GROWTH AND CARCASS CHARACTERISTICS OF WEANER RABBITS FED MORINGA (*moringa oleifera) LEAF MEAL.*

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DEPARTMENT OF ANIMAL SCIENCE

UNIVERSITY OF NIGERIA NSUKKA

DECEMBER, 2009.

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF NIGERIA, NSUKKA, IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN ANIMAL PRODUCTION

SUPERVISOR: PROF. A. G. EZEKWE

DECEMBER, 2009.

CERIFICATION

WE CERTIFY THAT ENU, THOMAS MBEY. (PG/MSC/06/41605) carried out the research in the grasscutter unit of the Department of Animal science, University of Nigeria, Nsukka. The report embodied here is original and has not been submitted for any other degree of this or any University.

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Dr. S.O.C. UGWU	PROF. A.G EZEKWE
HEAD OF DEPARTMENT	PROJECT SUPERVISOR
DATE: ----------------------------	DATE-----------------------------

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EXTERNAL EXAMINER

DATE-----------------------------

DEDICATION

To the loving memory of my late father, Mr. Raphael Enu Akan.

ACKNOWLEDGMENT

I am most indebted to my project supervisor Prof. A.G Ezekwe for his painstaking, relentless efforts and useful criticism which made this project work possible.

My immense appreciation goes to all my lecturers in the Department of Animal Science who have in no small way contributed to the success of this work. My joy will not be complete without mentioning in a special way the love and support of my wife Mrs Lizzy Enu, my children MaryAnn, Joe Boy, Princess Rose and Benedicta. Worthy of mention also are my dear mother Mrs. Angelina Akan, brothers and sisters and all my friends throughout my period of study at Nsukka. I cannot forget my colleagues in the programme, Paul Okafor. Uchelle Okpanachi, Juliet Orji, Johnson Ezike, Francis Elile, Chinenye Oguijuba. Above all, I acknowledge the care, love, favour and protection of God Almighty over my life during my study and also during my shuttle to and from Nsukka.

ABSTRACT

Twenty four (24) cross bred rabbits of both sexes, made up of twelve (12) males and twelve (12) females were used for the experiment to investigate, the growth and carcass characteristics of weaner rabbits fed four(4) dietary levels of Moringa oleifera leaf, meal (MOLM). Treatments 1, 2, 3, and 4 received 0, 10, 20, and 30% MOLM, respectively.

Results obtained showed that rabbits on T_3 diet achieved the highest weight gain (1600.00 ±56.27g) while T_2, T_4 and T_1 recorded weight gains of (1583.33 ± 0.14g, 1441.67 ± 47.29g and 1366.67 ± 77.10g), respectively. Rabbits on T_3 diets also recorded a higher daily weight gain (9.54 ± 0.70g) than those on T_2, T_4 and T_1 (9.03 ± 0.39g, 7.54 ± 0.89g and 6.65 ± 0.85g), respectively. There was also significant difference (P< 0.05) on the feed cost per kg gain (₦) as Treatment 3 feeds was cheaper (₦77.08), than T_4, T_2 and T_1 whose feed costs were ₦85.57, ₦85.66 and ₦132.85, respectively. Feed intake, feed conversion ratio, and feed cost per kg feed (₦) had no significant difference (P > 0.05) across the treatments. Results of carcass evaluation showed a significant difference (P < 0.05) on the; thoraxic width, lion weight, liver weight, lungs weight and spleen weight.

However, there was no significant difference (P > 0.05) on the other parameters such as, liver weight, dressed weight, carcass length, head weight, fore limb weight, hind limb weight, heart weight and kidney weight, as was observed from the study. Evaluation of hematological characteristics of rabbits fed MOLM showed no significant difference (P>0.05) in packed cell volume (PCV) haemoglobin (HB g/d), red blood cell count (RBC) and white blood cell count (WBC). This investigation therefore suggests that, rabbits tolerate Moringa oliefera leaf meal (MOLM) up to 20% level, for optimal performance. Higher levels of incorporation resulted in decreased performance and should be discouraged.

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CHAPTER ONE

1.0 INTRODUCTION

The increasing demand for animal protein coupled with more stringent economic conditions have encouraged greater interest in fast growing animals with short generation interval. Poultry and pigs are the first choice but their production is more demanding because of the high cost of production and competition with man for feedstuffs. Fetuga (1997) reported on the disappointing rate and level of performance in the livestock industry in Nigeria. This he attributed, among other factors, to high cost of feeds arising largely from fluctuations in feed supplies, rising prices of ingredients, poor quality feeds, inefficiency in production and distribution in the feed industry.

Many investigators have suggested ways of increasing the low animal protein intake of Nigerians. One of the cheapest producers of meat that can easily fit into the wider segment of the population but which has been neglected in Nigeria is the rabbit. The rabbit has the ability to convert feedstuff such as forages, most agricultural by-products, kitchen waste etc that human being cannot consume directly into highly nutritious meat. Rabbits are highly prolific, cheap to feed because they can utilize roughage feeds, they have rapid growth rate, high dressing percentage, short gestation period and low purchasing price. However, efficient rabbit production is largely dependent upon adequate and correct nutrition (Standford 1979). There is no rabbit so good that poor nutrition will not ruin nor any bad one that good feeding will not improve.

A rabbit which is not well fed can not give its best, and when it is realised that the greatest cost of producing rabbits lies in the nutrition, correct feeding therefore becomes of utmost importance to the rabbit producer. The quantity of feed provided is important but the quality or type of feed is more important because poor nutrition result in slow growth rate, inefficient reproduction and predisposes the animals to diseases.

Aduku and Olukosi (1990) reported a digestible energy range of 10.00 – 10.46 MJ/Kg for optimum performance of rabbits in the tropics. The digestible energy (DE) level reported by these workers are, however, similar to digestible energy (DE) of 10.46 MJ/Kg recommended by NRC (1977) for growing rabbits in temperate zones. Aduku and Olukosi (1990) also reported a range of 2390-2500 K cal/Kg of energy and crude protein level of 12-17% for optimum performance of rabbits in the tropics. Fielding (1991) had reported a range of 16 – 18% crude protein (CP) as optimal for growing rabbits.

In recent years, there have been renewed interests in the use of non-conventional ingredients in feeds formulation for livestock. Standford (1979) reported that, there is a wide range of feedstuff on which rabbits can live on. Therefore, alternative feed sources need to be investigated such as, Moringa oleifera, the leaves of which have been used as animal feed in many places. Moringa oleifera leaves, stems, roots and other parts have been popularly used as animals feeds in countries such as Senegal, Niger, Kenya, Tanzania, Zimbabwe, Gambia, Malawi, India, Spain, USA and Germany etc (Fugile, 1999). However, it potentials as an animal feed supplement have not been properly documented in Nigeria.

Moringa oleifera is a multipurpose browse plant with useful characteristics. The leaves and green fresh pods are used as vegetable by man and are rich in carotene and ascorbic acid with a good profile of amino acids (Makkar and Becker 1996). It is also used as livestock feed and its twigs are reported to be very palatable to ruminants and have appreciable crude protein levels ranging from 26 – 27 percent (Sutherland *et al* 1990, Sarwatt *et al* 2002, Kimoro 2002).

Fuglie (1999) stated that the high bioavailability of Moringa oleifera leaves and stems make them an excellent feed for cattle, sheep, goats, pigs and rabbits. The leaves of Moringa oleifera are an excellent source of the sulphur containing amino acids, methionine and cysteine, which are often limiting in most feedstuff used for feeding animals (Maroyi, 2006). Moringa oleifera leaves have also been used as an alternative protein source for tilapia fish production (Becker *et al*, 2002).

Mathur (2006) indicated that cattle fed with the leaf and green stems of Moringa oleifera can increase milk production by 43 – 65% and increased daily weight gain in cattle by up to 32%. Onimisi *et al* (2007) indicated that Moringa oleifera leaf meal can be included up to 30% in rabbits diet without any adverse effect on the growth performance. Moringa oleifera can also be included up to 20% in the diets of laying birds without any adverse effect (Kakengi *et al* 2007).

The authors went further to state that, the high pepsin and total soluble protein makes Moringa oleifera leaf meal a more suitable feedstuff to monogastric animals.

In most parts of Nigeria especially in the north, the fresh leaves of Moringa oleifera are used as vegetable, roots for medicinal purposes and stem/branches for demarcation of property, boundaries in farmland and in house fencing (Muyibi and Evison, 1994). The abundance of Moringa oleifera plant in most part of the country as natural pasture, is a good indication that the plant can be successfully used to reduce the problems of the short supply of protein sources currently being experienced by feed millers. Nigeria like many other developing countries is currently faced with the shortage and high cost of conventional feeds for poultry, rabbits and other livestock with protein sources of plants and animal origin constituting one of the greatest part of the cost.

Therefore, there is the need to investigate alternative feed source like Moringa oleifera to see to what extent it can supplement or completely replace plant proteins sources in animal feeds.

1.1 Objectives

This research work was aimed at investigating the response of weaner rabbits to diets containing graded levels of Moringa oleifera leaf meal. The specific objectives of the study were as follows:

i. To assess the growth performance of weaner rabbits fed graded levels of Moringa oleifera leaf meal.

ii. To evaluate the effects of the diets on the carcass characteristics of the rabbits.

iii. To determine the haematological properties of rabbits fed Moringa oleifera leaf meal.

iv. To determine the cost implication of feeding graded levels of dietary Moringa oleifera leaves to rabbits.

1.2 Justification of the Study

The high cost of protein feedstuff for livestock feeding, resulting from the scarcity of feedstuff such as fishmeal, groundnut cake and soya bean meal and the high competition that exists between man and animals for the conventional feed stuffs, has necessitated the need for maximizing the effective utilization of non-conventional feedstuffs.

This can be achieved by reducing the quantity of these expensive feedstuffs and supplementing them with cheaper non-conventional protein feedstuff like Moringa oleifera. In this way the cost of production of rabbit feeds will be greatly reduced, thereby making the feeds affordable to rabbit farmers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Biology of the Rabbit

Rabbits (Oryctolagus cunniculus) are non ruminant herbivores. The origin of the wild rabbit, from which the domestic variety was derived, is a subject of speculation. There is no doubt however that the rabbit was well known in the Mediterranean area some two thousand years ago, for it was depicted on many of the coins of the Roman emperor Hadrian in the years A.D. 120-130 (Standford, 1979). Fielding (1991) and Aduku and Olukosi (1990) reported that, rabbits were first known in South West Europe and North Africa. Domestic rabbits are reared mainly for meat and the skin is of secondary importance.

Fielding (1991) and Aduku and Olukosi (1990) stated that all the domesticated rabbits found in different parts of the world were developed from the European/North African wild rabbits distributed to various parts of the world by sailors leaving Europe to explore the world in the 18th century. These sailors took rabbits on their ships and often released them in the countries where they berthed. The purpose of this, was to allow rabbits breed and multiply in those areas and the resulting offsprings would be available as a source of fresh meat when they mature, whenever the sailors returned again to these parts of the world. In this way, rabbits were introduced to many parts of the world and this must be the most probable means of early introduction of rabbit to Nigeria.

One contribution of rabbit to animal production is their ability to convert feed such as forages, most agricultural by-products, grasses, kitchen waste etc, that human beings cannot consume directly into highly nutritious meat.

Their ability to convert these products into meat is made possible by their well adapted dental formula. Standford, (1979) stated that the teeth of the rabbit are well adapted to its normal foods. All the teeth of rabbit grow continuously throughout life, the teeth surfaces constantly wearing down in order to maintain the correct length. Standford, (1979) further stressed that, leading into the mouth are several ducts from the especially well developed system of salivary glands which secrete saliva when the rabbit is eating.

From the mouth, a slender tube, the oesophagus, carries food to the stomach, which is a thin walled organ having little power of contraction. Food passes from the stomach through a muscular band of tissue known as the pylorus, which controls the entrance of the food into the small intestine. The first part of the small intestine is looped to form the duodenum, and within this duodenal loop lies the pancreas. This is a diffuse irregular organ which supplies certain fluids to the duodenum. Also entering into the duodenum from the gall bladder in the liver, is a bile duct which carries bile from the liver where it is produced.

The small intestine continues until it enlarges into the sacculus rotundus, an enlarged sac peculiar to the rabbit. From the sacculus rotundus arises the large intestine consisting of the caecum, the colon and the rectum. The caecum meets the colon at the sacculus rotundus and is a relatively very large organ, with the appendix attached to the end (Standford, 1979). Microbial symbiosis exists towards the end of the gastro-intestinal tract. That is, fermentation is posterior to intestinal digestion and absorption, efficient absorption of high quality feedstuff occurs after the intestinal digestion and absorption process.

2.2 Importance of Rabbits Production

Rabbits are kept for a variety of reasons and purposes which include the following:

- Laboratory animals: Rabbits can be purposely kept for the production and development of new vaccines, for immunological and technological studies and for drug testing.
- Pets: Rabbits are mainly kept as pet or for exhibitions in the U.K., U.S.A., and Canada.
- Wool or Fur: The Angora rabbit is bred for the production of wool or fur and 80% of total Angora rabbits comes from China (Niyi, 1997). The fur of rabbits is used to manufacture hat, gloves, coats and other wooly products.

- Meat Production: Approximately 2,721,552kg of rabbit meat is produced annually in the U.S.A. It is estimated that 4.1 – 5million kg is consumed each year in the United States (Niyi, 1997).

Rabbits produce white meat that is palatable and nutritious, high in protein, and low in calories, fat and cholesterol. Other attributes of rabbits which have created renewed interest in its rearing as source of protein are:

- Rabbits are noted to have short generation interval and fast growth rate and they have the potentials of high rate of multiplication (Ezekwe, *et al* 2002).
- Rabbits also have a peculiar digestive physiology which enables it to utilize forages, industrial and agricultural by-products. As a non-ruminant herbivore, the rabbit can be raised like other ruminants on green vegetables and on food remains at home.
- Rabbits have the ability to be raised on a limited space where it is impossible to raise other livestock.
- Their small size eliminates the problem of processing and preservation of the meat. This makes it easy to handle and consume rabbit meat without causing any inconvenience to the consumer.
- A relatively low investment is required to start a rabbit unit and a quick financial return upon investment has been observed.

- Rabbits are also known to be noiseless, docile and non aggressive animals, this makes their keeping compatible with human dwelling (Niyi, 1997).

2.3 Constraints to Rabbits Production

The major constraints to successful commercial rabbit production in the tropics are problems of inadequate nutrition, poor management, and low reproductive efficiency, diseases, shortage of pure breeding stock and marketing problem.

Nutrition is perhaps the most important constraint in livestock production. Inadequate supply of feed both in quantity and quality is one of the factors responsible for the low productivity of livestock in the tropics. Inadequate energy, protein or micronutrients in the diet may impair reproduction of rabbits (Niyi, 1997). In the temperate climates, the digestible energy (DE) requirement for growth of rabbits has been given as 2500K cal, DE/Kg. A dietary crude protein (CP) level of 16% is deemed adequate to promote rapid gain in temperate climates. Since high ambient temperatures are known to depress feed intake, therefore better fortified diet would be required in the tropics (Anugwa, *et al*, 1982). The full exploitation of the potentials of rabbit as a meat animal in our tropical environment requires an understanding of their protein and energy needs.

2.4 Feeds and Feeding

The feeding of domestic animals like rabbits is on the basis of information about its mode of digestion and feed utilization efficiency. Anugwa *et al* (1982) stated that rabbits are monogastric animals as well as herbivores even though they are non-ruminants.

Standford (1979) reported that, the correct feeding of the domestic rabbits is perhaps the most important aspect of rabbit keeping. There is no rabbit so good that poor feeding will not ruin, nor any so bad that good feeding will not improve. An animal which is not well fed cannot give its best. Whenever the cost of feeds accounts for the greatest cost of producing rabbits, every effort must therefore be made to ensure that rabbits are fed with cheaper alternative feed sources. There are a wide range of feedstuffs on which rabbits can live on. For example, rabbits could be maintained on waste from gardens, whereas others are maintained almost entirely on purchased feedstuffs, while others again can be raised on specially home grown foods. Feedstuffs can be conveniently grouped into; roughages (hay and similar materials), succulent feedstuff (grass, roots and all green feeds), and concentrate (all cereals and their by-products, and animal products such as fish meal, meat meal etc), and all these feedstuffs contain water, carbohydrates, proteins, oil or fats, minerals and vitamins in varying proportions.

Anugwa *et al* (1982) indicated that, succulent forages can be offered to rabbits and the digestion of these green forages is as a result of the presence of a large caecum in its digestive tract. He further stated that this large caecum contains a few micro organism, which eventually foster the conversion of cellulose in the forages to digestible glucose.

Grass, both fresh and dried is an important food for domestic rabbits. At the onset of the rains and throughout the raining season, grasses grow rapidly, and at this period the plant is leafy and is rich in protein and low in fibre content. During dry season when the plant flowers, there is a great increase in fibre and a reduction in protein and often digestible nutrients (Standford, 1979). A good quality hay is an excellent food for rabbits, and most breeders have agreed that it should be fed when available and that the hay should be leafy, for it is the leaf that is the most nutritious part.

Ojomo (1975) reported that zero feeding can be practiced in rabbit management, this being a system of feeding whereby freshly cut forages are fed to rabbits and this is done because rabbits are always confined.

Badmus (1992) indicated that, it is relevant to wash plant materials with clean water with an addition of salt after which it should be allowed to dry before used as feed to rabbits. The washing helps to remove dust, insect deposit on the leaves and also tries much to protect it from contamination with other harmful substances.

Standford (1979) stated that, there is an infinite variety of green foods which are useful for feeding purposes, and many breeders on a small scale rely for the bulk of their food supply on wild plants. On a large scale, some breeders will grow green food crops, of which cabbage, chicory, kale, red clover, lucerne, macie, oats and tare mixture are probably the most satisfactory, and that, there are a number of crops for human consumption which supply considerable amount of food for rabbits. For example, carrot tops, waste cabbage leaves and rhubarbs leaves are all valuable. Most of the roots fed to rabbits which include carrots, sugar beet, fodder beet, mangold, swede, kohl, rabi and turnip have a low dry matter content. Fodder beet and fugal beet however, have much higher dry matter content and are nearly twice as nutritious as other roots. Standford (1979) stated that, when roots are first introduced, they should be fed in limited quantities. If given in too great a bulk they will almost certainly scour the rabbit. However, potatoes could be considered separately from the other roots, as they have a very high dry matter content compared with the others.

Anugwa *et al* (1982) stated that concentrate ration should be used as supplements of the vegetable feed, which is mainly used as maintenance ration for adults. The concentrate ration should have a protein content of as high as 24% which is usually balanced with adequate supply of vitamins and other essential minerals (Komolafe *et al*, 1979).

Okorie (1983) reported that, rations for dry does, bucks and growing rabbits should contain 12-15% protein. Those of pregnant does and does with a litter should contain more protein 16-20%. The protein content is important in the growth of the young.

Standford (1979) stated that, beans and pears have high protein contents and are regarded as one of the most valuable vegetable proteins. Old beans are preferred for feeding, as new beans, when ground, are very liable to heat and to become very unpalatable and even dangerous for feeding.

Standford(1979) indicated that, brans are used as suitable feeds to dry off wet mashes, and because it enjoys a reputation for stimulating milk production and is also laxative in nature, is usually more expensive than its mere feeding values merit.

Oil meals and cakes are never fed by themselves, except in the case of linseed mash, which is now not often fed. Depending on the method used to extract the oil from the original seeds, the various cakes may have an oil content of 2 - 8%. Some of the oil cakes have had a proportion of the fibre removed and they are known as decorticated cakes. The undecorticated cake contains a high proportion of fibre and is not desirable.

Groundnut cake, when decorticated, is a valuable and palatable food. It is usually much cheaper than linseed cake. Soyabean cake and meal are extremely rich in protein and are very palatable. They constitute one of the most popular protein supplements used for rabbit feeding. They can be used safely in moderation to balance the rations, but the addition of calcium is necessary.

2.5 Nutrient Requirements of Rabbits

The influence of various dietary nutrients on production capabilities in domestic animals depends largely on the quality and quantity of nutrients consumed (Ijaiya, *et al;* 2002). Deshmuk and Pathak (1991) noted that feed intake increased with an increased level of dietary protein. Fordyce *et al*, (1986) reported that the composition and availability of nutrients are the major factors influencing voluntary intake. The concentration of proteins, the balance of amino acids and deficiency or excess of minerals or vitamins can affect feed intake and general body growth and performance of animals. The major parameter which determines the amount of feed eaten is the concentration of available energy.

Essential nutrients required by rabbits are those which will be able to maintain normal physiological processes of the body such as growth, health, digestion, reproduction and lactation etc. A balanced diet containing prerequisites amounts of energy, proteins, fat, minerals, vitamins, coccidiostats (additives), antibiotics and water are essential for rabbits reared under intensive production (Ibeawuchi and Fajuyitan, 1986, Aduku and Olukosi, 1990, Fielding, 1991, Gillespie, 1992,). Fibre is also an important nutrient component which rabbits require in their ration. Rabbits nutrition and requirements for feed intake vary with age and particularly with reproductive status. The nutritional requirements of rabbits at different physiological stages are presented in Table 1.0.

Table 1.0: Nutritional Requirements of Rabbits at Various Physiological Stages

Nutrient	Growing state 4-12wks	Lactation state	Gestation state	Maintenance state	Does/Litter fed one diet
Crude protein (%)	16-18	17-18	15-17	13-15	17-19
Crude fibre (%)	14	12	14	15-16	14
Nitrogen free extract (%)	44-52	44-52	44-52	44-52	44-52
Indigestible fat %	3-6	3-6	3-6	2-4	3-6
Ash %	5-6.5	5-6.5	5-6.5	5-6.5	5-6.5
Digestible energy (Kcalkg)	2500	2500	2500	2500	2500
Metabolizable energy (Kcal/Kg	2410	2400	2600	2400	2120

Source: Lebas (1980) and NRC, (1977). As cited by Aduku and Olukosi (1990).

Fielding (1991), Ibeawuchi and Fajujitan, (1986), and Gillespie (1992) indicated that, rabbits nutrient requirement can be grouped into the following categories; energy, protein, minerals, vitamins, water and fibre.

2.5.1 Energy Requirement

The energy requirement of rabbit is met from non fibrous components of the feed. Energy required by rabbit from growing stage to adult stage is within 1500 - 2390 Kcal/Kg or 2600-2700Kcal/Kg metabolizable energy respectively, (Fielding 1991). The same author indicated that the physiological state of the animal (i.e. maintenance, pregnancy, growth, lactation etc) determines the energy requirement of the rabbit and this energy can be supplied mainly from carbohydrate and fat. Lang (1988) reported that energy requirements are greater for lactation than for other productive functions because milk has a high energy content of about 8.4-12.6mj/kg. Table 2.0 shows the energy requirement of different classes of rabbit.

Table 2.0: Energy Requirement of Rabbit

Energy	**Growing 4-12wks**	**Lactation**	**Gestation**	**maintenance**	**Does/Litter fed one diet**
Digestible Energy (Kcal/kg)	2500	2700	2500	2200	2410
Fat (%)	3	5	3	3	3
Metabolizable Energy (Kcal/kg)	2400	2400	2400	2120	2410

Source: Lebas (1980) cited in Aduku and Olukosi (1990)

Rabbits are known not to digest cellulose by their own enzyme but this can only be broken down by the bacteria in their caecum. Energy is required by the rabbit for the contraction of muscles which enable the rabbit to move, build up their physiology and make products such as hair, milk and meat etc (Fielding 1991). The accuracy with which animal's performance can be predicted depends upon knowledge of energy requirements and the nutritional value of feeds consumed (Ranjhan, 1993). Animals in good health normally consume sufficient feed to meet their energy requirements.

2.5.2: Energy Requirements for Growth

Growth in animals is an increase in the structural tissues including muscles, bones, fats and organs. The new tissues consist largely of protein, fat and water (Obinne, 2000). Aduku and Olukosi (1990) reported that the energy requirement of rabbits ranged from 2390-2500 Kcal/kg.

Anugwa *et al.,* (1982) stated that, the digestible energy requirement for growth and optimial productivity of rabbits in the temperate climates is 2500kcal/kg, while in the tropical climates, the digestible energy for growth and development is given as 2800 kcal/kg of feed.

Cheeks *et al*, (1982) recommended digestible energy requirements of rabbits to be 2500 Kcal for growth.

The efficiency of energy utilization for growth is clearly influenced by the composition of growth, because energy is retained less efficiently as protein than when it is retained as fat (Blaxter, 1989; Close, 1990).
Hill and Dansky (1950) found that growth was reduced when a high energy and low protein ration was fed to rabbits but that growth was restored when the energy level was lowered. Lukefahr (1992) showed that a ration high in protein and low in energy reduced growth and efficiency of feed utilization.

2.5.3 Protein Requirement

Protein is the chief organic component of the cellular structure and also the fundamental component of animal tissues. It is a major component of muscle tissues, cell membrane, certain hormones, cell enzymes and important chemical body structure (Fielding, 1991). Many attempts have been made to determine the exact protein requirements of rabbits. Report obtained so far have shown a dietary requirement for ten amino acids (NRC, 1997, Fielding, 1991 and Adamson and Fisher, 1971). Aduku and Olukosi, (1990) stated that the quantity and quality of these amino acids are not critical in rabbit, as in other animals such as poultry. This is because rabbits practice caprophagy and can adapt to low protein situation, though at the expense of productivity. With high and good protein quality however, optimum productivity can be achieved. NRC (1977) and Lebas (1980) recommended 12-13% crude protein (CP) for maintenance, 15-16% for growth, 15-18% for gestation and 17-18% for lactation. Cheeke *et al*, (1982) and Ranjhan (1993) reported crude protein levels of 12, 15, 16 and 17% for maintenance, normal growth and pregnancy, normal growth and fattening and lactation, respectively, in rabbit diets for optimum performance.

2.5.4 Protein Requirements for Growth

Much attention and consideration was not given to the quality of protein in rabbits feeds until recently, because all the essential amino acid requirements were believed to be supplied through caecotrophy. Caecotrophy or caprophyagy refers to soft feaces which rabbits eat at the early morning hours. These soft feaces represents only about 0.14% of the total protein intake in intensively reared rabbits, therefore it must be considered in practical feed formulation to make up for any deficiency in the feeds fed to the rabbits

(Davidson and Spreadbury 1978, and De Blas and Wiseman, 1998). Ten amino-acids known to be essential in the diet of rabbit are lysine, methionine, arginine, phenylalanine, histidine, valine, threonine, tryptophan, leucine and isoleucine, but the two most important are lysine and methionine, (Fielding, 1993). The recommended crude protein level for rabbits in the dry matter of ration is, over 18% for newly weaned, 16-18% for rabbits from 12-24weeks, 12-14% for all other stock (Fielding, 1993).

Current recommendations suggest CP levels of 160g/kg diet for growth with digestible energy contents of 10.5mj/kg diet (NRC, 1977). Hume (1971) recommended crude protein (CP) level of 12-15% for non-pregnant does, bucks and young growing rabbits.

Agunbiade (1997) indicated that under good management conditions, growth rates of fryer rabbits average 33g with upper levels of between 40 to 45g per day. However, research reports available in Nigeria indicate slower growth rate ranging from 11g to 24.3g (Balogun and Ekukude, 1991, and Iyeghe *et al*, 2000). They went further to state that nutrition was probably responsible for the inferior performance of rabbits in the tropics.

Rao *et al*, (1977) reported an average daily weight gain of 28.89g for the first three weeks of age and 27.5g from three to eight weeks of life. Omole (1977) also stated that growing rabbits fed dietary levels of 18% CP did better than those fed 14% and 22% CP. The essential amino acids requirement for rabbit is shown in Table 3.0

Table 3.0: Essential Amino Acids Requirement of Rabbits (%)

Amino Acid (%)	Growing 4-14wks	Lactating stage	Gestati on stage	Maintenance stage	Does/Litter fed one diet
Crude protein a	15	18	18	13	17
Crude protein b	16	17	15	12	-
Sulphur acid	0.50	0.60	-	-	0.55
Lysine	0.60	0.75	-	-	0.90
Arginine	0.90	0.80	-	-	0.90
Threonine	0.55	0.70	-	-	0.60
Tryptophan	0.18	0.22	-	-	0.20
Histidine	0.35	0.43	-	-	0.40
Isoluecine	0.60	0.70	-	-	0.25
Luecine	1.05	1.25	-	-	1.25
Valine	0.70	0.85	-	-	0.80
Phenylalanine	-	-	-	-	-
Tgrosine	1.20	-	-	-	1.20

Source: Lebas (1980), NRC (1977).

2.5.5 Fat Requirement

Arrinton *et al*, (1974) and Aduku and Olukosi (1990) reported that, fat has carbohydrate function and is primarily considered as energy source. Rabbits can handle up to 20-25% fat in their diets depending on their age. Fats provide energy as well as supplying essential fatty acids like oleic, linoleic and arachidonic acids (Aduku and Olukosi, 1990). Fat has been reported to serve as carriers of fat soluble vitamins and help in increasing animal weight (Fielding, 1990). Fat also improves texture, flavour, palatability and satiety of feed and reduces dustiness in feed, speeds up pellet mill capacity and reduces machine wear and improves glossiness of the hair coat (Gillespie, 1987 and Gillespie, 1992). Research has shown that rabbits prefer a diet with some fat added. Vegetable oil is a good source of fat in rabbits diet (Gillespie, 1992). However, excess of fat in diet will reduce feed intake and increase the chance of scouring. Fat requirement for rabbit may vary from 2-3% with no adverse effect on the rabbits (Berge *et al*, 1984).

2.5.6 Minerals Requirement

The minerals required by rabbits are divided into two categories namely, major minerals and trace minerals (Jenny 1981, Cheeke *et al* 1982, and Fielding 1991). Major minerals are required in relatively large amounts while the trace (minor) minerals are required in relatively small amounts (Table 2.5.6). Most of the minerals in the rabbit's body are in the bones and teeth, which contains large proportion of two minerals namely calcium (Ca^{2+}) and phosphorus (P^{5+}) both of which help to give the bones their hardness. They are involved in maintaining the acid-alkaline balance in the blood (Fielding 1991). Phosphorus is also involved in energy transfer within the body cells. A Ca: P ratio of 1:1 in rabbit diet will meet the needs for those mineral elements. Rabbits can tolerate high levels of calcium in their diet without adverse effects (Gillespie 1992). Levels of P greater than 1% of the diet reduces palatability of the ration and may lower feed intake. Alfalfa and other legumes are good sources of P. A combination of alfalfa and grain will generally supply the Ca and P needed in rabbit diet

(Gillespie 1992). Jenny (1981) indicated that magnesium (Mg) is also important and is also a component of bones and is important in chemical reactions involving enzymes. Sodium (Na), potassium (K) and chlorine (Cl) are very important in maintaining the acid-alkaline balance in the body. The use of iodised salt at the level of 0.5% of the diet will supply the needed amount of these minerals and this can also be met by adding mineral/vitamin premix to the diet. However, if rabbits are fed well balanced diets, there will be little or no need for mineral supplementation (Jenny, 1981).

The major and trace minerals required in rabbit nutrition are shown in table 4.0.

Table 4.0: Major and Trace Minerals Required in Rabbit Nutrition

Major Minerals	**Trace Mineral**
Calcium (Ca)	Iron (Fe)
Phosphorus (P)	Copper (Cu)
Magnesium (Mg)	Sulphur (S)
Potassium (K)	Cobalt (Co)
Chlorine (Cl)	Zinc (Zn)
Sodium (Na)	Manganese (Mn)
	Iodine (I)

Source: Fielding (1991).

2.5.7 Vitamins Requirements

Fielding (1991) stated that vitamins are organic substances that are required in minute quantities for normal metabolism. The most important vitamins are the vitamins A, D and B, choline and thiamine, vitamins B, C, E and K are also important. These vitamins (A, D, and B) cannot be synthesized in the body of rabbits except some B-complex vitamins, so they have to be supplied in the diets. Gillespie (1992) reported that rabbits needs fat soluble vitamins. Deficiency of vitamin A results in xerophthalmia and nervous disturbance (Adams 1987). Lack of vitamin D which is very rare in the tropics may lead to rachitis condition (Braunlich, 1965). Vitamin E deficiency causes muscular dystrophy and myocardial damage. Vitamin K deficiency results to distorted reproductive functions. However, these deficiencies are rare due to the synthesis of vitamins in the gastrointestinal tract. Ayoade *et al*, (1985) observed that in rabbits fed fresh diets, oil meal diets such as groundnut cake and soyabean meal, vitamin supplementation would not be necessary as caprophagy takes on with it vitamin production. The vitamins requirements of rabbits are shown in Table 5.0.

Table 5.0: Vitamins Requirements of Rabbits

Vitamins	**Requirements**
A	800/U/Kg DM
D – Choline	1500mg/kg DM
B – Thiamine	1200 mg/kg DM

Source: Fielding (1991)

2.5.8: Water Requirement

Cheeke, *et al* (1982) and Fielding (1991) reported that water may not technically be a nutrient because its properties and functions are quite different from those of other nutrients found in the farm animals feeds, nonetheless, it is an essential requirement.

Standford (1979) reported that, the question as to whether domestic rabbits should be given water or not has been the subject of considerable controversy amongst rabbit admirers for many years. The reason for this is that, it is possible to maintain rabbits without free water if sufficient green food or roots are fed, and several imaginary troubles have been attributed to water. That rabbits can be maintained on a green food diet, which contains considerable water, does not affect the fact that free drinking water is highly desirable.

Water consumption in rabbit is greater than might be anticipated. Rabbits need good supply of cool clean water at all times for the maintenance of good health. Rabbits usually consume 2.5-3times more water than dry matter (Gillespie 1992). Water consumption is increased with both hot and cold air temperature as well as salt content of the feed (Stephen, 1980). For example, at 30^{o}C rabbits water consumption increases by 50% than at 20^{o}C. Similarly, feed intake is reduced and water intake is increased, while under cold conditions, feed intake is increased and water intake is reduced. Extremes of both hot and cold temperatures could also reduce milk supply of suckling does and may predispose the rabbits to digestive disorders. Water intake in rabbits increases when the diet contains high levels of protein and fibre (Stephen, 1980).

Standford (1979) indicated that, water is essential as a constituent of all tissues of the body and without it no food could be digested. The maintenance of effective elimination of harmful products via the urine is dependent upon sufficient water, as is also the maintenance of almost all other physiological processes. The water requirement of rabbit is variable. It is higher in the young rabbits than in the older ones, and thus, a shortage of water in early life has serious effect and even a restricted amount of water may seriously retard growth.

Komolafe *et al* (1979) pointed out that water requirement in the rabbit production process may vary depending on the ambient temperature and the type of feed fed to them. Food with high fibre, protein and mineral contents stimulates higher water intake. In the case of high protein diets the increased water requirement is due to the necessity for adequate water to be needed in the dilution and elimination of urea, the waste product from the utilization of protein. Standford (1979) stated that, the water requirement of rabbits can be satisfied by feeding highly succulent rations which is generally not desirable. It is preferable to supply fresh drinking water to rabbits.

2.6 Forage Utilization by Rabbits

Aduku (1992) reported that, rabbits can be produced on high quality forages and low grain diets that are largely non-competitive with human food requirements. Unlike chickens, they can be successfully raised on forages alone. They are more efficient than beef cattle in the conversion of forages to meat.

Cheeke and Patton (1979) reported that with high legume forage diets, feed conversion in rabbits is 3-3.5g feed/unit gain, while it is 12-15gfeed/unit gain in beef cattle, and supplementary feeding with concentrate mashes or pellets may not be necessary.

Pote *et al* (1980) observed that rabbits fed free choice green forage gained 25g per day. This is about the gain of broilers on high concentrate diet. However, free choice feeding also reduces pellets fed by 50% without adverse effect on growth rate. Research results indicate that, farmers can feed forages without any supplementation and have achieved good production results. Rabbit farmers thus do not need to purchase mashes so as to keep their production cost low. In addition to feeding forages, farmers may need feedstuffs from the farm, crop residues and kitchen wastes. The feedstuffs are generally surplus and include banana, plantain, palm nuts, mangoes etc, while the forages fed include elephant grasses, brachyaria and desmodium (Aduku, 1992). Aduku (1992) also indicated that among the tested forages preferred by rabbits, desmodium ranked fourth and is highly preferred by rabbits.

Ajala (1990) reported that, forages such as Aspilla Spp, Tridax Spp, Amaranthus Spp, sunflower, elephant grass, centrosema, guinea grass, sweet potato leaves, water leaf, pawpaw leaves and cassava leaves etc could be fed to rabbits with good results. Harris *et al*, (1983) indicated that rabbits prefer some forages to others. However, Aduku (1988) investigated the preference of rabbits fed different forages through voluntary feed intake and found that rabbit prefer the following forages at different percentages, green beans vine (95.4g), sunflower leaf (94.4g), carrot tops (92.9g), corn leaves (58.8g). He also found that more succulent forages were preferred to the non-succulent forages and that preference declined as the plants became more woody. Tridax procumbens is consumed more than any other greens forage probably because of it's succulent nature (Aduku, 1988).

Ekpenyong (1986) reported that Tridax procumbens can meet rabbit requirement of between 15-17% crude protein (CP) for growth, lactation and reproduction. The ability of rabbits to utilize forages offers a significant possibility for reduction in feed cost and reduces the use of expensive feed ingredients. Both grasses and broad leave plants are acceptable to rabbits.

Pote *et al*, (1980) reported a growth rate of 25g/day over a four weeks period when weaner rabbits were fed fresh forages with no other supplementary feed, while another group fed fresh forages plus 25g commercial pellets per day recorded average daily gain of 26g/day.

2.7 Fibre Digestion and Utilization by Rabbits

Hintz *et al*, (1998) reported that, the presence of the caecum and the fermentation process which takes place there enable the rabbit to digest fibre relatively well. The authors also went further to separate fibre in the hard faeces and the retention of the non-fibre constituents for fermentation in the caecum, and observed that the non-fibre components were digested efficiently because they were re-ingested as the caecotropes and thus subjected to more than one passage through the digestive tract. Fibre on the other hand is very poorly ingested in the rabbit digestive tract; hence it is rapidly propelled through the colon and excreted in hard faeces. It has been revealed that with hindgut fermentation a high intake of high fibre diet can be achieved with nutrients requirements met by the high digestibility of non-fibre components.

Standford (1979) stated that, of the factors which affect the digestibility of any feedstuff, fibre content is probably the most important. Furthermore, as the proportion of fibre rises, so the individual digestibility of the various constituents of the food falls. The reason the author advanced for this was that, the fibre tends to protect the more digestible constituents from the digestive juices.

The digestibility coefficients for crude fibre vary considerably depending upon the feedstuff involved. Feeds high in cellulose and lignin generally have a crude fibre digestibility of less than 15% in rabbits, whereas in non-lignified materials such as beet pulp, crude fibre digestibility can be as high as 60% (Maertens and Groote, 1984).

De Blas *et al* (1978) indicated that alkali treatment of cereal straw increased the digestibility of crude fibre. Similarly, Omole and Onwudike (1981) found that alkali treatment of sawdust improved its utilization. The effect of alkali is probably due to a reduction in lignin content and possibly to increase degradation of small particles sizes resulting in increased caecal retention of the non-fibre fraction. Grinding of feeds to reduce the particles size resulted in an increased caecal retention time (Laplace and Lebas, 1977). Reduction of the fibre particle size by dry grinding presumably would increase the amount of fibre retained in the caecum and subjected to bacterial digestion. However, this process may interfere with the protective effect of fibre against enteritis. Some feedstuffs such as alfalfa meal and beet pulp absorb large amounts of water and swell to several times their original volumes. Other feedstuffs such as cereal grains and rice hulls, have very little swelling capacity. It is interesting that feeds of the same fibre and energy content, but differing in bulk density and swelling capacity could have different transit rates through the digestive tracts and affects feed intake through swelling effects on the stomach capacity.

2.8 The Roles of Fibre in Rabbit Nutrition

Research data indicate that rabbits do not make as efficient use of plant fibre in the diet as do other animals. However, data indicate that plant fibre is necessary in rabbit diet for normal functioning of the digestive tract. Rabbits require a level of crude fibre in excess of 9% for normal growth and to reduce incidence of enteritis and diarrhoea. Low fibre level of below 10% leads to hypomotility which predisposes the animal to diarrhoea (Champ and Maurice, 1983). However, higher fibre level in excess of 20% may provide caecal impaction (De Blas *et al* 1986 and Cheeke 1987). While crude fibre level of between 10-17% was found to support weight gain, the optimum level of crude fibre supporting optimum weight gain of 41.3g/day/animal was 14.8% (De Blas *et al.,* 1986). The same authours observed that a crude fibre level exceeding 17% reduced performances by limiting energy intake.

Pote *et al* (1980) fed a diet containing 50% alfalfa and 19.1% acid detergent factor (ADF) and obtained optimum daily weight gain of 14.1g. The range of fibre required in the diet suggests a high requirement for forage in the diets of rabbits for optimum growth.

Laplace and Lebas (1977) observed that highly digestible diets are consumed in lower quantities and retained in the digestive tract longer than high fibre diets. Lebas (1980) noted that increasing retention time of feed in the digestive tract is a precursory sign of diarrhoea which is preceeded by caecal-colonic hypomotility. The favourable effect of fibre termed "ballast effect" as reported by Lebas (1980) are apparently due to circulation of caecal-colonic motility, probably by the scabrous effects of larger particles and the increased bulk of the digesta. This is analogous to the roughage effect of forages in ruminants in which fibre is necessary for normal gut motility.

Lebas (1980), Pote *et al* (1980) and Davidson and Spreadbury (1978) noted that dietary fibre has a protective effect against diarrhoea in weaner rabbits.

Rabbits eat hair from their body when fed low fibre diet in attempt to satisfy craving for fibre. Increased dietary fibre reduces the trichobezoar (intestinal obstruction with wool) problem by reducing hair consumption. Feeding hay or other coarse roughages also helps to "sweep" hair from the stomach, hence prevention of trichobezoar or hair balls which can block the pyloric opening of the stomach and ultimately leads to death due to starvation (Standford 1979).

2.9 Nutrient Composition of Forages Used in Rabbit Nutrition

The nutrient content of forages vary greatly among species, cultivars within species and among stages of growth in the same cultivars. The young growing forage plants are excellent food for all classes of livestock, although older plants are not so valuable and satisfactory. This variation is as a result of liginifications of old grown forages and it is important to note because young rabbits may easily starve if fed on old grown forages, since they cannot digest it enough to meet their body requirements. The presence of phenolics in some forages and other toxic components exert deleterious effect on animals (Aduku 1988). The nutrients composition of some tropical forages used in rabbit nutrition are presented in Table 6.0.

Table 6.0: Nutrient Composition (%) of Some Tropical Forages Used in Rabbits Nutrition

Feedstuff	DM	CP	CF	EE	NFE	ASH
Leacaene	29.02	27.84	22.47	4.13	40.36	5.20
Manihot	41.98	13.20	18.73	7.98	38.11	3.26
Elephant grass	19.18	12.97	30.33	4.00	43.69	9.01
Amaranthus	13.57	28.00	11.12	2.45	39.71	18.72
Sugar cane	23.99	4.79	20.92	3.34	66.77	4.96
Banana leaves	35.71	20.04	23.98	1.13	43.92	11.01
Paw paw	25.24	33.16	8.81	0.97	44.18	10.88
Talignum triangulare	10.17	22.16	11.21	1.52	31.29	33.98
Tridax procumbens		25.50	25.40			17.72
Desmodium Scorpiusus	48.74	15.50	29.30			14.00
Plantain leaves	19.27	18.21	20.03	1.42	46.62	13.72
Parkia (whole pod)	92.00	13.70	19.40	7.30	0.90	6.70
Imparata cylindrical	31.30	9.40	31.20	1.00	46.70	11.70

Source: Lebas (1980) and NRC (1977), cited by Aduku and Olukosi (1980).

2.10 Characteristics of the Tested Forage (Moringa Oleifera)

Moringa oleifera, is a multipurpose tree, and it possesses useful characteristic as other multipurpose tree species. Moringa oleifera is native in Himalaya but is currently spread almost world wide, (Kakengi *et al*, 2007). Moringa oleifera (Horse radish tree or Drumstic) is a medium sized tree (about 10m tall), which belongs to the moringaceae family with a single genus and 14 known species (Kakengi *et al*, 2007).

Fugile (2001) described Moringa oleifera as a short, slender, deciduous, perennial tree, of about 10m tall and rather slender with drooping branches. The branches and stems are brittle, with corky bark and feathery leaves. These leaves are pale green, compound, tripinnate, 30-60cm long, with many small leaflets. The leaves are 1.3-2cm long, 0.6-0.3cm wide, the lateral ones are somewhat elliplic, terminal ones obovate and are slightly larger than the lateral ones. Their flowers are fragrant white or creamy white. The flowers are also 2.5cm in diameter, borne on sprays, stamens are yellow. Pods are pendulous, brown, triangular, splitting lengthwise into 3parts when dry. The pods are 30-120cm long, 1.8cm wide, containing about 20 seeds embedded in the pith. The pods appears tapering at both ends (Fugile 2001).

2.11 Soil and Water Requirement

Moringa oleifera plants grows in a wide variety of climates and soils ranging from tropical, subtropical, very dry, to moist atmospheric conditions. Moringa oleifera is tolerant to annual precipitations of 40.3-48mm annual rainfall. Annual temperature of 18.7-28.5^{o}C and PH of 4.5-8.0. It thrives in subtropical and tropical climates, flowering and fruiting freely and continuously. It grows best on a dry sandy soil and it is drought resistant (Fugile, 2001).

2.12 Cultivation

The plant can be propagated by seeds and by planting limb cutting 1-2m long preferably from June-August. The plant starts bearing pods 6-8months after planting, but regular fruiting starts after the second year. The tree fruits for several years (Sarwatt *et al*. 2002).

2.13 Chemical Composition of Moringa Oleifera Leaves

The protein content of moringa oleifera does not vary substantially from place to place. The crude protein content of extracted and unextracted leaves was 43.5% and 25.1%, respectively. Table 7.0 below shows the chemical composition of unextracted and extracted moringa leaves

Table 7.0: The Chemical Composition of Unextracted and Extracted Moringa Leaves

Type of leaf	Crude protein %	Lipid %	Ash %	NDF %	ADF %	ADL %	GE (kcal/kg)
Extracted leaves	43.5	1.4	10.0	47.4	16.3	2.2	17.7
Unextracted leaves	25.1	5.4	11.5	21.9	11.4	1.8	18.7

NDF – neutral detergent fibre, ADF - acid detergent fibre, ADL – acid detergent lignin. (Makkar and Becker, 1996).

2.14 Amino Acid Composition of Moringa oleifera Leaves

Zarkada *et al.,* (1995) reported that the amino acids content (g/16gN) of unextracted leaves was lower than that of extracted leaves which is due to the presence of a higher amount of non protein nitrogen in the unextracted leaves.

Table 8.0 shows the amino acid composition of extracted and unextracted moringa oleifera leaves.

Table 8.0: Amino Acid Composition of Extracted and Unextracted Moringa Leaves

Amino acid	Extracted leaves		Unextracted leaves	
	(g/16gN)	(g/kgDM)	(g/16gN)	(g/kgDM)
Lysine	6.61	26.77	5.6	14.06
Leucine	9.86	42.89	8.70	21.84
Isoleucine	5.18	22.53	4.50	11.30
Methionine	2.06	8.96	1.98	4.97
Cystine	1.19	5.18	1.35	3.39
Phenylalanine	6.24	27.14	6.18	15.51
Tyrosine	4.34	18.88	3.87	9.71
Valine	6.34	27.58	5.68	14.26
Histidine	3.12	13.57	2.99	7.50
Threonine	5.05	21.97	4.66	11.70
Serine	4.78	20.79	4.12	10.34
Glutamic acid	11.69	50.85	10.22	25.65
Aspartic acid	10.60	46.11	8.83	22.16
Proline	5.92	25.75	5.43	13.63
Glycine	6.12	26.62	5.47	13.73
Alanine	6.59	28.67	7.32	18.37
Arginine	6.96	30.28	6.23	15.64
Tryptophan	2.13	9.26	2.10	5.27

Data from Zarkadas *et al* (1995).

Makkar and Becker (1996) reported that Moringa oleifera leaves contains anti nutritional factors such as phenols, tannins, saponins and phytate at various percentage levels. The leaves of Moringa oleifera are quite rich in mineral and the presence of oxalates and phytates at various concentrations are likely to decrease the minerals bioavailability. Saponin from some plants have an adverse effect on the growth of animals but those present in moringa oleifera leaves appears to be innocuous (do not show haemolytic activity), and even humans consume them without apparent harm (Makkar and Becker, 1996).

2.15 Utilization of Moringa oleifera Leaves as Animal Feed Nutrient

There is scanty information worldwide on the potentials of Moringa oleifera as an animal feed (Kakengi *et al*, 2007). However, Maroyi (2006) reported that, the leaves are readily eaten by cattle, sheep, goats, pigs and rabbits. Branches are occasionally lopped for feeding cattle. Moringa oleifera tree can also be used in the face of shortage of grasses for cattle feeding. Leaves are known to be used to feed fish, chickens and several bird species.

Kakengi *et al* (2007) reported that Moringa oleifera leaves and green fresh pods can be used as vegetable by humans and are rich in carotene and ascorbic acid with a good profile of amino acids. It is also used as livestock feed and its twigs are very palatable to ruminants and have appreciable crude protein levels (Sutherland *et al*, 1990, Sarwatt *et al*, 2002, Kimoro 2002). Kakengi *et al* (2003) evaluated and compared nutritive value of different morphological components of Moringa oleifera with Leucaena leucocephala leaf meal and observed high pepsin and total soluble protein in Moringa oleifera leaf meal (MOLM) than other parts of the plant. The high pepsin and total soluble protein makes MOLM more suitable to monogastric animals.

Kakengi *et al* (2007) also evaluated the effect of Moringa oleifera leaf meal as a substitute for sunflower seed meal as a protein source on the performance of laying hens and reported a significant progress at 10 and 20% MOLM levels for both dry matter feed intake and egg mass. A highly significant performance was obtained at 20% levels of MOLM inclusion.

Onimisi *et al* (2007) reported on the evaluation of Moringa oleifera leaf meal as protein source in rabbits and observed that, growth rate and body weight gain of rabbits decreased linearly with increasing levels of MOLM in the diet. They noted however, that all the treatments containing MOLM were not different in their daily weight gain and final weight and only 40% level of inclusion was significantly lower than the control diet. Becker *et al* (1998) reported that moringa leaves can be used as cattle feed (beef and dairy cows), swine feed, and poultry feed. With moringa leaves constituting 40-50% of feed, milk yield for diary cows and daily weight gains for beef cattle increased by 30%, while birth weight, averaging 22kg for Jersey cattle, increased by 3-5kg (Fugile, 2001).

The high protein content of moringa leaves must be balanced with other energy feeds. Cattle feed consisting of 40-50% Moringa oleifera leaves should be mixed with molasses, young elephant grass, sweet (young) sorghum plants or whatever else is locally available (Becker *et al*, 1998).

Care must be taken to avoid excessive protein intake. Too much protein in pig feeds will increase muscle development at the expense of fat production.

Nutrient value of moringa leaves can be increased for poultry and swine through the addition of an enzyme (phytase) to break down the phytates, leading to increased absorption of the phosphorus found in moringa. Dairy cattle fed moringa leaves daily increased milk production by 10 litres/day and weight gain of 1,200 grams/day, while those not fed moringa, had milk yield of 7litres/day and weight gain of 900 grams/day, respectively (Fugile, 2001). There was also higher birth weight of (3-5kg) by cattle, (Becker *et al*, 1998). The authours further stated that, the protein content desired in chicken feeds was 22%, and that the proteins can be extracted from the leaves in the form of a concentrate which can be added to the chickens feeds.

Moringa oleifera leaves have also been evaluated as alternative protein source for tilapia fish (Richter *et al*, 2002). Moringa oleifera a leguminous multipurpose tree with a high crude protein in the leaves and negligible content of tannins and other anti-nutritive compounds can offers an alternative source of protein to ruminants wherever they prosper (Makar and Becker 1996).

The leaves of Moringa oleifera is rich in crude protein ranging from 26-29%, carotene, iron and ascorbic acid, (Sutherland *et al*, 1990, Sarwatt *et al*, 2002, Kimoro 2002). Moringa oleifera has high productivity of fresh material per unit area compared with other forage crops.

Makkar and Becker, (1997) stated that, the crude protein content of extracted and unextracted moringa leaves is high (43.5% and 25.1%, respectively) with the true protein content of above 95%. About 95% of the total crude protein was found to be available either in the rumen or in the post rumen, with a high proportion resistant to rumen degradation but available in the post rumen for production purposes. Moringa oleifera leaves are good sources of protein supplement for high producing cows, the fibre quality of the leaves is also good. Although Moringa oleifera leaves contains a phytate level of 3.1% and this can decrease the availability of minerals made absorbable to monogastirc animals. However, the extracted leaves with 80% aqueous ethanol would be a better sources of feed (protein supplement) besides being free of tannins, lectins, trypsin inhibitors, cyanogenic glucosides, glucosinolates, and flatus factors, have low levels of saponins and phytates. The essential amino acid composition of these leaves is comparable to that of soybean. Moringa oleifera leaves are a good source of proteins for monogastric animals (Makkar and Becker, 1997).

The kernel of Moringa oleifera can be crushed and its water extract used for purification of water, and the water extract is a viable replacement coagulant for chemicals such as aluminum sulphate (alum) in developing countries. The moringa oil can be used for human consumption. The residue obtained after removal of water soluble coagulants from kernel and seed meals and by-products generated in the process of extraction of oil, include growth hormones and coagulants which can be used as animal feeds (Makkar and Becker, 1997).

2.16 Medicinal Uses of Moringa oleifera Leaves

Fugile (1999) listed the medicinal uses of Moringa oleifera leaves to include the following:

- Juice from leaves has stabilizing effect on blood pressure and used to treat anxiety in humans.
- Leaf juice is commonly used to control glucose levels in cases of diabetes.
- Leaves are mixed with honey and drank with coconut milk 2-3times a day as remedy for diarrhoea, dysentery and colitis (inflammation of the colon)
- Leaf juice with carrot juice added is used as a diuretic (to increase urine flow).
- Eating the leaves is recommended for gonorrhea on account of diuretic action.
- Leaves can be applied as eye drop to treat conjunctivities.
- Leaf juice can also be used as a skin antiseptic.
- Leaves and young buds are rubbed on the temple of the head to control headache.
- Poultice made from fresh leaves is applied to reduce glandular swelling.
- Poultice can also be applied to the abdomen to expel intestinal worms.
- Leaves can also be used to treat fever, bronchitis, eye and ear infections, scurvy and catarrh (inflammation of the mucus membrane).

2.17 Other Uses of Moringa oleifera Plant

Fugile, (2001) listed other attributes of Moringa oleifera as follows:

- They are used in alley cropping systems, due to their rapid growth, long tap root, few lateral roots, minimal shade and large production of high protein biomass.
- Moringa leaves provide excellent materials for production of biogas.
- The wood yields a blue dye.
- The tree is commonly used as a living support for fencing around gardens and yards.
- Juice extracted from the leaves can be used to make a foliar nutrient capable of increasing crop yield by up to 30%, therefore serving as a growth hormones for crops.
- The gum produced from the cut tree trunk can be used in calico printing, in making medicine and as a bland tasting condiment.
- Powdered seeds can be used to clarify honey without boiling. Seeds powder can also be used to clarify sugar cane juice.
- Flowers are a good source of nectar for honey producing bees.
- The seed kernels contains about 40% edible oil, similar in quality to olive oil.
- Moringa trees are planted in gardens and along avenues as ornamental trees.

- Incorporating moringa leaves into the soil before planting can prevent damping off disease (Pythum debaryanum) among seedlings.
- The soft spongy wood makes poor firewood, but the wood pulp is highly suitable for making newsprint and writing paper.
- The bark of the tree can be beaten into a fibre for production of ropes or mats.
- The bark and gum can be used in tanning hides.
- Powdered seed kernels act as natural plocculent, able to clarify even the most turbid water, (Fugile, 2001).

2.18 Plant Growth Hormones

Makkar and Becker, (1996) indicated that extract obtained from the leaves of moringa and added to 80% ethanol contains growth enhancing principles (ie hormones of the cytokinine type). The extract can be used in form of a foliar spray to accelerate the growth of young plants. The growth hormone spray will also cause the plants to be firmer and more resistant to pest and diseases. Plants treated with this growth hormone are known to produce more and larger fruits and consequently have a higher yield at harvest (Makkar and Becker, 1996).

2.19. Growth and development of Rabbits.

Growth in animals is an increase in structural tissues including muscles, bones, organs and new tissues consisting largely of protein, fat and water. As the animals advances in age, the muscles and bones constitute the weight of the carcass which develops at a faster rate than the other parts (heart, liver, spleen and kidney etc). Ouhayoun (1998) reported that, the genetic variability between breeds and crosses plays a major role in the growth rate and weight of adult rabbits between 1 and 8 kg.

Body weight gain is a function of the growth of the different body components, which all develop at different rates. In order to remain functional it appears that the relative size of individual body components in the growing rabbit cannot remain constant. Thus the allometry growth of the organs and tissues is considered, and this leads to major changes in the morphology and body composition of rabbits from birth onwards (ouhayoun, 1998). The same author also indicated that ranking allometric growth coefficient of rabbits in increasing order, shows that the growth in individual tissues and organs occurs at different times as shown in table 9.0

Table 9.0: Mean allometric growth coefficient of rabbit's main tissues and organs between 9 and 182 days of life.

Organs	Allometric growth coefficient.
Rabbits	0.27
Kidney	0.70
Skin	0.79
Digestive tract	0.79
Skeleton	0.81
Liver	0.94
Blood	0.94
Muscle tissues	1.15
Adipose tissue	1.31

Ouhayoun (1998) further stated that the growth of the brain is the earliest, whilst that of adipose tissue the latest. However, allometry coefficient usually varies during growth, with the exception of the adipose tissue and the skin, which usually decreases. The allometric growth of blood, digestive tract and the skin is negative, whilst that of the carcass is positive. This explains the increase in carcass yield as a function of weight. The variation in carcass composition results mainly from the allometric growth of bones, muscles and adipose tissues. The relative growth rate of the bone tissues decreases when the empty body weight reaches about 1000g, whereas that of the muscle decreases at an empty weight of about 2,450g (De Blas and Wiseman, 1998). Between those two weights, the muscle: bone ratio of the carcass increases very rapidly and reaches its maximum value. Beyond 2,450g it tends to decrease. The relative growth rate of adipose tissue is slow before reaching an empty body weight of 950g then rapid up to 2100g and very rapid thereafter (De Blas and Wiseman, 1998).

2.20. Factors Affecting Rabbits Growth

i. Age and Weight:

Animals body weight increases as a function of age. Body composition varies as a function of body weight and growth rate.

Ouhayoun, (1998) stated that body weight at slaughter has no significant effect on other characteristics, probably because of the variability in adults body weight and in early growth rate of rabbits. Heavier rabbits are, however, characterized by a perirenal adiposity and a muscle lipid content higher than those of lighter rabbits. This however, means that, they are more mature. This maturity is associated with increased glycolytic energy metabolism and the low ultimate pH and water holding capacity of the meat. Rapid growth disadvantages early maturing tissues. Rapidly growing rabbits are, thus, characterised by smaller relative development of the muscles, especially the adipose tissues (Ouhayoun, 1998).

ii. Muscle development and Growth.

Muscle development occurs in two phases; morphological, functional/ metabolic differentiation phase. Premyoblasts actively divide during the early stages of development, and then lose their ability to undergo mitosis, but acquire the ability to fuse. During prenatal period, fibres are moderately oxidative and very weakly glycolytic. All fibres are of the oxidative type at birth and difference appears only later. In rabbits, muscles fibres continue to multiply after birth. This process last longer (up to 17 days) in the muscles whose relative growth is slow. Muscle weight thereafter increases as a result of the lengthening of the fibres, which follows bone growth, and an increase in diameter, which continues for much longer. These muscles fibres gradually acquire the functional and metabolic properties which make them suitable for specific movements and postures. That is, oxidative and glycolytic energy metabolism, slow or fast contraction, which enables either a moderate, prolonged or short and intense muscular activity (Ouhayoun and Dalle Zotte, 1993).

iii. Effect of Feed Nutrients on Growth;

Nutrients necessary for optimal growth and development of rabbits viz; protein, energy, fat, vitamins/ minerals and water are required at appropriate levels for the maximum productivity of the rabbits.

Hulot *et al*., (1996) reported that rabbits diets with a high fibre content decrease growth rate and also reduce the dressing proportion of meat. This reduction is as a result of the increase in the weight of the digestive tract. This invariably slows down the growth rate of the rabbits.

Perrier and Ouhayoun (1996) also indicated that for rabbits to achieve maximum growth, dietary protein should have an optimum composition of constituent amino acids. The optimum amino acids increases with the level of the protein content of the diet, as this enhances growth and body composition of rabbits, (Perrier and Ouhayoun, 1996).

The same authors further stated that, for a given protein, if the energy level of the diet increases, the intake of the poor protein diet decreases and this invariably leads to poor growth rate.

The slowing down of the growth rate delays the development of the relatively fast growing tissues, whereas, the relatively high energy level of the diet enhance muscle fat development. The acceleration of growth rate resulting from an increase in the protein content of the diet with a constant energy level is accompanied by the increase in the nitrogen content of the muscles.

2.21 Haematological Characteristics:

In higher animals, blood serves the purpose of supplying each cell with the required water, oxygen, electrolytes, nutrients and hormones and receives the waste products of metabolism for transport to organs of excretion.

Rivers (1973) indicated that rabbit blood is made up of the following composition, red blood cell (RBC) 4.6 – 5.7 (10^4) or 5.4 ± 0.55 (10^4) Cu.mm, white blood cell (WBC) 5.2 – 12.0 (10^3) or 7.07 ± 1.88 (10^3)Cu.mm.

Dabew et al (1976) also stated that analysed samples of rabbit blood contains the following; PCV (%) 30-50, Hb (g.dl) 10-15, WBC (X1000) 7-13 Cu.mm Vuong *et al* (2008) gave the major blood parameters of rabbit as shown in Table 10.0

Table 10.0: Physiological Blood Chemistry in Adults Rabbits

Red blood cells ($10^6/mm^3$)	5.23 ± 0.38
White blood cells ($10^3/mm^3$)	8.61 ± 0.77
Monocyte (%)	2.40 ± 0.13
Lymphocyte (%)	23.41 ± 0.85
Neutrophil (%)	63.20 ± 1.30
Eosinopil and Basophil (%)	11.23 ± 1.49

2.22 Carcass Characteristics/Quality of Rabbit Meat

Rabbit meat is a very nutritious and healthy food as it is low in cholesterol. Beymen (1984) stated that rabbit meat is composed of; 8g fat; 3g sulphur; 1g phosporus; 21g protein; 70g water; 50g cholesterol and 156 k cal of energy.

Arrington and Kelly (1976) gave the gross composition of rabbit meat to be 69% water; 21% protein, 8% fat; 4.8% ash and 162 k cal/100g energy.

Roa *et al* (1979) indicated that because of its extremely low cholesterol and sodium levels (136mg and 393ppm, respectively), rabbit meat may play an important role in prevention of vascular diseases.

The dressing percentage in rabbits varies from 50 – 57% in skinned animals. Although in Nigeria, the head, skin and legs are left on the carcass, making the dressing percentage (74%) higher than the dressing percentage of (60 – 62%) in Europe (Aduku and Olukosi, 1990). Wendroff (1984) compared smoked rabbit rolls produced from thighs and loins with rolls produced from other animal species. Rabbit rolls were comparable in flavour and appearance to those of pork and turkey. Rabbit and turkey did show better binding properties than pork. The result indicated that an acceptable ham like cured product can be produced from rabbit meat with standard processing procedures. In comparism, rabbit meat is found to contain more protein than broilers (Arrington and Kelly, 1976). The authours further described rabbit meat as being pink, deliciously flavoured, and is usually considered a premium product. Also rabbit meat is known to have more protein and less fat and calories per gram than beef, pork, lamb and chicken (Arrington and Kelly, 1976).

Fielding, (1991) compared the chemical composition of rabbit meat with other farm animal's meat and his findings are shown in Table 11.0

Table 11.0: The Chemical Composition of Rabbit Meat as Compared with other Animals Meat:

Meat	Dry matter %	Protein %	Fat %	Energy MJ/Kg
Rabbit	20 – 23	20 – 22	10 – 12	7 – 8
Chickens	20 – 23	19 – 21	11 – 13	7 – 8
Turkey	38 – 42	19 – 21	20 - 22	10 – 12
Beef	40 – 50	15 – 17	27 – 29	11 – 14
Lamb	40 – 50	14 – 18	26 – 30	11 – 14
Pork	50 – 55	10 – 12	42 - 48	17 – 20

CHAPTER THREE

3.0 Materials and Methods

3.1 Location

The research was conducted at the Grasscutter and Rabbitry unit of the Department of Animal Science, University of Nigeria, Nsukka.

Nsukka lies within longitude $6^{o}25^{1}$N and latitude $7^{o}24^{1}$E (Ofomata, 1975) and at an altitude of 430m above sea level (Breinholt *et al.,* 1981). This study area is in the derived savannah zone.

The climate of the study area is typically tropical with relative humidity ranging from 65-80% and mean daily temperature of 26.8^{o}C (Agbagha *et al*., 2000). The rainy season is between April – October and dry season between November – March, with annual rainfall range of 1680 – 1700mm (Clark, 1981).

3.2 Experimental Materials and Duration of Study

Twenty four (24) cross bred rabbits of both sexes were used for this study. Some of the rabbits were bought from the open market, while others were bought from a rabbit farmer at Enugu.

The rabbits were made up of twelve (12) males and twelve (12) females. Six (6) rabbits were randomly assigned to each treatment in the ratio of three (3) males and three (3) females per treatment. There were four treatments in all. And the experiment lasted for twelve (12) weeks after a one week of prefeeding trial.

The Moringa oleifera leaves were harvested from household gardens, fence and fields, dried inside an open airy room for 4-5 days to reduce the moisture content. The leaves were later collected and ground into powder before incorporating it into the rabbits diets.

3.3 Experimental Diets

Four experimental diets were formulated to contain 0%, 10%, 20% and 30% Moringa oleifera leaf meal (MOLM), the composition of the diet is shown in Table 12.0

Table 12.0: Percentage Composition of Experimental Diets

Ingredients	0%	10%	20%	30%
Maize	34.11	32.60	31.05	28.98
Wheat offals	41.74	39.81	37.97	35.45
Moringa oleifera	-	10.00	20.00	30.00
Groundnut cake	10.52	6.91	3.29	0.32
Palm kernel cake	8.62	5.64	2.69	0.25
Bone meal	4.00	4.00	4.00	4.00
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Crude protein (%)	16.00	16.00	16.00	16.00
Energy (Kcal of ME/kg)	2452.17	2379.94	2308.61	2236.96
Crude fibre (%)	9.96	10.95	11.94	12.92

3.4 Proximate Composition of Experimental Diet.

The result of the proximate composition of the experimental diet is presented in table 13.0

Table 13.0: **Proximate composition of experimental diet.**

Parameters	0%	10%	20%	30%
Moisture	10.30	10.10	10.35	10.40
Crude protein	16.60	16.30	16.40	16.40
Crude fibre	14.60	16.03	17.80	19.30
Ether extract	1.50	1.00	1.10	1.35
Ash	8.40	8.45	7.30	11.45

3.5 Experimental Animals and Management

Twenty four (24) mixed bred rabbits of both sexes with ages ranging from 6-8 weeks old and their weights ranging from 500g-800g were randomly divided into four treatment groups of six (6) rabbits each. The groups were also randomly assigned to four diets containing 0%, 10%, 20% and 30% Moringa oleifera leaf meal (MOLM). A known quatity of feed (100g) was fed daily to each rabbit. Water was given ad libitum. The treatments were balanced for the sexes, (ie. same number of males and females in each treatment).

3.6 Data Collection

The following parameters were evaluated:

i. **Average daily feed intake**

Feed given and the left over were weighed, the difference between the quantity of feed given and the left over, gave the daily feed intake for the previous day.

ii. **Average body weight**

Initial body weights of each of the rabbits was taken before assigning them to the various treatments. Weekly measurement of body weight was also taken using a weighing balance.

iii. **Average weight gain:**

This was taken as the difference between the initial body weights and the final body weights of the rabbits. This measurement was carried out on weekly basis.

iv. **Feed conversion ratio**:

The quantity of feed consumed per unit increase in live weight. It is the reciprocal of feed efficiency and is estimated as:

$$FCR = \frac{Feed\ consumed\ (g)}{Weight\ gain\ (g)}$$

v. **Feed cost per Kg gain:**

The ratio of cost in naira of the total feed consumed and the total weight gain in Kg per treatment ie. FCR X cost of feed.

$$Feed\ cost\ per\ Kg\ gain = \frac{Total\ feed\ consumed\ in\ Kg\ X\ cost}{Total\ weight\ gain\ (Kg)}$$

vi. **Feed cost per Kg feed:**

The cost of producing 1 kg of each feed (feed cost X ₦)Kg. this was done using current price of the feed ingredients. It was done per treatment.

$$Feed\cos t\ per\ Kg\ \ gain = \frac{Summation\ of\ \ the\cos t\ \ of\ \ all\ the\ \ feedstuff\ \ used\,(N)}{Total\ \ Kg\ \ of\ \ \ feed\ \ per\ treatment}$$

vii. **Carcass characteristics:**

Parameters measured were:

Live weight (Kg)

Dressed weight (Kg)

Dressed percentage (%)

Carcass length (cm)

Head weight (g)

Thorax width (g)

Loin weight (g)

Fore limb weight (g)

Hind limb weight (g)

Internal organs:

Liver weight (g)

Heart weight (g)

Kidney weight (g)

Lungs weight (g)

Spleen weight (g)

vii. **Haematological characteristics**:

Red blood cell count

Haemoglobin concentration

Packed cell volume

White blood cell count.

3.7 Experimental Design:

A completely randomised design was used, with the following statistical model:

Xij = U + Ti + eij.

Where:

Xij = individual observation on the experimental unit.

U = population mean

Ti = effect of the different levels of Moringa oleifera leaf meal (MOLM).

Eij = random error associated with the Xij.

The Proximate analysis of the diets was determined according to the A.O.A.C. (1990) for moisture, Crude protein, Crude fibre, Ether extract (fat), and Ash. All data collected were subjected to analysis of variance (ANOVA) using SAS (2001).

CHAPTER FOUR

4.0 RESULTS

4.1 EFFECT OF Moringa oleifera LEAF MEAL (MOLM) ON GROWTH PERFORMANCE OF RABBITS.

Table 14.0 shows the effect of Moringa oleifera leaf meal on the growth performance of rabbits.

Table 14.0: Growth performance of rabbits fed Moringa oleifera leaf meal (MOLM)

Dietary Treatments

Parameters	1(0%)	2(10%)	3(20%)	4(30%)	
Initial average body weight (g)	775.00	770.00	772.00	771.00	NS
Final average body weight (g)	1366.67 ± 77.10[c]	1583.33 ± 40.14[a]	1600.00 ± 56.27[a]	1441.67 ± 47.29[b]	
Daily average feed intake (g)	72.07 ± 3.13	78.13 ± 1.25	78.66 ± 1.87	78.64 ± 0.92	NS
Daily average weight gain (g)	6.65 ± 0.85[c]	9.03 ± 0.39[a]	9.54 ± 0.70[a]	7.54 ± 0.89[b]	
Feed conversion ratio(g)	11.75 ± 1.45[b]	8.77 ± 0.35[a]	8.45 ± 0.60[a]	11.64 ± 2.13[b]	
Feed cost per Kg gain (₦)	132. 85[c]	85. 66[b]	77. 08[a]	85. 57[b]	
Feed cost per Kg feed (₦)	46.97	38.86	33.86	31.79	-
Mortality	0	0	0	0	-

a,b,c Means with different superscript on the same row differ significantly ($P < 0.05$);

NS: not significantly.

4.1.1 Final average body weight (g)

The effect of dietary levels of MOLM on the final average body weight of rabbits is presented in Table 14.0. There was a significant effect of the dietary treatment ($p < 0.05$) on the final body weight of rabbits during the experimental period. Rabbits on T_2 (10%) and T_3 (20%) MOLM had better final body weight, than rabbits on T_1 (0%) and T_4 (30%) MOLM.

4.1.2. Average daily feed intake (g)

The effect of varying levels of MOLM is presented in Table 14.0. There was no significant difference ($p > 0.05$) on the average daily feed intake of rabbits fed MOLM at different levels. Feed intake was therefore, unaffected by the dietary treatments.

4.1.3 Average daily weight gain (g)

Average daily weight gain of rabbits fed MOLM is presented in Table 14.0. There was a significant ($p < 0.05$) effect of MOLM on the average daily weight gain of rabbits.

Rabbits on T_2 (10%) and T_3 (20%) MOLM had better weight gain, than T_1 (0%) and T_4 (30%).

4.1.4. Feed conversion ratio (g)

The effect of varying dietary levels of MOLM on feed conversion ration is presented in Table14.0. The effect of MOLM was significant ($p < 0.05$) across treatments although the efficiency of feed conversion was better at T_2 (10%) and T3 (20%) levels of MOLM inclusion.

4.1.5 **Feed cost per kg gain (₦)**

The effect of dietary levels of MOLM on feed cost per kg gain is presented in Table 14.0. The effect of dietary levels of MOLM on the feed cost per kg gain was significant ($p < 0.05$) across treatments. Diet T_3 with 20% level of MOLM was cheaper than the other three diets.

4.1.6 **Feed cost per kg feed (₦)**

The effect of dietary levels of MOLM on the feed cost per kg feed is presented in Table 14.0. There was no significant difference on the feed cost per kg feed, although numerically, feeds formulated with MOLM levels of inclusion appeared cheaper.

4.1.7 **Mortality**

The effect of dietary levels of MOLM on mortality is presented in Table 14.0 Rabbits fed varying levels of MOLM in their diets did not record any mortality.

4.2 **EFFECT OF Moringa oleifera LEAF MEAL (MOLM) ON THE CARCASS EVALUATION OF RABBITS.**

The results of carcass evaluation of rabbits fed Moringa oleifera leaf meal (MOLM) is presented in Table 15.0

Table 15.0: Carcass Evaluation of Rabbits fed Moringa oleifera Leaf Meal (MOLM)

Dietary Treatments

Parameters	1(0%)	2(10%)	3(20%)	4(30%)	
Live wt (g)	1375.00 ± 25.00	1550.00 ± 100.00	1600.05 ± 99.95	1425.00 ± 75.00	NS
Dressed wt (g)	925.00 ± 75.00	1000.01 ± 0.10	1050.50 ± 0.50	875.00 ± 25.00	NS
Dressed percentage (%)	81.18	86.50	86.66	84.00	NS
Carcass length (cm)	30.05 ± 0.05	38.00 ± 2.00	36.50 ± 1.50	35.00 ± 3.00	NS
Head wt (g)	125.00 ± 15.00	135.00 ± 5.00	140.50 ± 0.50	141.00 ± 1.00	NS
Thorax width (cm)	110.00 ± 0.00[c]	162.50 ± 12.50[b]	205.00 ± 15.00[a]	220.00 ± 20.00[a]	
Loin weight (g)	200.00 ± 10. 00[a]	235.00 ± 5. 00[b]	235.00 ± 15.00[b]	190.00 ± 0.05[a]	
Fore limb wt (g)	60.00 ± 10.00	72.50 ± 7.50	65.00 ± 15.00	55.00 ± 5.00	NS
Hind limb wt (g)	100.00 ± 10.00	120.05 ± 0.05	110.00 ± 10.00	120.10 ± 0.10	NS
Liver wt (g)	34. 00 ± 1.95[c]	39. 20 ± 0.80[b]	40. 30 ± 1.00[b]	44. 10 ± 2.70[a]	
Heart wt (g)	2.5 ± 0.00	3.0 ± 0.05	3.0 ± 0.00	3.5 ± 0.60	NS
Kidney wt (g)	4.4 ± 0.45	4.6 ± 0.20	4.7 ± 0.25	6.3 ± 0.95	NS
Lungs wt (g)	6.9 ± 0.20[c]	8. 8 ± 0.15[b]	10. 0 ± 0.55[a]	11. 3 ± 1.40[a]	
Spleen wt (g)	0.7 ± 0.00[b]	0.9 ± 0.00[a]	0.9 ± 0.00[a]	0.9 ± 0.00[a]	

a,b,c Means with different superscript on the same row differ significantly ($P < 0.05$) levels of significant.

NS: Not significant.

4.2.1 Dressed weight (g)

The effect of dietary levels of MOLM on the dressed weight of rabbits is presented in Table 15.0. There was no significant difference ($P > 0.05$) among the treatment means.

4.2.2. Dre**ssed percentage (%)**

The effect of dietary levels of MOLM on the dressed percentage (%) of rabbits is presented in Table 15.0. The effect of MOLM on the dressed percentage of rabbits was not significant.

4.2.3. **Carcass length (cm)**

The effect of MOLM on the carcass length of the rabbits is presented in Table 15.0. There was no significant difference on the carcass length of rabbits fed MOLM.

4.2.4. **Head Weight (g)**

The effect of MOLM on the head weight of rabbits is shown in Table 15.0. There was no significant ($p > 0.05$) effect of dietary treatment of MOLM on head weight of rabbits.

4.2.5 Thorax width (cm)

The effect of dietary levels of MOLM on thorax width is presented in Table 15.0. There was a significant ($p<0.05$) effect of MOLM on the thorax width of rabbits across treatments. Treatments T_3 and T_4, recorded better results than T_1 and $T_{2.}$

2.6 Loin Weight (g)

The effect of dietary levels of MOLM on the loin weight (g) is presented in Table 15.0. The effect of MOLM on loin weight was significant ($p < 0.05$). The loin weights increased from $T_1 - T_3$ and slightly decreased at T_4.

4.2.7 **Fore Limb Weight (g)**

The effect of dietary levels of MOLM on limb weight is presented in Table 15.0. The effect of dietary levels of MOLM on the fore limb weight was not significant ($p > 0.05$).

4.2.8 **Hind limb weight (g)**

The effect of dietary levels of MOLM on the hind limb weight of rabbits is presented in Table 15.0. There was no significant ($p>0.05$) difference on the hind limb weight of rabbits fed MOLM.

4.2.9 **Liver weight (g)**

The effect of dietary levels of MOLM on liver weight of rabbits is presented in Table 15.0. The effect of MOLM on liver weight was significant ($P<0.05$). Treatment (T_4) had a higher liver weight than other treatments.

4.2.10 **Heart Weight (g)**

The effect of dietary levels of MOLM on the heart weight of rabbits is presented in Table 15.0. The dietary levels of MOLM had no significant ($p>0.05$) effect on the heart weight of the rabbits.

4.2.11 **Kidney weight (g)**

The effect of MOLM on the kidney weight of rabbits is presented in Table 15.0. There was no significant ($P< 0.05$) effect of MOLM on the kidney weight of the rabbits.

4.2.12 **Lungs weight (g)**

The effect of dietary levels of MOLM on the lungs weight of rabbits is presented in Table 15.0. There was a significant ($p< 0.05$) effect of MOLM on the lungs weight of rabbits fed MOLM. The lungs of rabbits in T_3 and T_4 were larger than those of rabbits on T_1 and T_2.

4.2.13 Spleen **weight (g)**

The effect of dietary levels of MOLM is presented in Table 15.0. There was a significant ($p <0.05$) effect of MOLM on the spleen weight of rabbits fed MOLM. Rabbits on diets (T_2 – T_4) had the same spleen weight, which differed from the rabbits on the control diet.

4.3 EFFECT OF Moringa oeifera LEAF MEAL (MOLM) ON THE HAEMATOLOGICAL CHARACTERISTICS OF RABBITS

Table 16.0: Haematological Characteristics of Rabbits Fed Moringa oleifera Leaf Meal

Parameters	1(0%)	2(10%)	3(20%)	4(30%)	
Packed cell volume (PCV)	31.25 ± 2.36	31.75 ± 1.25	31.50 ± 2.10	27.75 ± 2.59	NS
Haemoglobin (HB g/d)	10.15 ± 0.42	10.65 ± 0.61	10.73 ± 0.84	9.40 ± 0.89	NS
Red blood cell count x 10^6 (RBC)	5.05 ± 0.33	5.55 ± 0.45	5.35 ± 0.42	4.54 ± 0.43	NS
White blood cell count x 10^3 (WBC)	4287.50 ± 567.29	6632.50 ± 1886.97	6487.50 ± 556.91	4550.00 ± 543.90	NS

Dietary Treatments

NS: Not significant

4.3.1 Pack cell volume (PCV)

The effect of MOLM dietary levels on the pack cell volume of rabbits is presented in Table 16.0. There was no significant (p>0.05) effect of MOLM on the PCV of rabbits fed MOLM diet.

4.3.2 Haemoglobin (HB g/d)

The effect of dietary levels of MOLM on the haemoglobin of rabbits fed MOLM is presented in Table 16.0. There was no significant (p>0.05) effect of MOLM on the haemoglobin of rabbits fed MOLM diets.

4.3.3 **Red blood cell x 10^6**

The effect of dietary levels of MOLM on the red blood cells of rabbits fed MOLM is presented in Table 16.0 There was no significant ($p>0.05$) effect of MOLM on the red blood cells of rabbits fed MOLM diets.

4.3.4 **White blood cell x 10^3**

The effect of MOLM on the white blood cells of rabbits fed MOLM is presented in Table 16.0. There was no significant ($p> 0.05$) effect of MOLM on the white blood cells.

CHAPTER FIVE

5.0 DISCUSSION

The results of this experiment are shown in Table 14.0, 15.0 and 16.0. The result of the growth study is shown in Table14.0. Significant difference ($p<0.05$) were noticed in final average body weight and average daily weight gain across treatments. Growth performance was highest in T_3 (20%), but rabbits in treatment T_1 (control) had the least performance on all parameters.

Average daily feed intake increase linearly from T_1 to T_3 as the energy content of the feed decreased, except in T_4, where there was a slight decrease in feed intake. This shows that rabbits eat to satisfy their energy requirements. The lower performance observed in T_4 is similar to the results of Bhatnagar *et al.,* (1996) and Kakengi *et al.,*(2007) who observed that feed utilization was low in laying birds fed 20% levels of MOLM and above in their diets. This could be attributed to the low availability of energy and crude protein, arising from low digestibility of crude fibre (CF) and crude protein (CP) components of the leaves when MOLM was high in the diet. Energy, crude protein (CP) and crude fibre (CF) contents of the diet have been shown to influence feed intake and weight gain in animals (Makkar and Becker, 1997). Research results have also shown that at higher levels of inclusion, unconventional feedstuff may alter the texture, colour, taste and odour of diets. Feed consumption and ultimately utilization might be affected by each of the factors above, independently or in combination (Uchegbu *el al.,* 2004).

Daily weight gain was observed to be highest in rabbits on T_3 (20%) MOLM diet with a daily weight gain of 9.45g compared with 9.03g, 7.54g and 6.65g for T_2, T_4 and T_1 respectively. This shows that diets containing 20% MOLM produced rabbits with higher body weights and higher weight gain than rabbit in the control and other diets. This could be attributed to the high content of methionine, cysteine and other sulphur containing amino acids which are available in Moringa oleifera leaves. These surlphur containing amino acids are found limiting in livestock feeds. This is in line with the report of Oluyemi and Roberts (1988), who stated that methionine supplementation improves the efficiency of feed utilization and weight gain of poultry. The higher weight gain of rabbits fed moringa diets might be an indication that the diets were more palatable and easily assimilated by the rabbits. These results are in agreement with (Kakengi *et al.,* 2007). These authors reported that moringa leaf meal diets were highly preferred by chickens because of its palatability. The energy available to the rabbits per unit diet decreased from treatment 1 to 4. Similar results have also been reported by Onimisi *et al.,* (2007), when they fed MOLM to rabbits. The authors attributed this to the similar ability of the rabbits to convert the feed materials into flesh across the dietary treatments. This also implies that the diets were similarly digestible.

Although there was no significant difference ($p > 0.05$) in feed intake among the treatments, the feed cost per kg gain and feed conversion ratio showed significant ($p < 0.05$) differences among treatments. These results collaborate that of Shaalu *et al.,* (2008) and Kakengi *et al.,* (2007), who observed significant ($P < 0.05$) differences on feed cost per kg gain and feed conversion ration. Results of this research showed that T_3 (20%) MOLM had the best feed cost per kg gain of ₦77.08 and feed conversion ratio of 8.45 (g). Based on this research, it would be more economical and better to use T_3 diet in terms of the rabbit's body weight and daily weight gain.

Results on Table 14.0. also indicate that feed cost per kg feed was not significantly different ($p > 0.05$) among the treatments. Treatment 4 (T_4 30% MOLM) had the lowest feed cost per kg feed (₦31.79) and the highest feed cost per kg feed was incurred on the control diet T_1 (0% MOLM) which had more maize and groundnut cake (GNC). The reduction in feed cost observed from the diets containing MOLM was due to the relatively little or minimal cost incurred in obtaining Moringa oleifera leaves. This means that cheaper feeds can be produced by the inclusion of MOLM up to 20% without any adverse effect on the growth performance of rabbits. This results also agrees with that of (Onimisi *et al.,* 2007).

From Table 15.0 it was observed that rabbits fed 20% MOLM had higher dressing percentage than rabbits on 10% and 30% dietary treatments. This was also similar to their live weights and dressed weights. This indicates that the experimental rabbits fed 20% MOLM, assimilated the MOLM diet better than rabbits on the other treatment diets and deposited more proteins as flesh or muscle tissues than the rabbit on 10% and 30% MOLM diets. Observation of the internal organs indicates that, the weights of internal organs of rabbits on T_4 (30%) MOLM were highest, when compared to rabbits on other treatment diets. Most carcass characteristics evaluated were not significantly different in all treatments, except, thoracic width, loin weight, liver weight, lungs weight and spleen weight which were significantly different ($p < 0.05$) between the treatments. The significant difference in the weights of these internal organs (liver, lung and spleen etc) could probably be due to the higher physiological activities by these organs, triggered by the presence of anti-nutritional factors and their concomitant effects. This result is in line with the report of Bone (1979) who reported that, if there is any toxic elements in the feed, abnormalities in weights of liver and kidney would be observed. This was further collaborated by Ahamefule *et al.,* (2006) who indicated that these abnormalities may arise in the weights of liver and kidney because of increased metabolic rate of the organs in attempts to reduce these toxic elements or anti-nutritional factors to non-toxic metabolites. However, the concentration of the anti-nutritional factors in the leaves was not high enough to have any toxic effect or mortality on the rabbits. Further more, the liver and the spleen function in the detoxification and excretion of most toxic materials from the body which leads to the increase in their weights (Jubb *et al.,* 1995). Hence, they were the most affected organs in rabbits fed MOLM diets in this study.

The effects of MOLM on the haematological parameters of rabbits are shown in Table 16.0. There were no significant (p > 0.05) differences among the treatment groups in terms of packed cell volume (PCV), haemoglobin, red blood cell (RBC) and white blood cell (WBC). Values that ranged from 27.75± 2.59 - 31.25± 2.36 PVC, 9.40 ± 0.89 – 10.15 ± 0.42 haemoglobin, 4.54 ± 0.43 – 5. 05 ± 0.33 RBC and 4287.50 ± 567.29 – 4550.00 ± 543.90 WBC, were within the recommended values of 4.6-5.7 (10^4)RBC, 5.2-12.0 (10^3) WBC and 30 – 50 (%) PVC. (Rivers, 1973 and Dabew *et al.,* 1976). These values are also in line with the study carried out by (Okeke *et al.,* 2008), who studied the effect of organic minerals on nutrient digestibility and haematological profile of weaner rabbits. However, the general results of the haematological study showed linear increase of haemoglobin, red blood cell and white blood cell of those rabbits fed diets containing MOLM from Treatments 1 to 3, but with a decrease in Treatment 4. Numerically, more white blood cells were produced by rabbits fed MOLM, as indicated by treatments 2 to 4, when compared to the control treatment. This means that MOLM helps in boosting the immune system of rabbits as it produces more WBC, and haemoglobin. These various blood corpuscles are known to provide defenece against infections and foreign bodies, in animals. The lower performance observed in treatment 4, might be as a result of the high quantity of moringa leaves fed to the rabbits. The moringa leaves would have invariably increased the concentration of phytate, which is known to decrease the bioavailability of minerals in monogastrics. Moringa leaves are also known to produce flatulence in the rabbits, resulting to poor performance (Makkar and Becker, 1996). Generally, blood is known to be a good indicator of the health status of an organism. Blood acts as a pathological reflector of the whole body. Hence haematological parameters are important in diagnosing the functional status of animals exposed to toxicant (Joshi *et a.,* 2002). The increase in the total white blood cells (WBC) produced by the rabbits fed with MOLM diets can be attributed to the increase production of leucocytes in the haematopoietic tissue of the kidney and perhaps the spleen. Similarly, lymphocytes are the most numerous cells comprising the leucocytes which function in the production of antibodies and chemical substances serving as defence against infection. Therefore, Moringa oleifera leaf meal (MOLM) can be incorporated in feeds to manage rabbits that are immuno-suppressed and anaemic. This is because the leaves of Moringa oleifera are known to be innocuous to animals as a result of the presence of saponin in the leaves (Makkar and Becker, 1996).

5.2 **CONCLUSION**

The results of this experiment have shown that Moringa oleifera leaf meal (MOLM) can be incorporated up to 20% level in the diets of growing rabbits. Since it met the growth performance, carcass characteristics and haematological requirements of the rabbits without any deleterious effects. Since Moringa oleifera trees grow widely in this part of the country, the leaves can be easily and cheaply obtained at minimal cost. The moringa leaves are known to contain high levels of crude protein 26-27%, energy 18.7MJ/Kg/DM and crude fibre 19.1% (Makkar and Becker, 1996). Therefore its utilization as rabbits feed will go a long way in solving Nigeria's protein shortage problems.

5.3 RECOMMENDATIONS

In this experiment, the best performance was observed by rabbits on T_3 (20%) level of MOLM inclusion. This indicates that rabbits tolerate Moringa oleifera leaf meal (MOLM) up to 20% level of incorporation for optimal performance. Higher levels of incorporation results to decrease performance in terms of body weight, weight gain, feed conversion ration etc and should be discouraged. However, more research may be required on the use of Moringa oleifera leaf meal, as a protein supplement on the diets of other livestock species including poultry.

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