ($P<0.05$) than those of treatments T_{32} and T_{47}. The gross margin per rabbit was highest ($P<0.05$) in treatment T_{47} followed by treatments T_{18}, T_{32} and lowest in T_0. The gross margin per kilogram of carcass was not significant ($P>0.05$) though highest value was in treatment T_{18} followed by T_{47}. It should be noted that the cost involved are those used for purchasing various feed ingredients to compound the diets. Labour cost and transport cost were not considered in this study.

Table 13: Effect of treatments on the economics of using chickpea seed waste (LSM)

Parameter	Treatment				SED	Sign
	T_0	T_{18}	T_{32}	T_{47}		
Mean feed consumed (kg)	4.5^b	4.6^b	5.6^a	6.0^a	0.1	***
Cost (T.shs.)/kg feed	458.0^a	377.0^b	330.0^c	277.5^d	5.0	***
Mean value (T.shs.) of feed consumed	2076.0^a	1722.9^c	1840.6^b	1661.9^d	42.6	***
Mean carcass weight (g)	944.3^a	837.8^a	794.8^b	730.0^b	48.0	*
Cost (T.shs.)/kg carcass	3056.2^a	2939.7^a	2846.1^b	2861.6^b	55.1	*
Gross margin (T.shs.)/rabbit	3924.1^d	4287.1^b	4150.2^c	4332.7^a	42.6	***
Gross margin (T.shs)/kg carcass	980.3	1226.8	996.3	1194.3	76.8	NS

, P<0.05; **, P<0.01;*, P<0.001*
Values in the same row bearing same superscripts letters are not significantly different (P>0.05)
NS-Not significant
SED-Standard error of the mean difference
Sign-Significance level

CHAPTER FIVE

5.0 DISCUSSION

The findings of the present study are discussed in relation to findings reported elsewhere:

5.1 Nutritional values of experimental diets

The observed value (852 g/kg DM) of dry matter content of chickpea seed waste was lower than 897.8 g/kg DM, 912 g/kg DM and 915 g/kg DM, reported by Maheri-sis *et al*. (2007), Aghdam-shahriar *et al*. (2004) and Mousavi and Mirza (2007), respectively. The variation in dry matter content could be due to different levels of drying of chickpea seed prior processing. The protein content (162 g/kg DM) chickpea seed waste was within the range of 44-279 g/kg DM reported by Abdi and Danesh (2010). The lowest value of crude protein (44 g/kg DM) reported by Abdi and Danesh (2010) could have been probably caused by high precision of processing machine, that the materials had high ratios of hulls which lead to lowering crude protein. Nevertheless the crude protein in the present study was lower than 218 g/kg DM reported by Maheri-sis *et al*. (2007), 200 g/kg DM reported by Mousavi and Mirza (2007) and Aghdam-shahriar *et al*. (2004) and of 185 g/kg DM reported by Ferdinand (2011). The variations could be due to precision of processing machine and sampling procedure used to obtain the samples. High precision of processing machines affect the ratio of bran in the waste, if the sample is taken from such kind of material will result into low crude protein and *vice versa*. Similarly, the crude protein varies depending on the type of material sampled; chickpea pre-screening waste has high crude protein as it contains deformed whole chickpea seeds than the processing waste which contains mainly bran. Also the variation could be due to different chickpea varieties and growing conditions in terms of geographical, seasonal variation and soil characteristics (Maheri-sis *et al*. 2008; Ramalho and Portugal, 1990, and Zia-Ul-Hag *et al*. 2007). Chickpea seed waste showed lower crude protein content (162 g/kg DM) than that of sunflower seed cake (241 g/kg DM) implying that chickpea seed waste cannot be used to make total replacement of sunflower seed cake since it may result into decreased dietary crude protein content. This was clearly shown by decreased crude protein content when sunflower seed cake was substituted with chickpea seed waste in the experimental diets. The mean crude protein content of the experimental diets (171g/kg DM) was within the range of 160-220 g CP/kg DM recommended as optimum to promote growth in growing rabbits (Carbano *et al*. 2008, Lebas 2004 and Lebas *et al*. 1997).

The crude fibre content of chickpea seed waste (304 g/kg DM) observed in the present study was higher than values (263 g/kg DM and 178 g/kg DM) reported by Maheri-sis *et al*. (2007) and Abdi and Danesh (2010), respectively but was close to the value (289 g/kg DM) reported by Ferdinand (2011) in similar environment of the study. The lowest value (72 g/kg DM) of crude fibre obtained by Abdi and Danesh (2010) for the chickpea prescreening waste was probably due to the fact that chickpea prescreening has high ratio of deformed and cracked chickpea than hulls. The higher fibre content in chickpea seed waste than sunflower seed cake (243 g/kg DM) implies that chickpea seed waste can completely used to replace sunflower seed cake in the diet without affecting the fibre required by rabbits because the amount of fibre exceeds the range of fibre requirement by rabbits (200-250 g/kg DM).

The range of crude fibre contents in the diets (164-202g/kg DM) was lower than 200-250g/kg DM recommended for growing rabbits by Meredith (2010) and Leng (2008). This might have led to the observed low intake by rabbits as pointed out by Thu and Dong (2008) that low fibre in rabbit diets reduce intake. For instance the diet which contained 164 g/kg DM fibre had the mean intake of 58.8 g/day versus 60.3 g/day for the diet with crude fibre of 202 g/kg DM.

Ether extract content (19 g/kg DM) observed in the present study was lower than 31 g/kg DM, 30 g/kg DM, 32.5 g/kg DM and 20 g/kg DM reported by Maheri-sis *et al*. (2007); Aghdam-shahriar *et al*. (2004) and Mousavi and Mirza (2007). This variation could have been caused by difference between varieties. The amount of ether extract varies depending on the variety of chickpea as reported by Ramalho and Portugal (1990) among eight chickpea varieties, ether extract ranged from 51-64 g/kg DM.

The observed decreases of ether extract contents of diets with increasing level of chickpea seed waste in the diet was attributed due to low level of ether extract (19 g/kg DM) in the chickpea seed waste. Nevertheless, the range of ether extract in the diet (69-130g/kg DM) was higher than the recommended range of 20-50 g/kg DM for rabbit diets (Amy, 2010). The relatively high level of ether extract in the diet was due to higher levels of ether extract in the feed ingredients used to compound the diets, which are sunflower seed cake, maize bran and fish meal. The observed mean dietary energy for the experimental diets (9.6 MJME/kg DM) was within the range of recommended dietary energy of 9.2-13.0 MJME/kg DM for growing rabbits (Lebas, 2004 and Partridge, 1989).

The observed decreased dry matter digestibility with increased chickpea seed waste in the diet was in agreement with results reported by Thi and Dong (2008) and Garcial *et al*. (1997) using soy bean hulls in rabbit diets. This can be explained by the fact that increased fibre in the diet leads to decreased retention time in the gastrointestinal tract due to high passage rate of digesta, hence reducing digestion time (Leng, 2008).

The observed decreased mean digestibility of crude protein with increased level of crude fibre in the diets was in agreement with findings by Ubwe (2002); Maeda (2000) and Garcial *et al*. (1997) using *Trichanthera gigantea*, *Morus alba* and soy bean hulls in rabbits diets, respectively. The decrease in digestibility with increased level of dietary fibre is possibly due to high passage of digesta through the gastrointestinal tract thus reducing digestibility (Leng, 2008). This decrease in crude protein digestibility was associated with significant ($P<0.05$) increase in faecal nitrogen and decreased nitrogen absorbed as chickpea seed waste increased. The observed decreased nitrogen intake with increased level of chickpea seed waste in the diets was possibly due to decreased levels of crude protein as chickpea seed waste level increased in the diets. The observed high levels of faecal nitrogen output in the diets containing chickpea seed waste could also imply the presence of antinutritional factors which impaired digestion and therefore needs further study. Nitrogen retained and efficiencies were not affected by the inclusion of chickpea seed waste in diets.

The level of chickpea seed waste in the diet was determined using protein digestibility curve. The decreased digestibility with increased chickpea seed waste indicates that sunflower seed cake cannot be substituted with chickpea seed waste by weight. Therefore, further study is recommended on substitution of the two ingredients based on protein levels.

The observed increased dry matter intake with increased chickpea seed waste inclusion level in the diets was possibly due to increased dietary crude fibre contents as pointed out by Thi and Dong. (2008). High amount of crude fibre inclusion in the diet tends to lower energy content of the diet and therefore rabbits adjust the voluntary feed intake so as to meet body energy demand (McNitt *et al*., 2000 and Partridge, 1989). The observed association of higher dietary fibre content with increased dry matter intake has also been reported by Adeniji and Lawal (2012); Amaefule *et al*. (2011); Hue and Preston (2006) and De Blas *et al*. (1981). The maximum dry matter intake of 62.0 g/day recorded on the rabbits in the present study was lower than the range of 86.6-93.0 g/day recommended by Lebas *et al*. (1986) for rabbits aged 56 days and 140-160 g/day for rabbits aged 112 days. The relatively low dry matter intake in the present study could be due to hot climatic condition during the study period, particularly temperature was very high (30˚C). It has been reported by Fielding (1991) and Lebas *et al*. (1986) that high ambient temperature above 30˚C has adverse effects on feed intake. The average dry matter intake of 60.5 g/day was lower than 67.3, 75.5, 82.3 and 87.0 g/day obtained by Ubwe (2002), Maeda (2000), Lugembe (1996) and Swai (1985), respectively using leaf meal to substitute control diet under similar environmental conditions. The observed relatively high intake might have been contributed by differences in the amino acid profile of the diets and palatability of the leaf meals included in the diets making rabbits to eat more. The observed decreased growth rate, feed conversion efficiency, total weight gained and final weight of rabbits as chickpea seed waste inclusion level increased was probably caused by the decreased protein intake. The crude protein in the experimental diets decreased as chickpea seed waste inclusion level increased in the diets, followed by the same trend of decreased protein intake. The results in the present study were in agreement with those obtained by Yassein *et al*. (2011) when they used varying levels of protein in the diets of rabbits.

The observed overall mean growth rate of 15.2 g/day of rabbits fed the diets containing chickpea seed waste was lower than 18.8g/day observed by Ubwe (2002) when included *Trichanthera gigantea* in rabbit diets at a level of 9% under similar environment of the study. This deviation could be due to the difference in the nutritive values of the diets. High nutritive value of diets promotes high growth rate while diets of poor nutritive value lower growth rate of the animals. The observed none significant sex effect on the parameters considered was in agreement with De Blas *et al*. (1981) when he studied the influence of sex on rabbit growth performance.

The observed values of feed conversion efficiency of 25.1, 24.5 and 21.2 for treatments T_0, T_{18} and T_{32}, respectively were higher than the value (20.0) reported by Lebas *et al*. (1997) for growing rabbits. Treatment T_{47} had lower (19.9) value than that reported for rabbits. This could be due to the fact that it had the lowest level of crude protein (148 g/kg DM) than the minimum amount of 160 g/kg DM recommended by Lebas (2004) for growing rabbits. In addition, rabbits on treatment T_{47} had the lowest amount of protein intake. According to Yassein *et al*. (2011), dietary crude protein below 160 g/kg DM tends to lower growth rate and hence reduced feed conversion efficiency. The coefficient of determination (R^2) of 93.1%, 89.3% and 75% implies that inclusion levels accounted for the much of the variation in growth rate, feed conversion efficiency and dry matter intake, respectively and the developed regression equations could be used to predict the optimum level of chickpea seed waste inclusion. Growth rate curve gave relatively high level of determination (R^2) in the inclusion of chickpea seed waste. The decreased growth rate with increased chickpea seed waste levels signifies that sunflower seed cake cannot be substituted with chickpea seed waste by weight in the diet of growing rabbits. Substitution based on protein levels is recommended for further studies.

The range of slaughter weight of 1.5-1.8 kg observed in the present study was similar to 1.6-1.8 kg reported by Lugembe (1985). The slaughter weights did not vary ($P>0.05$) between treatments nevertheless the final weight were significantly ($p<0.04$) different where T_0, T_{18} and T_{47} were similar and higher than $T_{32.}$ This could have been contributed by the differences in treatments and planning of experiments where less number of animals was randomly selected and used for slaughter. Inclusion of chickpea seed waste in the diets did not influence the non carcass components of growing rabbits. The limitation of the present study was that the diets were not iso-nitrogenous. Substitution based on the protein contents in the two ingredients could bring different results, hence recommended for a further study.

5.2 Economics of using chickpea seed waste

The mean feed consumed increased with increased levels of chickpea seed waste in the diets due to increased dietary crude fibre which increased feed intake by rabbits. Feed cost per kilogram decreased (31.8% to 19.2%) with increased level of chickpea seed waste due to decreased price of ingredients used to compound diets. The high mean value (T.Shs.) for the control (T_0) diet was due to high price of feed ingredients used where as high value of treatment T_{32} was caused by high amount of feed intake. This is in agreement with the observation made by Ubwe (2002) when substituted sunflower seed cake with *Trichanthera gigantea* in rabbit's diets. However, the cost per kilogram carcass decreased with increased level of chickpea seed waste inclusion in the diets, this was due to decreased dressing percentage which decreased with level of chickpea seed waste in the diets. The gross margin per rabbit was highest (26%) in treatment T_{47} attributed by lowest value of feed consumed and lowest (23.5%) gross margin in the control diet due to high value of the feed. Therefore inclusion of chickpea seed waste in diets reduced feed cost by 12.6% and increased gross margin per rabbit by 2.5%.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Observations from the conducted studies indicated that inclusion of chickpea seed waste in the diets of growing rabbits increased dry matter intake that attributed to rapid transit of digesta in the gastrointestinal tract resulting into lowering of nutrients digestibility. Nevertheless, inclusion of chickpea seed waste in the diets reduces hot carcass weight without influencing the non carcass components of growing rabbits. The practice also reduced feed cost by 12.6 percent and increased gross margin per rabbit by 2.5 percent. Furthermore, it was revealed that Chickpea seed waste cannot substitute sunflower seed cake in weight by weight in the diets of rabbits.

6.2 Recommendations

Based on the present findings it is recommended that:

i. Substitution based on the protein contents of the two ingredients is recommended for further study. The use of iso-nitrogenous diets is also important.

ii. Amino acid profiles of chickpea seed waste should be determined to know whether they meet nutritional demands since they have relation with how best the rabbits utilize feeds.

iii. Further investigations are necessary on the possibility of the presence of ant nutritional factors in chickpea seed waste.

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APPENDICES

Appendix 1: Individual daily feed intake (g) by rabbits

Treatment	Days							AVERAGE
	1	2	3	4	5	6	7	
T0	77.3	110.0	91.4	87.9	110.0	79.4	81.8	91.1
	100.0	105.6	110.0	103.0	97.0	89.7	105.6	101.6
	100.0	110.0	110.0	110.0	109.0	103.0	102.8	106.4
	100.0	110.0	110.0	110.0	79.0	107.7	110.0	103.8
	100.0	110.0	110.0	110.0	108.0	104.3	104.0	106.6
	93.5	110.0	110.0	110.0	106.0	110.0	110.0	107.1
Mean	**95.1**	**109.3**	**106.9**	**105.2**	**101.5**	**99.0**	**102.4**	**102.8**
T18	100.0	110.0	97.0	110.0	110.0	110.0	110.0	106.7
	100.0	110.0	110.0	110.0	110.0	95.6	102.3	105.4
	90.9	110.0	99.6	110.0	97.0	110.0	84.5	100.3
	73.8	100.7	98.9	101.4	83.0	110.0	84.9	93.2
	100.0	110.0	110.0	110.0	108.0	93.5	110.0	105.9
	100.0	110.0	100.9	102.7	110.0	103.6	107.9	105.0
Mean	**94.1**	**108.5**	**102.7**	**107.4**	**103.0**	**103.8**	**99.9**	**102.8**
T32	100.0	103.6	108.0	97.9	91.0	81.8	79.7	94.6
	100.0	110.0	110.0	110.0	105.0	105.5	105.6	106.6
	79.3	92.9	97.5	97.9	96.0	96.5	98.3	94.1
	100.0	106.4	110.0	108.2	98.0	108.3	85.7	102.4
	100.0	110.0	110.0	110.0	109.0	99.5	110.0	106.9
	100.0	110.0	110.0	110.0	108.0	110.0	110.0	108.3
Mean	**96.6**	**105.5**	**107.6**	**105.7**	**101.2**	**100.3**	**98.2**	**102.1**
T47	100.0	110.0	73.6	108.2	108.0	108.2	108.3	102.3
	100.0	110.0	110.0	104.0	110.0	110.0	110.0	107.7
	91.2	90.6	110.0	108.2	106.0	106.3	106.6	102.7
	100.0	110.0	104.8	100.3	87.0	83.4	87.2	96.1
	100.0	100.5	105.0	109.0	96.0	104.7	97.5	101.8
	100.0	105.5	110.0	106.7	105.0	106.0	106.8	105.7
Mean	**98.5**	**104.4**	**102.2**	**106.1**	**102.0**	**103.1**	**102.7**	**102.7**

Appendix 2: Individual daily values for weight of wet faeces (g) voided by rabbits

Treatment	Days							Average
	1	2	3	4	5	6	7	
T_0	98.2	44	49.7	48.1	50	45.4	61.2	56.7
	34.4	41.5	52.4	47.3	62	56.8	52.1	49.5
	56.4	48.2	40.9	49.8	62	42	56.5	50.8
	65.8	31.3	42.3	47.4	56	42.1	56.5	48.8
	75.9	40.8	58.3	43.3	59	53.6	67.8	57.0
	51.5	50.6	39.1	58.3	56	75.2	66.8	56.8
Mean	**63.7**	**42.7**	**47.1**	**49.0**	**57.5**	**52.5**	**60.2**	**53.3**
T_{18}	116.5	61.9	55.9	59.3	78	72.2	82	75.1
	82.1	63.1	71.4	65.1	88	100.8	79.4	78.6
	72.8	47.6	57.6	60.4	62	59.2	61.2	60.1
	84.7	42.9	46.4	54.9	52	47.8	83.2	58.8
	70	49.5	56.9	59.1	55	53.2	73.5	59.6
	17.6	30.4	36.4	35.6	56	42.2	69	41.0
Mean	**74.0**	**49.2**	**54.1**	**55.7**	**65.2**	**62.6**	**74.7**	**62.2**
T_{32}	60.7	56.5	56.1	48.8	72	55.1	74.7	60.6
	64	53.2	52.6	60	79	68.4	77.9	65.0
	53.4	76.2	63.8	67.6	85	81.2	78.7	72.3
	54.6	58.1	64.4	69.2	70.1	66.2	84.1	66.7
	51.7	46.6	75.4	67.3	95	83	97.3	73.8
	73.9	40.8	63.4	60	85	75.6	93.9	70.4
Mean	**59.7**	**55.2**	**62.6**	**62.2**	**81.0**	**71.6**	**84.4**	**68.1**
T_{47}	85.4	47	2.3	100.6	115	79.5	85.9	73.7
	133.5	57.6	81.5	96.1	100.1	95	100.5	94.9
	54.1	62.1	83	67.8	77	82.4	69.8	70.9
	54.6	22.9	60.5	53.5	72	54.3	60.5	54.0
	112.2	61.8	68.6	85.3	80	68.3	91	81.0
	59.5	52.8	66.1	67.6	80.1	77.2	79	68.9
Mean	**83.2**	**50.7**	**60.3**	**78.5**	**87.4**	**76.1**	**81.1**	**73.9**

Appendix 3: Individual daily values for weight of faeces (g on dry basis) voided by rabbits

Treatment	Days							Average
	1	**2**	**3**	**4**	**5**	**6**	**7**	
T_0	85.8	38.4	43.4	42.0	43.7	39.7	53.5	49.5
	30.1	36.3	45.8	41.3	54.2	49.6	45.5	43.2
	49.3	42.1	35.7	43.5	54.2	36.7	49.4	44.4
	57.5	27.3	37.0	41.4	48.9	36.8	49.4	42.6
	66.3	35.6	50.9	37.8	51.5	46.8	59.2	49.8
	45.0	44.2	34.2	50.9	48.9	65.7	58.4	49.6
Mean	**55.6**	**37.3**	**41.2**	**42.8**	**50.2**	**45.9**	**52.5**	**46.5**
T_{18}	102.1	54.2	49.0	51.9	68.3	63.2	71.8	65.6
	71.9	55.3	62.5	57.0	77.1	88.3	69.6	68.6
	63.8	41.7	50.5	52.9	54.3	51.9	53.6	52.5
	74.2	37.6	40.6	48.1	45.6	41.9	72.9	51.4
	61.3	43.4	49.8	51.8	48.2	46.6	64.4	52.1
	15.4	26.6	31.9	31.2	49.1	37.0	60.4	35.8
Mean	**64.8**	**43.1**	**47.4**	**48.8**	**57.1**	**54.8**	**65.5**	**54.3**
T_{32}	50.4	46.9	46.6	40.5	59.8	45.8	62.0	50.3
	53.2	44.2	43.7	49.8	65.6	56.8	64.7	54.0
	44.4	63.3	53.0	56.1	70.6	67.4	65.4	60.0
	45.4	48.3	53.5	57.5	58.2	55.0	69.9	55.4
	42.9	38.7	62.6	55.9	78.9	68.9	80.8	61.3
	61.4	33.9	52.7	49.8	70.6	62.8	78.0	58.5
Mean	**49.6**	**45.9**	**52.0**	**51.6**	**67.3**	**59.5**	**70.1**	**56.6**
T_{47}	67.5	37.2	1.8	79.5	90.9	62.8	67.9	58.2
	105.5	45.5	64.4	76.0	79.1	75.1	79.4	75.0
	42.8	49.1	65.6	53.6	60.9	65.1	55.2	56.0
	43.2	18.1	47.8	42.3	56.9	42.9	47.8	42.7
	88.7	48.9	54.2	67.4	63.2	54.0	71.9	64.1
	47.0	41.7	52.3	53.4	63.3	61.0	62.4	54.5
Mean	**65.8**	**40.1**	**47.7**	**62.0**	**69.1**	**60.2**	**64.1**	**58.4**

Appendix 4: Individual daily values for weights of fresh urine (g) voided by rabbits

Treatment	**Days**							**Average**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
T_0	50	46	45	60	31	5	-	33.9
	-	17	38	10	-	58	35	22.6
	18	90	56	20	-	40	10	33.4
	47	71	30	80	98	24	30	54.3
	5	25	32	17	2	85	42	29.7
	25	50	18	47	43	55	36	39.1
Mean	**24.2**	**50.0**	**36.5**	**39**	**29**	**44.5**	**25.5**	**35.5**
T_{18}	75	132	160	78	105	65	66	97.3
	10	40	48	38	30	40	35	34.4
	12	63	45	-	42	43	42	35.3
	150	138	170	225	100	115	175	153.3
	62	74	62	105	90	60	100	79.0
	-	29	-	41	50	47	50	31.0
Mean	**51.5**	**79.3**	**80.8**	**81.2**	**69.5**	**61.7**	**78.0**	**71.7**
T_{32}	17	45	45	52	63	64	5	41.6
	90	43	50	75	75	46	45	60.6
	15	80	60	54	35	15	10	38.4
	20	45	61	-	75	60	35	42.3
	140	220	90	225	115	210	70	152.9
	92	51	69	78	100	86	71	78.1
Mean	**62.3**	**80.7**	**62.5**	**80.7**	**77.2**	**80.2**	**39.3**	**69.0**
T_{47}	50	73	250	47	96	125	175	116.6
	-	440	335	280	242	260	150	243.9
	2	27	44	38	43	40	48	34.6
	200	85	46	100	13	74	36	79.1
	164	145	75	125	136	165	100	130.0
	45	43	60	45	67	38	50	49.7
Mean	**76.8**	**135.5**	**135.0**	**105.8**	**99.5**	**117.0**	**93.2**	**109.0**

Appendix 5: Individual chemical composition values for dry faeces fresh faeces and urine voided by rabbits

Treatment	Composition % DM basis				%N	
	DM	**CP**	**CF**	**EE**	**Faecal**	**Urine**
T_0	63.03	10.08	34.09	3.87	1.23	1.24
	54.54	8.18	36.96	2.73	1.48	1.27
	56.27	7.93	32.38	3.24	0.59	1.07
	60.99	10.49	35.69	2.77	1.65	1.17
	61.90	8.36	34.94	2.92	1.67	1.26
	69.40	10.27	36.71	10.31	0.64	1.25
MEAN	**60.95**	**9.20**	**35.13**	**4.28**	**1.21**	**1.21**
T_{18}	61.89	9.22	35.23	5.51	1.35	1.37
	63.51	9.97	38.04	3.90	1.15	1.31
	64.92	9.80	34.79	3.49	0.88	1.34
	66.42	9.83	32.77	3.20	0.74	1.4
	63.88	9.77	36.41	3.66	1.01	1.38
	64.11	9.87	36.67	3.35	1.23	1.36
MEAN	**64.12**	**9.75**	**35.64**	**3.85**	**1.06**	**1.36**
T_{32}	58.06	9.00	34.94	2.88	0.56	1.44
	57.55	7.65	31.90	2.95	0.54	1.41
	58.45	6.31	33.32	3.50	0.98	1.49
	59.63	8.17	34.29	4.34	0.27	1.43
	57.54	7.37	35.89	2.33	0.15	1.46
	57.77	7.57	34.45	0.99	0.14	1.41
MEAN	**58.17**	**7.68**	**34.15**	**2.82**	**0.44**	**1.44**
T_{47}	54.72	5.53	34.19	1.94	0.62	1.31
	56.79	6.93	35.88	1.88	0.61	1.25
	56.84	6.31	34.04	2.73	0.71	1.23
	54.32	5.60	35.63	2.45	0.66	1.26
	54.60	5.68	33.23	1.78	0.67	1.24
	58.14	5.87	34.32	1.00	0.81	1.27
MEAN	**55.91**	**5.98**	**34.55**	**1.98**	**0.68**	**1.26**

Appendix 6: Individual values for digestible nutrients of diets

Treatment	Digestible nutrients (g/kg DM)			
	DM	CP	CF	EE
T1	397.07	109.35	67.21	82.27
	491.24	120.91	42.82	100.09
	514.02	134.02	31.03	102.79
	520.32	134.28	15.08	102.71
	502.43	131.99	55.97	103.41
	503.17	136.39	49.70	64.63
Mean	**488.04**	**127.82**	**43.64**	**92.65**
T2	371.91	66.51	102.49	68.58
	347.64	74.58	136.96	78.04
	412.20	102.17	49.39	82.93
	378.38	80.09	68.85	79.91
	455.39	100.14	57.70	87.08
	554.97	118.17	0.65	94.17
Mean	**420.08**	**90.28**	**69.34**	**81.79**
T3	303.25	55.12	57.42	53.35
	388.46	64.74	49.14	63.25
	246.10	43.38	82.77	48.42
	326.80	60.74	59.38	50.15
	328.70	56.35	62.86	65.30
	354.95	62.27	59.50	76.65
Mean	**324.71**	**57.10**	**61.84**	**59.52**
T4	303.22	37.12	74.32	48.53
	238.78	25.75	142.11	46.83
	368.06	53.70	58.13	44.05
	374.62	47.61	20.14	44.84
	264.26	43.07	106.95	48.05
	332.96	54.71	40.80	58.38
Mean	**313.65**	**43.66**	**73.74**	**48.45**

Appendix 7: Individual values for apparent digestibility coefficients of dry matter (DMD), crude protein (CPD), crude fibre (CFD) and ether extract (EED) of dietary treatment by rabbits

Treatment	Digestibility (%)			
	DMD	**CPD**	**CFD**	**EED**
T_0	56.3	68.6	51.2	79.0
	63.9	69.6	29.9	88.2
	63.3	73.1	20.5	85.8
	66.0	75.4	10.3	88.2
	61.8	71.8	37.0	86.2
	60.9	73.1	32.3	53.1
Mean	**62.0**	**71.9**	**30.2**	**80.1**
T_{18}	46.0	39.5	66.8	62.4
	43.6	45.0	90.5	72.0
	54.0	64.3	34.1	79.8
	52.3	53.2	50.2	81.2
	56.9	60.0	37.9	79.9
	70.0	71.6	0.4	87.2
Mean	**53.8**	**55.6**	**46.7**	**77.1**
T_{32}	43.8	42.4	36.5	74.7
	48.8	43.3	27.2	77.0
	34.5	32.4	51.0	65.8
	43.0	42.6	34.4	64.0
	41.2	37.5	34.6	79.2
	43.8	40.9	32.3	91.6
Mean	**42.5**	**39.8**	**36.0**	**75.4**
T_{47}	40.0	28.5	41.8	77.6
	29.7	18.6	75.3	70.6
	47.7	40.5	32.1	69.2
	53.2	39.3	12.2	77.2
	35.1	33.2	60.5	77.3
	42.3	40.4	22.1	89.9
Mean	**41.3**	**33.4**	**40.7**	**77.0**

Appendix 8: Summary of ANOVA to show the effect of diets on digestibility of dry matter (DMD), crude protein (CPD), crude fibre (CFD) and ether extract (EED) by rabbits

Dependent Variable: DMD

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	1743.676751	581.225584	12.12	<.0001

R-Square	CV	Root MSE	DMD Mean
0.645087	13.87288	6.925794	49.92327

Dependent Variable: CPD

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	5345.163219	1781.721073	29.14	<.0001

R-Square	C V	Root MSE	CPD Mean
0.813797	15.57574	7.819900	50.20565

Dependent Variable: CFD

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	877.2145984	292.4048661	0.66	0.5854

R-Square	C V	Root MSE	CFD Mean
0.090257	54.78516	21.02595	38.37891

Dependent Variable: EED

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	69.94363530	23.31454510	0.22	0.8789

R-Square	C V	Root MSE	EED Mean
0.032437	13.19991	10.21366	77.37676

Appendix 9: Individual values for nitrogen utilization by rabbits

Traetment	Nitrogen intake (g/day)	Faecal nitrogen (g/day)	Nitrogen absorbed (g/day)	Urine nitrogen (g/day)	Total nitrogen excreted (g/day)	Nitrogen retained (g/day)	Nitrogen retained/ nitrogen intake	Nitrogen retained/ nitrogen absorbed
T_0	2.55	1.24	1.31	1.23	2.47	0.08	0.03	0.06
	2.78	1.27	1.51	1.48	2.75	0.03	0.01	0.02
	2.93	1.07	1.86	0.59	1.66	1.27	0.43	0.68
	2.85	1.17	1.68	1.65	2.82	0.03	0.01	0.02
	2.94	1.26	1.68	1.67	2.93	0.01	0.00	0.01
	2.98	1.25	1.73	0.64	1.89	1.09	0.37	0.63
Mean	**2.84**	**1.21**	**1.63**	**1.21**	**2.42**	**0.42**	**0.14**	**0.24**
T_{18}	2.69	1.37	1.32	1.35	2.72	-0.03	-0.01	-0.02
	2.65	1.31	1.34	1.15	2.46	0.19	0.07	0.14
	2.54	1.34	1.20	0.88	2.22	0.32	0.13	0.27
	2.41	1.40	1.01	0.74	2.14	0.27	0.11	0.27
	2.67	1.38	1.29	1.01	2.39	0.28	0.10	0.22
	2.64	1.36	1.28	1.23	2.59	0.05	0.02	0.04
Mean	**2.60**	**1.36**	**1.24**	**1.06**	**2.42**	**0.18**	**0.07**	**0.15**
T_{32}	2.08	1.44	0.64	0.56	2.00	0.08	0.04	0.13
	2.39	1.41	0.98	0.54	1.95	0.44	0.18	0.45
	2.14	1.49	0.65	0.98	2.47	-0.33	-0.15	-0.50
	2.28	1.43	0.85	0.27	1.70	0.58	0.26	0.68
	2.40	1.46	0.94	0.15	1.61	0.79	0.33	0.84
	2.44	1.41	1.03	0.14	1.55	0.89	0.36	0.86
Mean	**2.29**	**1.44**	**0.85**	**0.44**	**1.88**	**0.41**	**0.17**	**0.41**
T_{47}	2.08	1.31	0.77	0.62	1.93	0.15	0.07	0.20
	2.21	1.25	0.96	0.61	1.86	0.35	0.16	0.37
	2.12	1.23	0.89	0.71	1.94	0.18	0.09	0.21
	1.94	1.26	0.68	0.66	1.92	0.02	0.01	0.03
	2.07	1.24	0.83	0.67	1.91	0.16	0.08	0.20
	2.17	1.27	0.90	0.81	2.08	0.09	0.04	0.10
Mean	**2.10**	**1.26**	**0.84**	**0.68**	**1.94**	**0.16**	**0.07**	**0.18**

Appendix 10: Summary of ANOVA to show dietary effect on nitrogen utilization by rabbits

Dependent Variable: Nitrogen intake (NIT)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	1.93653784	0.64551261	38.03	<.0001

R-Square	CV	Root MSE	NIT Mean
0.850835	5.302072	0.130290	2.457333

Dependent Variable: Faecal nitrogen (FCN)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.19005000	0.06335000	29.06	<.0001

R-Square	CV	Root MSE	FCN Mean
0.813396	3.543869	0.046690	1.317500

Dependent Variable: Absorbed nitrogen (ABN)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	2.54517385	0.84839128	37.31	<.0001

R-Square	CV	Root MSE	ABN Mean
0.848404	13.22953	0.150795	1.139833

Dependent Variable: Urinary nitrogen (UN)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	2.22405000	0.74135000	7.44	0.0015

R-Square	CV	Root MSE	UN Mean
0.527520	37.23831	0.315595	0.847500

Dependent Variable: Total nitrogen excreted (TNE)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	1.57140000	0.52380000	4.68	0.0124

R-Square	CV	Root MSE	TNE Mean
0.412419	15.45378	0.334574	2.165000

Dependent Variable: Nitrogen retained (NRT)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.35989130	0.11996377	0.80	0.5064

R-Square	CV	Root MSE	NRT Mean
0.107601	132.1493	0.386316	0.292333

Appendix 10 continues

Dependent Variable: NRT/NIT

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.04443779	0.01481260	0.70	0.5611

R-Square	CV	Root MSE	NRT/NIT Mean
0.095445	126.7262	0.145111	0.114508

Dependent Variable: NRT/ABN

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.24208491	0.08069497	0.79	0.5144

R-Square	CV	Root MSE	NRT/ABN Mean
0.105781	130.4434	0.319880	0.245225

Appendix 11: Individual weekly liveweights (g) of rabbits

T	WT0	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	WT9	WT10
T_0	981.4	1139.3	1143.7	1286	1499.5	1552.2	1724.3	1789.4	1858.4	1952	2070.5
	634.4	827.5	859.3	801.7	1103	1272.7	1402	1578.6	1744.2	1856.5	1959.3
	618.6	881.2	934.8	1008.6	1187	1294.4	1492.5	1629	1751.8	1879.3	2029.7
	572.4	753.4	724.1	824.7	957.2	1080.1	1245.7	1320.6	1367.8	1473.5	1576.5
	1125.7	1154.4	1289.5	1296.6	1434.3	1577.1	1584.1	1598.4	1670.6	1755.6	1871.1
	1025.5	1198.1	1190.1	1216	1515.1	1674.5	1843	1949.2	2035.4	2112.2	2144.5
	682	909.3	936.3	1116.6	1340	1282.8	1444.9	1550	1680.4	1783.5	1953.8
	782.4	908.8	850.5	992.4	1147	1205.3	1301.2	1324.2	1331.5	1397.2	1493.1
	399.8	544	822.3	1000.1	1101.1	1264.6	1454.4	1470.4	1490.7	1572	1669.7
	739.4	1015.1	1218.3	1281.7	1571.4	1591.5	1790.4	1981.2	2092.6	2223.8	2331.6
	805.2	909.2	982.5	1029.1	1309.9	1426.3	1663.7	1723.8	1807.2	1912.3	2044.9
	820.3	1024.4	1154.4	1323	1472.4	1604.7	1765	1825.9	1885.3	1989.9	2062.8
	716.3	803.4	825.4	946.8	1145.2	1321.6	1459.9	1515.4	1554.5	1698.8	1841.7
	525.8	640.1	649.3	695	904.7	1105.2	1188.1	1355.4	1524.3	1635.9	1764.8
	452.6	465.3	482.8	569	701.8	830.4	940.6	1048.2	1137.5	1250.7	1343.7
	340.7	456.3	447.9	494.5	629.7	763.6	902.8	1000.2	1035.8	1151.6	1293.6
Mean	**2337.2**	**2086.0**	**1706.1**	**1055.9**	**1237.3**	**1302.9**	**1450.2**	**1541.2**	**1623.0**	**1727.8**	**1840.7**
T_{18}	1004.6	1143.9	1255.6	1243	1338.1	1464	1638	1765.5	1934.3	1979.5	2150.5
	1116	1357.8	1415.2	1489.6	1661.9	1822.8	1877.3	1978.1	2022.1	2022	2178
	811.5	989.9	1069.7	1213.8	1424.4	1500.5	1601.3	1685.5	1762.2	1793	1866.3
	364.4	495.7	478.5	485.9	936	627.2	734.4	818.9	918.7	991.1	1165.4
	608	753.2	778.6	848.6	1163.7	1194.2	1391.1	1496.2	1581.2	1674.3	1780.4
	488.2	650.7	669.1	794.4	950.4	1151.5	1298	1424.6	1511.1	1565.6	1635.9
	505.6	762	667.4	728.3	1007.2	1222.3	1437.1	1527.4	1664.4	1782.3	1880.2
	484.2	689.9	829	1058.3	1041.4	1291.9	1399.3	1570.1	1638.9	1736.4	1838.2
	862.9	932.2	966.5	1016.7	1313.4	1436.9	1529.2	1645.8	1730.5	1759	1892.8
	599.8	815.2	906.3	1072.6	1273.4	1444.3	1642.8	1851	1995.5	2119.1	2274.6
	506.7	679.3	732.2	837.2	1057.7	1272.2	1388.7	1531	1612.6	1662	1731.3
	631.6	777.3	953.2	1120.7	1204.1	1347.5	1518.1	1619.9	1708.6	1824.5	1942
	589.4	759.1	816.1	933.6	1056.5	1206	1315.2	1444.6	1597.3	1657.2	1766.9
	705.2	914.8	1005.6	1049.8	1217.6	1403.3	1492.8	1543.8	1550.5	1615.4	1761.2

	333	408	365.2	424.4	577.7	663.3	819.4	951.9	1103.2	1209.8	1365.9
	327.7	423.3	402.5	558.4	700.7	842.5	940.6	1138.2	1250.6	1324	1368.8
Mean	**621.2**	**784.5**	**831.9**	**929.7**	**1120.3**	**1243.2**	**1376.5**	**1499.5**	**1598.9**	**1669.7**	**1787.4**

Appendix 11 continues

T	WT0	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	WT9	WT10
T_{32}	872.1	1017.7	1166.8	1235.5	1425	1458	1538.1	1643	1728.2	1706.7	1859.5
	538.1	651.6	665.4	765.9	860.2	1010.3	1192.7	1303.3	1368.7	1414.4	1486.3
	371.4	525.6	544.6	657.1	764.6	946.6	1062.7	1204.6	1280.1	1351.6	1446.9
	578.5	776.1	813.7	967.7	1150.4	1279.2	1405.2	1511	1608.8	1652.3	1740.4
	953.5	956.1	842.1	955.2	1165.5	1289.8	1481.1	1604.2	1708.3	1770.3	1910.5
	602.1	641.2	596.3	672.8	787.7	974.1	1106.6	1262.6	1287.7	1387	1548.4
	460.5	609.4	637	692	760.4	841.5	950.5	1047.3	1191.4	1318.8	1496.2
	406.6	526.9	518.6	571.1	662.9	753	907.3	1014.7	1103.9	1165.5	1310.4
	615.7	763.5	822.3	946.7	1124.5	1170.2	1268.1	1361.4	1484.2	1521.1	1659.2
	1046.7	679.3	732.8	837.2	1057.7	1597.3	1750.7	1841.9	1798.2	1940	2141.7
	783.4	968.4	1119.6	1255.2	1324	1460.9	1604	1772	1900.1	1838.3	2132.2
	878.7	959.7	974.1	1179.6	1247.5	1378	1509.4	1579.2	1697.3	1733.2	1883.6
	510.8	581	598.5	577	829.5	941.6	1105.3	1232.1	1390.9	1462.8	1525.5
	869	1029.2	987.6	1027.1	1331.8	1394.5	1555.4	1700.2	1788.2	1829.3	2026
	1038.2	1053.1	1177	1206.9	1480.1	1496.8	1605	1706	1762.3	1772.7	1908.1
	1054.8	954.3	951.6	924	1199.1	1343.2	1483.6	1613.5	1735.5	1678.8	1866.6
Mean	**723.8**	**793.3**	**821.8**	**904.4**	**1073.2**	**1208.4**	**1345.4**	**1462.3**	**1552.1**	**1596.4**	**1746.3**
T_{47}	883.6	956.9	1010.5	1109.9	12348	1320.1	1411.6	1490.4	1570.1	1526.9	1671.3
	650.5	820.9	810.3	889.9	936	999.2	1130.1	1238.3	1331.7	1405	1476.8
	526.9	605.5	619.9	765.1	824	981.6	1123.9	1232.8	1370.1	1507.7	1599.8
	719.4	793.8	754.4	789.3	962	1050.1	1140.7	1189.5	1269.5	1302.4	1417.3
	922.3	930.2	959.3	1050.7	1139.7	1164.4	1296.2	1332.7	1321.2	1368.4	15053.3
	836.1	898.3	953.6	1092.7	1120.8	1255.2	1287.4	1396.4	1532.3	1521.9	1519.6
	717.2	865.2	883	1023	1041.4	1145.3	3122.9	1490.9	1554	1596.3	1738.8
	884	996.2	931.5	1001.6	1340	1251.4	1420.9	1543.1	1690.3	1713	1764
	534.1	678	683.2	784.9	940.1	1007.8	1185.9	1281.9	1434.3	1572.5	1617.3
	570.1	715	756.5	796.6	874.1	978.7	1148.7	1249.9	1352.2	1366	1499.3
	675.1	798.1	846.3	1009.6	1073.4	1182	1306.1	1371.5	1445.9	1531.5	1628.6

	831.1	968.2	990.6	1066.7	1156.8	1234.2	1368.3	1426	1585.1	1696.8	1897.6
	603.2	752.3	756.5	937.1	1057.1	1184.1	1274.1	1350.1	1490	1592.9	1666.7
	874.4	1025.1	1059	1129	1304	1344.6	1472.2	1570.1	1692.2	1716.7	1894.9
	620.4	785.3	896.6	1052.9	1183.9	1230.8	1391.3	1494.5	1650.7	1747	1834.2
	800	920.2	892.4	998.4	991.8	1107.6	1272.2	1363.5	1481.9	1583.1	1689.9
Mean	**728.0**	**844.3**	**862.7**	**968.6**	**1768.3**	**1152.3**	**1397.0**	**1376.4**	**1485.7**	**1546.8**	**2498.1**

Appendix 12: Individual growth rates (g/day) of rabbits

Treatment	**Weeks**				
	0-2	**2-4**	**4-6**	**6-8**	**8-10**
T_0	0.31	15.25	12.29	4.93	8.46
	2.27	21.52	9.24	11.83	7.34
	3.83	12.74	14.15	8.77	10.74
	-2.09	9.46	11.83	3.37	7.36
	9.65	9.84	0.50	5.16	8.25
	-0.57	21.36	12.04	6.16	2.31
	1.93	15.96	11.58	9.31	12.16
	-4.16	11.04	6.85	0.52	6.85
	19.88	7.21	13.56	1.45	6.98
	14.51	20.69	14.21	7.96	7.70
	5.24	20.06	16.96	5.96	9.47
	9.29	10.67	11.45	4.24	5.21
	1.57	14.17	9.88	2.79	10.21
	0.66	14.98	5.92	12.06	9.21
	1.25	9.49	7.87	6.38	6.64
	-0.60	9.66	9.94	2.54	10.14
Mean	**3.93**	**14.01**	**10.52**	**5.84**	**8.06**
T_{18}	7.98	6.79	12.43	12.06	12.21
	4.10	12.31	3.89	3.14	11.14
	5.70	15.04	7.20	5.48	5.24
	-1.23	32.15	7.66	7.13	12.45
	1.81	22.51	14.06	6.07	7.58
	1.31	11.14	10.46	6.18	5.02
	-6.76	19.92	15.34	9.79	6.99
	9.94	-1.21	7.67	4.91	7.27
	2.45	21.19	6.59	6.05	9.56
	6.51	14.34	14.18	10.32	11.11
	3.78	15.75	8.32	5.83	4.95
	12.56	5.96	12.19	6.34	8.39
	4.07	8.78	7.80	10.91	7.84

	6.49	11.99	6.39	0.48	10.41
	-3.06	10.95	11.15	10.81	11.15
	-1.49	10.16	7.01	8.03	3.20
Mean	**3.39**	**13.61**	**9.52**	**7.09**	**8.41**

Appendix 12: continues

Treatment			**Weeks**		
	0-2	**2-4**	**4-6**	**6-8**	**8-10**
T_{32}	10.65	13.54	5.72	6.09	10.91
	0.99	6.74	13.03	4.67	5.14
	1.36	7.68	8.29	5.39	6.81
	2.69	13.05	9.00	6.99	6.29
	-8.14	15.02	13.66	7.44	10.01
	-3.21	8.21	9.46	1.79	11.53
	1.97	4.89	7.79	10.29	12.67
	-0.59	6.56	11.02	6.37	10.35
	4.20	12.70	6.99	8.77	9.86
	3.82	15.75	10.96	-3.12	14.41
	10.80	4.91	10.22	9.15	20.99
	1.03	4.85	9.39	8.44	10.74
	1.25	18.04	11.69	11.34	4.48
	-2.97	21.76	11.49	6.29	14.05
	8.85	19.51	7.73	4.02	9.67
	-0.19	19.65	10.03	8.71	13.41
Mean	**2.03**	**12.05**	**9.78**	**6.41**	**10.71**
T_{47}	3.83	8.03	6.54	5.69	10.31
	-0.76	3.29	9.35	6.67	5.13
	1.03	4.21	10.16	9.81	6.58
	-2.81	12.34	6.47	5.71	8.21
	2.08	6.36	9.41	-0.82	9.77
	3.95	2.01	2.30	9.71	-0.16
	1.27	1.31	14.13	4.51	10.18
	-4.62	24.17	12.11	10.51	3.64
	0.37	11.09	12.72	10.89	3.20
	2.96	5.54	12.14	7.31	9.52
	3.44	4.56	8.86	5.31	6.94
	1.60	6.44	9.58	11.36	14.34

	0.30	8.57	6.43	9.99	5.27
	2.42	12.50	9.11	8.72	12.73
	7.95	9.36	11.46	11.16	6.23
	-1.99	-0.47	11.76	8.46	7.63
Mean	**1.31**	**7.46**	**9.53**	**7.81**	**7.47**

Appendix 13: Individual values for feed intake (g/day) between time intervals

Treatment			**Weeks**		
	0-2	**2-4**	**4-6**	**6-8**	**8-10**
T_0	34.14	75.17	84.44	69.51	86.18
	41.04	57.71	81.76	77.74	76.90
	36.21	59.52	85.75	78.69	88.81
	21.43	46.04	81.91	62.92	77.69
	41.86	62.70	84.46	65.11	85.84
	41.62	67.37	82.20	78.79	85.32
	39.55	56.69	68.13	59.41	85.09
	35.50	67.42	82.96	58.70	79.19
	38.74	57.79	69.54	40.44	75.78
	28.51	54.70	86.67	82.97	86.85
	43.05	59.81	82.97	75.98	85.61
	51.43	75.87	78.41	60.26	83.04
	42.64	62.26	78.44	44.96	60.98
	33.56	58.93	86.13	71.16	85.12
	38.08	44.09	75.87	54.16	91.88
	33.40	49.88	76.71	62.52	87.38
	37.55	59.75	80.40	65.21	82.60
Mean	**32.29**	**55.28**	**86.33**	**78.50**	**78.81**
T_{18}	50.03	64.34	88.68	70.22	81.28
	43.26	71.49	89.05	70.88	86.84
	17.98	38.82	63.40	56.22	75.86
	38.66	63.56	85.64	71.29	88.52
	25.50	48.94	83.54	70.63	82.00
	23.96	49.05	86.22	72.00	82.59
	43.03	78.36	85.86	68.84	82.47
	46.70	57.00	87.74	68.55	74.57
	45.64	71.69	86.47	74.36	77.48
	31.66	58.29	82.81	77.36	85.54
	45.38	61.14	82.01	76.73	88.20

	39.67	50.54	86.61	76.13	88.04
	42.09	64.74	87.10	65.94	85.52
	42.43	48.91	69.11	73.86	85.74
	26.76	52.32	80.26	73.42	86.55
Mean	**37.19**	**58.40**	**83.18**	**71.56**	**83.13**

Appendix 13: continues

Treatment	Weeks				
	0-2	**2-4**	**4-6**	**6-8**	**8-10**
	52.97	70.99	89.80	67.76	85.61
	38.28	56.91	86.66	76.09	89.03
	36.60	59.52	88.79	70.99	89.29
T_{32}	30.16	68.41	85.43	78.31	90.76
	28.96	67.36	87.87	74.66	88.66
	30.12	57.17	85.80	73.09	88.79
	38.04	61.52	82.98	57.03	87.63
	33.74	47.79	79.45	58.53	88.77
	55.08	67.82	83.68	64.81	84.61
	35.26	71.45	86.07	80.27	88.35
	51.99	64.38	80.39	81.99	86.74
	39.75	59.98	80.29	71.56	89.14
	43.49	47.69	89.69	70.99	87.30
	51.00	55.81	88.86	73.29	85.47
	46.74	73.90	84.97	72.72	87.02
	32.46	74.56	90.37	77.57	88.84
Mean	**40.29**	**62.83**	**85.69**	**71.85**	**87.88**
	46.17	63.59	87.16	64.66	83.31
	36.75	57.99	84.24	65.04	82.36
	28.04	64.86	81.79	72.04	86.79
	40.77	50.64	84.96	68.49	84.67
T_{47}	42.70	64.86	85.22	65.57	82.34
	49.36	62.22	89.39	67.94	84.88
	38.74	58.70	81.65	65.44	87.21
	45.11	62.42	84.69	73.90	86.53
	47.63	61.18	84.28	72.52	87.96
	32.74	60.63	69.54	59.34	87.76

	45.86	62.77	86.72	75.43	86.84
	42.39	61.69	85.29	76.24	85.79
	26.04	53.00	78.69	65.71	84.10
	41.16	68.07	81.97	66.33	84.71
	45.40	67.93	88.82	57.70	87.69
	41.57	52.62	70.49	64.99	87.48
Mean	**40.65**	**60.82**	**82.81**	**67.58**	**85.65**

Appendix 14: Summary of ANOVA to show the effect of diets, sex and interaction between diet and sex on the feed intake (DMI), Metabolizable energy intake (ME), protein intake (PI), liveweight (LW), growth rate (GR) and feed conversion efficiency (FCE)

Dependent variable DMI

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	84.9277965	28.3092655	2.65	0.0510
SEX	1	2.8747889	2.8747889	0.27	0.6062
DIET*SEX	3	41.9166568	13.9722189	1.31	0.2816

R-Square	CV	Root MSE	DMI Mean
0.410506	5.407234	3.270583	60.48532

Dependent variable ME

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	0.01630531	0.00543510	4.88	0.0044
SEX	1	0.00089079	0.00089079	0.80	0.3750
DIET*SEX	3	0.00331847	0.00110616	0.99	0.4028

R-Square	CV	Root MSE	ME Mean
0.409642	5.825838	0.033369	0.572781

Dependent variable PI

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	69.21346427	23.07115476	8.34	0.0001
SEX	1	0.07400863	0.07400863	0.03	0.8707
DIET*SEX	3	13.85928955	4.61976318	1.67	0.1840

R-Square	CV	Root MSE	PI Mean
0.352387	16.37138	1.663037	10.15820

Dependent variable FW

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	535237.089	178412.363	5.08	0.0360
SEX	1	347.283	347.283	0.01	0.9212
DIET*SEX	3	95165.864	31721.955	0.90	0.4457

R-Square	CV	Root MSE	FW Mean
0.545832	10.66687	187.4380	1757.197

Appendix 14: continues

Dependent variable WG

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	535237.0886	178412.3629	5.08	0.0036
SEX	1	347.2827	347.2827	0.01	0.9212
DIET*SEX	3	95165.8638	31721.9546	0.90	0.4457

R-Square	CV	Root MSE	WG Mean
0.277882	17.62287	187.4380	1063.606

Dependent variable GR

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	109.2320590	36.4106863	5.08	0.0036
SEX	1	0.0708740	0.0708740	0.01	0.9212
DIET*SEX	3	19.4216049	6.4738683	0.90	0.4457

R-Square	CV	Root MSE	GR Mean
0.277882	17.62287	2.677685	15.19438

Dependent variable FCE

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DIET	3	307.0098622	102.3366207	7.87	0.0002
SEX	1	2.1488659	2.1488659	0.17	0.6859
DIET*SEX	3	26.4829065	8.8276355	0.68	0.5687

R-Square	CV	Root MSE	FCE Mean
0.422449	15.91308	3.605966	22.66038

Appendix 15: Individual values for slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW) and dressing percentages

Treatment	SW (g)	EBW (g)	HCW (g)	(EBW/SW)*100	(HCW/EBW)*100	HCW/SW)*100
T_0	2030.0	1520.0	1092.2	74.9	71.9	53.8
	2008.3	1561.7	1021.7	77.8	65.4	50.9
	1289.5	949.5	631.7	73.6	66.5	49.0
	1997.4	1513.6	1032.5	75.8	68.2	51.7
	1883.2	1344.3	911.2	71.4	67.8	48.4
	2007.9	1512.1	1062.3	75.3	70.3	52.9
	1299.0	819.8	657.8	63.1	80.2	50.6
	2280.7	1813.4	1145.1	79.5	63.1	50.2
Mean	**1849.5**	**1379.3**	**944.3**	**73.9**	**69.2**	**50.9**
T_{18}	1998.0	1515.2	1038.0	75.8	68.5	52.0
	1283.1	820.9	633.1	64.0	77.1	49.3
	1750.2	1400.5	816.0	80.0	58.3	46.6
	1704.0	1392.3	813.9	81.7	58.5	47.8
	1659.7	1296.9	886.0	78.1	68.3	53.4
	1825.9	1333.7	886.7	73.0	66.5	48.6
	1302.0	954.8	605.4	73.3	63.4	46.5
	2139.0	1570.4	1023.2	73.4	65.2	47.8
Mean	**1707.7**	**1285.6**	**837.8**	**74.9**	**65.7**	**49.0**
T_{32}	1395.7	1296.9	634.8	92.9	48.9	45.5
	1672.5	1006.7	816.1	60.2	81.1	48.8
	1490.9	1147.4	743.9	77.0	64.8	49.9
	1500.0	1164.6	709.3	77.6	60.9	47.3
	2010.3	1670.7	1047.6	83.1	62.7	52.1
	1792.2	1421.6	850.6	79.3	59.8	47.5
	1708.1	1300.3	820.3	76.1	63.1	48.0
	1820.5	1430.0	736.0	78.5	51.5	40.4
Mean	**1673.8**	**1304.8**	**794.8**	**78.1**	**61.6**	**47.4**
T_{47}	1794.2	1333.0	841.9	74.3	63.2	46.9

	1620.0	1220.0	810.7	75.3	66.5	50.0
	1597.1	1130.4	768.4	70.8	68.0	48.1
	1388.5	1020.2	715.5	73.5	70.1	51.5
	1455.9	1090.0	667.4	74.9	61.2	45.8
	1346.2	1006.7	650.9	74.8	64.7	48.4
	1634.8	1250.8	718.9	76.5	57.5	44.0
	1424.1	1083.2	666.1	76.1	61.5	46.8
Mean	**1532.6**	**1141.8**	**730.0**	**74.5**	**64.1**	**47.7**

Appendix 16: Summary of ANOVA to show the effect of treatments on slaughter characteristics of rabbits (g)

Dependent Variable: Slaughter weight (SW)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	406316.9359	135438.9786	2.26	0.1072
SEX	1	7.5078	7.5078	0.00	0.9912

R-Square	CV	Root MSE	SW Mean
0.401675	14.47466	244.7525	1690.903

Dependent Variable: Empty body weight (EBW)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	236719.4425	78906.4808	1.42	0.2601
SEX	1	1210.3200	1210.3200	0.02	0.8837

R-Square	CV	Root MSE	EBW Mean
0.296522	18.41678	235.3411	1277.863

Dependent Variable: EBW % of SW (EBSW)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	83.96160526	27.98720175	0.75	0.5313
SEX	1	7.74685089	7.74685089	0.21	0.6521

R-Square	CV	Root MSE	EBSW Mean
0.163336	8.087811	6.095515	75.36668

Dependent Variable: Hot carcass weight (HCW)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	194618.9725	64872.9908	3.52	0.0303
SEX	1	1365.0313	1365.0313	0.07	0.7879

R-Square	CV	Root MSE	HCW Mean
0.435435	16.42364	135.7783	826.7250

Dependent Variable: HCW % of EBW (HCEB)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	242.3024453	80.7674818	1.88	0.1602

SEX	1	22.6419111	22.6419111	0.53	0.4751

R-Square	CV	Root MSE	HCEB Mean
0.297283	10.06658	6.557669	65.14297

Dependent Variable: Dressing % (DRP)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	61.48082824	20.49360941	2.89	0.0561
SEX	1	3.72049027	3.72049027	0.53	0.4756

R-Square	CV	Root MSE	DRP Mean
0.321914	5.457650	2.661441	48.76533

Appendix 17: Individual values for the effects of diets on the weights of non carcass components of rabbits (g)

Treatment	Head	Oesophagus	Kidneys	Skin	Blood	Lungs	Liver	Heart	Spleen	Kidney fat	GIT (full)	GIT (empty)	GIT contents	Gut fat	Reproductive	Feet	Tail
T_0	167.8	2.9	11.4	232.8	72.3	17.7	52.8	4.7	0.5	38.3	319.1	114.1	205	30.1	2.8	57.8	3.4
	169.4	2.2	8.5	193.8	74.7	15.6	44.2	5.7	1	42.7	331.6	133.1	198.5	47.6	14.3	41.2	8
	127.3	1.3	6.8	126.6	74.1	7.1	31.6	3.3	0.5	7.8	220.4	112.4	108	5.6	5	37.7	5.9
	151.5	1.8	9.9	182.3	82.1	9	49.3	4.5	0.9	22.4	293	120.8	172.2	27.5	8.4	51.4	10.3
	176	2.6	11.9	180	43.1	8.9	35.1	3.2	0.8	19.4	290.3	108.1	182.2	17	5.9	44.5	6.1
	150.9	2.9	9.9	200.6	59.8	17.1	44.6	4.2	0.7	34	300.1	115.6	184.5	27.9	6.8	50.1	5.7
	121.1	1.6	5.3	119.9	59.5	6.1	31.8	2.9	0.6	9	308.2	111.5	196.7	9.8	4.3	29.8	7.3
	172.3	2.9	12.2	298.7	90.9	18.7	60.1	5.9	1	40.3	356.8	188.3	168.5	31.4	3	59.6	4.2
Mean	**154.5**	**2.3**	**9.5**	**191.8**	**69.6**	**12.5**	**43.7**	**4.3**	**0.8**	**26.7**	**302.4**	**125.5**	**177.0**	**24.6**	**6.3**	**46.5**	**6.4**
T_{18}	179.4	2.7	10	180.7	58.4	14	50.1	3.8	0.8	30.1	290.6	119.4	171.2	24.7	7.1	50	6.5
	122.6	1.9	7.4	120	60.1	7.9	30.9	3	0.5	8	225.5	110.7	114.8	10.3	4.2	30.1	6.1
	141	2.4	9	160	63.6	9	30.7	3.9	0.5	16.4	314.3	114	200.3	16.3	5.4	40.9	6.1
	139.8	2.8	9.1	155.2	60	9.6	32.1	3.3	0.4	16.7	311.1	130.1	181	15.7	6.1	41.4	5.8
	149.4	2.9	9.9	160.5	58.9	17.5	47.3	3.5	0.8	28	303.5	116.6	186.9	15.3	5.6	46.4	6.5
	170.9	2.9	13.9	199.6	20.5	10.4	33.4	4.8	0.9	24	285.3	107.2	178.1	19.2	7.5	49.9	7.1
	130.5	1.9	8.1	136.4	63.5	6.4	33.7	3.4	0.5	5.5	238.2	103	135.2	6.3	2.4	39.6	5.8
	189.1	2.8	11	245.3	93.9	8	54.4	6	0.5	33.3	346.8	117.1	229.7	33.5	7.9	50.4	9.6
Mean	**152.8**	**2.5**	**9.8**	**169.7**	**59.9**	**10.4**	**39.1**	**4.0**	**0.6**	**20.3**	**289.4**	**114.8**	**174.7**	**17.7**	**5.8**	**43.6**	**6.7**

Appendix 17: continues

T_{32}	149.4	2.5	8.3	140	60.1	6.5	38.6	3.8	0.7	6.3	313.3	116.7	196.6	12.3	3.5	48.5	6.5
	146.5	2	8	159	60.4	11.9	42.9	5.1	1.1	16.6	315.2	116.7	198.5	15.5	5	48	6.3
	123	1.7	8.3	142.6	63.9	6.8	37.8	3.6	0.5	17.7	269.1	115.1	154	12.4	3.2	41.7	7
	133.4	1.6	8.5	120.9	57	8.9	47.7	3.7	0.7	12.2	310.1	123.2	186.9	13	4.1	44.9	2.5
	153.1	2.9	10.8	212.4	69.2	16.9	50.3	4.1	0.6	35.4	311	116.3	194.7	24.7	7.1	54.7	4.2
	144.2	2.5	9.8	171.1	57.1	10.5	31.4	3.5	0.6	17.2	320.2	113.5	206.7	16	6	43.2	7
	137.4	1.9	9	170.3	62.1	9.4	31	3.7	0.9	23.1	298.4	116.1	182.3	14.9	3.3	42.1	5.7
	135.4	2.2	8.2	180.1	50.4	10.1	32.2	3.6	0.3	21.4	311	114.9	196.1	16.1	6.4	40.3	5.9
Mean	**140.3**	**2.2**	**8.9**	**162.1**	**60.0**	**10.1**	**39.0**	**3.9**	**0.7**	**18.7**	**306.0**	**116.6**	**189.5**	**15.6**	**4.8**	**45.4**	**5.6**
T_{47}	130.8	2.6	7.7	162.5	58	8.7	39.1	3.5	0.7	19	230.3	112	118.3	15.5	4.9	42	3.5
	130.3	2.8	9.2	157.1	60	10.7	45	3.1	0.9	13.1	358.7	110.9	247.8	16.2	4.9	41.3	7
	135	1.7	7.5	143.3	57.1	8	34.7	3	0.9	26.1	299.2	115	184.2	15.1	4.6	40.2	6.2
	124.5	2	5.6	127.8	63.3	6.9	34.3	3.1	0.6	5.1	251.9	135.9	116	9.5	3.9	33.5	6.9
	130.5	1.9	7.3	131.6	77.1	7.7	34.1	2.8	0.7	13.8	315.3	112	203.3	15.4	4.2	40.6	5.2
	125.3	2.8	6.5	133.3	59.2	7.1	47	5.9	0.7	6.9	246.4	137.7	108.7	105	3.5	35.2	6.5
	136.8	2.4	8.6	160	62.9	13.4	50.3	3.6	1	14.4	360.1	112.5	247.6	16.9	5.1	41.8	7.8
	128.2	1.8	6.6	144.7	57.1	8.3	46.4	5.2	0.6	16.6	277.3	112.9	164.4	20.3	1.9	44.9	4.5
Mean	**130.2**	**2.3**	**7.4**	**145.0**	**61.8**	**8.9**	**41.4**	**3.8**	**0.8**	**14.4**	**292.4**	**118.6**	**173.8**	**26.7**	**4.1**	**39.9**	**6.0**

Appendix 18: Summary of ANOVA to show the effect of treatments on non carcass components of rabbits (g)

Dependent Variable: Slaughter weight (SW)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	406316.9359	135438.9786	2.26	0.1072
SEX	1	7.5078	7.5078	0.00	0.9912

R-Square	CV	Root MSE	SW Mean
0.401675	14.47466	244.7525	1690.903

Dependent Variable: HEAD

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	3.44923326	1.14974442	0.62	0.6099
SEX	1	4.57644276	4.57644276	2.46	0.1298

R-Square	CV	Root MSE	HEAD Mean
0.236999	6.363665	1.363550	21.42712

Dependent Variable: PLUCK

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.89532003	0.29844001	0.97	0.4241
SEX	1	0.15094777	0.15094777	0.49	0.4909

R-Square	CV	Root MSE	PLUCK Mean
0.213887	16.04481	0.555288	3.460858

Dependent Variable: GIT full (GITF)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	31.93416696	10.64472232	1.80	0.1746
SEX	1	5.37966911	5.37966911	0.91	0.3501

R-Square	CV	Root MSE	GITF Mean
0.309008	13.62205	2.433646	17.86549

Dependent Variable: GIT empty (GITE)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	4.98099670	1.66033223	1.38	0.2724
SEX	1	0.21945402	0.21945402	0.18	0.6730

R-Square	CV	Root MSE	GITE Mean
0.390651	15.27357	1.096309	7.177814

Appendix 18 continues

Dependent Variable: GIT content (GITC)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	15.62821561	5.20940520	0.96	0.4281
SEX	1	3.42602395	3.42602395	0.63	0.4349

R-Square	CV	Root MSE	GITC Mean
0.154854	21.80862	2.330836	10.68768

Dependent Variable: Total internal fat (TIF)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	3.36919504	1.12306501	0.64	0.5950
SEX	1	1.38923044	1.38923044	0.80	0.3814

R-Square	CV	Root MSE	TIF Mean
0.228760	55.49434	1.321747	2.381769

Dependent Variable: Kidney (KDN)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.04022578	0.01340859	2.72	0.0669
SEX	1	0.00068751	0.00068751	0.14	0.7121

R-Square	CV	Root MSE	KDN Mean
0.277410	13.37653	0.070213	0.524900

Dependent Variable: Reproductive organ (RPD)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	0.03421726	0.01140575	1.27	0.3067
SEX	1	0.01402324	0.01402324	1.56	0.2233

R-Square	CV	Root MSE	RPD Mean
0.377798	30.82751	0.094723	0.307267

Appendix 19: Individual values for rabbits for the economics of using of using chickpea seed waste in rabbit diet

Treatment	Control (kg)	Chickpea seed waste (kg)	Total feed (kg)	Cost (T.Shs.)/kg feed	Total value (T.Shs.)	Cost (T.Shs.)/kg carcass	Gross margin (T.Shs.)/rabbit	Gross margin (T.Shs.)/kg carcass
T_0	4.89	0.00	4.89	457.97	2240.44	3228.18	3759.56	987.74
	4.76	0.00	4.76	457.97	2179.71	3052.43	3820.29	872.72
	4.89	0.00	4.89	457.97	2237.73	2939.28	3762.27	701.55
	4.34	0.00	4.34	457.97	1986.90	3101.53	4013.10	1114.63
	4.32	0.00	4.32	457.97	1980.35	2903.14	4019.65	922.79
	4.05	0.00	4.05	457.97	1854.73	3174.36	4145.27	1319.63
	4.26	0.00	4.26	457.97	1949.67	3038.34	4050.33	1088.67
	4.76	0.00	4.76	457.97	2178.01	3012.50	3821.99	834.48
Mean	**4.53**	**0.00**	**4.53**	**457.97**	**2075.94**	**3056.22**	**3924.06**	**980.28**
T_{18}	3.12	0.68	3.80	383.70	1456.53	3117.12	4543.47	1660.59
	3.60	0.79	4.39	383.70	1685.82	2960.49	4314.18	1274.66
	3.67	0.80	4.47	383.70	1715.25	2797.39	4284.75	1082.14
	4.18	1.63	5.81	329.95	1915.85	2865.85	4084.15	950.00
	3.84	0.84	4.68	383.70	1797.17	3202.99	4202.83	1405.81
	3.34	0.73	4.07	383.70	1561.66	2913.74	4438.34	1352.08
	3.67	0.80	4.47	383.70	1715.25	2789.86	4284.75	1074.61
	3.97	0.87	4.84	383.70	1855.42	2870.13	4144.58	1014.71
Mean	**3.67**	**0.89**	**4.57**	**376.98**	**1712.87**	**2939.70**	**4287.13**	**1226.83**
T_{32}	3.76	1.47	5.22	329.95	1723.04	2728.95	4276.96	1005.92
	3.89	1.52	5.41	329.95	1786.04	2927.71	4213.96	1141.67
	3.89	1.52	5.41	329.95	1786.04	2993.76	4213.96	1207.72
	3.98	1.55	5.54	329.95	1827.15	2837.20	4172.85	1010.05
	4.15	1.62	5.77	329.95	1903.13	3126.70	4096.87	1223.56
	4.21	1.64	5.86	329.95	1933.26	2847.67	4066.74	914.41
	4.18	1.63	5.81	329.95	1915.85	2881.45	4084.15	965.60
	4.19	1.64	5.83	329.95	1923.97	2425.71	4076.03	501.74
Mean	**4.03**	**1.57**	**5.61**	**329.95**	**1849.81**	**2846.14**	**4150.19**	**996.33**
T_{47}	4.06	2.33	6.39	269.95	1723.73	2815.41	4276.27	1091.67
	3.91	2.24	6.15	269.95	1660.98	3002.59	4339.02	1341.61
	4.11	2.35	6.46	269.95	1743.55	2886.73	4256.45	1143.19
	3.64	2.09	5.73	269.95	1546.20	3091.83	4453.80	1545.63
	3.81	2.18	5.99	269.95	1617.34	2750.46	4382.66	1133.12
	3.91	2.24	6.15	269.95	1660.98	2901.05	4339.02	1240.08
	3.91	1.53	5.44	329.95	1794.24	2638.49	4205.76	844.25
	3.75	2.15	5.89	269.95	1591.16	2806.40	4408.84	1215.25
Mean	**3.89**	**2.14**	**6.03**	**277.45**	**1667.27**	**2861.62**	**4332.73**	**1194.35**

Appendix 20: Summary of ANOVA to show the effect of treatment on the economics of using Chickpea seed waste in rabbit diet

Dependent Variable: Mean feed consumed (kg) (TOF)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	13.53601734	4.51200578	28.28	<.0001

R-Square	CV	Root MSE	TOF Mean
0.751852	7.707492	0.399444	5.182541

Dependent Variable: Cost (T.Shs)/kg feed (CKG)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	140820.8533	46940.2844	231.48	<.0001

R-Square	CV	Root MSE	CKG Mean
0.961242	3.949162	14.24020	360.5878

Dependent Variable: Value (T.Shs) of feed consumed (TVA)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	808247.0035	269415.6678	18.54	<.0001

R-Square	CV	Root MSE	TVA Mean
0.665172	6.599687	120.5416	1826.474

Dependent Variable: Cost (T.Shs)/kg carcass (CCARC)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	221330.9814	73776.9938	3.03	0.0457

R-Square	CV	Root MSE	CCARC Mean
0.245233	5.330845	155.9763	2925.920

Dependent Variable: Gross margin (T.Shs)/rabbit (GMRB)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	808247.0035	269415.6678	18.54	<.0001

R-Square	CV	Root MSE	GMRB Mean
0.665172	2.888242	120.5416	4173.526

Dependent Variable: Gross margin (T.Shs)/carcass (GMCARC)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
T	3	400524.4272	133508.1424	2.83	0.0563

R-Square	CV	Root MSE	GMCARC Mean
0.232815	19.74721	217.1099	1099.446