GROWTH PERFORMANCE OF WEANER RABBITS FED DIETS CONTAINING DIFFERENT FORAGES

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B. AGRICULTURE

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DECLARATION

I hereby declare that this work is the product of my research efforts under the supervision of Prof. G. S. Bawa and been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up by **“Ibrahim**, Abdurrahman Khalid SPS/12/MAS/00009**”** were carried out under our supervision.

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APPROVAL

This dissertation has been examined and approved for the award of Masters Degree in Animal Science (Monogastric Nutrition and Management).

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DEDICATION

This dissertation is dedicated to Almighty Allah, the uncreated creator who creates the created creatures and to my little kids, Abdussamad Ibrahim and Aisha Ibrahim

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ABSTRACT

A study was conducted using a total of 30 weaner rabbits of mixed breeds aged between 6-8 weeks with an average weight of 620g to determine their performance when fed different forage based diets. The rabbits were randomly allotted to the treatment groups in a Completely Randomized Design of 3x2 factorial arrangements. The factors considered were forage types (Moringa, Groundnut haulms and Amaranthus), and levels of inclusion (20 and 40%). Interactions between the forage types and levels were evaluated. Water and feeds were supplied *ad libitum.* The study lasted for 56 days. However, the result of feed intake, feed conversion ratio and body weight changes were significantly better in rabbits fed Moringa forage meal. There were no significant ($p>0.05$) differences among all the treatment means in terms of forage inclusion levels. Cost of feed/kg weight gain (N521.21) was also higher in rabbit fed moringa at 40% levels followed by those fed 20% levels of moringa (N378.93). There were interaction effects between forage types and forage levels on the performance of rabbits. The result of carcass analysis showed that there were significant ($p<0.05$) differences observed in all the carcass parameters measured except for the forelimbs. Rabbits fed moringa based diets had the highest values in all the parameters followed by those on groundnut haulms and amaranthus based diets. Results for the haematological and blood serum biochemistry parameters showed significant ($p<0.05$) differences in all the parameters measured except for MCHC, in which rabbits fed forages at 40% level of inclusion tended to have higher values compared to 20% forage level. Digestibility study showed that, there were no significant ($p>0.05$) differences in all the parameters both at 20% and 40% levels. The study concluded that 40% level of moringa in the diet of rabbits improved growth performance and live weight gain with no health hazard in terms of blood properties. Based on the findings of the study, it is recommended that 40% level of moringa should be used in the diet of rabbits and 20% level can be used to reduce the cost of feed as well as cost of production.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

The state of nutrition in Nigerian population is grossly marked by inadequate intake of protein both in quality and quantity. Animal protein consumption is very essential for meeting protein requirement of man. The average daily protein intake is still far less than the 35g per adult per day recommended by FAO (2007). This shortage has given rise to high prices of animal protein. Therefore, efforts are being directed towards exploring all reasonable options to meet the recommended level at an affordable price (Ojebiyi *et al*., 2008).

In order to maximize food production and meet protein requirements in Nigeria, viable options need to be explored and evaluated (Owen *et al*., 2008). Among such alternatives is the use of livestock species that are yet to play a major role in animal production in the country. Rabbit production is a veritable way of alleviating animal protein deficiency in Nigeria (Ajala and Balogun, 2004). The rabbits have immense potentials and good attributes which include high growth rate, high efficiency in converting forage to meat, short gestation period, high prolificacy, relatively low cost of production and high nutritional quality of rabbit meat which includes low fat, sodium and cholesterol levels. It also has a high protein level of about 20.8% and its consumption is bereft of cultural and religious biases (Biobaku and Oguntona, 1997)

Domestic rabbits (*Oryctolagus cuniculus)* are ubiquitous, providing protein, fiber, research models, and companionship. Rabbits have high reproductive potentials and fast growth rate, utilize low grain and high roughage diets and sbreed all-year round (Irlbeck, 2001, Hassan *et al*., 2012). Other attributes are short gestation interval, early sexual maturity and ability to rebreed shortly after kindling (Hassan *et al*., 2012). These qualities confer on rabbits is a potential to bridge the shortage of animal protein in developing countries, where grain can only be justified for human use (Irlbeck, 2001; Hassan *et al*., 2012).

Rabbit production is suitable because as monogastric herbivores, they do not compete directly with man for both cereal and legume grains. In spite of the various attributes of rabbits over other livestock, the cost of production is high due to the ever increasing cost of concentrate feeds. In view of this, the need to develop alternative feed resources that are cheap, readily available and with great potentials in supporting livestock growth becomes imperative (Omoikhoje *et al*., 2006). Consequently, researchers are diverting attention to the rabbit's natural habit of high forage intake (Omoikhoje *et al*., 2006).

Forages, especially legumes, with their high protein content, have the potential of meeting the need for cheaper feed sources for rabbits (Iyeghe- Erakpotobor, 2007). However, feeding forage alone will not support adequate growth performance in rabbits. Supplementation with sources of energy is needed. Potential energy sources include root and tubers (cassava, sweet potatoes), fruit (bananas, plantains, mangoes), rice bran, other grain processing by-products, sugarcane products (whole cane, molasses, juice) (Onifade *et al*., 1999) and fats such as palm oil. The main advantage of using oil in rabbit feed is its high calorie density in the absence of fiber. This creates opportunities for using forage whose energy content might be a limitation (Blas *et al*., 2008). Rabbits could utilize forages (Omole *et al*., 2007), which helps in reducing the cost of feeding compared to poultry which competes with man for cereal and legumes based feed sources.

Rabbit production in developing countries is based on low cost feeding, using locally available feedstuffs. Rabbit husbandry in these countries emphasizes on simple feeding methods. In developed countries where commercial rabbitry is on the lead, feeds are compounded to increase growth rate and to minimize labour requirements (Wahlstrom, 1974). However, in developing countries more important considerations would be to formulate cheap diets based on feedstuffs that are of little direct value as human food. If the rabbits are kept on a small scale, diets such as green succulent fodders can be fed with little costs. Current feeding practices vary widely in the tropics, depending on the types of feed materials that are available locally (Aduku and Olukosi, 1990).

Rabbit farming in Nigeria is faced with myriad of problems, which have resulted to a gross shortage of meat to meet up the population challenge in our country (Nworgu, 2007). The growth rate of the Nigerian agricultural sector is below the potentials of natural and human resources due to high cost of agricultural inputs, poor funding of agriculture, inadequate functional infrastructural facilities, inconsistencies of government agricultural policies, inadequate private sector participation, poor mechanized farming and little or no adoption of some simple agricultural technologies developed by scientists (Nworgu, 2007). In Nigeria, consumption of animal protein remains low at about 6.0-8.4 g/head/day which are far below the 13.5g per day prescribed by the WHO (Egbunike, 1997). The presence of ceacal microbes enables the rabbit to digest large amounts of fibrous feed as most non ruminant species cannot (Taiwo *et al*., 1999).

1.2 PROBLEM STATEMENT

The state of nutrition of the Nigerian populace is marked by inadequate intake of protein both in quality and quantity. Animal protein consumption is very essential for meeting protein requirement of man. The average daily protein intake per adult is still far less than the 35g per adult per day recommended by FAO (2007). This shortage has given rise to high prices of animal protein. Therefore, efforts are being directed towards exploring all reasonable options to meet the recommended level at an affordable price (Ojebiyi *et al*., 2008)

Information on the nutritional potential of forages within the Nigerian environment as feedstuff for rabbits is scanty but it is needed for a well planned and cost effective feeding programme. According to Aduku and Olukosi (1990), the nutritive content of forages varies greatly among species, among cultivars within species, and among stages of growth among the same cultivar.

1.3 JUSTIFICATION OF THE STUDY

Over the years, the rearing and production of rabbits and other livestock species have been faced with the challenges of feeding and feed availability. Most of the conventional feedstuffs are highly competed for by man, hence the need to source for cheaper but readily available feedstuffs so as to mitigate these challenges. One of such feedstuffs consumed by rabbits is forage plants such as Groundnut haulms (*Arachis hypogea*), Moringa (*Moringa oleifera*) and Thorny pigweeds (*Amaranthus spinosus*). These are emerging and non-conventional feedstuff for rabbits in Kano environs that could serve as cheap sources of fibre and protein. However, there is dearth of information on the use of these forage plants in rabbits diets. It is against this background that this study was designed to evaluate the growth performance of weaner rabbits fed different forage based diets.

1.4 OBJECTIVES OF THE STUDY

The objectives of this study were to determine the:

(i) Growth Performance and nutrient intake of rabbit fed different Moringa, Amaranthus and groundnut haulms forage materials

(ii) Nutrients digestibility of rabbits fed different forage materials.

(iii) Carcass characteristics of weaner rabbits fed different forage materials.

(iv) Blood parameters of the rabbits fed different forage based diet.

(v) Financial benefit of feeding different forages in the diets of weaner rabbits

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BRIEF HISTORY OF RABBITS

The domestication of the major livestock species (cattle, sheep, pigs) and the small species (poultry) is lost in the dawn of prehistory, but rabbit domestication dates back no further than the present millennium (FAO, 1997). Indeed, the wild rabbit *Oryctolagus cuniculus* of southern Europe and North Africa is thought to have been discovered by Phoenicians when they trenched the shores of Spain about 1000BC. In Roman times the rabbits were still emblematic in Spain. The Romans apparently spread the rabbit through the Roman Empire as a game animal. Like the Spaniards of that time, they ate foetuses or newborn rabbits, which they called *laurices.* Rabbits had still not been domesticated, but Varron (116 to 27 BC) suggested that rabbits be kept in *leporaria,* stone-walled pens or parks, with hares and other wild species for hunting. These leporaria were the origin of the warrens or game parks that subsequently developed in the Middle Ages (FAO 1997).

2.2 BREEDS OF RABBITS

The United State Department of Agriculture (USDA, 1972) classified rabbits according to size, weight, and type of felts as follows: small rabbits weigh about 1.4-2kg at maturity, medium breeds 4- 5.4kg, and large breeds 6.4-7.3kg. Based on this classification, the most popular breeds for meat production include the New Zealand White and the Californian. These breeds are most popular because they combine white fur and good growth characteristics. The New Zealand rabbit with 4-5.9kg body weight is slightly larger than the Californian breed with body weight of 3.6-4.5kg. The New Zealand rabbit has a completely white, red or black body, whereas the Californian is white with coloured nose, ears and feet.

The two most popular rabbits for fur production are the Rex and the American Chinchilla. The Rex is slightly smaller than the American Chinchilla, 3.2kg versus 4.5kg (USDA, 1972). According to USDA (1972), there are many breeds of rabbits being used for both meat and skin production in developing countries. For example in Brazil there are New Zealand White, Californian, Chinchilla, Palomino, Hollander, Rex, Dalmatian, Flemish Giant, New Zealand Red, Barboleta, Champagne; in Equador there are the New Zealand White, Blue Viennese, Silver German and Angora. In Malawi there are the New Zealand White, Californian, Angora, Rex; in Nepal there are the Californian Hybrids while in Ghana there are Thuringa, Blue Viennese, Flemish Giant, Lop, Californian, Alaska, and the Yellow Silver. In Nigeria, the commonest breeds include the New Zealand White, Californian, Rex, amongst others all of which are descendants of the European wild rabbit *Oryctolagus cunuculus* (Aduku and Olukosi, 1990).

2.3 IMPORTANCE OF RABBIT PRODUCTION

The advantage of keeping rabbits over other livestock is manifold. Schiere (2004) stated that starting a rabbit project requires minimal initial capital outlay. Additionally, a rabbit can be easily sold when small amount of money is needed to meet immediate family needs.

Rabbits are characterized by small body size, short gestation period, high reproductive potential, rapid growth rate, genetic diversity, their ability to utilize forages (Mailafia *et al*., 2010) and disease tolerance (Begensel, 2008). In addition, rabbits require small amounts of feed and use inexpensive, easily constructed housing (Cheeke 1986a). Rabbits could be produced using inexpensive and renewable resources such as garden "wastes" and products of grains (Lukefahr, 2009). Rabbits are able to thrive on non-conventional feedstuffs (Omole, 1982; 1988) with their utilization of large forage diets limited as a result of post gastric fibre digestion in the caecum ((Belenguer *et al*., 2008). Furthermore, rabbits do not compete with humans for grains as strongly as chickens (Price and Regier, 1982; Van Dijk, 2003; Moreki, 2007). Rabbits compliment well with vegetable production as garden wastes are fed to rabbits, whereas the manure is used to fertilize the soil (Price and Regier, 1982). Unlike poultry manure, rabbit manure will not burn the plants and can be applied directly to the plant or its roots. Schiere (2004) opined that rabbit farming exposes children to learning how to tend for and appreciate animals. Unlike bigger animals such as cattle, rabbits and can be tended by woman, children or men as they do not need forced to be restrained (Schiere, 2004). The small body size of a rabbit provides a small carcass that can be consumed by a family a family in one meal, eliminating the need for meat storage and refrigeration. The meat is stored on the live animal until needed resulting in rabbits being referred to as ‘’biological refrigerators” (Cheeke, 1986a).

2.4 PRODUCTION CHARACTERISTICS

Medium-weight breeds (4.5-6kg) are able to start breeding at 6 to 7 months of age, with males maturing one month later than females. One buck can service about 10 does, but no more than two to three times a week. The females are usually placed in the buck’s cage for breeding; if the buck is put in the cage of the doe she will fight to protect her territory. Mating should occur immediately, and the doe then returned to her cage. The average gestation period is about 3 days and if properly managed a doe can produce 5-6 litters in a year with an average of 6 kittens per litter (Cheeke 1986b). Twenty eight days after breeding a nest box are placed in the cage of the doe. According to Morimoto (2009), gestation length in different breeds of rabbits ranged between 28-36 days. However, a rabbit does normally kindle 31-33 days (Rashwan *et al*., 2003). Onifade *et al*., (1999) stated that Nigerian does kindle 5-8 kits per litter, and on the average 4-5 kits reach weaning stage. Twenty eight days after breeding a nest box are placed in the cage of the doe. The nest box can be removed 15-21 days after birth. The young are weaned in about 30 days so that the doe will produce five litters a year (Penn State, 1994).

2.5 NUTRIENTS REQUIREMENTS OF RABBITS

Rabbit is herbivorous animal which can obtain most of its vitamin, minerals, fiber from leaves of the plant and its protein from grains. However, a balanced diet containing requisite amount of energy, protein, fat, minerals and vitamins is essential for rabbit production as well as coccidiostat and antibiotics

2.5.1 Protein Requirement

The crude protein requirement for rabbits is 12 to 18% dry matter (DM). The protein requirements of rabbits vary with life stage. Gestation and lactation require 18% DM protein, growth requires 15 to 16% DM protein, and maintenance 13% DM protein. Pet rabbits need 12 to 16% protein; higher levels may be excessive and may be detrimental to long-term health (Lebas, 1980).

The quantity and quality of protein requirement in the rabbits is not as critical as in poultry because the rabbit practice caprophagy (which is the recycling of soft faeces) (Aduku *et al.,* 1986). According to Aduku (1990) they can adopt to low and poor protein situations, but production will not be optimum. However, with high protein and good protein quality, optimum production can be attained. He also reported crude protein requirements of 12-17%, lysine requirement of 0.65% and methionine requirement of 0.65% can easily be met by combining protein source like groundnut cake etc. The nutrient requirement by rabbits vary depending on their stage of growth (Lebas, 1980)

2.5.2 Energy Requirements

The energy needed for organic synthesis is usually supplied by carbohydrates and to a lesser extent by fats. Where there is an excess of proteins these also help to supply energy after deamination. The growing rabbit, like the breeding doe, adjusts its feed intake according to the energy concentration of the feeds offered to it where the proteins and other dietary components are balanced (FAO, 1997). According to Xiccato and Trocino, (2010) growing rabbit in good sanitary condition consume sufficient feed to meet its energy requirement for maintenance and growth; voluntary energy intake is proportional to metabolic live weight (LW0.75), on average 950KJ/d/kg LW0.75. It has been shown that intake is only correctly regulated between 2200 and 3200 kcal DE/kg of feed. Because of this, concentrated energy feed must also contain all the other required nutrients in concentrated form so that a smaller volume of feed will supply the rabbit's needs. Energy intake regulation functions well in temperate climates so long as variations in energy content are linked to the presence of fairly digestible carbohydrates (e.g. starch / fibre substitution) (FAO, 1997). At high temperatures (28 to 32°C), where more than 10 percent of the digestible energy is provided by fat, regulation may suffer and the animals may easily consume more of the fatty feed owing to the absence of extra heat from the consumption of lipids (FAO, 1997).

A high energy concentration in the diet of livestock can result in market changes in food consumptions and productive efficiency by the animals (Partridge *et al.,* 1986). In rabbits the energy requirement may be met from consumption of fibrous and non-fibrous part of the feed and also from fat and grains (Aduku *et al.,* 1990). Aduku *et al.* 1990 also reported that the energy requirement of the rabbit ranges between 2390 and 2.50 kcal digestible energy.

2.5.3 Fat Requirement

Fats are currently being used extensively in animal feeding to increase energy density of diets for both ruminant and non ruminant farm animals in intensive production system (Partridge *et al*., 1986). Diets prepared for commercial rabbits rarely contain supplementary fat, and there is no evidence from the literature that the rabbit requires fat in its diet except as a source of essential fatty acid and to facilitate the supply and absorption of fat soluble vitamins and development of immune resource (Jezcova and Pets, 1976); and Partridge *et al.,* 1986). Fats are also essential in ensuring adequate utilisation of nutrients for growth and reproduction (Sell and Owings, 1986). Fat in the diet of rabbits can reduce intake but at the same time increase rate of weight gain as reported by Eshiett *et al.,* 1976; and Iyeghe and Ekpenyong, 1990).

2.5.4 Vitamins Requirement

Rabbits require water-soluble (B and C) as well as fat-soluble (A, D, E and K) vitamins. Micro-organisms in the digestive flora synthesize sizeable quantities of water-soluble vitamins which are utilized by the rabbit through caecotrophy (Coudert *et al*., 1986). The intake is sufficient to cover maintenance requirements and for average production as far as the B group vitamins and vitamin C are concerned. However, fast growing animals respond favourably to the addition of 1 to 2ppm (part per million) of vitamins B1 and B6, 6ppm of vitamin B2 and 30 to 60ppm of nicotinic acid (vitamin PP) in the diet. The addition of vitamin C will not influence growth, even at 1% of diet under temperate condition (Coudert *et al*., 1986).

2.5.5 Mineral Requirement

The rabbits require minerals in low amounts, but these compounds are still essential for normal function. A balanced diet normally supplies enough minerals, but lactating and pregnant does mat need additional minerals to produce milk, tissues and bones for the kittens (FAO, 1997). Macro minerals; sodium, potassium, calcium, magnesium and phosphorous are present at larger levels in animal's body and are required in larger amount in the body. Microminerals; they are present at low level in the body and are often referred to as trace minerals; they are present at low level in the body and are required in smaller amount in the diets (Dairy herd, 2009). Ash residue is generally taken to be a measure of the mineral content of the original food and it tends to vary depending on the type of feed (Onwuka, 2005).

Pond *et al*. (1995) stated that the major mineral element of concern in rabbit diet formulation are calcium (Ca) and Phosphorous (P), and that the other minerals are usually provided in adequate amounts by the ingredients used plus the addition of trace mineralised salt.

2.5.6 Water Requirement for Rabbits

Water consumption is very important for the feed intake of rabbits. In normal conditions the consumption of water is around 100 ml to 600 ml/day or 50 ml to 100 ml/kg BW (Nakkiset, 2007). Verdelhan, Bourdillon, Morel-Saives and Audion (2004) observed that the feed intake of rabbits was significantly reduced when water consumption was restricted. Water is normally considered a nutrient, although its properties and functions are quite different from those of other nutrients found in feeds. Water is the major component of the rabbit's body, making up 70% of the lean body mass (Maertens, 1992). Maertens (1992) further indicated that rabbits would die more rapidly from water deprivation than from food deprivation and that restricting drinking water or limiting drinking time leads to reduced feed intake that is directly proportional to the amount of water being consumed. Maertens (1992) also reported that water and feed consumption varies with changes in environmental temperature and humidity. As the temperature rises above 20˚C day and night, feed intake tends to drop while consumptions increase. At high temperatures (30˚C and over), feed and water intakes decline, affecting the performance of growing and lactating animals (Fernandez-Carmona, Cervera, and Blas, 1996). According to Pond *et al*., (1995) water plays an essential role in a number of functions vital to an animal such as digestion, nutrient transport, waste excretion, and temperature regulation. One of the most important properties of water in nutrition is its remarkable ability to dissolve substances (Pond *et al*., 1995).

Aduku *et al.* (1990) reported that rabbits can handle about 20-25% fat in their diet (but there is lack of information on the effect of fat addition to fibrous diets on body composition (Fernadez *et al*. 1996), but depending on their age.

2.5.7 Fibre Requirement

Very few studies have explored the consequence of lows dietary fibre on growth performance and mortality in rabbits (Licos *et al*., 1980)[1]; Champe and Maurice 1983[2]; Peeters and Chalier 1984[3]; Blas *et al*., 1986[4] observed that with low fibre diets enhanced the frequency of digestive troubles (mainly diarrhoea) in rabbits.

Cheeke *et al.* (1983) reported that a fibre level 15-20% in the diet of rabbits is required for normal growth and any level in excess of 20% may produce a caecal impaction and limit energy intake. In addition he also reported that a crude fiber level of between 10-17% was found to support weight gain and any level exceeding 17% reduces performance by limiting energy intake

2.6 COMPOSITION OF RABBIT MEAT

Rabbit meat is of high quality, being high in protein and low in fat content (Mailafia *et al.,* 2010). Rabbit meat is very nutritious and a rich source of protein, energy, minerals and vitamins. Relative to other common meats, rabbit meat is low in fat, sodium and cholesterol (Lebas and Motheron, 1982). Fielding (1991) stated that rabbit meat is especially high in protein and low in fat and that, the fat in the meat is mainly unsaturated which is believed to be a more healthy type of fat than saturated fat which is common in other meats. Rao *et al*. (1987) reported that rabbit meat is mainly composed of 18.8 -19.4% proteins, 9.9-10.9% fat and 68.5-72.0% moisture.

In an experiment using New Zealand White rabbit, Mohammed (1989) reported the meat composition as 77.34% moisture, 21.55% protein, 2.73% ether extract and 1.63% ash. Table 2.1 shows rabbit meat composition relative to other common meats.

Table 2.1: Composition of Rabbit Meat Relative to Other Common Meat

Meat Composition	Source	Moisture (%)	DM(%)	Protein (%)	Fat (%)	Energy
	1	-	20-23	20-22	10-12	7-8
Rabbit	2	67.9	-	20.8	10.2	1749
	1	-	20-23	19-21	11-13	7-8
Chicken	2	67.9	-	20.0	11.0	1782
	1	-	38-42	19-21	20-22	10-12
Turkey	2	58.3	-	20.0	20.0	2618
	1	-	40-50	15-17	27.29	11-14
Beef	2	55.0	-	16.3	28.0	3168
	1	-	40-50	14-18	26.30	11-14
Lamb	2	55.8	-	15.7	27.7	3124
	1	-	50-55	10-12	42.48	17-20
Pork	2	42.0	-	11.9	45.0	4510

Source 1= Fielding (1991) DM= Dry matter
2= USDA (1968)
Energy values: 1=MJ/kg
2= kcal/kg

2.7 GROWTH PERFORMANCE OF RABBITS

The growth performance of rabbits in tropical countries is generally in the range of 10-20g per day, in contrast to 35-40g per day commonly observed in the temperate regions (Cheeke, 2003). Daily body weight gain vary from 8-13g (Abu and Onifade, 1996), 16-25g (Omole and Sonaiya , 1981). These are low values compared with values of 42g/day for rabbits obtainable in temperate climates (Abu *et al*., 2008). Linga and Lukefahr (2000) reported growth rate of 28.9g/day for rabbits fed alfalfa with molasses blocks and growth rates of 10 to 12g/day with fresh lablab fed along with molasses or sugar cane. This report agreed with that of Linga *et al*. (2000). Weight gains reported on forage-concentrate diets under most tropical conditions range between 5-20g/d (Aduku *et al*., 1986; Bamgbose *et al*., 2002; Hongthong *el al*., 2004) with a turn off target weight of 2.3-2.5kg at 4-5 months of age. These weight gains depend on the type of forage used, state of forage used (fresh forage or hay) and the environmental conditions.

Wasem, (2013) observed a significant increase in feed intake (74.79g) of rabbits fed 50% groundnut haulms than those paid *Ipomoea eriocarpa* which feed intake of 70.98g. Adejinmi *et al*., (2013), observed average feed intake of 63.89-82.46 g per animal per day which compares favourably well with the result of Attah *et al*., (2011) who reported average feed intake of 77.64-87.51 g. Attah and Ekpeyong (1998) reported average feed intake of 51.28-71.88 g, while Agunbiade *et al*., (1999) reported average feed intake of 60.08-62.86 g for the same species of animal.

2.8 DIGESTIVE SYSTEM OF RABBIT

The digestive system of rabbit is characterized by the relative importance of the caecum and colon when compared with other species (Portsmouth, 1977). The microbial activity of the caecum is of great importance for the processes of digestion, nutrient utilization, and the control of digestive pathologies. Furthermore, caecotrophy, the behaviour of ingestion of soft faeces of caecal origin, makes microbial digestion in the caecum more important for the overall utilization of nutrients by the rabbit. Additionally, the rabbit has developed a strategy of high feed intake (65–80 g kg^{-1} body weight) and a rapid transit of feed through the digestive system to meet nutritional requirements. The digestive system of the growing rabbit must go through a period of adaptation from milk based feeding to the sole dependence on solid feed before it can attain its full functional capacity. This adaptation process not only affects the digestion processes, but also microbiota colonization and the development of gut barrier mechanisms that protect the animal against digestive pathologies.

The first important compartment of the digestive system of the rabbit is the stomach. This has a very weak muscular layer and is always partially filled. After caecotrophy, the fundic region of the stomach acts as a storage cavity for caecotrophs. Thus, the stomach is continuously secreting and the pH is acidic. The stomach pH ranges from 1 to 5, depending on site of determination (fundus versus cardiac-pyloric region) (Gutierrez *et al*., 2003; Chamorro *et al*., 2007; Orengo and Gidenne, 2007; Gomez-Conde *et al*., 2009), the presence or absence of soft faeces (Griffiths and Davies, 1963), the time from feed intake (Alexander and Chowdhury, 1958) and the age of the rabbit (Grobner, 1982). The lowest figures (from 1 to 2.5) are determined in the cardiac region, in the absence of soft faeces, after 4 hours of diet ingestion and in rabbits older than 3 weeks with 34 low presence of milk (Orengo and Gidenne, 2007). The capacity of the stomach is about 0.34 of the total capacity of the digestive system (Portsmouth, 1977).

The stomach is linked with a coiled caecum by a small intestine approximately 3 m long, where the secretion of bile, digestive enzymes and buffers occurs. The pH of the small intestine is close to 7 (Nicodemus *et al*., 2002). The small intestine is the site where greater part of digestion and absorption takes place by passive or active transportation throughout the mucosa. Digestibility at the end of the ileum accounts for 0.8–1 of the total dietary amino acid and starch digestibility (Gutierrez *et al*., 2002 Garcia *et al*., 2005 Carabano *et al*., 2009).The caecum is characterized by a weak muscular layer and contents with a dry matter (DM) of 200g kg$-^{1}$. The ceacal contents are slightly acidic (pH 5.4–6.8) (Garcia *et al*., 2002). The rabbit's caecum is proportionally the largest of any mammal. It is twice the length of the abdominal cavity and 40–60 % of the total volume of the gastrointestinal tract (Jenkins, 2000). The proximal colon can be further divided into three segments: the first segment possesses three *taeniae* with *haustra* between them; the second segment has a single *taenia* covering half of the circumference of the digestive tube; and the third segment or *fusus coli* has no *taeniae* or *haustra*, but is densely enervated. Thus, it acts as a pacemaker for the colon during the phase of hard faeces formation (Snipes *et al*., 1982).

The different segments of the digestive system of the rabbit grow at different rates until reaching maturity. The development of the digestive tract begins in the foetal stage; at birth, the stomach and small intestine are the main components of digestive tract. According to Sabatakou *et al*. (1999), the stomach glands are evident in late fetuses (26 days' gestation) and true villi and intestinal glands (Crypts of Lieberkuhn) are observed at 29 days' gestation. At birth however, the intestine of the newborn does not possess all of the mucosal constituents that are present. These appear in the first week of age (Brunner's glands in the duodenum) and the adult morphology is not completed until 20 days of age. The developmental pattern follows a craniocaudal gradient. The early development of these two segments is important to ensure the survival of the newborn. From birth to 18–20 days of age, kits suckle large amounts of milk during a once-daily nursing, an amount that can reach 0.12 of their body weight. At around 18 days of age the suckling rabbit begins to eat solid food and decrease its milk intake and the caecum and colon develop faster than the rest of the digestive tract.

Rabbits are herbivores, are concentrate selectors, and are classified as hindgut (Caecum and Colon) fermentors (McNitt *et al*., 1996). Because there are no mammalian enzymes to break down the cellulose components of their plant-based diets, rabbits as well as other herbivores have a symbiotic microbe population (Primarily *Bacteroides).* In rabbits, the microbial population is found in the caecum. The rabbit caecum is very large, compared with the rest of the gut (Stevens and Hume, 1995) and forms a spiral that fills the abdominal cavity. The caecum has a capacity 10 times that of the rabbit's stomach, about 40 % of the gastrointestinal tract (Jenkins, 1999). Instead of completely fermenting fibre, rabbits utilize a mechanism to sort out indigestible fibre and expel it from the body, a process that is a specialized feeding strategy that overcomes poor-quality protein (Carabano and Piquer, 1998; Jenkins, 1999). This sorting mechanism occurs as digesta enters the rabbit's large intestine and muscular contractions facilitate the separation of fibre and non-fibre fractions. A series of peristaltic and anti-peristaltic waves separate out no fibre fractions for further fermentation in the caecum (Cheeke, 1987; Carabano and Piquer, 1998); particle size and density aid separation (Cheeke, 1994). The fibre components are voided from the body about 4 hours after consumption of the diet (Cheeke, 1994). After fermentation of 36 the non-fibre components in the caecum, a pellet is formed (called a cecotrophy or soft faeces) that is voided from the body approximately 8 h after consumption of the diet (Cheeke, 1994). A neural response (Jenkins, 1999) or the strong odour of VFA (Stevens and Hume, 1995) in the cecotrope seems to stimulate its consumption directly from the anus. This practice of consuming cecotropes is called coprophagy, or cecotrophy (Cheeke, 1987). In natural settings, coprophagy usually occurs during the day, opposite of feed intake and the voiding of hard faeces, in a circadian rhythmic pattern (Carabano and Piquer, 1998; Jenkins, 1999), and is an integral part of the rabbit's digestion process (Cheeke, 1994). If a rabbit is equipped with a collar preventing coprophagy, the digestion of the diet is significantly reduced, even when a highly digestible diet is fed.

Gut micro flora of rabbits are sensitive to most antibiotics (McNitt *et al.*, 1996). If antibiotics are fed, the microbe population is altered, favouring *E. coli* and *Clostridia* organisms that produce toxins harming the gut lining, causing diarrhoea and enterotoxemia (Cheeke, 1994; Stein and Walshaw, 1996; Brooks, 1997). Antibiotics that may cause this effect include lincomycin, ampicillin, amoxicillin, procaine penicillin, cephalexin, erythromycin, clindamycin, tylosin, and metronidazole. The actual effect from each of the drugs will differ between animals (Stein and Walshaw, 1996). Oxytetracycline, virginiamycin (Cheeke, 1994), or tetracycline (Brooks, 1997) are exceptions and are used as growth promoters, and sulfaquinoxaline is to control coccidiosis (Brooks, 1997). Under no circumstances should the inophore monensin be fed to rabbits; it is toxic even at low concentrations (McNitt *et al.,* 1996; Martin, 2000).

2.9 FORAGES AS A DIET OF RABBITS

The term forage refers to herbaceous plants or plant parts fed to domestic animals. Generally, the term refers to such materials as pastures, hay, silage, and green chop, in contrast to less digestible materials known as roughages. In practice, the concept is often extended to woody plants producing succulent growth. In the tropics, some shrubs and trees are of considerable importance in this respect. Forage crops may be used in the pastures or may be cut and carried to the animals (Bello, 2003).

The potentials of forages as feed for rabbits are of particular significance because of their availability and ability of the rabbits to effectively digest leaf protein (Bello, 2003). Forage legumes are a dependable source of protein feed for animals. The seeds and leaves are rich in nitrogen. Forage legumes are adequately supplied with protein for livestock feeding, even when harvested at an advanced stage of maturity. When an appropriate balance of nutrients is available in forages as in alfalfa meal, the forage can replace grain in rabbit diet, thereby reducing the concentrate need of rabbits (Aduku et al 1989). Fibre supplies an important source of dietary energy for animals (Schoknecht 1997). Dietary fibre has positive effects on gut health, welfare and reproductive performance (Johnson *et al..,* 2003). Higher digestibility and utilisation of dietary fibre showed great potential for the practical use of various fibrous feeds and had no adverse effects on reproductive performance (Danielson and Noonan 1975, Pond *et al.,* 1985 and Schoknecht 1997)

Forage legumes can be grazed, harvested and fed fresh or stored as hay or silage (Harricharan et al 1988). A sustainable way of improving the feeding value of poor quality crop residues and pastures, especially for resource poor small holders, is through supplementation with forage legumes (Barro and Ribeiro 1983)

2.9.1 Importance of Forage in Rabbit Diets

Alexandra and McDowell, (1998) noted that it is important to feed rabbits daily with variety of fresh plants to help balance the nutritional needs in its diet. The authors also recommended that fresh plants should be fed rabbits for optimum body weight and that to make sure the rabbits get the necessary nutrients, they should be offered, at least three different vegetables (forages) daily. It was also suggested that one or more of the forages should contain vitamin A (Alexandra and
McDowell, 1998). They observed that the vegetables and the forages been fed to rabbits are spinach, garden egg plants, okro, plant, pumpkin leaves, cabbages, lettuce, carrot leaves, broccoli leaves raspberry leaves and strawberry leaves. There are different opinions regarding which vegetables are the best for rabbits. It was reported that carrots, carrot tops, broccoli and parsley are safe and that potatoes and some lettuce are potentially problematic (Teselle and McBee, 2001).

Teselle and McBee (2001) noted that, forages provide valuable roughage, as well as essential vitamins and that as early as three weeks of age one can begin to offer vegetables. These authors also mentioned that, new vegetables should be introduced to rabbits one at a time and vegetables of different colours should be served. The authors also opined that once the rabbits is used to several forages, they should be fed at least three different kinds of forage daily for a mix of nutrients (Teselle and MacBee, 2011).

Teselle and MacBee (2011) also discovered that kale, mustard greens and spinach (*Amaranthus)* contains high levels of oxalates which can accumulate in the system and can cause toxicity overtime. They also found out that in addition to nutrition, forages are also important to the rabbits dental health. They noted that diet that requires little chewing produces uneven tooth wear, causing enamel to grow on the side of the teeth. It was explained that these spikes can cause several oral pain and excessive salivation. They also cause reluctance to chew, inability to close the mouth, and reduced feed intake. The situation deteriorates as the teeth continue to grow, and if it is not treated, results sin severe malnutrition.

Peteducation.com (2011) equally reported, that forage should be added to the diet of rabbit one at a time and that it should be eliminated if it causes soft stools or diarrhoea. They also observed that because of their unique digestive systems, rabbits require a diet that is high in fibre and low in protein. Therefore forages are found to be the best for rabbits to eat as they are low in calories and high in fiber (Peteducation.com, 2011). University Federation of Animal Welfare (UFAW) handbook (1987) reported that in recent years, commercial pellets particularly when fed in large amount may not be the best choice for all rabbits. In rabbit the concentrated nature of pellets can lead to obsesity and its attendant medical problems especially in spayed or neutered rabbits. Because of several potential problems associated with pellets, some veterinarians now recommended that pellets be not only rationed, but rationed severely (UFAW Handbook, 1987).

Once pellets have been reduced, it is equally important to make sure that fresh grass and hay is available to the rabbit at all times and that fresh vegetables (forages) be given in larger amounts. Actually, because of the problems usually associated with overfeeding of pellets, some rabbits do better if they receive no pellets at all. Instead, they eat several fresh vegetables a day and all the grass hay they want. Other rabbits still eat pellets, but receive significantly less amounts with corresponding increase in the amount of vegetable offered. These more extreme measures are particularly helpful for overweight rabbits that need to lose weight safely (Teselle and MacBee, 2011). In feeding trials in which pelleted feed was reduced to 50% of normal intake and the diet was supplemented with greens, young rabbits maintained normal growth and when the amount of pellets was reduced to below 50% of “normal”, growth rate declined. These studies indicated that even young unaltered rabbits do well on a reduced pellet diet and since most of the house rabbit need to lose weight rather than gain, reducing pellets below 50% should not affect sprayed or neutered adults adversely (Teselle and macBee, 2011).

2.9.2 Utilisation of Forages by Rabbits

Forages are cheap and readily available in Nigeria. Studies on their chemical composition show their potential as the major source of nutrients for herbivorous animals (Skerman, 1977). The potential of forages is particularly significant for rabbits since they are capable of digesting leaf proteins effectively (Cheeke and Myer, 1975). Cheeke and Patton (1979) hypothetically computed that rabbit can produce five times more meat than cattle from the same amount of groundnut haulms based diet. Feeding of rabbits with forage allowed for better rate of growth when compared to rabbits which were not fed forage (Aduku and Olukosi , 1990; Onwudike, 1995).

High fibre materials which are usually a constraint in poultry diet is beneficial to rabbits for preventing enteritis (Cheeke and Patton, 1979). El-Gendy, (1999a) and Rohilla and Bujabaruah (2000) reported that up to 30 to 40% *Acacia saligna* dried leaves can replace Clover hay and banana leaves without deleterious effect on growth. El-Ayouty *et al.* (2000) showed that complete replacement of fresh berseem (*Trifolium alexandrium*) with berseem silage had no negative effect on growth of rabbits and edible body organs. It has been reported that rabbits can tolerate up to 40% of broom grass (*Thysanolaena maxima*) in their diets without adverse effect on the growth performance (Rohilla and Bujarbaruah, 2000). Scapinello *et al.* (2000) observed that inclusion up to 20% of cassava leaves and stem hay in rabbit diet had no effect on the general performance. Similarly, Fotso *et al*., (2000) reported that up to 42% of cassava leaf meal can be fed to growing rabbits with positive result on growth performance. Tangenjaja *et al.* (1990) reported that incorporating *Leucaena leucocephala* at 40% level as replacement for concentrate is ideal as it can support growth without adverse effect. These were supported by Scapinello *et al.* (2000) Nieves *et al*.,

(1998) and El-Gali *et al*., (2001) who fed similar forages. Lupin (*Lupines albus*) was fed at 0, 10, 20, 30 and 40% level to growing rabbits and the report indicated the optimum inclusion level as 20% for the best weight gain (El-Gendy, 1990). El-Ayouty *et al*., (2000) reported that up to 100% of maize silage (whole plant) can be fed to growing rabbits without affecting the body weight gain. Similarly, Auxilia and Masoero (1980) fed maize plant (whole plant dried) up to 40% and reported also that it can support weight gain.

Payne *et al*., (1983) and Aderibigbe et al. (1992) reported that Rye grass as a basal diet can be fed to growing rabbits at levels between 20 and 50% without compromising the growth performance of the rabbits. Raju and Screemanna (1995) stated that up to 15% level of sea weed (*Ulva fascilate*) can be incorporated into the diet of growing rabbits. Bamikole and Ezenwa (1999) reported the incorporation of *Stylosanthes hamata* at 50% level in diets of growing rabbits is ideal for maximum weight gain. Harris *et al*. (1981) reported that when sun flower leaves were fed up to 40% to growing rabbits, positive weight gain was observed. Abu *et al*. (1999) reported that inclusion of sweet potato tops up to 40% in the diet of growing rabbits did not have adverse effect on the body weight gain. Lopez *et al*. (1996) indicated that rabbits can tolerate up to 60% level of *Vicia sativa* with positive weight gain. This report was supported by Sese *et al.* (1999) who fed similar forage (60%) to growing rabbits and revealed higher weight gain. Linga and Lukefahr (2000) reported growth rate of 28.9g/day for rabbits fed alfalfa with molasses blocks and growth rates of 10 to 12g/day with fresh lablab fed along with molasses or sugar cane. This report agreed with that of Linga *et al*. (2003). Sanni *et al.* (2005) evaluated the economies of producing grower rabbits fed different combinations of concentrates and *Stylosanthes* and found that 50:75 combination gave better return on investment, thus cost of feeding grower rabbits could be lowered by supplementing concentrate diets with *Stylosanthes*. Ikurior *et al.* (2009) reported that *Tridax procumbens* can be included in cassava based diets for rabbits and nutrient digestibility can be maximized at 10% level of inclusion. Nyako (2001) in is experiment with bitter leaf in weaner rabbit diets reported that 25% of the leaves can be incorporated into the rabbit feeds to obtain high yield of meat.

2.9.3 <u>Groundnut Haulms in Livestock Feeds</u>

Groundnut (*Arachis hypogaea* L.) also known as peanut, is an annual legume and it is important in human nutrition, due to its high protein and energy content (Garduno-Lugo and Olvera-Novoa, 2008). Groundnut haulms constitute approximately 45% of the total plant biomass and provide excellent forage for livestock in many regions. Haulms are reach in protein and more palatable than many other fodders (Liao and Holbrook, 2007).

Groundnut haulms is a nutritious feed for herbivores. It contains protein (8-15%), lipids (1-3%), minerals (9-17%) and carbohydrates (38-45%) at levels higher than the cereal fodder. The digestibility of nutrients in groundnut haulm is around 35%and that of crude protein is 88% in animals (Ozyigit and Bilgen, 2012). Haulms release energy up to 2.337cal kg^{-1} of dry matter (Singh and Diwakar, 1993). Groundnut haulms have also shown great promise as a source of protein for feeding rabbits (Iyeghe-Erakpotobor *et al*., 2002, 2006, Iyeghe-Erakpotobor, 2007). In addition to the seed, peanut plants produce high-protein forage that has long been used as ruminant feed (Garduno-Lugo and Olvera-Novoa, 2008). Groundnut haulms were more cost effective than sweet potato forage for feeding rabbits (Iyeghe-Erakpotobor, 2007). Substitution of 33 to 100% clover hay with groundnut hay insignificantly increased nutrient digestibility, live weight, live weight gain, carcass characteristics and protein and fat contents of meat (Ibrahim 2000). Ngodigha *et al*., (1994) observed that up to 50% of groundnut haulms can support weight gain of growing rabbits. Similarly Bawa *et al*., (2008), fed rabbits groundnut haulms and cowpea shells and obtained a significant difference ($p<0.05$) in final weight, feed intake, weight gain and cost per kg gain between the dietary treatments. Ososanya (2012), observed a positive linear effect ($p\leq0.05$) on intakes when rams were fed 0, 50 and 100% groundnut haulms, the highest weight gain was observed in ram fed 50% groundnut haulms compared to 0% and 100% groundnut haulms.

2.9.4 Moringa (*Moringa oleifera*)

Moringa oleifera is the most widely cultivated species of the genus *Moringa,* which is the only genus in the family Moringaceae. It is an exceptiuonally nutritious vegetable tree with a variety of potential uses. The tree itself is slender with dropping branches that grow approximately 3.05 meter in height (NRC, 2006). It is grown in semi-arid, tropical and sub-tropical areas. While it grows best in dry sandy soil, it tolerates poor soils, including coastal areas. Today, it is widely cultivated in Africa, Central and South America. It is considered one of the world's most useful trees, as most every part of *Moringa* tree can be used as food or has some other beneficial properties such as forage for livestock. It is used as metabolic conditioner to aid against endemic diseases in developing countries (NRC, 2006) *Moringa* is known by some as nature's energy miracle tree, a tree that is packed with so much nutrition, that some call it one of the most powerful foods on the planet. Moringa is a tree that is filled with antioxidants, amino acid and essential fatty acids (Moringa Herbalist, 2008).

The nutritional values of *Moringa oleifera* per 100g is moisture (86.9 g), calories (6.5 kcal), protein (2.5 g), fat (0.1 g), carbohydrates (3.7 g), fiber (4.8g), minerals (2.0 g), calcium (30 mg) Mg (24 mg), Potassium (110 mg), K (259 mg), Cu (3.1 mg), Fe (5.3 mg), S (137 mg), Oxalic acid (10 mg), vitamin A carotene (0.11 mg), choline (423 mg), vitamin B1 thaimine (0.05 mg), vitamin B3 nicotinic (0.2 mg) and vitamin C (120 mg).

The dry leaves contain 7.5g water. 6.7g protein, 1.7g fat, 14.3g total carbohydrates, 0.9g fiber, 2.3g ash, 440mg Ca, 70mg P, 7 mg Fe, 110mg Cu, 11,3000 IU vitamin A, 20 mg vitamin B, 0.8mg nicotinic acid, 220mg ascorbic acid and 7.4 mg tocopherol per 100mg (James 1998). Vitamin A content of *Moringa oleifera* was reported by USDA (2014) to be

378 ug (1260i.u). The anti nutritional factors of Moringa are phenols (3.4%), tannins (1.4%), saponins (5%) and phytate (3.1%) as reported by Foidi, Makkar and Becker (2001).

Moringa has been reported by Moringa herbalist (2008) to have the following benefits; Increases energy, improves digestion, helps regulate cholesterol levels, gives a huge range of important vitamins and minerals, effectively combats free radicals, enhances circulations, provides extremely degree of fibers, detoxifies the body of toxins, improves immune system, gives beautiful looking skin, helps prevent arteriosclerosis, and reduces inflammation. It is also reported the help combat wide range of different cancers, improves reproduction, and generally increases the general well-being of the body. Moringa leaves are dried carefully to prevent their nutrient loss and it is powdered. This will provide all its beneficial properties (Moringa Herbalist, 2008)

2.9.5 Thorny Pigweed (*Amaranthus spinosus)*

Amaranthus spinosus is a flowering plant in the family *Amaranthaceae.* It is native to central and south western Asia. It is an annual plant rarely biennial, which grows to a height of up to 30 cm. The leaves are alternate simple, ovate to triangular based, very variable in size from about 20-30 cm long and 1-15 cm broad. The flowers are inconspicuous, yellow green, 3-4 mm in diameter maturing into a small hard, dry lumpy fruit cluster 5-10 mm across containing seeds (Clifford, 2001). The nutritional value per 100g of Amaranthus includes 24.25 kcal energy, 3.6 g carbohydrate, 0.4 g sugar, 2.2 g dietary fibre, 0.4 g fat, and 2.2 g proteins. The minerals and vitamins content per 100g of amaranthus are 9400 i.u vitamin A (Beta-carotene 5626 ug), 194 ug folate, 28 mg vitamin C, 2 mg vitamin E, 483 ug vitamin K, 99 mg calcium and 2.7 mg iron (united state department of agriculture (USDA, 2011). Anti nutritional factors fund found in amaranthus are: oxalates, tannin, phytate, and nitrate (Ajala, 2009), Amarnthus greens are common leaf vegetables throughout the tropics and in many warm temperate regions. They are good sources of vitamin including vitamin A, vitamin K, vitamin B6, vitamin C, riboflavin, folate, and dietary minerals including calcium, iron, magnesium, phosphorous, potassium, zinc, copper, and manganese. Amaranthus seeds contain protein that is usually complete for plant sources (Wikipedia, 2011). The nutritional and chemical values of amaranthus were investigated by Akubugwo, Obasi, Chinyere and Ugbogu (2007) using standard analytical methods in order to assess the numerous potential of the plant leaves, the proximate analysis showed the percentage moisture content, ash content, crude protein, crude lipid, crude fibre and carbohydrates of the leaves as 84.48, 13.80, 17.92 4.65, 8.61 and 55.03% respectively, while the caloric value is 268.92 kcal/100g. Elemental analysis in mg/100g (DW) indicated that the leaves contained sodium (7.43), potassium (54.20) calcium (44.15), magnesium (231.22), iron (13.58), zinc (3.80) and phosphorous (34.91).

The vitamin compositions of the leaves in mg (DW) are carotene (3.29), thiamine (2.75), riboflavin (4.24), niacin (1.54), pyridoxine (2.33), ascorbic acids (25.40) and tocopherol (0.50). Seventeen amino acids (g/100g) were detected in amaranthus which includes isoleucine (3.39), leucine (6.70), lysine (3.03), methionine (1.76), cystine (0.46), phenylalmine (4.00), tyrosine (3.05), threonine (2.62), valine (3,50), alanine (2.15), arginine (3,35), aspartic acids (3,94), glutamic acids (5.40), glycine (15.79), histidine (3.81), proline (3.43) and serine (3.04). The chemical composition in mg/100g (DW) for alkaloid, flavonoid, saponins, tannins, phenols, hydrocyanic acid and phytic acid were 3.54, 0.83, 1.68, 0.49, 0.35, 16.99, and 1.32, respectively. Comparing the nutrients and chemical constituents with recommended dietary allowance (RDA) values, showed that the leaves contains an appreciable amount of nutrients, minerals, vitamins, amino acids, and phytochemicals and low level of toxicants (Akubugwo *et al*., 2007).

Adeyeye and Omolayo, (2011) evaluated the proximate, mineral and amino acid composition and functional properties of leaf protein concentrates of *Amaranthus spinosus* and *Telfairia occidentales* leaves on dry weight basis.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

The trial was conducted at Dan Amarya farms, Tudun Wada Local Government Area (LGA) Kano state. Kano state lies between longitude 9°30' and 12°30' north and latitude 9°30' and 8°42' east in the Sudan savannah zone of Nigeria. It is bordered by neighbouring states such as Katsina to the north-west, Jigawa to the north-east, Kaduna to the south-west and Bauchi to the south-east. The climate of the state consists of two seasons; the rainy season and dry seasons. The annual rainfall ranges from 787-960mm and temperature ranges between 21°C and 39°C (KNARDA, 2001). This makes the environment conducive for livestock production and arable crop cultivations.

3.2 SOURCE AND PROCESSING OF FORAGE PLANTS

Thorny pigweed (*Amaranthus spinosus*) was harvested from the nearby farms, gathered and chopped for easy drying under the shade to ensure that the minerals and other nutrients are not altered by excessive heat from the sun. Groundnut haulms and Moringa were purchased from the open market in Tudun Wada Local government. The forage plants were air-dried separately for 7 days, chopped and milled with machine before incorporated into the experimental diets. Proximate composition of experimental ingredients (Moringa, Groundnut haulms and Amaranthus) on dry matter basis is presented on Table 3.1

Table 3.1: Proximate Composition of the Experimental Ingredients

Proximate content	Moringa	Groundnut haulms	Amaranthus
Moisture	8.14	8.78	8.70
Dry matter	91.86	91.22	91.30
Crude protein	20.66	19.50	18.78
Crude fiber	7.42	10.50	16.45
Ether extract	7.15	6.98	1.60
Ash	9.52	15.20	18.08
Nitrogen free extract	47.11	39.04	36.41

3.3 SOURCE OF EXPERIMENTAL ANIMALS

Thirty rabbits aged 8 weeks old and of mixed sexes were used for this study. The rabbits were purchased from Tudun wada central market.

3.4 DESIGN, MANAGEMENT OF EXPERIMENTAL ANIMALS AND DATA COLLECTION

A total of thirty (30) crossbred rabbits of mixed sexes, aged 6-8 weeks, and average weight of 620g were used in the study. Rabbits were weighed using weighing balance and allotted to six dietary groups of 3 x 2 factorial arrangements in a completely randomised design (CRD) consisting 5 rabbits per treatment. The treatments were 3 forage types (Groundnut haulms, Moringa and Thorny pigweed) and included at 20 and 40%, respectively. Feeds and water were provided *ad libitum* and allowed 7 days adjustment period before the feeding trial began and administered with Ivomectin at 0.2mls/ rabbit as a control measure against endo and ecto parasites. The feeders and drinkers were washed daily before water was supplied. The rabbits were weighed on weekly basis and body weight gain was calculated. The feed intake was determined also on the daily basis by subtracting the leftover feed from the total feed given. The experimental feeds were weighed and fed to the rabbits every morning. The leftover feeds, before the next meal, was weighed and subtracted from the feed given to know the exact feed intake.

The rabbit's live weight was determined using a Camry weighing scale on weekly basis with 0.5g graduation. Body weight gain was calculated using the formula:

Body weight gain = Final body weight – initial body weight

3.5 EXPERIMENTAL DIETS

The diets formulated were designated as diets 1, 2, 3, 4, 5 and 6 and the experimental forages incorporated into the rations at 20 and 40% levels. The feed ingredients in the diets formulated consisted of maize, maize offal, groundnut cake, salt, bone meal and vitamins/minerals (premix). The maize and groundnut cake were varied to give 18% crude protein needed for growth performance in rabbits

The experimental forages incorporated were *Moringa oleifera, Arachis hypogea*, and *Amaranthus spinosus* at 20 and 40% levels of inclusion respectively, as presented in Table 3.2. All the feed ingredients and the forages were ground and mixed before being fed to the rabbits.

Table 3.2: Gross Composition of Experimental Diets Fed to Rabbits

	Dietary Treatments					
Ingredients	1	2	3	4	5	6
Maize	47.27	30.68	47.27	30.68	47.27	30.68
GNC	21.63	18.22	21.63	18.22	21.63	18.22
Maize offal	8.00	8.00	8.00	8.00	8.00	8.00
Moringa	20.0	40.0	-	-	-	-
G/nut Haulms	-	-	20.0	40.0	-	-
Amaranthus	-	-	-	-	20.0	40.0
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Vit. Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100**	**100**	**100**	**100**	**100**	**100**
Calculated Analysis						
Energy (kcal/kg)	2808	2563	2934	2814	2814	2575
Crude Protein (%)	18.5	19.7	18.2	19.0	18.1	19.0
Lysine	1.2	1.8	1.1	1.6	0.7	0.8
Methionine	0.5	0.7	0.5	0.5	0.4	0.4
Calcium	1.1	1.5	0.7	0.8	0.7	0.7
Phosphorous	0.4	0.5	0.5	0.6	0.4	0.5
Crude Fibre	7.7	9.8	8.3	9.1	8.7	8.9
Ether Extract	4.6	4.9	4.1	3.9	4.1	3.9

*Bio-premix supplied per kg of diet: Vitamin A, 1200 I.U; Vitamin D3, 2500 I.U; Vitamin E, 50mg; Vitamin K_3, 2.5mg; Vitamin B_6, 6.0mg; Niacin, 40.0mg; Calcium pantothenate, 10.0mg; Biotin, 0.8mg; Vitamin B_{12}, 0.25mg; Folic acid, 1.0mg; Choline chloride, 300mg; Iron, 100mg; Zinc, 50mg; Iodine, 1.55 I.U; Selenium, 0.1mg.

Chemical Composition (%) of the Experimental Diets

The proximate compositions of the experimental diets are presented in Table 3.3.

Table 3.3 Chemical Composition of the Experimental Diets

	Dietary treatments (%)					
Parameters	1	2	3	4	5	6
Dry matter	96.57	97.50	96.81	96.71	97.33	96.72
Crude Protein	18.00	19.50	17.50	17.90	17.10	17.40
Ether Extract	4.50	4.80	3.90	3.60	3.85	3.50
Crude fiber	4.50	5.60	4.10	5.00	4.00	4.00
Ash	3.43	2.50	319	3.29	2.67	3.28

Source: proximate Analysis

3.6 NUTRIENTS DIGESTIBILITY TRIAL

Thirty weaner rabbits were used for the nutrient digestibility studies. The animals were allowed an adjustment period of 7 days. Daily faeces were collected separately from each replicate for a period of 7 days. The faeces collected were weighed, oven dried until constant weight was obtained. 2g sub-sample was taken from the dried faecal samples which is then analysed for a proximate composition as recommended by AOAC (2000). The apparent digestibility of nutrients was calculated using the following formula:

$$\frac{\text{Amount of nutrient intake - Amount of Nutrient excreted in faeces X100}}{\text{Amount of nutrients intake}}$$

3.7 BLOOD SAMPLE COLLECTION AND ANALYSIS

Blood samples were collected from the central ear vein of 3 rabbits per treatment in a sterile sample bottles containing anti-coagulant (Ethylenediaminetetraacetic acid) for haematological analysis. This was carried out immediately after the feeding trial. The Red Blood Cell (RBC) counts, Total White Blood Cell (WBC) counts, Haemoglobin (Hb) concentration and Packed Cell Volume (PCV) were determined following standard procedures described by Dacie and Lewis (1991). The Mean Corpuscular Volume (MCV) and Mean Corpuscular Haemoglobin Concentration (MCHC) were calculated using the formula given by Merck veterinary manual (2005)

$$MCV\ (fl) = \frac{PCV\ (\%)\ x10}{RBC\ (x10^{12}/L)}$$ `

$$MCH = \frac{Hb\ (g/dl)\ x\ 10}{RBC}$$

$$MCHC\ (g/dl) = \frac{\text{whole blood haemoglobin concentration (g/dl) x 100}}{PCV}$$

3.8 COST ANALYSIS

The feed cost benefit analysis was computed based on the prevailing market price of forages and feed ingredients used at the time of the experiment. Cost/kg of diet, total feed intake, total cost of feed, total weight gain and value of gain were used to calculate the return per rabbit according to the method described by Abdu *et al.* (2012).

3.9 STATISTICAL ANALYSIS

The data collected were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) of SAS (2001). Mean with significant differences were separated using Duncan Multiple Range Test (Duncan, 1955)

General Linear Model

$Y_{ijk} = \mu + F_i + N_j +_I + \ell ijkm$

Where:

μ = overall mean

$F_i = i^{th}$ effect of the forage type

$N_j = j^{th}$ effect of the forage level

I = effect of all interactions

$\ell ijkm$ = Random error

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Main Effects of Forage Type on the Growth Performance of Rabbits

Table 4.1 shows the effects of forage types on the growth performance of rabbits. The results revealed that there were significant ($p<0.05$) difference among the parameters measured except for feed intake. Rabbits fed moringa based diets had the highest final weight followed by those on Groundnut haulms based diets and those fed amaranthus had the least. Rabbits on moringa diets had the highest daily weight gain and the overall weight gain when compared with those rabbits fed groundnut haulms and amaranthus based diets. However, rabbits on amaranthus diets had the highest feed conversion ratio followed by groundnut haulms and Moringa which is the least.

Table 4.1: Main Effects of Forage Type on the Growth performance of Rabbit

	Forage Types				
Parameter	Moringa	G/nut haulms	Amaranthus	SEM	Sig.
Initial weight (g)	622.00	621.00	619.00	150.25	NS
Final weight (g)	1203.45^{a}	1155.90^{b}	1109.35^{c}	150.25	*
Total weight gain (g)	581.45^{a}	534.90^{b}	490.35^{c}	353.19	*
Daily weight gain (g)	10.38^{a}	9.55^{b}	8.75^{c}	0.11	*
Daily Feed Intake (g)	48.37	48.02	46.96	12.59	NS
Feed conversion ratio	4.66^{b}	5.03^{ab}	5.36^{a}	0.17	*

SEM= Standard error of mean, Sig. = significance, NS = Not significant, *= Significantly different ($p<0.05$)
^{abc} means within rows with different superscripts are significantly ($p<0.05$) different

4.1.2 Main Effect of Forage Levels on the Growth Performance of Rabbits

Table 4.2 shows the effect of forage levels on the growth performance of rabbits. The results revealed that there is no significant different ($p>0.05$) among the treatment means measured. However, rabbits fed at 40% level of inclusion had slightly higher values when compared with the 20% level of inclusion in all the parameters measured.

Table 4.2: Main Effect of Forage Levels on the Growth Performance of Rabbits

	Forage Levels (%)			
Parameter	20	40	SEM	Sig.
Initial weight (g)	619.66	621.66	150.25	NS
Final weight (g)	1150.52	1161.92	248.98	NS
Total weight gain (g)	530.86	540.28	353.19	NS
Daily weight gain (g)	9.47	9.64	0.11	NS
Daily feed intake (g)	47.14	48.42	12.59	NS
Feed conversion ratio	5.00	5.04	0.17	NS

SEM= Standard error of mean, Sig. = significance, NS = Not significant, *= significantly different ($p<0.05$)
^{abc} means within rows with different superscripts are significantly ($p<0.05$) different

4.1.3 Interaction Effects of Forage Types and Levels on the Growth Performance of Rabbits

Table 4.3 shows the interaction effect of forage type and level on the growth performance of rabbits. The result showed that there were no significant ($p>0.05$) difference among the forage type and forage level across the treatment means observed in feed intake. However, Final weight, total weight gain, daily weight gain, and feed conversion ratio shows significant ($p>0.05$) difference across the dietary treatments. Rabbits fed Moringa at 40% level had the highest values of final weight, feed intake, total weight gain, and daily weight gain compared to rabbits fed 20% level of moringa forage. However, those rabbits fed 40%

level of amaranthus had higher values of final weight, total weight gain and daily weight gain than those on 20% level. But rabbits on groundnut haulms were different, in which rabbits on 20% level gained more weight than the 40% level.

Rabbits gained more weight at 40% level of inclusion of moringa than at 20% level of inclusion. Groundnut haulms and Amaranthus recorded similar weight among the levels. The same trend is observed in daily weight gain. Rabbits fed amaranthus at 20% levels had the highest feed conversion ratio when compared with other parameters.

Cost of feeding rabbit at 40% level (₦111.23) is higher than that of 20% level (₦81.92) for moringa followed by groundnut haulms (₦45.92) and (₦ 39.23) at 40 and 20%, respectively. Cost of feed consumed per day is higher with rabbits fed 40% moringa (₦ 5.53) followed by (₦ 3.85) for 20% level of moringa. For groundnut haulms 20% level (₦2.13) is higher than 40% level (₦ 1.94) and the least is amaranthus with (₦ 2.10) and (₦1.62) at 20 and 40%, respectively.

Cost of feed/kg weight gain was higher for moringa at 40% level (₦521.21) followed by 20% level of moringa (₦378.93). Amaranthus at 20% level (₦242.21) recorded higher than (₦183.25) at 40% level. The least is the groundnut haulms at 20% level (₦221.64) and (₦204.21) at 40% level.

Table 4.3: Interaction Effects of Forage Types and Forage Levels on the Growth Performance of Rabbits

	Moringa (%)		G/nut haulms (%)		Amaranthus (%)			
Parameters	20	40	20	40	20	40	SEM	Sig.
Initial weight (g)	620.00	624.00	619.00	623.00	620.00	618.00	145.83	NS
Final weight (g)	1188.86[b]	1218.05[a]	1157.01[c]	1154.81[c]	1105.71[d]	1112.99[d]	249.39	*
Daily Feed Intake (g)	47.01	49.73	46.59	49.46	47.83	46.10	11.49	NS
Total Weight gain (g)	568.86[b]	594.05[a]	538.01[c]	531.81[c]	485.71[d]	494.99[d]	327.98	*
Daily weight gain (g)	10.16[b]	10.61[a]	9.61[c]	9.50[c]	8.67[d]	8.84[d]	0.10	*
Feed conversion ratio	4.63[c]	4.70[bc]	4.85[bc]	5.21[ab]	5.52[a]	5.21[ab]	0.15	*
Cost of feed (₦/kg)	81.92	111.23	45.92	39.23	43.92	35.23	-	-
Cost of feed consumed (₦/day)	3.85	5.53	2.13	1.94	2.10	1.62	-	-
Cost of feed/Kg WG (₦)	378.93	521.21	221.64	204.21	242.21	183.25	-	-

[abc] means with different superscripts within row are significantly ($p<0.05$) different; NS = Not significant, SEM = Standard Error of Mean, WG = Weight gain
* = Significantly different

4.1.4 Main Effects of Forage Type on Carcass Characteristics of Rabbit

The effect of forage type on carcass characteristics is presented in Table 4.4.

There were significant ($p<0.05$) differences observed in all the parameters except for forelimbs that is shown no significant ($p>0.05$) difference among the treatments means. However, rabbits fed Moringa based diets had the highest values in all the parameters followed by groundnut haulms and amaranthus with a slight differences between them. Also, dressing percentage, head, hind limbs, thigh, neck, rack and rib, liver, heart, and lungs for groundnut haulms and amaranthus are statistically similar.

Table 4.4: Main Effect of Forage Type on Carcass Characteristics of Rabbits

	Forage types				
Parameters (%)	Moringa	G/nut haulms	Amaranthus	SEM	Sig.
Live weight (g)	1212.30^{a}	1158.68^{b}	1114.52^{c}	289.58	*
Dressed Weight (g)	767.45^{a}	700.00^{b}	667.00^{c}	333.37	*
Dressing percentage	63.30^{a}	60.41^{b}	59.84^{b}	0.61	*
Head	8.15^{a}	6.88^{b}	6.69^{b}	0.13	*
Forelimbs	4.95	5.45	4.95	0.47	NS
Hind limbs	8.14^{a}	6.86^{b}	6.62^{b}	0.62	*
Thigh	19.21^{a}	17.30^{b}	16.95^{b}	0.17	*
Neck	3.60^{a}	3.23^{b}	3.03^{b}	0.05	*
Rack & Rib	27.57^{a}	26.31^{b}	26.00^{b}	0.49	*
Liver	3.39^{a}	3.08^{ab}	3.01^{b}	0.06	*
Skin	7.37^{a}	6.90^{b}	6.33^{c}	0.13	*
Heart	0.56^{a}	0.42^{ab}	0.26^{b}	0.02	*
Lungs	1.21^{a}	1.03^{b}	0.91^{b}	0.01	*
Large intestine	10.95^{a}	10.05^{b}	9.48^{c}	0.14	*
Small Intestine	9.56^{a}	8.79^{b}	8.16^{c}	0.05	*
Kidney	0.97^{a}	0.82^{b}	0.63^{c}	0.01	*
Stomach	6.47^{a}	5.74^{b}	5.07^{c}	0.04	*

abc means within rows with different superscripts are significantly different($p<0.05$), * = Significantly different, NS = Not significant , SEM = Standard error of mean

4.1.5 Main Effects of Forage Levels on Carcass Characteristics of Rabbits

Table 4.5 shows the result of effects of forage levels on carcass characteristics of rabbits. There was no significant ($p>0.05$) difference in live weight, dressed weight, head, forelimbs, hind limbs neck, and kidney while significant ($p<0.05$) differences exist with respect to other parameters. Dressing percentage shows higher values at 20% level of inclusion while value of thigh was higher at 40 % level. Rack and rib, liver, skin, head, large intestine, small intestine and stomach follow similar trend.

Table: 4.5 Main Effect of Forage Level on Carcass Characteristics of Rabbits

	Forage levels (%)			
Parameter (%)	20	40	SEM	Sig
Live weight (g)	1154.41	1169.25	289.58	NS
Dressed weight (g)	714.44	708.52	333.37	NS
Dressing percentage	61.83^{a}	60.54^{b}	0.61	*
Head	6.99	7.49	0.31	NS
Forelimbs	4.93	5.31	0.47	NS
Hind limbs	7.23	7.17	0.62	NS
Thigh	17.54^{b}	18.10^{a}	0.17	*
Neck	3.12	3.45	0.05	NS
Rack & Rib	25.86^{b}	27.39^{a}	0.49	*
Liver	2.98^{b}	3.34^{a}	0.06	*
Skin	6.57^{b}	7.16^{a}	0.13	*
Heart	0.31^{b}	0.52^{a}	0.02	*
Lungs	0.97^{b}	1.13^{a}	0.01	*
Large intestine	9.90^{b}	10.42^{a}	0.14	*
Small intestine	8.70^{b}	8.97^{a}	0.05	*
Kidney	0.79	0.82	0.01	NS
Stomach	5.60^{b}	5.91^{a}	0.04	*

SEM= Standard error of mean, Sig. = significance, NS = Not significant, *= Significantly different
^{abc} means within rows with different superscripts are significantly ($p<0.05$) different

4.1.6 Interaction Effects of Forage Type and Levels on Carcass Characteristics of Rabbits

The interaction effect of forage type and forage levels on carcass characteristics of rabbits is presented in Table 4.6. There was a significant ($p<0.05$) difference in all the parameters measured except for forelimbs, which showed no significant ($p<0.05$) difference. However, rabbits fed Moringa leaf meal based diet at 20 and 40% did not show any different with the respect to level of inclusion so also groundnut haulms and amaranthus for live weight, and dressing percentage. Rabbits fed moringa at 40% had higher values in hind limbs, stomach, thigh, neck, rack and rib, liver, skin, heart, lungs, large intestine, small intestine and kidney.

Table: 4.6 Interaction Effects of Forage Type and Forage Level on Carcass Characteristics of Rabbits

	Forage types							
	Moringa (%)		G/nut Haulms (%)		Amaranthus (%)			
Parameters (%)	20	40	20	40	20	40	SEM	Sig
Live weight (g)	1198.71[a]	1225.88[a]	1156.22[b]	1161.15[b]	1108.32[c]	1120.71[c]	305.81	*
Dressed weight (g)	770.25[a]	764.64[a]	704.03[b]	695.97[bc]	669.04[bc]	664.96[c]	387.93	*
Dressing percentage	64.25[a]	62.35[b]	60.88[c]	59.93[c]	60.35[cd]	59.33[d]	0.64	*
Head	7.76[b]	8.55[c]	6.73[c]	7.03[c]	6.48[c]	6.89[c]	0.13	*
Forelimbs	4.64	5.27	5.28	5.63	4.87	5.03	0.53	NS
Hind limbs	7.91[ab]	8.37[a]	7.16[ab]	6.57[b]	6.65[b]	6.59[b]	0.66	*
Stomach	6.21[b]	6.73[a]	5.54[c]	5.94[b]	5.06[d]	5.07[d]	0.02	*
Thigh	18.76[b]	19.66[a]	17.05[c]	17.54[c]	16.81[c]	17.10[c]	0.17	*
Neck	3.32[b]	3.89[a]	3.10[b]	3.37[b]	2.95[b]	3.11[b]	0.05	*
Rack & Rib	26.53[bc]	28.62[a]	25.56[c]	27.06[b]	25.50[c]	26.50[bc]	0.50	*
Liver	2.98[b]	3.80[a]	3.02[b]	3.14[b]	2.94[b]	3.08[b]	0.03	*
Skin	6.87[bc]	7.88[a]	6.62[bc]	7.17[b]	6.21[c]	6.44[c]	0.12	*
Heart	0.37[bc]	0.75[a]	0.31[c]	0.53[b]	0.26[c]	0.27[c]	0.01	*
Lungs	1.04[bc]	1.39[a]	0.96[bc]	1.11[b]	0.92[c]	0.91[c]	0.00	*
Large Intestine	10.66[ab]	11.25[a]	9.81[cd]	10.29[bc]	9.22[d]	9.72[cd]	0.16	*
Small Intestine	9.19[b]	9.92[a]	8.76[c]	8.82[c]	8.15[d]	8.18[d]	0.02	*
Kidney	0.91[ab]	1.04[a]	0.87[b]	0.76[bc]	0.59[d]	0.67[cd]	0.00	*

4.1.7 Main Effect of Forage Type on Blood Parameters of Rabbits

Table 4.7 shows the effects of forage type on blood parameters of rabbits. There was a significant ($p<0.05$) difference in all the parameters measured except for MCHC (g/dl). However, rabbits fed with moringa based diets had the highest Packed Cell volume (PCV), Hemoglobin (Hb), White Blood Cells, Red Blood Cells, Total Proteins, MCV, and MCH values, respectively. Moringa and Amaranthus are statistically similar in MCV (fl) and MCH (pg). Groundnut haulms and Amaranthus were also statistically similar in PCV, Hb, and WBC, but statistically different ($p<0.05$) in RBC, TP, MCV and MCH.

Table: 4.7 Main Effect of Forage Type on Blood Parameters of rabbits

	Forage type				
Parameters	Moringa	G/nut haulms	Amaranthus	SEM	Sig
Packed Cell Volume (%)	48.17^a	33.98^b	34.47^b	1.18	*
Hemoglobin (g/dl)	14.11^a	10.31^b	9.95^b	0.88	*
WBC ($x10^9$)/L	7.34^a	6.90^b	6.73^b	0.19	*
RBC ($x10^{12}$)/L	7.42^a	6.34^b	5.18^c	0.15	*
Total Protein (g/dl)	6.93^a	6.66^a	6.29^b	0.07	*
MCV (fl)	65.04^a	53.65^b	66.96^a	20.12	*
MCH (pg)	19.01^a	16.30^b	19.34^a	4.76	*
MCHC (g/dl)	29.28	30.35	28.83	5.93	NS

WBC= White Blood Cells, RBC= Red Blood Cells, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Hemoglobin, MCHC= mean corpuscular Hemoglobin Concentration, SEM= Standard Error of Mean, Sig = Significance

4.1.8 Main Effect of Forage Level on Blood Parameters of Rabbits

The main effect of forage level on blood parameters of rabbits is presented in Table 4.8. The results shows there was a significant ($p<0.05$) difference in packed cell volume and Total protein. However, rabbit fed at 40% level of inclusion tends to have higher values when compared with their 20% level counterpart.

Table: 4.8 Main Effect of Forage Level on Blood Parameters of Rabbit

Forage levels (%)				
Parameter	20	40	SEM	Sig
Packed Cell Volume (%)	38.23^{b}	39.51^{a}	1.18	*
Hemoglobin (g/dl)	11.02	11.88	0.88	NS
WBC $(x10^{9})$/L	6.87	7.48	0.19	NS
RBC $(x10^{12})$/L	6.12	6.51	0.15	NS
Total protein (g/dl)	6.43^{b}	6.83^{a}	0.07	*
MCV (fl)	62.94	60.84	20.12	NS
MCH (pg)	18.09	18.35	4.76	NS
MCHC (g/dl)	28.91	30.07	5.93	NS

WBC= White Blood Cells, RBC= Red Blood Cells, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Hemoglobin, MCHC= mean corpuscular Hemoglobin Concentration, SEM = Standard Error of Mean, Sig = Significance

4.1.9 Interaction Effect of Forage Type and Level on the Blood Parameters of Rabbits

The interaction effect of forage type and forage level on blood parameters of rabbits is presented in Table 4.9. There was no significant ($p>0.05$) difference observed among dietary treatments in MCH (pg) and MCHC (g/dl). However, other parameters (PCV (%), Hb (g/dl), WBC, RBC, TP, and MCV) revealed a significant ($p<0.05$) different among the treatment means. However, Rabbits fed on moringa based diets had highest values of PCV, Hb, for both 20 and 40% level of inclusion. Values of White Blood

Cells are also higher for rabbits fed moringa at 40 and 20% levels while g/nut haulms and Amaranthus are statistically the same. Red Blood Cells revealed highest value (7.81) at 40% level of inclusion when compared to 20% level of inclusion in rabbits fed moringa diet. Groundnut haulms and Amaranthus show similarity at both 20 and 40% but only differs in rabbits fed Amaranthus 40% level (5.54).

Total protein values were statistically the same for rabbits fed with moringa and Groundnut haulms at 20% level of inclusion. MCH (g/dl) recorded higher values for rabbits fed 20 and 40% level of Amaranthus followed by 20 and 40% moringa which are statistically similar.

Table: 4.9 Interaction Effects of Forage Type and Levels on Blood Parameters of Rabbits

	Forage types							
	Moringa (%)		G/nut haulms (%)		Amaranthus (%)			
Parameters	20	40	20	40	20	40	SEM	Sig
Packed Cell Volume (%)	47.65^{a}	48.69^{a}	33.36^{b}	34.60^{b}	33.70^{b}	35.24^{b}	1.36	*
Hemoglobin (g/dl)	13.55^{a}	14.66^{a}	10.25^{b}	10.37^{b}	9.28^{b}	10.62^{b}	0.92	*
WBC (x10^{9})/L	7.47^{ab}	8.22^{a}	6.56^{c}	7.36^{c}	6.59^{c}	6.86^{bc}	0.20	*
RBC (x10^{12})/L	7.04^{b}	7.81^{a}	6.50^{c}	6.18^{c}	4.83^{c}	5.54^{d}	0.09	*
TP (g/dl)	6.77^{ab}	7.10^{a}	6.51^{b}	6.81^{ab}	6.00^{c}	6.58^{ab}	0.08	*
MCV (fl)	67.67^{a}	62.41^{ab}	51.36^{c}	55.94^{bc}	69.77$_{a}$	64.15^{a}	15.12	*
MCH (pg)	19.24	18.79	16.79	16.79	19.25	19.47	5.42	NS
MCHC (g/dl)	28.43	30.14	29.98	29.98	27.57	30.09	6.20	NS

WBC= White Blood Cells, RBC= Red Blood Cells, TP= Total protein, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Hemoglobin, MCHC= mean corpuscular Hemoglobin Concentration , SEM = Standard Error of mean, NS = Not significant, * = Significance

4.1.10 Main Effect of Forage Type on Nutrient Digestibility of Rabbits

Table 4.10 presented the main effect of forage type on nutrient digestibility of rabbits fed different forage type.

There were significant ($p<0.05$) differences among the treatment means in dry matter, crude fiber and ether extract, while non significant ($p>0.05$) differences were observed in crude protein, ash and nitrogen free extract. Rabbits fed moringa and Groundnut haulms based diets had higher dry matter values although statistically similar. Rabbits on Amaranthus based diets had the least values of dry matter. Similarly, rabbits fed Amaranthus based diets had higher values for crude fiber and then moringa followed by Groundnut haulms that are statistically similar.

Table: 4.10 Main Effect of Forage Type on Nutrient Digestibility of Rabbits

	Forage types				
Parameter (%)	Moringa	G/nut haulms	Amaranthus	SEM	Sig
Dry Matter	73.08^{a}	73.08^{a}	71.92^{b}	13.67	*
Crude Protein	85.68	85.68	83.15	3.47	NS
Crude Fiber	74.32^{b}	74.32^{b}	79.29^{a}	5.81	*
Ether Extract	87.12^{b}	87.12^{b}	88.92^{ab}	2.25	*
Ash	76.38	76.38	77.54	21.40	NS
Nitrogen Free Extract	63.74	63.74	64.90	27.15	NS

SEM = Standard Error of Mean, Sig = Significance, NS = Not significant, * = Significant
abc means with different superscripts within row are significsntly ($P<0.05$) different

4.1.11 Main Effect of Forage Level inclusion on the nutrient Digestibility of Rabbits

Table 4.11 presented the effect of forage level inclusion on the nutrient digestibility of rabbits.

The table shows that, there was no significant (p>0.05) difference in all the parameters both at 20 and 40% levels of inclusion

Table 4.11 Main Effect of Forage Levels on Digestibility of Rabbits

	Forage levels (%)			
Parameter	20	40	SEM	Sig
Dry Matter	72.34	72.59	13.67	NS
Crude Protein	83.98	84.43	3.47	NS
Crude Fiber	75.98	75.72	5.81	NS
Ether Extract	88.16	89.65	2.25	NS
Ash	73.69	76.02	21.40	NS
Nitrogen Free Extract	64.01	66.71	27.15	NS

SEM = Standard Error of Mean, Sig = Significance, NS = Not significant, * = significance

4.1.12 Interaction Effect of Forage Type and Levels on the Nutrients Digestibility of Rabbits

Table 4.12 presented the interaction effect of forage type and forage levels on the nutrients digestibility of weaner rabbits. There was significant (p<0.05) difference among the treatment means in crude fiber, ether extract, ash and nitrogen free extract. However, there was no significant (p>0.05) difference observed in dry matter and crude protein. Amaranthus at 40% level of inclusion had highest value for crude fiber and then 20% level of inclusion of rabbits fed amaranthus based diets. Rabbits fed Groundnut haulms and Moringa at 20% and 40% levels were statistically similar. Similarly, Groundnut haulms at 40% level of inclusion were higher with respect to ether extract and then amaranthus at 20% level of inclusion. Values of Moringa are statistically similar with respect to ether extract at 20% and 40% level of inclusion.

Rabbits fed Amaranthus based diet at 40% and rabbit fed Groundnut haulms at 20% level are statistically the similar. Rabbits fed moringa based diet at 20% level of inclusion and rabbits fed amaranthus based diet at 40% level of inclusion had highest values for ash, while rabbits fed moringa based diet at 40% level, Groundnut haulms at 40% level and Amaranthus at 20% levels are statistically similar. Groundnut haulms at 20% level had the least value of 65.95%.

Groundnut haulms at 40% level of inclusion are higher for the values of nitrogen free extract and then Moringa at 40% level of inclusion. Rabbits fed moringa at 20% level, Groundnut haulms at 20% level, and Amaranthus at 20 and 40% are statistically the similar.

Table: 4.12 Interaction Effects of Forage Type and Forage Levels on Nutrient (%) Digestibility of Rabbits

	Forage Types							
	Moringa		G/nut haulms		Amaranthus			
Parameters	20	40	20	40	20	40	SEM	Sig
Dry matter	75.02	71.14	70.81	73.98	71.19	72.65	12.56	NS
Crude protein	85.93	85.43	83.42	84.16	82.60	83.69	3.87	NS
Crude Fiber	75.59^{abc}	73.04^{c}	73.23^{c}	74.67^{bc}	79.13^{ab}	79.45^{a}	5.72	*
Ether Extract	87.05^{b}	87.18^{b}	89.35^{ab}	92.02^{a}	88.09^{b}	89.74^{ab}	2.22	*
Ash	80.09^{a}	72.68^{b}	65.95^{c}	75.39^{b}	75.03^{b}	80.05^{a}	5.98	*
Nitrogen Free Extract	65.81^{ab}	61.67^{b}	63.55^{ab}	71.29^{a}	62.64^{ab}	67.16^{ab}	22.24	*

SEM = Standard Error of Mean, Sig = Significance, NS = not significant , * = significance
abc means with different superscripts within row are significsntly (P<0.05) different

4.2 DISCUSSION

4.2.1 Main Effects of Forage Levels on the Growth Performance of Rabbits

The higher total weight gain and daily weight gain observed in rabbits fed 40% forage meal than those fed 20% forage meal could be as a result of higher feed intake and feed utilization and conversion efficiency. This finding supported the report of Tangedja *et al*., (1990) who fed 40% *Leucaena leucocephala,* but disagree with the report of El-Gendy, (1999) who reported 20% *Lupines albus* to be adequate for growing rabbits.

The final body weight value was higher than the values of 632.00 - 820.63g obtained by Bouaten *et al*. (2011) but lower than the values of 1466.6 -1798.0g reported by Adeneji, (2013) in growing rabbits fed *Gmelilia arborea* leaf meal based diets.

The highest feed intake observed in rabbits fed 40% forage meal could be attributed to increase fiber and energy content of the diet. This is in line with the report of Taiwo *et al*., 1990 who reported increase in feed intake is due to rabbit's ability to eat more diets containing high crude fiber while Rohilla and Bujarbaruah, (2000) reported that rabbits can tolerate up to 40% brown grass (*Thysanolaena maxima)* in their diets without adverse effect on the growth performance.

4.2.2 Main Effect of Forage Type on the Growth Performance of Rabbits

The non significant ($p>0.05$) difference in terms of feed intake observed by rabbits fed different forage meal indicated the palatability and acceptance of forage meal by the rabbit. This is in line with the findings of Iyeghe-Erekpotobor ,(2012) who reported that forage type did not affect feed intake. Rabbits fed Moringa forage meal based diet had high performance values in terms of all growth parameters compared with remaining forage type. According to Moyo *et al.,* (2011) Moringa leaves have nutritional and anti-microbial properties. Daily weight gain in this study are lower than the values of

(12.16g) for those fed Lablab forage meal reported by Iyeghe-Erekpotobor (2011). However, feed conversion ratio is the measure of how efficiently animals converts feed consumed in to flesh. Therefore, the smaller the values the better. Feed conversion ratio for rabbits fed Moringa was better compared to the remaining forage type. The values obtained in this study compare fairly well with the 5.20-6.50 reported by Farinu *et al*. (2008) and 4.85- 5.77 reported by Iyayi *et al*. (2003).

4.2.3 Interaction Effects of Forage Level and Forage Type on the Growth Performance of Rabbits

The higher feed intake obtained in rabbits fed 40% Moringa might be as a result of increased crude protein and fiber content in the diet. However, this is contrary to the report of Nworgu (1999) who showed a reduction in feed intake by rabbit on increased forage meal in the diet.

Rabbits fed 20% and 40% Moringa forage meal had the highest growth parameters compared to rabbits fed 20% and 40% G/nut haulms and Amaranthus, respectively. This finding agrees with Ngodigha *et al*., (1994) who observed that up to 50% of G/nut haulms can support weight gain of growing rabbit. Iyeghe-Erekpotobor *et al*. (2012) also observed that weight gain of rabbit were unaffected by the level of Groundnut forage and rabbits can be fed up to 45% groundnut forage meal. Fotso *et al.* (2000) reported that up to 42% cassava peel meal can be fed to growing rabbit. Similarly Rohilla and Bujarbaruah, (2000) reported that rabbit can tolerate up to 40% broom grass (*Thysanolaena maxima)* in the diets without adverse effect on growth performance.

Cost of feed of Moringa at 40% level is higher than that of 20% level while the remaining forage meals (groundnut haulms and amaranthus) 20% level is higher than that at 40% level. Cost of feed, cost of feed consumed in Naira per day and cost of feed per kg weight gain increased with increase in level of Moringa forage meal in the diet. Increase in the level of the remaining forage meal (groundnut haulms and amaranthus) decreases cost. The decrease in the cost of feed could be attributed to the use of forage meal at the expense of maize which cost higher compared to the test ingredients except for Moringa at 40% level of inclusion. This finding is in line with the report of Adeneji *et al*. (2013) who reported decrease in cost of feed, cost of feed consumed in Naira per day and cost of feed per kg weight gain when groundnut haulms replaced *Gmelina arborea* leaf meal in diets for growing rabbits.

4.2.4 Main Effect of Forage Type on Carcass Characteristics of Rabbits

The significant ($p<0.05$) differences observed on Live weight, slaughter weight and dressing percentage (with 20 and 40% Moringa having the highest level than the remaining forage type) agreed with the findings of Bawa *et al*. (2008) who reported significant difference for the pre-slaughter weight, carcass weight and dressing percentage when rabbits were fed groundnut haulms and cowpea shells. Similarly, Wasem, (2013) observed significant increase in the loin, head, neck, heart, liver and lungs of rabbits fed with 50% groundnut nut haulms.

The non-significant different observed in forelimbs was in agreement of the findings of Omole *et al*. (2007) who observed a non-significant effect in the forelimbs and hind limbs when he fed *Stylosanthes guinensis* and *Lablab purpereus* forage.

4.2.5 Main Effect of Forage Level on Carcass Characteristics of Rabbits

The non-significant ($p>0.05$) difference obtained in live weight, head, fore limbs, hind limbs, neck and kidney could be attributed to the level of inclusion of the forage. This finding was in agreement with the report of Adesun and Iyeghe-Erakpotobor, (2012) who reported similar fore limbs, hind limbs, and kidney for rabbits fed 0, 10, 20, 30, and 40% sugarcane peel diets, but disagrees with Abdu *et al*. (2012) who observed significant different in the shoulder, thigh, and loin when rabbits were fed carrot leaf meal at 0, 15, 30, 45 and 60% level of inclusion.

The significant ($p<0.05$) difference observed in dressing percentage, thigh, rack and rib, liver, skin, heart, lungs, large intestine, small intestine and stomach showed a trend in these parameters with 40% forage inclusion level being higher than those fed 20% forage.

4.2.6 Interaction Effect of Forage Type and Level on Carcass Characteristics of Rabbits

The interaction effect of forage type and forage level on the carcass characteristics of rabbits is presented in Table 6. There were significant ($p>0.05$) differences in all the carcass parameters except for head value. There were higher values of live weight, dressed weights and dressing percentage obtained in rabbits fed 40% level (Moringa) when compared to other forages at all levels. This is a reflection of feed intake and subsequently weight gain as reported by Okorie, (2003). The slaughter weights values obtained in this trial can be compared to the values reported by Iyayi *et al*. (2003) of 1053 to 1186g. The dressing percentage values of 59.93 to 64.25% obtained in this trial were lower than 72.6 to 76.20% reported by Okorie, (2003) but closely similar to the values of 48.56 to 59.78% obtained by Iyayi *et al*. (2008).

The weight of the head differed significantly among the experimental diets with rabbits on Moringa diet at 40% level (8.55g) being the biggest while the smallest was in rabbit fed amaranthus diet at 20% level (6.48g) compared with remaining forages. The weight of head was found to be inversely proportional to the weight of the rabbit. This means that, the heavier the rabbit the smaller the head as seen in the rabbits fed Moringa based diets and less in the rabbits fed amaranthus and ground nut haulms based diet. This could be attributed to the physical and genetic constitution of the rabbits as reported by Biya *et al*. (2008).

The values of kidney in this trial ranged from 0.59% at 20% level (amaranthus) to 1.04% at 40% level (Moringa) which compared favorably with the values of 0.62 to 1.03% obtained by Okorie, (2003), and fairly with 0.73 to 1.26 % obtained by Biya *et al.* (2008). The values 2.94% at 20% level (amaranthus) got in this trial was similar to the values 2.84 to 3.64% obtained by Biya *et al.* (2008). The proportion of the heart (percentage) obtained in this trial ranges 0.26 at 20% level (amaranthus) to 0.75% at 40% level (Moringa) was lower than the values obtained by Biya *et al*. (2008) which ranged from 1.07 to 1.16%. These differences obtained among the carcass parameters in this study could be as a result of the differences in the body weight of the rabbits.

4.2.7 <u>Main Effect of Forage Type on the Haematological Characteristics of Rabbit</u>

There was a significant (P<0.05) differences in all the parameters considered except for MCHC (Table 7). The values obtained were all within the normal values reported by Hillyer, (1994) and Mercks Veterinary Manual (2005). These normal values indicated that the rabbits were healthy and not anaemic. This confirmed the report of El-Medany *et al*. (2008) that dried leaves up to 50% can be used in growing rabbit's diet in place of conventional ingredients without any adverse effects on the blood components. All the parameters considered could be compared to those obtained in the report by Ahemen *et al.* (2008). The haemoglobin, PCV, RBC and WBC values agreed with those reported by Nuhu, (2010) but generally higher compared to Hb (5.53-10.20), RBC (5.30-6.23), PCV (19.60-46.50) and WBC (5.00-7.30) values reported by other researchers in the tropics (Ahamefule *et al*., 2006; Yakubu *et al*. 2008; Ahamefule *et al*. 2008)

4.2.8 Main Effect of Forage Level on Haematological Parameters of Rabbits

Table 8 showed the effect of different forage type and forage level on haematological indices of rabbits. In all the parameters considered, the values obtained from each of the groups were not significantly (P>0.05) different except for MCV and PCV. Rabbits fed at 40% level of inclusion of forages had higher value (39.51%) of PVC than those fed 20% level with lower value (38.23%). For MCV, also the group fed with 40% level of inclusion of moringa indicated the highest value.

However, haematological values are within the normal ranges reported by Hillyer, (1994) and Mercks Veterinary Manual, (2005). It appears that there is more efficient erythropoesis in rabbits on 40% forages as this may be responsible for higher PCV values compared to other group. The fact that WBC values for both groups fall within the normal ranges indicated a normal antibody production which help in maintaining strong disease resistance. This is evident by the fact that no mortality was recorded during the experiment. Pharmacological potentials of forages have been reported (Satish and Turhar, 2012). The ranges of Hb values (11.02-11.88 g/dl) observed in this study being within normal ranges for rabbit indicates the normal physiological relationship of haemoglobin with oxygen in the transport of gasses to and from the tissue of the body (Njidda *et al*. 2006). The MCHC, MCH and MCV values in this experiment were in consonance with the normal ranges reported by Hillyer, (1994). This is an indication that rabbits on both levels of forages inclusion were in a healthy body condition.

4.2.9 Interaction Effect of Forage Type and Forage Level on Blood Parameters

The fact that no significant ($p>0.05$) difference was found on MCH(pg) and MCHC (g/dl) disagreed with the findings of Ojabo *et al.* (2012) who fed sweet orange rind to rabbits at 20-40%. These values give an indication that the experimental diets are in no way inferior to other conventional rabbit's feeds.

Rabbits fed moringa based diet had the highest value of PCV (%) and Hb (g/dl) at both 40 and 20% levels. These values were lower than the values reported by Ojabo *et al*. (2012) who reported range of 27.40-32.8%. Good adequate nutrition has been recognised as an important factor that enhances erythropoiesis. White blood cells are also higher for Moringa at 20% and 40% compared to other forages. These values were below levels of 7.5-13.5($x10^9$)/l reported by Mitruka, (1981). The superior performance of rabbits fed Moringa based diets was corroborated by the numerical increase in total protein which is a good index of the quality of dietary proteins. Results of the total protein are however lower than the values of (7.80-9.50g/dl) reported by Ojabo *et al*. (2012).

4.2.10 Main Effect of Forage Type on Nutrient Digestibility of Rabbit

The lower nutrients digestibility in rabbits fed amaranthus could be due to presence of anti-nutritional factors. McNitt *et al,* (1996) observed that high starch diets are not completely digested in the small intestine and rabbits fed amaranthus feed meal had the highest NFE in the diet. Nityanand, (1997) reported that factors interfering with digestion and utilization of diets include tannins, trypsin, phytate and oxalate.

The values of nutrients digestibility obtained in this present study compare fairly well with the values reported by other researchers such as Bamikole *et al,* (2005), Iyeghe-Erakpotobor *et al*. (2005) and Iyeghe-Erakpotobor *et al*. 2006. This confirm that the apparent nutrient digestibility of the three forage type fed to rabbits in this trial falls within the values usually obtained in rabbits. The highest digestibility values obtained in rabbits fed moringa based diet could be attributed to its more digestible nature as reported by Fahey *et al*. (2010) who stated that *moringa oleifera* is an outstanding indigenous source of high digestible protein.

4.2.11 <u>Main Effect of Forage Levels on Nutrient Digestibility of Rabbits</u>

There were no significant different observed in all the parameters measured. The effect of forage level on digestibility of rabbit showed that 40% levels have high digestibility value in terms of crude protein which could be attributed to its high digestible nature. This is in line with the report of Fahey *et al*. (2001) who stated that *Moringa oleifera* is an outstanding indigenous source of highly digestible protein.

Forage level on digestibility of rabbit fed 20% showed that crude fiber has the highest digestibility value. This is in agreement with the report of McNitt, (1996) who reported that fiber is important in the transit of digestible feed materials and has protection against digestible trouble.

4.2.12 <u>Interaction Effect of Forage Type and Forage Levels on the Digestibility of Rabbits</u>

The increase in digestibility of dry matter and crude protein across the treatments is contrary to the report of Gholizadeh, (2010) who reported that dry matter and crude protein remained unchanged when dried citrus pulp was fed to Iranian *saanen* kids. The crude fiber levels in this study were within the acceptable range, thus the digestibility of the nutrients was high. The high digestibility of crude fiber in all the dietary treatment shows that the dietary fiber contains more of digestible fiber than indigestible. Gholizadeh and Naserian, (2010) attributed the increased digestibility of the fiber fraction to the low lignin content of the experimental materials. Dietary inclusion of the soluble fiber favors the growth of intestinal villi and activity of enterocytes (Chiou *et al*. 1994; Garcia-Ruiz *et al*. (1997).

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The study was conducted using a total of 30 mixed breed of weaner rabbits aged between 6-8 weeks with an average weight of 620g to determine the performance of weaner rabbits fed different forage based diets. The rabbits were randomly allotted to the treatment groups in a Completely Randomized Design in a 3x2 factorial arrangement. The factors considered were forage type (Moringa, groundnut haulms and amaranthus), and levels of inclusion of the forages (20 and 40%) and interactions between the forage type and forage level. Water and feeds were supplied *ad libitum.* The study lasted for 56 days. The results from the study showed that Moringa had the highest final weight gain and total weight gain, followed by groundnut haulms and amaranthus. While in terms of Feed conversion ratio, amaranthus recorded the highest value. Also, there were no significant ($p>0.05$) difference among all the treatment means with regards to forage levels. No significant effect ($p>0.05$) was observed among the forage type and forage levels across the treatment means in feed intake, initial weights of the rabbits. However, final weight, total weight gain, daily weight gain and feed conversion ratio showed significant different ($p<0.05$). Cost of feed/kg weight gain was also higher in moringa at 40% (N521.21) followed by 20% Moringa (N378.93). There were significant ($p<0.05$) difference observed in all the parameters except for forelimbs that showed no significant difference ($p>0.05$) among the treatment means. Rabbits fed Moringa based diets recorded the highest values in all the parameters followed by groundnut haulms and amaranthus with a slight difference between them. Rabbits fed forages at 20 and 40% did not show any significant ($p>0.05$) effect with respect to level of inclusion in terms of live weight, dressing percentage, head, forelimb, hind limb, neck and kidney. Blood analysis showed that there were significant ($p<0.05$) differences in all the parameters measured except for MCHC. Rabbits fed Moringa had the highest values for haemoglobin, WBC, Total protein, MCV and MCH. Blood parameters measured in terms of forage level showed that there is significant ($p<0.05$) difference in packed cell volume and Total protein. However, rabbit fed at 40% level of inclusion tended to have higher values compared to 20% level. Digestibility study showed that, there were no significant ($p>0.05$) differences in all the parameters both at 20 and 40% level. Amaranthus at 40% level recorded the highest value for crude fiber followed by 20% amaranthus. Groundnut haulms and Moringa are statistically similar at 20 and 40% level. Similarly, Groundnut haulms at 40% level were higher with respect to ether extract followed by amaranthus at 20% level. Values of Moringa are statistically similar with respect to ether extract at 20 and 40% level. Amaranthus at 40% and Groundnut haulms at 20% are statistically the similar. Moringa at 20% and amaranthus at 40% recorded highest value for ash, while Moringa at 40%, Groundnut haulms at 40% and Amaranthus at 20% levels were statistically similar. Groundnut haulms at 20% level recorded the least value.

5.2 CONCLUSION

The study concluded that 40% level of Moringa in the diet of rabbits improves growth performance on feed intake and higher cost of feed/kg live weight gain and no health hazard in terms of blood profiles.

From the result of the study it could be concluded that, Moringa at 40% level could be used in the diet of rabbit without adverse effect on performance characteristics and health.

5.3 RECOMMENDATIONS

Based on the findings of this study the following recommendations were made:

- 40% level of Moringa should be used in the diet formulation for rabbits
- Moringa at 20% level can be used to reduce the cost of feed as well as cost of production
- Further research should be carried out on the use/ productive potential of Moringa, groundnut Haulms and amaranthus for better performance in rabbit production

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