EFFECT OF FORAGE TYPE, SEX AND PALM OIL SUPPLEMENTATION ON PERFORMANCE AND HORMONAL PROFILE OF WEANER RABBITS IN SUB-HUMID REGION

BY

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DECLARATION

I hereby declare that the work in this thesis entitled **"Effect of forage type, sex and palm oil supplementation on performance and hormone profile of weaner rabbits in sub-humid region"** was carried out by me in the Department of Animal Science under the supervision of Prof. (Mrs) G.T. Iyeghe-Erakpotobor and Dr. P.P. Barje.

Information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis has previously been presented for another degree or diploma at any University.

…… ……..

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CERTIFICATION

This Thesis titled **"Effect of forage type, sex and palm oil supplementation on performance and hormone profile of weaner rabbits in sub-humid region"** by **Okunlola**, Baliqis Olasunbo meets the regulations governing the award of the degree of Master of Science (Animal Science) of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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This project is dedicated to Almighty Allah, the uncreated creator who creates the created creatures and to my baby Nabeela Omodebola Raji.

ABSTRACT

Two studies were conducted using a total of 96 mixed breed rabbits aged between 5-7 weeks with an average weight of 789.71g to determine the effect of forage type, forage level, palm oil supplementation and sex on performance, carcass characteristics, serum progesterone and testosterone profile of weaner rabbits. The rabbits were randomly allotted to the treatment groups in a Completely Randomized Design in a factorial arrangement. The factors considered were forage type (groundnut, lablab), palm oil supplementation (without, with), forage level (20, 40) and sex (male, female). Water and feed were supplied *ad libitum*. Each study lasted for 98 days. The results showed that rabbits fed 40% forage had a significantly higher feed intake than rabbits fed 20% forage. Total weight gain of rabbits fed 20% forage were significantly higher ($P<0.05$) than those fed 40% forage. There were no significant differences ($P>0.05$) in the daily feed cost, total feed cost, feed cost per kg gain by rabbits fed 20% and 40% forage levels. Palm oil supplementation, forage type and sex had no significant effect ($P>0.05$) on the performance of the rabbits. There were interactions between forage level and palm oil supplementation, forage level and forage type, sex and forage level and palm oil supplementation and sex on the performance of rabbits. Carcass analysis showed that rabbits fed 40% forage had a significantly higher ($P<0.05$) carcass weight than those fed 20% forage. Similarly rabbits fed palm oil had significantly higher ($P<0.05$) weight than those without palm oil. The hormone profile of rabbits indicated an increase in the serum concentrations of progesterone and testosterone level of rabbits with age. Positive interaction effects were observed between forage level and palm oil, forage level and age, forage level and forage type, forage type and palm oil, forage type and age and palm oil and age on progesterone and testosterone profiles of rabbits. Palm oil supplementation did not

have effect on performance. Rabbit fed groundnut haulms had higher progesterone than those fed lablab and this is an indication that rabbits fed groundnut haulms could have attain puberty earlier than those fed lablab. It can be concluded from this study that feeding 20% forage is recommended as it gave better performance than 40% inclusion.

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ABBREVIATIONS

NAPRI- National Animal Production Research Institute

PO- Palm oil

GIT- Gastro intestinal tract

FAO- Food and Agricultural Organization

USDA- United State Department of Agriculture

SAS- Statistical Analysis Software

Kg- kilogram

Kj- kilojoules

Cal- calorie

ng- nanogram

ml- milliliter

CHAPTER ONE

1.0 INTRODUCTION

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

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

Domestic rabbits (*Oryctolagus cuniculus*) are ubiquitous, providing protein, fibre, research models, and companionship. Rabbits have high reproductive potentials, fast growth rate (Hassan *et al*., 2012), utilize low grain and high roughage diets and breed all year-round (Irlbeck, 2001). Other attributes are short gestation interval, early sexual maturity and ability to rebreed shortly after kindling (Hassan *et al*., 2012).

These qualities confer on rabbits a potential to bridge the shortage of animal protein in developing countries, where grain can only be justified for human use (Irlbeck, 2001; Hassan *et al*., 2012).

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

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

1.1 Justification

Over the years, the rearing and production of rabbits and other livestock species have been faced with the challenges of feeding and feed availability. Most of the conventional feedstuffs are highly competed for by man, hence the need to source for cheaper but readily available feedstuffs so as to mitigate these challenges. One of such feedstuffs consumed by rabbits is forage with emphasis on groundnut haulm and lablab. These are emerging and non-conventional feedstuff for rabbits, they could serve as cheap sources of fibre and protein for farm animals but should be compounded with additional feed source like concentrate for optimal utilization by rabbits. However, there is need to study the influence these feeds have on growth performance and hormone profile of rabbits so as to be able to estimate the period at which rabbits attain puberty since nutrition plays an important role in puberty attainment.

1.2 Objectives of this Study

The broad objective of this study was to study the effect of feeding different forage and palm oil on the performance of rabbits. The specific objectives were to determine the effect of:

1. Forage type, forage level, sex and palm oil supplementation on performance of weaner rabbits.
2. Forage type, forage level and palm oil supplementation on carcass characteristics of weaner rabbits.
3. Forage type, forage level and palm oil supplementation on hormone profile and attainment of puberty in rabbits.

Hypothesis

- Null Hypothesis (H_O)

Forage type, sex and palm oil supplementation does not affect performance, carcass characteristics and hormone profile of weaner rabbits.

- Alternate Hypothesis(H_a)

Forage type, sex and palm oil supplementation affect performance, carcass characteristics and hormone profile of weaner rabbits.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BRIEF HISTORY OF RABBITS

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

2.2 BREEDS OF RABBITS

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

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

2.3 IMPORTANCE OF RABBIT PRODUCTION

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

Rabbits are characterized by small body size, short gestation period, high reproductive potential, rapid growth rate, genetic diversity, their ability to utilize forages (Mailafia *et al*., 2010) and disease tolerance (Begensel, 2008). In addition, rabbits require small amounts of feed and use inexpensive, easily constructed housing (Cheeke, 1986a). Rabbits could be produced using inexpensive and renewable resources such as garden

“wastes” and by products of grains (Lukefahr, 2009). Rabbits are able to thrive on non-conventional feedstuffs (Omole, 1982; 1988) with their utilization of large forage diets limited as a result of post gastric fibre digestion in the caecum (Belenguer *et al*., 2008). Furthermore, rabbits do not compete with humans for grains as strongly as chickens (Price and Regier, 1982; van Dijk, 2003; Moreki, 2007). Rabbits compliment well with vegetable production as garden wastes are fed to rabbits, whereas the manure is used to fertilize the soil (Price and Regier, 1982). Unlike poultry manure, rabbit manure will not burn the plants and can be applied directly to the plant or its roots. Schiere (2004), opined that rabbit farming exposes children to learning how to tend for and appreciate animals. Unlike bigger animals such as cattle, rabbits can be tended by women, children or men as they do not need force to be restrained (Schiere, 2004). The small body size of a rabbit provides a small carcass that can be consumed by a family in one meal, eliminating the need for meat storage and refrigeration. The meat is stored on the live animal until needed resulting in rabbits being referred to as "biological refrigerators” (Cheeke, 1986a).

2.4 COMPOSITION OF RABBIT MEAT

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

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

Table 2.1: Composition of Rabbit meat relative to other common meat

Meat composition	Source	Moisture (%)	D M (%)	Protein (%)	Fat (%)	Energy
	1	-	20-23	20-22	10-12	7-8
Rabbit	2	67.9	-	20.8	10.2	1749
	1	-	20-23	19-21	11-13	7-8
Chicken	2	67.9	-	20.0	11.0	1782
	1	-	38-42	19-21	20-22	10-12
Turkey	2	58.3	-	20.0	20.2	2618
	1	-	40-50	15-17	27-29	11-14
Beef	2	55.0	-	16.3	28.0	3168
	1	-	40-50	14-18	26-30	11-14
Lamb	2	55.8	-	15.7	27.7	3124
	1	-	50-55	10-12	42-48	17-20
Pork	2	42.0	-	11.9	45.0	4510

Source: 1= Fielding (1991) DM= Dry matter
2= USDA (1963)
Energy values: 1=MJ/Kg
2=Kcal/Kg

2.5 PRODUCTION CHARACTERISTICS

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

2.6 GROWTH PERFORMANCE OF RABBITS

The growth performance of rabbits in studies reported from tropical countries is generally in the range of 10-20 g per day, in contrast to 35-40 g per day commonly observed in temperate regions (Cheeke, 2003). Daily body weight gains vary from 8-13 g (Abu and Onifade, 1996), 16-25 g (Omole and Sonaiya, 1981), these are low values compared with values of 42 g/day/rabbit obtainable in temperate climates (Abu *et al*. 2008). Linga and Lukefahr (2000) reported growth rate of 28.9g/day for rabbits fed alfalfa with molasses blocks and growth rates of 10 to 12g/day with fresh lablab

fed along with molasses or sugar cane (Linga *et al*., 2003). Weight gains reported on forage-concentrate diets under most tropical conditions range between 5-20 g/d (Aduku *et al*., 1986; Taiwo *et al*., 1999; Bamgbose *et al*., 2002; Hongthong *et al*., 2004) with a turn off target weight of 2.3-2.5 kg at 4-5 months of age. These weight gains depend on the type of rabbits used (weaners, 5-8 weeks old or growers, 9-15 weeks old), type of forage used, state of forage used (fresh forage or hay) and the environmental conditions.

Wasem (2013) observed a significant increase in feed intake (74.79g) of rabbits fed 50% groundnut haulm than those fed ipomoea eriocarpa with feed intake of 70.98g. Adejinmi *et al*. (2013), observed average feed intake of 63.89-82.46 g per animal per day when rabbits were fed diet containing different fibrous ingredients while the report of Attah *et al*. (2011) on average feed intake was 77.64-87.51 g when rabbits were fed *Citrullus vulgaris* seed offal to rabbits. Attah and Ekpeyong (1998) also reported average feed intake of 51.28-71.88 g when rabbits were fed with diet containing sodium hydroxide treated and untreated rice husk while Agunbiade *et al*. (1999) reported average feed intake of 60.08 - 62.86 g for the same species of animal when cassava peels and leaves were fed to them.

2.7 THE DIGESTIVE SYSTEM OF RABBIT

The digestive system of the rabbit is characterized by the relative importance of the caecum and colon when compared with other species (Portsmouth, 1977). As a consequence, the microbial activity of the caecum is of great importance for the processes of digestion and nutrient utilization as well as control of digestive pathologies. Furthermore, caecotrophy, the habit of ingestion of soft faeces of caecal

origin, makes microbial digestion in the caecum more important for the overall utilization of nutrients by the rabbit. In addition, the rabbit has developed a strategy of high feed intake of 65–80 g kg^{-1} body weight (BW) and a rapid transit of feed through the digestive system to meet nutritional requirements (Portsmouth, 1977). To reach its full functional capacity, the digestive system of the growing rabbit must go through a period of adaptation from milk base feeding to the sole dependence on solid feed. This adaptation process not only affects the digestion processes, but also microbiota colonization and the development of gut barrier mechanisms that protect the animal against digestive pathologies.

2.7.1 Stomach

The first important compartment of the digestive system of the rabbit is the stomach; this has a very weak muscular layer and is always partially filled. The stomach of the rabbit holds approximately 15% of the volume of the entire gastrointestinal tract (Johnson-Delaney, 2006). It is thin walled, J-shaped, and lies to the left of the midline (O'Malley, 2005). The well-developed cardiac sphincter is lined with non-glandular stratified squamous epithelium and prevents vomiting. The fundus contains parietal cells that secrete acid and intrinsic factor as well as chief cells that secrete pepsinogen. The pylorus has a well-developed, muscled sphincter and the adult rabbit stomach has a pH of 1-2 (O'Malley, 2005). The capacity of the stomach is about 0.34 of the total capacity of the digestive system (Portsmouth, 1977). The rabbit feeds frequently up to 30 times per day of 2-8 g of food over 4-6 minute periods. The stomach normally will contain a mixture of food, hair, and fluid even after 24 hours of fasting (O'Malley, 2005). The stomach pH of rabbits up until the time of weaning falls within the range of 5.0-6.5. After caecotrophy the fundic region of the stomach acts as a storage cavity for caecotrophes. The stomach pH ranges from 1 to 5,

depending on site of determination fundus versus cardiac-pyloric region (Gutierrez *et al*., 2002, 2003; Chamorro *et al*., 2007; Orengo and Gidenne, 2007; Gomez-Conde *et al*., 2009), the presence or absence of soft faeces (Griffiths and Davies, 1963), the time from feed intake (Alexander and Chowdhury, 1958) and the age of the rabbit (Grobner, 1982). The lowest figures (from 1 to 2.5) are recorded in the cardiac region, in the absence of soft faeces, after 4 hours of diet ingestion and in rabbits older than 3 weeks with low presence of milk (Orengo and Gidenne, 2007).

2.7.2 Small Intestine

The small intestine is approximately 12% of the gastrointestinal volume in the rabbit (O'Malley, 2005). The bile duct enters into the proximal duodenum. The right lobe of the pancreas is situated in the mesoduodenum of the duodenal loop. The left lobe lies between the stomach and transverse colon. There is a single pancreatic duct that opens at the junction of the transverse and ascending loops of the duodenum. The duct drains both pancreatic lobes. Technically this is the accessory pancreatic duct as the main pancreatic duct connection to the duodenum disappears during embryonic development (Johnson-Delaney, 2006).The jejunum is the longest section of small bowel and appears convoluted. Aggregates of lymphoid tissue are present in the lamina propria with increasing prominence distally. The distal end of the ileum has a spherical thick-walled enlargement known as the sacculus rotundus. This marks the junction between the ileum, cecum, and colon.

The stomach is linked to the coiled caecum by a small intestine approximately 3 m long, where the secretion of bile, digestive enzymes and buffers occur. The pH of the small intestine is close to 7 (Vernay and Raynaud, 1975). The small intestine is the site where the greater part of digestion and absorption take place by passive or active

transportation throughout the mucosa. Digestibility at the end of the ileum accounts for 0.8–1 of the total dietary amino acid and starch digestibility (Gutierrez *et al*., 2002, Garcia *et al*., 2005).

2.7.3 Hindgut

The hindgut consists of the cecum and colon. The cecum of the rabbit is large and may contain 40% of intestinal content which has 10 times the capacity of the stomach (O'Malley, 2005). The caecum is characterized by a weak muscular layer and contents with a dry matter (DM) of 200 g kg^{-1}. The caecal contents are slightly acid (pH 5.4-6.8) (Garcia *et al*., 2002). The capacity of the caecum is approximately 0.49 of the total capacity of the digestive tract (Portsmouth, 1977). The colon can be divided in two portions: the proximal colon (approximately 35 cm long) and the distal colon (80-100 cm long). The proximal colon can be further divided into three segments: the first segment possesses three taeniae with haustra between them; the second segment has a single taenia covering half of the circumference of the digestive tube; and the third segment or fusus coli has no taeniae or haustra, but is densely enervated. Thus, it acts as a pacemaker for the colon during the phase of hard faeces formation (Snipes *et al*., 1982). Gut-associated lymphoid tissue (GALT) and specialized cells (goblet or Paneth cells, responsible for mucus and antimicrobial peptide secretion, respectively) regulate the interaction of the gut mucosa with the microbiota and develop the mechanisms of tolerance and protection against pathogens. The gut barrier function has been recently reviewed by Forthun-Lamothe and Boullier (2007) and Carabano *et al.* (2008).

2.7.4 Cecotrophy

Coprophagia of the soft faecal pellets allows the rabbit to digest fibrous feeds efficiently. The primary monogastric type of digestion allows the animal to take advantage of proteins, sugars and starch in the feed. The rabbit feeds during the day and produces soft pellets at night. These soft pellets are consumed directly from the anus and the residues are excreted as hard pellets during the day (Leng *et al*., 2004). Cecotrophs are formed in the proximal colon and cecum. Rabbits begin consuming them between 2 and 3 weeks of age as they begin to eat solid food. Fiber material greater than 0.5 mm does not enter the caecum but transits to be formed and passed as hard fecal pellets. The smaller particles and fluid remain in the caecum or are returned to the cecum via antiperistalsis to form high nutrient particles that become coated with mucus as they pass through the colon (O'Malley, 2005). They are usually passed eight hours or so after feeding, which coincides usually to nighttime. This mechanism requires high fiber diets to function properly. Low fiber diets increase cecal retention time and promote hypomotility of the entire gut, which further reduces the cecotrophs produced. Fiber in the diet should be indigestible and at least 15% (O'Malley, 2005).

A low protein diet increases a rabbit's caecotroph ingestion, while high protein low fiber diet reduces consumption (O'Malley, 2005). In crude fiber terms, diets that are less than 150 g/kg of feed will almost always result in digestive upset while diets with greater than 200 g/kg crude fiber result in increased incidence of caecal impaction and mucoid enteritis. A diet devoid of fiber has a coefficient of apparent digestibility of organic matter of 0.90. This declines in a linear fashion to 0.40 when the diet contains 350 g crude fiber per kilogram of feed. Increased crude fiber of the diet increases the crude fiber of the cecal contents and decreases the protein content. Compounded pelleted diets require the addition of hay in order to supply a complete diet. In

general, the recommendation that hay be supplied on a free-choice basis as a rule of thumb for good husbandry of rabbit (Lowe, 2003).

Excess VFAs produce drops the cecal pH, which inhibits normal flora and allows pathogens to proliferate and colonize. Gas and toxins can be produced by pathogenic bacteria, and motility and nutrient production and absorption are interrupted. Fats such as full-fat soybeans, oilseeds can be used as a source of energy without causing caecal hyper-fermentation (O'Malley, 2005).

2.8 NUTRIENT REQUIREMENTS OF RABBITS

2.8.1 Crude Protein

Protein is perhaps the most frequent nutrient lacking in rabbit diets primarily because the common energy sources such as maize and other cereal grains and tuber crops are low in protein. The rabbit makes its own particular proteins from the proteins and amino acids it obtains from its food (Fielding, 1991). This protein synthesis uses up energy. The ten essential amino acids which must be provided in the diet if the rabbit is to survive and grow are: lysine; methionine; arginine; phenylalanine; histidine; valine; threonine; tryptophan; leucine; isoleucine (Fielding, 1991).

Reduction of the level of protein and essential amino acids in the diet, from an optimum level for growth in animals, is associated with a decreased growth rate and efficiency of feed utilization and a concomitant increase in body fat (Wahlstrom and Libal, 1974; Noblet and Henry, 1977; Russell *et al*., 1983). Dietary protein level is one of the several non-genetic factors that influence the amount of body fat in animals (Marks, 1990; Wang *et al*., 1991). Forbes (1995) reported that if the amino acid content in the feed of animals differed widely from the animal's requirement for

amino acids, feed intake would be depressed, but when the deficient amino acid is supplemented, intake would be increased.

Essential amino acids need to be included in the ration for rabbits. Lysine and methionine are usually the amino acids that are found to be deficient in rabbit rations (Gillespie, 1998). The recommended crude protein level (dry matter) in the rabbits ration is over 18% for newly weaned rabbits; 16-18% for rabbits from 12-24 weeks; 15-17% for breeding does; and 12-14% for all other stock (Fielding, 1991).

Martina and Damianan (1983) reported that crude protein fed to rabbits could be reduced to 16.32% with lysine and methionine supplementation without affecting weight gain and feed efficiency. Carregal and Nikuma (1983) used diets with increasing crude protein levels, 14.3, 17.2 and 21.4% and there were no significant difference among groups of rabbits with regard to body weight, feed intake or feed conversion efficiency. Abdella *et al*. (1988) also observed no differences in final body weight, live weight gain and feed intake when diets containing 16, 18 and 20% crude protein were fed to five week-old rabbits. Abdel-Salem *et al*. (1972) had earlier reported that diets containing 20.74% crude protein recorded the highest final live body weight and live weight gain.

According to Pond *et al*. (1995) dietary protein quality is particularly important for rapidly growing weaning rabbits, which may not have well developed caecal fermentation. Gillespie (1998) has shown that soya bean meal or fish meal promotes better growth rates than other protein supplements when the alternative supplements do not have essential amino acids added. Essential amino acids added to protein supplements such as cotton seed meal, rapeseed meal, horse beans, and peas enhanced growth rates similar to those achieved with soya bean and fish meals (Gillespie,

1998). It has been demonstrated that the amino acid requirements are age dependent and change during the reproduction cycle of the doe (Maertens *et al*., 1997). In early growth stage (4-7 weeks of age), rabbits need a higher dietary amount of digestible crude protein and amino acids (Maertens *et al*., 1997). Also, during peak lactation the response to higher amino acids is more pronounced (Taboada *et al*., 1994; Taboada *et al*., 1996).

2.8.2 Energy

The energy needed for organic synthesis is usually supplied by carbohydrates and to a lesser extent by fats. Where there is an excess of proteins these also help to supply energy after deamination. The growing rabbit, like the breeding doe, adjusts its feed intake according to the energy concentration of the feeds offered to it where the proteins and other dietary components are balanced (FAO, 1997). According to Xiccato and Trocino, (2010) growing rabbit in good sanitary condition consume sufficient feed to meet its energy requirement for maintenance and growth; voluntary energy intake is proportional to metabolic live weight ($LW^{0.75}$), on average 950KJ/d/kg $LW^{0.75}$. It has been shown that intake is only correctly regulated between 2200 and 3200 kcal DE/kg of feed. Because of this, concentrated energy feed must also contain all the other required nutrients in concentrated form so that a smaller volume of feed will supply the rabbit's needs. Energy intake regulation functions well in temperate climates so long as variations in energy content are linked to the presence of fairly digestible carbohydrates (e.g. starch / fibre substitution) (FAO, 1997). At high temperatures (28° to 32°C), where more than 10 percent of the digestible energy is provided by fat, regulation may suffer and the animals may easily consume more of the fatty feed owing to the absence of extra heat from the consumption of lipids (FAO, 1997).

2.8.3 Vitamins

Rabbits require water-soluble (B and C) as well as fat-soluble (A, D, E and K) vitamins. Micro-organisms in the digestive flora synthesize sizeable quantities of water-soluble vitamins which are utilized by the rabbit through caecotrophy (Coudert *et al.*, 1986). The intake is sufficient to cover maintenance requirements and for average production as far as the B group vitamins and vitamin C are concerned. However, fast growing animals respond favorably to the addition of 1 to 2ppm (part per million) of vitamins B_1 and B_6, 6ppm of vitamin B_2 and 30 to 60ppm of nicotinic acid (vitamin PP) in the diet. The addition of vitamin C will not influence growth, even at 1% of diet under temperate condition (Coudert *et al.*, 1986).

2.9 FORAGES

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

The potentials of forages as feed for rabbits are of particular significance because of their availability and ability of the rabbits to effectively digest leaf protein (Bello, 2003). Forage legumes are a dependable source of protein feed for animals. The seeds and leaves are rich in nitrogen. Forage legumes are adequately supplied with protein for livestock feeding, even when harvested at an advanced stage of maturity. When an appropriate balance of nutrients is available in forages as in alfalfa meal, the forage

can replace grain in rabbit diet thereby, reducing the concentrate need of rabbits (Aduku *et al*., 1989). Fibre supplies an important source of dietary energy for animals (Schoknecht, 1997). Dietary fibre has positive effects on gut health, welfare and reproductive performance (Johnson *et al*., 2003). Higher digestibility and utilization of dietary fibre showed great potential for the practical use of various fibrous feeds and had no adverse effects on reproductive performance (Danielson and Noonan 1975, Pond *et al*., 1985 and Schoknecht, 1997).

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

2.9.1 Utilization of forages by rabbits

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

High fibre material which is usually a constraint in poultry diet is beneficial to rabbits for preventing enteritis (Cheeke and Patton, 1979). El-Gendy (1999a), and Rohilla and Bujarbaruah (2000) reported that up to 30 to 40% of *Acacia saligna* (dried leaves) can replace Clover hay and banana leaves without deleterious effect on growth.

El-Ayouty *et al.* (2000) showed that complete replacement of fresh berseem (*Trifolium alexandrium*) with berseem silage had no negative effect on growth of rabbits and edible body organs. It has been reported that rabbits can tolerate up to 40% of broom grass (*Thysanolaena maxima*) in their diets without adverse effect on the growth performance (Rohilla and Bujarbaruah, 2000). Scapinello *et al*. (2000a) observed that inclusion up to 20% of cassava leaves and stem hay in rabbit diets had no effect on the general performance. Similarly, Fotso *et al.* (2000) reported that up to 42% of cassava leaf meal can be fed to growing rabbits with positive result. Tangenjaja *et al*. (1990) reported that incorporating *Leucaena leucocephala* at 40% level as replacement for concentrate is ideal as it can support growth without adverse effect. These findings was supported by Scapinello *et al.* (2000b); Nieves *et al*. (1998) and El-Gali *et al*. (2001) who fed similar forages. Lupin (*Lupines albus*) was fed at 0, 10, 20, 30 and 40% levels to growing rabbits and the report indicated the optimum inclusion level as 20% for the best weight gain (El- Gendy, 1999b). El-Ayouty *et al*. (2000) reported that up to 100% of maize silage (whole plant) can be fed to growing rabbits without affecting the body weight gain. Similarly, Auxilia and Masoero (1980) fed maize plant (whole plant dried) up to 40% and reported also that it can support weight gain.

Payne *et al*. (1983) and Aderibigbe *et al*. (1992) reported that Rye grass as a basal diet can be fed to growing rabbits at levels between 20 and 50% without compromising the biological performance of the rabbits. Raju and Screemanna (1995) stated that up to 15% level of sea weed (*Ulva fascilate*) can be incorporated into the diet of growing rabbits. Bamikole and Ezenwa (1999) reported the incorporation of *Stylosanthes hamata* at 50% level in diets of growing rabbits is ideal for maximum weight gain. Harris *et al*. (1981) reported that when sun flower leaves were fed up to 40% to

growing rabbits, positive weight gain was observed. Abu *et al*. (1999) reported that inclusion of sweet potato tops up to 40% in the diets of growing rabbits did not have adverse effect on the body weight gain. Lopez *et al*. (1996) indicated that rabbits can tolerate up to 60% level of *Vicia sativa* with positive weight gain recorded. This report was supported by Sese *et al*. (1999) who fed similar forage (60%) to growing rabbits and revealed higher weight gain. Linga and Lukefahr (2000) reported growth rate of 28.9g/day for rabbits fed alfalfa with molasses blocks and growth rates of 10 to 12g/day with fresh lablab fed along with molasses or sugar cane, this report agrees with that of Linga *et al.* (2003). Sanni *et al.* (2005) evaluated the economies of producing grower rabbits fed different combinations of concentrates and *Stylosanthes* and found that 50:75 combination gave better return on investment, thus cost of feeding grower rabbits could be lowered by supplementing concentrate diets with *Stylosanthes*. Ikurior *et al.* (2009) reported that *Tridax procumbens* can be included in cassava based diets for rabbits and nutrient digestibility can be maximized at 10% level of inclusion. Nyako (2001) in his experiment with bitter leaf in weaner rabbit diets reported that 25% of the leaves can be incorporated into rabbit feeds to obtain high yield of meat.

2.10 LABLAB PURPUREUS PLANT

Lablab purpureus is a dual-purpose legume crop that is rapidly gaining acceptance by agro pastoral farmers in Northern Nigeria. It is drought resistant and is sown after normal cropping season, thereby acting as a buffer crop for ruminant feeding during the dry season (Adu *et al*., 1991). It is easy to cultivate and it remains green far into the dry season. It is fairly high yielding (seed yield of 870-1170kg/ha) and the seeds have crude protein content ranging from 22-29% (Kay, 1979). Murphy *et al.* (1999)

reported *Lablab purpureus* as a valuable legume that can be used in tropical farming systems. *Lablab purpureus* is an important warm season annual forage legume in Australia, Brazil, and other tropical countries (Skerman *et al*., 1988).

Lablab purpureus (L) Sweet, also known as Egyptian bean, lablab bean, bonavist bean or hyacinth bean is considered to have originated from South- East Asian subcontinent and was introduced into Africa in the 8th century (Kay, 1979; Westphal, 1994). It has since been widely distributed in many tropical countries and has naturalized in some. *Lablab purpureus* is grown as an annual or short lived perennial in South and Central America, East and West Indies, Asia, China, Africa and India (Aganga and Tshwenyane, 2003). Both the seed and the immature pods are used for human food. The herbage is used as human manure, for erosion control and as feed supplement for cattle grazing in the dry season (Schaaffhausen, 1963).

Over 200 varieties of lablab have been recognized on the basis of the size, shape, the color of pods or seed as well as flower and leaf color (National Academy of Sciences, 1979). Barnard (1972) described the Rongai variety of *Lablab purpureus* as a summer growing, vigorously twinning herbaceous annual or short-lived perennial with trailing stems reaching 3-6m in length. The leaves are trifoliate, with leaflet broad ovate-rhomboid, 7-15cm long, thin, acute at the apex, almost glabrous on the upper surface with short hair on the lower surface. Petioles are long and slender and inflorescence lax, fascicled, of many-flowered recemes on elongated peduncle. Pods are 4-5cm in length, containing 2-4 buff or pale brown seeds with a conspicuous white hilum. Seed number per kg is 3400-4300. Plant of the cultivar Highworth is morphologically similar to Rongai (Aganga and Tshwenyane, 2003).

2.10.1 Protein and Fibre Composition of *Lablab Purpureus* plant.

The mean crude protein content of lablab herbage is 17% with a range of 10% to 22% on a dry matter basis. Leaf crude protein varied from 14.3% to 38.5%, while the stem crude protein content ranged from 7.0% to 20.1% (Milford and Minson 1968). The level of crude protein reported by Karachi (1997) was 25% for leaves and 11.88% fo`r stems. Evans (2002) reported a range between 12.7- 14.1% for the whole plant.

The average crude fibre of the whole plant is 27.8% with the average of NDF, ADF, and ADL being 43 %, 38.6%, and 7.1% respectively (dry matter basis). One of the challenges of growing forage in tropical environments is the effect of the environment on the nutritional characteristics of plants. High temperatures decrease the soluble carbohydrate content of plants, resulting in increased fibre content and decreased digestibility (Norton and Poppi 1995). To exacerbate this situation, crude fibre content of legumes generally increases with maturity (Minson, 1990)

2.10.2 Utilization of Lablab by Livestock

Lablab purpureus is a leguminous plant that has been used to feed sheep, cattle and goats (Babayemi *et al*., 2006). The nutrient composition of lablab compares well with that of alfalfa (Oyawoye *et al*., 1990). Ruiz and Lukefahr (1998) fed lablab at the rate of 0, 25 and 50% in combination with 100, 75 or 50% commercial pellet diet to growing rabbits and reported that partial replacement of commercial feed with fresh lablab forage, increased profit margins, despite their slow growth performance. *Lablab purpureus* have been used to feed broiler chickens, cattle, sheep and goats with proven good results which did not have any adverse effect on the health status of the animal (Babayemi *et al*., 2006; Odunsi *et al*., 2006). In a study on utilization of *Arachis hypogea* (groundnut) and *Lablab purpureus* (lablab) forage meals fed sole or

mixed by growing rabbits conducted by Iyeghe-Erakpotobor (2012b), rabbits performed equally well on groundnut, lablab and mixed forage meal diets.

In a study where lablab was used as a supplement to oat hay, average daily gain in sheep fed the supplement was almost double that of sheep fed solely the basal diet (Umunna *et al*., 1995). Ndlovu and Sibanda (1996) had similar results when sheep fed lablab as a supplement to Zimbabwe scrub land herbage gained a total of 3.1 kg in two months while unsupplemented sheep only gained 1.0 kg. Results from a goat study by Makembe and Ndlovu (1996), showed that maize stover diets supplemented with lablab resulted in better body weight changes of the does, higher kid birth weights, faster growth rates and more milk as compared to traditional small holder practices in which no supplementation was used. In addition, postpartum anoestrus periods were shorter for supplemented animals than in animals fed typical diets not including lablab. There were no dietary effects on carcass characteristics. Feeding lactating cows with lablab resulted in an increased milk production of 3 litres/cow/day (Cino *et al*., 1994; Sinclair, 1996). Similarly Barje *et al*. (2011), obtained a significantly increased daily weight gain and higher milk yield among cows supplemented with lablab than those supplemented with groundnut haulms.

2.11 GROUNDNUT HAULMS

Groundnut (*Arachis hypogaea* L.), also known as peanut, is an annual legume and it is important in human nutrition, due to its high protein and energy content (Garduno-Lugo and Olvera-Novoa, 2008).

Groundnut haulms constitute approximately 45% of the total plant biomass and provide excellent forage for livestock in many regions. Haulms are rich in protein and more palatable than many other fodders (Liao and Holbrook, 2007).

Groundnut haulm is a nutritious feed for herbivores. It contains protein (8-15%), lipids (1-3%), minerals (9-17%), and carbohydrate (38-45%) at levels higher than cereal fodder. The digestibility of nutrients in groundnut haulm is around 53% and that of crude protein is 88% in animals (Ozyigit and Bilgen, 2012). Haulms release energy up to 2.337 cal kg^{-1} of dry matter (Singh and Diwakar, 1993).

2.11.1 Groundnut Haulms in feeding Livestock

Groundnut haulms have also shown great promise as a source of protein for feeding rabbits (Iyeghe-Erakpotobor *et al*., 2002, Iyeghe-Erakpotobor 2006; Iyeghe-Erakpotobor, 2007). In addition to the seed, peanut plants produce high-protein forage that has long been used as ruminant feed (Garduno-Lugo and Olvera-Novoa, 2008). Groundnut haulms were more cost effective than sweet potato forage for feeding rabbits (Iyeghe-Erakpotobor, 2007). Substitution of 33 to 100% clover hay with groundnut hay insignificantly increased nutrient digestibility, live weight, live weight gain, carcass characteristics and protein and fat contents of meat (Ibrahim, 2000). Ngodigha *et al.* (1994) observed that up to 50% of groundnut haulms can support weight gain of growing rabbits. Similarly Bawa *et al*. (2008), fed rabbits groundnut haulms and cowpea shells and obtained a significant difference ($P<0.05$) in final weight, feed intake, weight gain and cost per kg gain between the dietary treatments. Ososanya (2012), observed a positive linear effect ($P <0.05$) on intake when rams were fed 0, 50 and 100% groundnut haulms, the highest weight gain was observed in ram fed 50% groundnut haulms compared to 0% and 100% groundnut haulms.

2.12 CONCENTRATE UTILIZATION BY RABBITS

Concentrates are feeds that contain a high density of nutrients, usually low in crude fibre content (less than 18% of dry matter (DM)) and high in total digestible nutrients. Concentrates may be high in energy, referred to as energy concentrates, such as cereals and milling by-products, or high in protein, with over 20% crude protein, referred to as protein concentrates.

Studies have shown that rabbits can utilize 50 g of concentrate with forage grass or legume without adverse effect on growth (Bamikole and Ezenwa, 1999; Iyeghe-Erakpotobor *et al.*, 2002, 2003; Iyeghe-Erakpotobor, 2006). Rabbits require concentrate feed, although they could manage high crude fibre levels (14-25%) in the diet (Adegbola *et al*., 1985).

2.13 CONCENTRATE: FORAGE UTILIZATION

Feeding rabbits solely on forages in the tropics has resulted in negative effect of weight loss (Adegbola *et al*., 1985; Bamikole and Ezenwa, 1999) and in some cases positive effect have been reported (Phimmasan *et al*., 2004; Hue and Preston, 2006). Rabbit can be maintained on green leaves alone without the supplementation of concentrate, but for the best growth to be achieved by rabbits, forage has to be supplemented with concentrate feed (Omole *et al*., 2007). The use of compounded concentrates alone has also not given optimum results (Iyeghe-Erakpotobor, 2007). Rabbits are never fed sole concentrate in other to meet their crude fibre requirement (Bamikole and Ezenwa, 1999) but are fed forage in mixed concentrate-forage diets. Raising rabbits on forages with an energy supplement has been reported to be more appropriate in developing countries where commercial feeds are either not available

or cost-prohibitive (Linga and Lukefahr, 2000). Rabbit can be maintained on green leaves alone without the supplementation of concentrate, but for best growth to be achieved, forage has to be supplemented with concentrate feed (Omole *et al*., 2007). A combination of concentrate diet and forage to achieve optimum performance is especially being sought after; to reduce cost of feeding, as well as the total cost of production for the small scale rabbit producers (Adeyemo *et al*., 2013).

Rabbit production system practiced in the rural areas under traditional condition is mainly forage-based. Hassanat *et al*. (2006) stated that supplementation of concentrate in addition to forage feeding improves the growth and reproductive performance of rabbits. The poor and unbalanced quality of grasses is a major constraint, which limits the successful production of rabbits. Studies have also shown that rabbits can utilize 50 g of concentrate with forage grasses or legumes and still grow at a rate of 5-13 g/day (Iyeghe-Erakpotobor 2006, 2009). Similarly, Adeyemo *et al*. (2013) studied the effect of concentrate to forage ratio on performance of rabbits observed that for optimum performance of rabbits, 50% concentrate and 50% forage should be given to rabbits for optimum performance. Cheeke and Raharjo (1988) in their review of rabbit production on tropical feed resources concluded that tropical grasses were unsuitable as the sole feed for rabbits due to their low digestibility (less than 10%). However, rabbits can successfully be raised on diets that are low in grains and high in roughage (Cheeke, 1986b).

Growing rabbits can be maintained satisfactorily on diets consisting of 100 to 200g green roughage and 40 to 60g concentrate mixtures for maximum production (Ranjhan, 1980). Farinu, (1994) evaluated the effects of feeding a compound diet based on non-conventional feedstuffs on growth and organ characteristics of rabbits

and confirmed that it was economical to rear rabbits on mixed diet of concentrate and forage.

2.14 PALM OIL

The oil-palm tree (*Elaeis guineensis*) originated from the west coast of Africa, where the oil has been used since very early times (P.O.R.I.M, 1988). The oil palm is cultivated widely in East Africa, South America, Indonesia and Malaysia. The palm oil is an unrefined, unbleached version and extremely rich in carotenoids. The total carotenoid content of palm oil is said to vary from 500-1600 ppm, α-Carotene (29%), β-carotene (62%), γ-carotene (4%), Xanthophyll and Lycopene (2%) which contribute to the red color (Wong *et al*., 1988). Palm Oil is the only vegetable oil that contains carotenoids of which 62-70% is beta-carotene (Kusum *et al*., 2011). Beta-carotene is the most common precursor of vitamin A, which is important for maintaining the skin and mucous membranes in good condition, as well as in promoting good vision, bone growth and reproduction (Kusum *et al*., 2011).

The phospholipid content of crude palm oil varies with the season and to a lesser extent with the mill operation. Palm oil contains 3.2-4.5 ppm iron. Recent studies indicate that beta-carotene acts as an anti-carcinogen, (Sylvester *et al*., 1986), and produce a hypo-cholesterolemic effect (Shaish *et al*., 1995) in conjunction with other favorable factors. One gram of palm oil contains 430-760 IU of vitamin A. However, there are hardly any reports to show the extent of change in carotenoid contents in palm oil kept for a long time under storage. Palm oil also contains about 1.5% of un-saponifiable matter, which includes sterols, tocols (tocopherol and tocotrienols) and the carotenes. The technology for retaining most of the β-carotene in palm oil has been developed (Manorama and Rukmini, 1992; Rajam *et al*., 2005). The

unsaponifiable fraction of the palm oil also contains tocopherol (20%), tocotrienols (25%) α-tocotrienols (45%) and γ-tocotrienols (10%). The later compounds vary from 600-1200 ppm. The tocopherols are not only good antioxidants; they are also physiologically active as vitamin E. In addition to tocopherols, one finds in palm oil tocotrienols constitute two – thirds of the total tocols that are present (Cottrell, 1991). Tocopherols and tocotrienols are known to scavenge free radicals (Packer, 1992), protect against oxidative injury (Serbinova *et al*., 1992), reduce platelet aggregation (Qureshi *et al*., 1991), and protect against atherogenesis (Hasselwander *et al*., 2002) and cancer. Table 2.2 shows the major components of palm oil.

Table 2.2: Major Components of Palm Oil

Components	level (ppm)
Carotenoids	500-700
Tocopherols and Tocotrienols	600-1000
Sterols	329-530
Phospholipids	5-130
Triterpene alcohols	40-80
Methyl sterols	40-80
Squalene	14-15
Aliphatic alcohols	100-200
Aliphatic hydrocarbons	50

Source: *Food and Nutrition Bulletin (1994);* Ppm= Parts per million

2.14.1 Utilization of Palm oil in Animal Feed

A review of literature shows that palm oil supplementation play an important role in influencing the feed intake of animals. Hutagalung (1977) reported improved live performance when pigs fed cassava based diets had supplementary palm oil in their diet. Omole and Onwudike (1983) reported that inclusion of palm oil in rabbit diets containing cassava peel meal reduced toxic effects of cyanide and increased the urinary excretion of thiocyanate in the urine.

Iyeghe and Ekpenyong (1990) reported that palm oil supplementation in rabbit diet improved growth performance by increasing weight gain, feed conversion, fat and crude fibre digestion. Fajimi *et al*. (1993), observed that broilers on palm oil diets consumed significantly ($P<0.05$) more feed and had higher body weight gain than those fed rubber seed oil and concluded that inclusion of palm oil in broiler diet results in superior performance than the inclusion of rubber seed oil.

2.15 CARCASS QUALITY

Wasem (2013), observed a significant difference in the carcass: loin, head, neck and organs: heart, liver and lung with 50% groundnut haulm performing better than other treatments. However, there was no significant difference in the weight of kidney. Bawa *et al*. (2008) observed a non significant difference in the yield of heart, kidney and thigh but observed a significant difference for the pre-slaughter weight, carcass weight and dressing percentage when rabbits were fed groundnut haulms and cowpea shells.

The result of carcass analysis reported by Omole *et al*. (2007) revealed that the dressing percentage, lung, liver and heart weight were not significantly affected by

dietary treatment when *Stylosanthes guianensis*, *Lablab purpureus* and sunflower were fed as sole feed to growing rabbits. Abdu *et al*. (2012), observed a significant difference in the shoulder, thigh and loin when rabbits were fed carrot leaf meal at 0, 15, 30, 45 and 60% inclusion level.

Amata (2010) also reported a non significant difference in the carcass characteristics of rabbits fed Gliricidia leaf meal (GLM). Similarly, Bawa *et al*. (2008) observed a non significant difference in the yield of heart, kidney and thigh but observed a significant difference for the pre-slaughter weight, carcass weight and dressing percentage when rabbits were fed groundnut haulms and cowpea shells. Fajimi *et al.* (1993), also observed non significant difference in all the organs except gizzard when broilers were fed palm oil.

2.16 HORMONES

Hormone is a chemical substance that is synthesized by particular endocrine glands and then enters the bloodstream to be carried to target tissues, which has specific receptors that binds it (Squires, 2003). Puberty is the developmental stage in an animal when physiological reproductive activities starts. This is initiated by the hormone estrogen in the female bringing about such activities as ovum development, ovulation, oestrus behavior and inter - uterine development (Ekeocha, 2009). In male animals, the hormone testosterone, initiates such activities like spermatozoa development, the growing urge to mate known as libido and the development of accessory sex organs.

When all these activities have reached the optimum stage, the animal is said to be sexually matured (Ekeocha, 2009). Sexual maturity comes after puberty attainment. All these developments are derived from the maturation of the sex organs and the accompanying surge in the secretion of sex hormones. The time of onset and the age and weight at which puberty is attained vary greatly. Factors affecting the onset of puberty include inheritance and genotype, geographical location, diseases and socio-economic factors especially as they affect nutrition and general well-being (Anderson, 1974).

2.16.1 Steroid Hormones

Steroid hormones regulate diverse physiological functions such as reproduction, blood salt balance, maintenance of secondary sexual characteristics, response to stress, neuronal function and various metabolic processes (Hu *et al*., 2010). There are five major classes of steroid hormones: testosterone (androgen), oestradiol (oestrogen), progesterone (progestin), cortisol/corticosterone (glucocorticoid), and aldosterone (mineralocorticoids) (Hu *et al*., 2010). Progesterone is the major progestin, which prepares the lining of the uterus for implanting of the ovum and is involved in the maintenance of pregnancy. Oestrogens, such as oestradiol are involved in the development of female secondary sexual characteristics and in the ovarian cycle. The androgens are involved in the development of male secondary sexual characteristics (Squire, 2003). Testosterone and its more potent metabolite dihydrotestosterone (DHT), progesterone and estradiol are classified as sex-steroids (Hu *et al*., 2010).

2.16.1.1 Testosterone

Testosterone is a steroid hormone from the androgen group and is found in mammals, reptiles, birds and other vertebrates (Cox and John, 2005; Reed *et al*., 2006). In mammals, testosterone is primarily secreted in the testicles of males and the ovaries of female, although small amounts are also secreted by the adrenal glands. It is the principal male sex hormone and an anabolic steroid. The importance of testosterone to the male animal cannot be overemphasized. The functions of testosterone can be broadly classified into two namely: androgenic function which includes the development of secondary male characteristics, and anabolic function which involves the promotion of protein synthesis (Raji, 1995).

Testosterone is needed to initiate spermatogenesis at puberty and for the maintenance of this process in the adult. It is also required for the completion of meiosis and for differentiation of spermatids (Castro *et al*., 2002). Several other androgens such as dihydrotestosterone, dehydro-epiandrosterone and androstenedione are produced in small amounts by the testis, but testosterone is the major androgen present in the blood of several species including the rabbit (Castro *et al*., 2002).

Testosterone plays a key role in the development of male reproductive tissues such as the testis and prostate as well as promoting secondary sexual characteristics such as increased muscle, bone mass, and the growth of body hair (Mooradian *et al*., 1987). In addition, testosterone is essential for health and well-being (Bassil *et al*., 2009) as well as the prevention of osteoporosis (Tuck and Francis, 2009).

2.16.1.2 Progesterone

The steroid hormone progesterone is a key component in the complex regulation of normal female reproductive function. Graham and Clarke (1997) enumerated the major physiological roles of progesterone in the mammal to include:

- Release of mature oocytes in the uterus and ovary, facilitation of implantation, maintenance of pregnancy, promotion of uterine growth and suppression of myometrial contractility.
- Lobular-alveolar development in preparation for milk secretion and suppression of milk protein synthesis before parturition in the mammary gland.
- Mediation of signals required for sexually responsive behavior in the brain

According to Hu *et al.* (2010), progesterone is required for follicular growth and ovulation responsible for changes associated with luteal phase of oestrus cycle, essential for establishment and maintenance of early pregnancy. It is the principal female sex steroid, required for growth and ovulation, responsible for secondary female sexual characteristics, regulator of cardiovascular physiology, bone integrity and neuronal growth (Hu *et al.*, 2010).

Synthesis and Secretion of Progesterone

The ovary is the major site of synthesis and secretion of estrogen and progesterone in the mammal and gives rise to cyclical fluctuations in the levels of these hormones in circulation. Primary follicles play a dual role in secreting both hormones as well as being responsible for the release of the ovum during the normal cycle. Before ovulation, granulosa cells in the follicle biosynthesize and secrete estrogen. After follicle rupture and release of the ovum, these granulosa cells mature to form the corpus luteum, which is responsible for secretion of progesterone and estrogen in the

latter part of the cycle (Graham and Clarke, 1997). In the human, if fertilization does not occur within 1 to 2 days, the corpus luteum will continue to enlarge for 10–12 days followed by regression of the gland and concomitant cessation of estrogen and progesterone release. If fertilization occurs, the corpus luteum will continue to grow and function for the first 2 to 3 months of pregnancy. After this time it will slowly regress as the placenta assumes the role of hormonal biosynthesis for the maintenance of pregnancy (Graham and Clarke, 1997).

Progesterone is a 21-carbon steroid which is a precursor molecule for steroids biosynthesis. Progesterone is primarily produced by the granulosa-lutein cells of the corpus luteum (CL) during the luteal phase of the menstrual/oestrous cycle and the syncytiotrophoblast of the placenta during pregnancy. However, zona fasciulata and zona reticularis of the adrenal cortex produce some amount of progesterone which is less than 1 mg/day (Pfeifer and Strauss, 1996). It is transported in the blood by transcortin (corticosteroid-binding globulin) and albumin with approximately 2% present in the free, unbound state. The half life of progesterone is approximately 5 minutes in the blood and its principle degradation product, pregnanediol, is formed in the liver.

Progesterone level at different physiological stages

Baldwin and Stabenfeldt (1974), reported progesterone level of 1.5, 13.3 and 3.3 ng/ml of plasma at the periods prior to mating, mid pregnancy (Day 18) and at the end of gestation respectively in rabbits. The plasma progesterone concentration is normally less than 2.25 nmol/l (1.5 ng/ml) during the follicular phase of the menstrual cycle. During the luteal phase, the plasma level rises to a peak value of approximately

40-50 nmol/l (12-16 ng/ml) (Al-Asmakh, 2007). Fritz and Speroff (2011) reported the following range of progesterone at various physiological stages.

- less than 1ng/ml (nanogram per milliliter) for female in pre-ovulatory stage
- 5-20ng/ml for female in the mid-cycle
- less than 1ng/ml for male
- less than 1ng/ml for postmenopausal
- And during pregnancy: 11.2-90.0ng/ml, 25.6-89.4ng/ml, 48.4-42.5ng/ml during the first, second and third trimester respectively.

2.16.2 Influence of Nutrition on Hormones in Animals

Inadequate nutrition is associated with the suppression of gonadal activity in many species. Long-term (26 weeks), nutritionally restricted cows have reduced concentrations and fewer pulses of LH than cows in moderate body condition (Richards *et al*., 1989). Dietary energy restriction inhibited LH secretion in ovariectomized heifers (Kurz *et al*., 1990). Although acute feed restriction decreases the concentration of LH in blood of male monkeys (Schreihofer *et al*., 1993), its effect on gonadotropins in cattle has not been established. Lower planes of nutrition delayed the onset of puberty by inhibiting maturation of the endocrine system (Patterson *et al*., 1992).

Environmental conditions, such as nutrition or environmental temperature can influence, notably, the hormonal profile of the rabbit and consequently, their reproductive and productive performance (Meshreky and Metry, 2000; Chiericato *et al.*, 2001; Meshreky and Shaheed, 2003 and Meshreky *et al*., 2007). Reproductive efficiency is a major factor affecting productive and economic efficiency of beef and

milk production. Energy status, particularly negative energy balance, has a major effect on reproductive performance, affecting age at puberty (Day *et al*., 1986; Moran *et al*., 1989; Kinder *et al*., 1995). Malnutrition was found to block growth, delay puberty, lower conception rate, reduce ovarian follicular growth and finally the retardation of both maternal and fetal growth through fetal/maternal competition for growth (Mello and Cury, 1989; Armstrong *et al*., 2001).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The first experiment was conducted at the Rabbitry Unit of the Department of Animal Science, Ahmadu Bello University, Zaria. Zaria is within the northern guinea savannah zone. Zaria is located between Latitude 11^0 and12^0N, Longitude $7^0$33$^{'}$E and Altitude of 646m above sea level (Meteorological unit, IAR 2011). The study was repeated at the National Animal Production Research Institute (NAPRI), Rabbitry, Shika.

3.2 Source and processing of Test Ingredients

Lablab was obtained from the Forage Production Unit of the National Animal Production Research Institute (NAPRI) while groundnut haulm was purchased from the open market in Zaria. The concentrate was compounded at Dasolag Feed Mill, Kaduna. The fodders (Lablab and groundnut haulms) were air-dried separately for 7days, chopped and were milled with machine, before being incorporated into the experimental diets.

3.3 Design, management of experimental animal and data collection

A total of ninety-six crossbred rabbits of mixed sexes, aged 5-7 weeks of average weight of 789.7grams were used in this study. The rabbits were purchased from the open market in Zaria and from NAPRI. Rabbits were weighed with a weighing balance at the onset of the experiment and allocated to eight dietary groups in a 2×2×2×2 factorial experiment in a completely randomized design (CRD). The factors considered were: forage type (groundnut haulm and lablab); level of inclusion of

forage meal (20% and 40%); level of palm oil inclusion (with, without); and sex effect (male and female).

The rabbits were housed individually in metal cages, measuring 40x60 cm in dimension located in the rabbitries, equipped with large windows for proper ventilation. Each cage was equipped with an aluminum drinker, a round bottom earthen pot with rim to prevent feed wastage. Iron trays were provided for collection of faecal droppings. The rabbits were administered an anti-stress (Vitalyte; Phoenix pharmaceuticals U.S.A), antibiotics (Tetracin; Vetinida Pharmaceutical Limited India), and were treated against external and internal parasites using coccidiostat (Amprolium; Lonye Technology Limited Guangzhou, China) and Ivomec (Savorite Pharmaceutical Limited Baroda (Guj), India) during the one week adjustment period. The rabbits were fed 100g of feed daily and water given *ad libitum.* The rabbits were weighed weekly and the data were used to calculate the performance as follows:

Weights were subtracted from previous weights to obtain weekly weight gain. Weighed left over feed was subtracted from total feed supplied for the week to obtain weekly feed intake. The weekly feed intake and weight gains were used to compute the feed-to-gain ratio. Feed cost per kilogram gain, daily feed cost and total feed cost were also calculated. No mortality was recorded during the experimental period.

3.4 Experimental Diets

The percentage composition of concentrate, percentage and proximate composition of experimental diets are presented in Tables 3.1, 3.2 and 3.3 respectively.

Table 3.1: Percentage Composition of Concentrate

Ingredient	Proportion (%)
Maize	39.5
Maize offal	15
Groundnut cake	42.26
Bone meal	3
Salt	0.25
Vitamin/mineral premix**	0.25

*** Biomix premix supplied per kg of diet: Vit. A, 10,000 iu; Vit. D_3, 2000 iu; Vit E, 23 mg; Vit. K, 2mg: Vit, B_1, 1.8; Vit B_2, 5.5mg; Niacin, 27.5mg; pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg: Folic acid, 0.75mg; Biotin, 0.06mg; chloride, 300mg; cobalt, 0.2; Copper, 3mg; Iodine 1 mg; Iron, 20 mg; Manganese, 40 mg; Selenium, 0.2 mg; Zinc, 30mg; Antioxidant, 1.25mg.* **(M**anufactured by: Bio-organics Nutrient System Limited, Ibafo Ogun state Nigeria).

Table 3.2: Percentage Composition of Experimental Diets

Ingredients (%)	Treatments							
	1	2	3	4	5	6	7	8
Concentrate	80	60	80	60	79	59	79	59
Groundnut Haulms	20	40	-	-	20	40	-	-
Lablab	-	-	20	40	-	-	20	40
Palm Oil	-	-	-	-	1	1	1	1

Table 3.3: Proximate Composition of Experimental Diets (%)

Forage	G/nut	G/nut	Lablab	Lablab	G/nut	G/nut	Lablab	Lablab
F. level	20	40	20	40	20	40	20	40
Palm oil	-	-	-	-	+	+	+	+
DM	92.22	90.91	91.54	91.55	91.22	91.59	91.91	91.96
Ash	6.37	6.41	6.85	5.25	5.69	7.10	6.92	9.21
EE	16.68	15.45	15.53	15.83	18.17	16.68	16.55	16.59
CF	17.76	16.86	16.09	16.28	18.82	16.06	17.26	17.25
NFE	42.22	45.72	42.15	44.83	40.82	44.48	43.58	40.95
CP	16.97	15.56	19.38	16.81	16.50	15.58	15.69	16.00

DM: Dry matter, EE: Ether extract, CF: Crude fibre, NFE: Nitrogen free extract, F. level: forage level, G/nut: groundnut meal, +PO: with palm oil, -PO: without PO

3.5 Carcass Analysis

After the feeding trials, five rabbits selected from each treatment based on the group average weight were slaughtered for carcass evaluation. Prior to slaughtering, the animals were starved over night to clear the gut and live weights were recorded. The rabbits were euthanized followed by flaying which was done by hanging the animals by the neck to a hook and pulling the skin downwards. Evisceration was carried out, the visceral content comprising the heart, lungs, kidney, gall bladder, liver and abdominal fat pad were carefully removed and weighed. The weight of the dressed carcass, head, legs and skin were recorded. The dressed carcass was cut into fore limb, hind leg and loin. The entire carcasses were weighed individually.

3.6 Laboratory Analysis

The proximate analysis of the experimental diets was carried out at the Animal Science Department Laboratory to determine the dry matter, crude protein, nitrogen free extract, ether extract, crude fibre and ash compositions using the procedure of AOAC (1995).

3.7 Hormone Analysis:

Blood samples were collected starting from the twelfth week of age and subsequently at two weeks interval to monitor the attainment of puberty. Hormones measured were progesterone and testosterone. The blood samples were obtained by puncture of the ear vein; into plain tubes and immediately centrifuged at 4000rpm for 15 mins to harvest the serum. Serum samples were stored at -20ºC until assayed. Samples were analyzed for concentration of progesterone (Eggleston *et al*., 1990) and testosterone (Olayemi, 2007). Serum progesterone and testosterone concentrations were determined by Enzyme-Linked Immunosorbent Assay test kits obtained from Accu-Bind Diagnostics, USA.

3.7.1 Testosterone Assay Procedure

Reagent materials provided with the kits included: Testosterone calibrators, Testosterone enzyme reagent, Steroid conjugate buffer, Testosterone biotin reagent, Streptavidin coated plates (96 wells), wash solution concentrate, substrate A, substrate B and stop solution. Materials required but were not provided included: Pipette of different sizes, dispensers, Microplate washer, Microplate reader with 450nm and 620nm wavelength absorbance capacity, absorbance paper, plastic wraps, timer and quality control materials.

Reagent Preparation:

1. Working Enzyme Reagent: 0.7ml of Testosterone Enzyme Reagent was measured and added to vial containing Steroid Conjugate Buffer and was stored at 2-8˚C.
2. Wash Buffer: Contents of wash solution was diluted in 1000ml of distilled water in a stable storage container.
3. Working Substrate Solution: Contents of the amber vial labeled Solution A was poured into clear vial labeled Solution B. These were mixed and labeled appropriately.

Test Procedures

- 0.010ml (10µl) of serum was pipetted in each assigned well and 0.050ml (50µl) of working Testosterone Enzyme Reagent was added to all wells. The microplate was swirled gently for 20-30 seconds to ensure proper mixing.
- 0.050ml of Testosterone Biotin Reagent was added to all wells and the microplate was swirled for another 20-30 seconds to mix, this was then covered and allowed to incubation at room temperature for 60 minutes.
- Contents of the microplate were discarded by decantation and the plate was blotted dry with absorbent paper. 350µl of wash buffer was added and then decanted. This was repeated two times for a total of three washes.
- 0.100ml (100µl) of working substrate solution was added to all wells, this was incubated at room temperature for 15 minutes. At the end of 15 minutes, 0.050ml of stop solution was added to each well and gently mixed for 15-20 seconds.
- The absorbance in each well was read at 450nm (using a reference wavelength of 620-630nm) in a micro-plate reader.

- The absorbance obtained from the micro-plate reader was recorded and a graph of the absorbance plotted against testosterone concentration to obtain the best fit curve. This was then used to determine the concentration of the test samples.

3.7.2 Progesterone Assay Procedure

Reagent material provided with the kits include: Progesterone calibrators, progesterone enzyme reagent, Progesterone biotin reagent, Streptavidin coated plates, wash solution concentrate, substrate reagent, stop solution and reagent instructions.

Reagent Preparation

Wash buffer: content of wash solution was diluted in 1000ml of distilled water in a suitable storage container.

Test Procedure

- The microplates' wells for each serum reference, control and rabbit serum to be assayed in duplicate were formatted.
- 0.025ml (25µl) of the appropriate serum reference, control and rabbit serum was pipetted into assigned well.
- 0.050ml (50µl) of Progesterone Enzyme reagent was added to all the wells, the microplate was swirled gently for 10-20 seconds to mix and 0.050ml (50µl) Progesterone Biotin Reagent was added to all wells; the microplate was again swirled gently for 10-20 seconds to mix.
- This was then covered and incubated for 60 minutes at room temperature.
- The content in the microplate was discarded by decantation and 350µl of wash buffer was added; this was decanted and repeated 2-3 times.
- 0.100ml (100µl) of substrate solution was added to all wells. This was incubated at room temperature (18-25˚C) for 20 minutes. The reaction was

stopped by adding 50µl stop solution to each well; this was gently mixed for 15-20 seconds.

- The absorbance in each well was read at 450nm (using a reference wavelength of 620-630nm) with microtiter plate reader within 15 minutes.
- The mean absorbance value for each set of reference standards, controls and samples were calculated. Standard curve was constructed by plotting the mean absorbance obtained from each reference standard against its concentration in ng/ml on a linear graph paper with absorbance values on the vertical or Y axis, and concentration on the horizontal or X axis.
- The mean absorbance value for each specimen was used to determine the corresponding concentration of progesterone in ng/ml from the standard curve.

3.8 Statistical Analysis:

Data collected were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2001). Significant differences in mean were separated using Pairwise Difference Procedure of SAS (2001).

General Linear Model

The model used is as follows:

$Y_{ijkl} = \mu + F_i + N_j + P_k + S_l + I + \ell_{ijklm}$

Where:

μ = overall mean

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

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

$P_k = k^{th}$ effect of palm oil supplementation

$S_l = l^{th}$ effect of sex

I= effect of all the interactions

ℓ_{ijkl}= Random error

Assumptions

- Existence of interaction within the variables
- Existence of random error term
- The main value of the variables will be significantly different from zero
- The performance, carcass characteristics and hormone profile are statistically different from zero.
- The performance, carcass characteristics and hormone profile are dependent of forage level, sex and forage type.

CHAPTER FOUR

4.0 RESULTS

4.1 PERFORMANCE OF RABBITS

4.1.1 Effect of Forage level on performance of rabbits

Table 4.1 shows the result of the performance of rabbits fed different levels of forage meals. Total weight gain, average daily gain, daily feed intake, total feed intake and feed to gain ratio were significantly ($P<0.05$) affected by forage levels. Total weight gain and average daily gain of rabbit fed 20% forage were significantly ($P<0.05$) higher than those fed 40% forage meal while feed intake, total feed intake and feed to gain ratio of rabbit fed 40% forage meal were significantly ($P<0.05$) higher than those fed 20% forage meal. Although the daily feed cost, total feed cost and feed cost per kg gain were not significantly different ($P>0.05$), these were slightly higher among rabbits fed 40% forage diet. Rabbits fed 20% forage gave saving per kilogram gain of ₦96.68 over those on 40% forage level.

4.1.2 Effect of Forage type on performance of rabbits

Table 4.1 shows the effect of forage type on performance of rabbits. There were no significant differences ($P>0.05$) between rabbits fed groundnut meal and lablab. There were no significant difference ($P>0.05$) in daily feed cost, total feed cost, feed cost per kilogram between forage types. Rabbits fed lablab forage gave saving per kilogram gain of ₦42.00 over those fed groundnut forage.

Table 4.1: Effect of Forage Level and Forage Type on Performance of Rabbits (LSM± SE)

	TWG	ADG	TFI	DFI	FGR	DFC	TFC	FC/Kg	S/Kg
				Forage Level					
20%	905.41±22.39[a]	9.68±0.23[a]	6007.61±118.98[b]	61.30±1.21[b]	7.31±0.29[b]	5.98±0.27	586.39±26.27	724.10±45.85	96.68
40%	832.10±21.53[b]	8.97±0.22[b]	6397.37±114.45[a]	65.28±1.17[a]	8.11±0.28[a]	6.43±0.26	631.10±25.27	820.78±44.11	-
P value	0.02	0.03	0.02	0.02	0.05	0.22	0.22	0.13	
				Forage Type					
G/nut	847.56±21.31	9.11±0.22	6213.32±113.28	63.40±1.16	8.09±0.27	6.09±0.26	597.26±25.01	793.44±43.67	-
Lablab	889.95±22.59	9.54±0.23	6191.66±120.06	63.18±1.23	7.33±0.29	6.33±0.27	620.24±26.51	751.44±46.27	42.00
P value	0.17	0.17	0.90	0.90	0.06	0.53	0.53	0.51	

[ab] Means with different superscripts within the same row are significantly (P<0.05) different. TWG: Total weight gain, ADG: Average daily gain, TFI: Totalfeed intake, DFI: Daily feed intake, FGR: Feed to gain ratio, DFC: Daily feed cost, TFC: Total feed cost, FC/Kg: Feed cost per kilogram, S/Kg: Savings per kilogram, G/nut: Groundnut haulms, LSM: Least square means, SE: Standard error.

4.1.3 Effect of Palm oil (PO) inclusion on performance of rabbits

Table 4.2 shows the performance of rabbits supplemented with palm oil. There were non-significant difference (P>0.05) in all performance parameters of rabbits with or without palm oil supplementation in the diet. Feed intake, daily gain and feed to gain ratio were similar across the treatment. Higher saving per kilogram gain of ₦23.10 was observed in diet without palm oil.

4.1.4 Effect of Sex on performance of rabbits

The effect of sex on performance of rabbits is shown in Table 4.2. Weight gain was similar for both male and female rabbits, there were no significant difference (P>0.05) in all the parameter studied for both sexes. However, female rabbits had a higher savings per kilogram gain (₦49.59) than male rabbits.

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Table 4.2: Effect of Palm oil and Sex on Performance of Rabbits (LSM± SE)

	TWG	ADG	TFI	DFI	FGR	DFC	TFC	FC/Kg	S/Kg
Palm oil									
- PO	850.60±22.55	9.08±0.23	6061.32±119.87	61.85±1.22	7.72±0.29	5.95±0.27	583.23±26.47	760.88±46.20	23.12
+ PO	886.91±21.33	9.58±0.22	6343.67±113.39	64.73±1.16	7.70±0.28	6.47±0.26	634.26±25.04	784.00±43.70	-
P value	0.24	0.11	0.09	0.09	0.95	0.54	0.16	0.71	
				Sex					
Male	881.35±22.16	9.43±0.23	6277.24±117.78	64.05±1.20	7.67±0.29	6.47±0.26	634.31±25.01	796.23±45.39	-
Female	856.16±21.77	9.23±0.22	6127.74±115.69	62.53±1.18	7.75±0.28	5.95±0.26	583.19±25.54	748.64±44.58	49.59
P value	0.42	0.53	0.37	0.37	0.84	0.16	0.16	0.46	

TWG: Total weight gain, ADG: Average daily gain, TFI: Total feed intake, DFI: Daily feed intake, FGR: Feed to gain ratio, DFC: Daily feed cost, TFC: Total feed cost, FC/Kg: Feed cost per kilogram, S/Kg: Savings per kilogram, -PO: Without palm oil, +PO: With palm oil, LSM: Least square means, SE: Standard error.

4.1.5 Interaction effects of Forage level and Palm oil (PO) on performance of rabbits

The interaction between forage level and palm oil inclusion in the diets on performance of rabbits are shown in Table 4.3. The result shows significant effects of interaction between forage level and palm oil on performance of rabbits. Total weight gain by rabbits fed 20% forage supplemented with palm oil was significantly ($P<0.05$) higher than those fed 40% forage supplemented with palm oil. However, total weight gain was not significantly different in rabbits fed the forage levels without palm oil supplementation. Similarly, average daily gain was significantly higher, in rabbits fed 20% forage supplemented with palm oil than those not supplemented while at 40% forage no difference was observed between supplemented and unsupplemented rabbits. Daily and total feed intakes were significantly higher in rabbits fed 20% forage supplemented with palm oil than the unsupplemented group while no difference was observed between supplemented and unsupplemented rabbits on 40% forage. Feed to gain ratio was significantly higher in rabbits fed 40% forage supplemented with palm oil and lowest in those fed 20% forage supplemented with palm oil. There were no significant interaction between forage level and palm oil supplementation on daily feed cost, total feed cost and feed cost per kilogram gain, rabbits fed 20% forage supplemented with palm oil and 40% forage unsupplemented rabbits had savings per kilogram gain of ₦37.00 and ₦83.24 respectively.

Table 4.3: Interaction Effects of Forage Level and Palm oil on Performance of Rabbits (LSM ± SE)

Forage levels	20	20	40	40	P value
Palm oil (PO)	Without PO	With PO	Without PO	With PO	
Total weight gain (g)	865.24±33.03[ab]	945.57±30.13[a]	835.96±30.72[ab]	828.25±30.19[b]	0.16
Average daily gain(g)	9.19±0.34[b]	10.18±0.31[a]	8.97±0.31[b]	8.98±0.31[b]	0.05
Daily feed intake (g)	59.52±1.79[b]	63.08±1.63[ab]	64.18±1.67[ab]	66.38±1.64[a]	0.05
Total feed intake (g)	5833.18±175.57[b]	6182.05±160.14[ab]	6289.45±163.25[ab]	6505.29±160.44[a]	0.05
Feed to gain ratio	7.49±0.43[ab]	7.14±0.39[b]	7.96±0.40[ab]	8.25±0.39[a]	0.05
Daily feed cost (₦)	5.74±0.40	6.22±0.36	6.16±0.37	6.72±0.36	0.94
Total feed cost(₦)	562.99±38.77	609.79±35.36	603.47±36.05	658.73±35.43	0.96
Feed cost/ Kg gain (₦)	742.60±67.66	705.60±61.72	779.16±62.91	862.40±61.83	0.52
Savings/Kg (₦)	-	37.00	83.24	-	

[ab] Means with different superscripts within the same row are significantly(P<0.05) different, LSM: Least square means, SE: Standard error.

4.1.6 Interaction effect of Forage level and Forage type on performance of rabbits

The interaction between forage level and forage type on the performance of rabbits is shown in Table 4.4. Significant difference ($P<0.05$) were observed in total weight gain and average daily gain of rabbits fed 20% lablab forage than those fed 40% groundnut forage. Rabbits fed 20% groundnut forage and those fed 40% lablab forage had similar weight gain. Rabbits fed diets with 40% groundnut forage had significantly higher total feed intake, daily feed intake and feed to gain ratio compared to rabbits fed 20% groundnut forage. Rabbits fed 20% and 40% lablab forage had similar intake. There were no significant interaction between forage level and forage type on daily feed cost, total feed cost and feed cost per kilogram, however rabbits fed 20% groundnut and lablab forage meals had savings per kilogram gain of ₦95.25 and ₦98.10 respectively.

Table 4.4: Interaction effect of Forage level and Forage type on Performance of Rabbits (LSM ± SE)

Forage level	20	40	20	40	P value
Forage type	Groundnut	Groundnut	Lablab	Lablab	
Total weight gain (g)	883.49±30.13^{ab}	811.30.13±30.13^{b}	927.30±33.03^{a}	852.51±30.82^{ab}	0.05
Average daily gain (g)	9.52±0.31^{ab}	8.70±0.31^{b}	9.84±0.34^{a}	9.25±0.31^{ab}	0.05
Feed intake (g)	60.20±1.63^{b}	66.60±1.63^{a}	62.40±1.79^{ab}	64.00±1.67^{ab}	0.05
Total feed intake (g)	5899.64±160.14^{b}	6527.00±160.15^{a}	6115.58±175.57^{ab}	6267.74±163.81^{ab}	0.05
Feed to gain ratio	7.54±0.39^{b}	8.64±0.39^{a}	7.09±0.43^{b}	7.57±0.40^{ab}	0.05
Daily feed cost (₦)	5.99±0.36	6.20±0.36	5.98±0.40	6.68±0.37	0.52
Total feed cost (₦)	586.66±35.36	607.86±35.36	586.13±38.77	654.35±36.17	0.64
Feed cost/ Kg gain (₦)	745.81±61.72	841.06±61.71	702.39±67.66	800.49±63.13	0.97
Savings/Kg (₦)	95.25	-	98.10	-	

ab Means with different superscripts within the same row are significantly(P<0.05) different, LSM: Least square mean, SE: Standard error.

4.1.7 Interaction effect of Forage level and Sex on performance of rabbits

The interaction between forage level and sex on performance of rabbits is shown in Table 4.5. Female rabbits fed both 20% and 40% forage had significantly ($p<0.05$) higher total weight gain and average daily gain than male rabbits fed 20% forage while male rabbits fed 40% forage were not significantly different from others. The highest daily feed intake and total feed intake were recorded in male rabbits fed 40% forage and these were significantly ($p<0.05$) higher than male rabbits fed 20% forage and female rabbits fed 20% and 40% forage. Feed to gain ratio of male rabbits fed 40% forage was higher than those fed 20% forage while female rabbits fed 20 and 40% forage had similar feed to gain ratio. There were no significant interactions between sex and forage level on daily feed cost, total feed cost and feed cost per kilogram gain. Saving per kilogram gain was N172.73 for male rabbits fed 20% forage and N20.62 for female rabbits fed 20% forage respectively.

Table 4.5: Interaction effect of Forage level and Sex on Performance of Rabbits (LSM ±SE)

Sex	Male		Female		P value
Forage Level	20	40	20	40	
Total weight gain(g)	746.31±31.79^{b}	816.39±30.80^{ab}	864.50±31.42^{a}	847.82±30.13^{a}	0.05
ADG (g)	8.05±0.32^{b}	8.80±0.31^{ab}	9.32±0.32^{a}	9.14±0.31^{a}	0.05
Daily feed intake (g)	60.99±1.72^{b}	67.11±1.67^{a}	61.61±1.70^{b}	63.44±1.63^{b}	0.05
Total feed intake (g)	5977.28±168.98^{b}	6577.20±163.68^{a}	6037.94±167.00^{b}	6217.55±160.14^{b}	0.05
Feed to gain ratio	6.68±0.41^{c}	8.66±0.40^{a}	7.95±0.41^{ab}	7.56±0.39^{bc}	0.04
Daily feed cost (₦)	6.31±0.38	6.63±0.37	5.66±0.38	6.25±0.36	0.72
Total feed cost (₦)	618.51±37.31	650.10±36.14	554.28±36.87	612.10±35.36	0.72
Feed cost per Kg (₦)	709.87±65.12	882.60±63.08	738.33±64.36	758.95±61.72	0.41
Savings/Kg (₦)	172.73	-	20.62	-	

abc Means with different superscripts within the same row are significantly($P<0.05$) different. ADG means average daily gain, LSM: Least square means, SE: Standard error.

4.1.8 Interaction effect of Palm oil and Sex on performance of rabbit

Interaction effect of Palm oil and Sex on performance of rabbits is shown in Table 4.6. The result showed that female rabbits fed diets without palm oil had significantly lower total weight gain, average daily gain, feed intake, total feed intake than does fed diets with palm oil and bucks fed diets with or without palm oil. Although, there were no significant differences (P>0.05) in total weight gain, average daily gain, total feed intake, daily feed intake in female rabbits fed diets with palm oil, and males fed diets with or without palm oil, the females fed palm oil diets had slightly higher values than those on the other diets followed by males fed diets with and without palm oil. There was no significant effect of interaction between sex and palm oil on feed to gain ratio observed and feed cost per kilogram gain. Daily feed cost and total feed cost were significantly (P<0.05) lower in female rabbits fed diets without palm oil, and higher in male fed diets with palm oil. Male and female rabbits without palm oil had savings per kilogram gain of ₦29.31 and ₦16.94 respectively.

Table 4.6: Interaction effect of Palm oil and Sex on Performance of Rabbits (LSM ± SE)

Palm oil	Diets Without PO	Diets With PO	Diets Without PO	Diets With PO	P value
Sex		Male	Female		
Total weight gain (g)	892.82±32.29^{ab}	869.88±30.24^{ab}	808.37±31.42^{b}	903.94±30.13^{a}	0.05
Average daily gain (g)	9.68±0.33^{ab}	9.43±0.31^{ab}	8.76±0.32^{b}	9.80±0.31^{a}	0.05
Daily feed intake (g)	65.00±1.75^{a}	63.11±1.64^{ab}	58.70±1.70^{b}	66.36±1.63^{a}	0.005
Total feed intake (g)	6369.99±171.62^{a}	6184.49±160.71^{ab}	5752.64±167.00^{b}	6502.85±160.14^{a}	0.005
Feed to gain ratio	7.79±0.42	7.55±0.39	7.66±0.41	7.84±0.39	0.56
Daily feed cost (₦)	6.26±0.39^{ab}	6.68±0.36^{a}	5.64±0.38^{b}	6.26±0.36^{ab}	0.05
Total feed cost (₦)	613.94±37.89^{ab}	654.67±35.48^{a}	552.53±36.87^{b}	613.85±35.36^{ab}	0.05
Feed cost/ Kg gain(₦)	781.58±66.14	810.89±61.93	740.17±64.36	757.11±61.72	0.94
Savings/Kg (₦)	29.31	-	16.94	-	-

ab Means with different superscripts within the same row are significantly($P<0.05$) different. ADG means average daily gain, LSM: Least square mean, SE: Standard error.

4.2 CARCASS CHARACTERISTICS

4.2.1 Effect of Forage type and level on Carcass characteristics of rabbits

The effect of forage type and forage level on carcass characteristics of rabbit are presented in Table 4.7 and 4.8 respectively. Although forage type had no significant effect ($P>0.05$) on carcass characteristics, rabbits fed lablab forage meal tended to have higher carcass parameters than those fed groundnut forage meal. On the other hand, forage level had a significant effect ($P<0.05$) on live weight, slaughter weight and skin, liver, kidney and GIT weights; with rabbits fed 40% forage diet having significantly higher value than those fed 20% forage diets.

4.2.2 Effect of Palm oil on Carcass characteristics of rabbits

The carcass characteristic of rabbits as affected by palm oil supplementation is presented in Table 4.9. Significant differences ($P<0.05$, $P<0.01$) were observed in live weight, slaughter weight, skin, loin, kidney and dress weight with palm oil supplemented rabbits performing better than the unsupplemented group. Although no significant difference ($P>0.05$) were observed in head, hind leg, fore limb, liver, abdominal fat, heart, lungs, dressed weight, gastro intestinal tract and dressing percentage however, rabbit fed palm oil seems to have higher carcass than those fed without palm oil.

Table 4.7: Effect of Forage type on Carcass Characteristics of Rabbits (LSM ± SE)

Parameters	Forage meal type		P value
	Groundnut	Lablab	
Live weight (kg)	1.58±0.03	1.63±0.03	0.27
Slaughter wt. (g)	1.50±0.03	1.60±0.03	0.06
Head (g)	138.38±4.55	142.00±4.55	0.57
Hind leg (g)	27.88±1.21	29.25±1.21	0.43
Fore limb (g)	11.50±0.49	10.50±0.49	0.17
Skin (g)	156.75±4.67	159.75±4.67	0.65
Loin (g)	294.38±7.37	316.50±7.37	0.06
Liver (g)	35.25±0.87	33.38±0.87	0.13
Abdominal fat(g)	32.63±4.03	35.25±4.03	0.64
Kidney (g)	12.00±0.50	13.13±0.50	0.12
Heart (g)	3.25±0.21	3.56±0.21	0.29
Lungs (g)	12.50±0.80	13.88±0.80	0.24
Dressed wt. (g)	785.75±19.18	825.50±19.18	0.16
GIT (g)	15.81±0.38	15.94±0.38	0.82
Dressing percentage	51.69±0.82	52.50±0.38	0.82

GIT= Gastro intestinal tract. G/haulm= Groundnut haulm wt=weight, g= gram, LSM: Least square mean, SE: Standard error.

Table 4.8: Effect of Forage level on Carcass Characteristics of Rabbits (LSM ± SE)

Parameters	Level (%) Forage		P value
	20	40	
Live weight (kg)	1.52±0.03[b]	1.68±0.03[a]	0.003
Slaughter wt. (g)	1.49±0.03[b]	1.61±0.03[a]	0.008
Head (g)	141.25±4.55	139.13±4.55	0.94
Hind leg (g)	28.63±1.21	28.50±1.21	0.94
Fore limb (g)	11.38±0.49	10.63±0.49	0.29
Skin (g)	147.75±4.67[b]	168.75±4.67[a]	0.004
Loin (g)	295.88±7.37	315.00±7.37	0.08
Liver (g)	32.75±0.87[b]	35.88±0.87[a]	0.02
Abdominal fat (g)	29.25±4.03	38.63±4.03	0.11
Kidney (g)	11.25±0.50[b]	13.88±0.50[a]	0.001
Heart (g)	3.56±0.21	3.25±0.21	0.29
Lungs (g)	12.50±0.80	13.88±0.80	0.24
Dressed wt. (g)	782.13±19.18	829.13±19.18	0.10
GIT (g)	15.13±0.38[b]	16.63±0.38[a]	0.01
Dressing percentage	52.58±0.82	51.61±0.82	0.84

[ab] Means with different superscripts within the same row are significantly($P<0.05$) different.GIT= Gastro intestinal tract, wt=weight. g= gram, LSM: Least square mean, SE: Standard error.

Table 4.9: Effect of Palm oil (PO) supplementation on Carcass Characteristics of Rabbits (LSM ± SE)

Parameters	Palm oil Supplementation		P value
	Without PO	With PO	
Live weight (kg)	1.52±0.03[b]	1.68±0.03[a]	0.003
Slaughter wt. (g)	1.42±0.03[b]	1.58±0.03[a]	0.003
Head (g)	136.00±4.55	144.38±4.55	0.21
Hind leg (g)	28.13±1.21	29.00±1.21	0.61
Fore limb (g)	10.75±0.49	11.25±0.49	0.48
Skin (g)	151.13±4.67[b]	165.38±4.67[a]	0.04
Loin (g)	291.25±7.37[b]	319.63±7.37[a]	0.01
Liver (g)	33.25±0.87	35.38±0.87	0.10
Abdominal fat (g)	29.13±4.03	38.75±4.03	0.10
Kidney (g)	11.75±0.50[b]	13.38±0.50[a]	0.03
Heart (g)	3.44±0.21	3.38±0.21	0.83
Lungs (g)	12.25±0.80	14.13±0.80	0.11
Dressed wt. (g)	771.75±19.18[b]	839.50±19.18[a]	0.02
GIT (g)	15.63±0.48	16.13±0.48	0.37
Dressing percentage	52.32±0.82	51.87±0.82	0.70

[ab] Means with different superscripts within the same row are significantly($P<0.05$) different. GIT= Gastro intestinal tract, wt=weight. g= gram, LSM: Least square mean, SE: Standard error.

4.2.3 Interaction effect of Forage type and Palm oil supplementation on carcass characteristics of rabbits

Table 4.10 shows the effect of interaction between forage type and palm oil supplementation on carcass characteristics of rabbits. There was a significant interaction effects on carcass characteristics in rabbits. Live weight of rabbits fed lablab forage and palm oil were significantly higher ($P<0.05$) than those fed either groundnut or lablab forage without palm oil. However, live weights of those fed groundnut forage with palm oil were not significantly different. Rabbits fed groundnut forage meal with palm oil had significantly ($P<0.05$) higher weight of skin than those without palm oil, these were not significantly different from those fed lablab forage with and without palm oil. Highly significant difference were observed in the weight of loin ($P<0.05$), kidney ($P<0.01$) and heart ($P<0.01$) of rabbits fed lablab and palm oil compared to other treatments. Rabbits fed groundnut forage meal supplemented with palm oil had significantly ($P<0.05$) higher weight of abdominal fat than those without palm oil which were similar with lablab forage meal fed rabbits with or without palm oil supplementation. Generally, rabbits fed lablab and palm oil had significantly higher carcass parts and organs studied. There were no significant difference ($P>0.05$) in head, hind leg, fore limb, dressing percentage and gastro intestinal tract.

Table 4.10: Interaction effect of Forage type and Palm oil (PO) on Carcass Characteristics of Rabbits (LSM ± SE).

Forage type	Groundnut		Lablab		
Palm oil	Without PO	With PO	Without PO	With PO	P value
Live weight (kg)	1.53±0.05^{b}	1.63±0.05^{ab}	1.52±0.05^{b}	1.74±0.05^{a}	0.05
Slaughter wt. (g)	1.48±0.04^{b}	1.53±0.04^{b}	1.47±0.04^{b}	1.64±0.04^{a}	0.05
Head (g)	136.25±6.44	140.50±6.44	135.75±6.44	148.25±6.44	0.53
Hind leg (g)	28.00±1.71	27.75±1.71	28.25±1.71	30.25±1.71	0.52
Fore limb (g)	11.00±0.70	12.00±0.70	10.50±0.70	10.50±0.70	0.48
Skin (g)	146.25±6.60^{b}	167.25±6.60^{a}	156.00±6.60^{ab}	163.50±6.60^{ab}	0.02
Loin (g)	286.00±10.42^{b}	302.75±10.42^{b}	296.50±10.42^{b}	336.50±10.42^{a}	0.02
Liver (g)	35.50±1.23^{a}	35.00±1.23^{a}	31.00±1.23^{b}	35.75±1.23^{a}	0.04
Abd. fat (g)	21.50±5.70^{b}	43.75±5.70^{a}	36.75±5.70^{ab}	33.75±5.70^{ab}	0.04
Kidney (g)	12.50±0.70^{b}	11.50±0.70^{b}	11.00±0.70^{b}	15.25±0.70^{a}	0.001
Heart (g)	3.75±0.29^{ab}	2.75±0.29^{c}	3.13±0.29^{bc}	4.00±0.29^{a}	0.004
Lung (g)	11.50±1.13^{a}	13.50±1.13^{ab}	13.00±1.13^{ab}	14.75±1.13^{a}	0.04
Dressed wt. (g)	766.00±27.12^{c}	805.50±27.12^{ab}	777.50±27.18^{bc}	873.15±27.13^{a}	0.05
GIT (g)	15.38±0.54	16.25±0.54	15.88±0.54	16.00±0.54	0.50
Dressing %	52.01±1.17	51.37±1.17	52.64±1.17	52.36±1.17	0.88

abc Means with different superscripts within the same row are significantly($P<0.05$) different. GIT= Gastro intestinal tract. Abd. fat = Abdominal fat, wt=weight, LSM: Least square mean, SE: Standard error.

4.2.4 Interaction effect of Forage type and Forage level on carcass characteristics of rabbits

Table 4.11 shows the effect of interaction between forage type and forage level on carcass characteristics of rabbits. There were highly significant differences ($P<0.01$) in live weight and slaughter weight of rabbits fed 40% lablab forage than those fed groundnut forage at 20 and 40% and lablab at 20% levels. The weight of skin of rabbits fed 40% lablab forage was significantly higher ($P<0.05$) from those fed 20% forage and lablab, these were not significantly different from other treatments. Similarly, the weight of the loin was significantly higher ($P<0.05$) in rabbits fed 40% lablab forage, than those fed groundnut forage at 20 and 40% and lablab at 20%. Also, the weight of the liver was significantly higher ($P<0.01$) in rabbits fed 40% lablab forage than rabbits fed 40% groundnut and 20% lablab, while 20% groundnut was not significantly different from rabbits fed 40% lablab forage. The weight of kidney, and gastro intestinal tract was significantly higher ($P<0.05$) in 40% lablab forage and lower in rabbits fed 20% groundnut forage which was similar with rabbits on 20% lablab and 40% groundnut forage meals. Rabbits fed 40% lablab forage had significantly higher ($P<0.01$) dressed weight than other treatments. There was no significant interaction ($P>0.05$) between forage type and level on head, hind leg, fore limb, abdominal fat, heart, lungs and dressing percentage.

Table 4.11: Interaction effect of Forage type and Forage level on Carcass Characteristics of Rabbits (LSM ± SE).

	Groundnut		Lablab		P value
Forage level	20	40	20	40	
Live weight (kg)	1.59±0.05^{b}	1.56±0.05^{b}	1.46±0.05^{b}	1.81±0.05^{a}	0.008
Slaughter wt. (g)	1.53±0.04^{b}	1.48±0.04^{b}	1.40±0.04^{b}	1.74±0.04^{a}	0.004
Head (g)	139.00±6.44	137.75±6.44	143.50±6.44	140.50±6.44	0.89
Hind leg (g)	29.00±1.71	26.75±1.71	28.25±1.71	30.25±1.71	0.23
Fore limb (g)	11.75±0.70	11.25±0.70	11.00±0.70	10.00±0.70	0.72
Skin (g)	148.75±6.60^{ab}	164.75±6.60^{ab}	146.75±6.60^{b}	172.75±6.60^{a}	0.05
Loin (g)	295.75±10.42^{b}	293.00±10.42^{b}	296.00±10.42^{b}	337.00±10.42^{a}	0.05
Liver (g)	36.75±1.23^{ab}	33.75±1.23^{b}	28.75±1.23^{c}	38.00±1.23^{a}	0.001
Abd. Fat (g)	31.25±5.70	34.00±5.70	27.25±5.70	43.25±5.70	0.26
Kidney (g)	11.00±0.70^{b}	13.00±0.70^{ab}	11.50±0.70^{ab}	14.75±0.70^{a}	0.03
Heart (g)	3.50±0.29	3.00±0.29	3.63±0.29	3.50±0.29	0.53
Lung (g)	12.25±1.13	12.75±1.13	12.75±1.13	15.00±1.13	0.45
Dressed wt (g)	799.00±27.12^{b}	772.50±27.12^{b}	765.25±27.12^{b}	885.75±27.12^{a}	0.01
GIT (g)	15.25±0.54^{ab}	16.38±0.54^{ab}	15.00±0.54^{b}	16.88±0.54^{a}	0.05
Dressing %	51.94±1.17	53.22±1.17	51.45±1.17	51.78±1.17	0.68

^{abc} Means with different superscripts within the same row are significantly($P<0.05$) different. GIT= Gastro intestinal tract. Abd. fat = Abdominal fat, wt=weight, LSM: Least square mean, SE: Standard error.

4.2.5 Interaction effect of Forage level and Palm oil (PO) on carcass characteristics of rabbits.

Table 4.12 shows the interaction effect of forage level and palm oil (PO) supplementation on carcass characteristics of rabbits. The result showed significant ($P<0.05$) interaction between forage level and palm oil supplementation for most parameters except in head, hind leg and fore limb. Rabbits fed 40% forage with palm oil had a significant increase in live weight and slaughter weight ($P<0.05$) while those in the rest of the treatment had similar live weight and slaughter weights. Also rabbits fed 40% forage with palm oil had a significantly higher weight of skin ($P< 0.05$) and loin ($P<0.05$) than those fed 20% without palm oil, while the rest of the treatment had similar weight for loin. The weight of the liver($P< 0.01$) and abdominal fat ($P<0.05$) were significantly lower in rabbits fed 20% forage without palm oil compared to other treatments which were not significantly different. Rabbits fed 40% forage with palm oil also had the highest kidney weight and was significantly different ($P<0.05$) from the rest of the treatments. The weight of the heart was significantly higher ($P< 0.05$) in rabbits fed 20% forage without palm oil than rabbits fed 40% forage without palm oil, these were not significantly different from those fed 20% and 40% with palm oil. The weight of the lungs was significantly higher ($P<0.05$) in rabbits fed 40% forage with palm oil than rabbits fed 20%without palm oil while these were not significantly different from other treatments. There were no significant difference ($P>0.05$) in the dressing percentage but rabbits fed 20% forage with palm oil had a slightly higher dressing percentage than other treatments. The dressed weight ($P<0.05$) and gastrointestinal tract ($P<0.05$) of rabbits fed 40% forage with palm oil were significantly higher than other treatments.

Table 4.11: Interaction effect of Forage level and Palm oil (PO) on Carcass Characteristics of Rabbits (LSM ± SE).

Forage level	20	20	40	40	P value
Palm oil	Without	With	Without	With	
Live weight (kg)	1.50±0.05^{b}	1.59±0.05^{b}	1.59±0.05^{b}	1.78±0.05^{a}	0.05
Slaughter wt.(g)	1.46±0.04^{b}	1.49±0.04^{b}	1.54±0.04^{b}	1.68±0.04^{a}	0.05
Head (g)	136.25±6.44	146.25±6.44	135.75±6.44	142.50±6.44	0.80
Hind leg (g)	28.50±1.71	28.75±1.71	27.75±1.71	29.25±1.71	0.72
Fore limb (g)	11.25±0.70	11.50±0.70	10.25±0.70	11.00±0.70	0.72
Skin (g)	139.75±6.60^{c}	155.75±6.60^{bc}	162.50±6.60^{ab}	175.00±6.60^{a}	0.05
Loin (g)	295.25±10.42^{b}	296.50±10.42^{b}	287.25±10.42^{b}	342.75±10.42^{a}	0.02
Liver (g)	29.25±1.23^{b}	36.25±1.23^{a}	37.25±1.23^{a}	34.50±1.23^{a}	0.006
Abd. Fat (g)	20.75±5.70^{b}	37.75±5.70^{a}	37.50±5.70^{a}	39.75±5.70^{a}	0.05
Kidney(g)	11.25±0.70^{b}	11.25±0.70^{b}	12.25±0.70^{b}	15.50±0.70^{a}	0.03
Heart (g)	3.88±0.29^{a}	3.25±0.29^{ab}	3.00±0.29^{b}	3.50±0.29^{ab}	0.05
Lung (g)	11.25±1.13^{b}	13.75±1.13^{ab}	13.25±1.13^{ab}	14.50±1.13^{a}	0.04
Dressed wt. (g)	772.50±27.12^{b}	791.75±27.12^{b}	771.00±27.12^{b}	887.25±27.12^{a}	0.03
GIT (g)	15.25±0.54^{ab}	15.00±0.54^{b}	16.00±0.54^{ab}	17.25±0.54^{a}	0.05
Dressing %	53.11±1.17	52.05±1.17	51.54±1.17	51.69±1.17	0.61

abc Means with different superscripts within the same row are significantly($P<0.05$) different. GIT= Gastro intestinal tract. Abd. fat = Abdominal fat, LSM: Least square mean, SE: Standard error.

4.3 HORMONE PROFILE OF RABBITS

4.3.1 Effect of Age (weeks) on hormone profile of rabbits

Table 4.13 shows the hormone profile of rabbits fed diets containing different level of forage with or without palm oil. The result shows a significant surge ($P<0.05$) in serum concentration of testosterone in males and progesterone in females at 14 weeks of age. Progesterone in males showed a consistent gradual increase with age. However level of progesterone were significantly higher ($P<0.05$) in females than males of the same age.

4.3.2 Effect of Forage type on hormone profile of rabbits

The effect of forage type on hormone profile of rabbits is presented in Table 4.14. There was no significant difference ($P>0.05$) in serum concentration of testosterone between rabbits fed groundnut meal and lablab forage meal. However, there were significant difference ($P<0.05$) in serum concentrations of progesterone in both male ($P<0.05$) and female ($P<0.01$) rabbits fed groundnut forage meal than those fed lablab forage meal.

Table 4.12: Effect of Age (weeks) on Hormone Profile of Rabbits

Hormone (ng/ml)	12	14	16	18
Testosterone	0.81 ± 0.48^{c}	2.50 ± 0.48^{b}	3.35 ± 0.48^{b}	5.67 ± 0.48^{a}
Progesterone (F)	0.59 ± 0.54^{d}	2.17 ± 0.54^{c}	3.83 ± 0.54^{b}	6.27 ± 0.54^{a}
Progesterone (M)	0.11 ± 0.12^{c}	0.24 ± 0.12^{c}	0.75 ± 0.12^{b}	1.50 ± 0.12^{a}

[abcd]Means with different superscripts within the same row are significantly ($P<0.05$) different. ng/ml: nanogram per milliliter, F: Female, M: Male

4.3.3 Effect of Forage level on hormone profile of rabbits.

The effect of forage level on hormone profile of rabbits is shown in Table 4.14. There were no significant differences ($P>0.05$) in testosterone of male and progesterone levels in female rabbits fed with 20% or 40% forage meal diets. Significantly higher ($P<0.01$) progesterone level was observed in male rabbits fed with 40% forage level than those fed 20%.

4.3.4 Effect of Palm oil (PO) on hormone profile of rabbits.

The effect of palm oil on hormone profile of rabbits is shown in Table 4.14. There were no significant differences ($P>0.05$) in serum testosterone and progesterone of female rabbits fed diets with or without PO. Progesterone levels was however highly significant ($P<0.01$) in male rabbits fed forage diets supplemented with palm oil than those fed diets without PO.

Table 4.13: Effect of Forage type, Forage level and Palm oil (PO) on Hormone profile of Rabbits.

	Forage type			Forage level			Palm oil		
Hormone (ng/ml)	Groundnut	Lablab	P value	20	40	P value	-PO	+PO	P value
Testosterone	3.02±0.46	3.13±0.46	0.87	3.15±0.46	3.02±0.46	0.80	3.46±0.46	2.71±0.46	0.25
Progesterone (F)	3.90±0.43[a]	2.53±0.43[b]	0.03	2.88±0.44	3.55±0.11	0.29	2.98±0.44	3.46±0.44	0.44
Progesterone (M)	0.92±0.11[a]	0.39±0.11[b]	0.0007	0.44±0.11[b]	0.87±0.11[a]	0.007	0.46±0.11[b]	0.85±0.11[a]	0.01

[ab]Means with different superscripts within the same row are significantly different. ng/ml: nanogram per milliliter, F: Female, M: Male. –PO: without palm oil. +PO: with palm oil.

4.3.5 Interaction effect of Forage type and Age on hormone profile of rabbits.

Interaction effect of forage type and age on hormone profile of rabbits is shown in Table 4.15. The result showed that serum testosterone and progesterone level of rabbits increased significantly as the animal aged. The general trend observed in this result indicated that as the animal aged, the serum testosterone and progesterone level increase except for rabbits fed lablab at 16 weeks which had a reduction in the level of testosterone from (3.20±0.62) at 14^{th} week to (2.05±0.62) at 16 weeks. Rabbits fed lablab at 18 weeks had significantly ($P<0.05$) higher testosterone level than those fed groundnut forage meal. Serum progesterone levels were higher for male and female rabbits fed groundnut forage meal than lablab forage meal at 18 weeks of age.

4.3.6 Interaction effect of Forage level and Age on hormone profile of rabbits

The effect of interaction between forage level and age on hormone profile of rabbits is presented in Table 4.16. The result showed that rabbits fed 20% and 40% forage had significantly ($P<0.05$) higher serum testosterone and progesterone (female) levels with age being highest at 18 weeks. The serum progesterone level of male rabbits fed 40% forage at 18 weeks was significantly ($P<0.05$) higher than in those fed 20% forage.

Table 4.14: Interaction effect of Forage types and Age on Hormone Profile of Rabbits

Hormone (ng/ml)	Groundnut				Lablab			
	Age (weeks)				Age (weeks)			
	12	14	16	18	12	14	16	18
Testosterone	0.78±0.62^{d}	1.80±0.62^{cd}	4.65±0.62^{b}	4.89±0.62^{b}	0.84±0.62^{d}	3.20±0.62^{c}	2.05±0.62^{c}	6.45±0.62^{a}
Progesterone (F)	1.03±0.76^{cd}	2.55±0.76^{c}	4.56±0.76^{b}	7.45±0.76^{a}	0.16±0.76^{e}	1.79±0.76^{cd}	3.10±0.76^{bc}	5.09±0.76^{b}
Progesterone (M)	0.14±0.17^{c}	0.36±0.17^{c}	1.11±0.17^{b}	2.05±0.17^{a}	0.08±0.17^{c}	0.13±0.17^{c}	0.39±0.17^{c}	0.95±0.17^{b}

^{abcde}Means with different superscripts within the same row are significantly (P<0.05) different. ng/ml: nanogram per milliliter, F:Female, M:Male

Table 4.15: Interaction effect of Forage level and Age on Hormone Profile of Rabbits

Hormone (ng/ml)	20% forage				40% forage			
	Age (weeks)				Age (weeks)			
	12	14	16	18	12	14	16	18
Testosterone	1.05±0.69^{cd}	2.84±0.69^{b}	3.00±0.69^{b}	5.70±0.69^{a}	0.56±0.69^{d}	2.16±0.69^{bc}	3.70±0.69^{b}	5.64±0.69^{a}
Progesterone (F)	0.21±0.77^{de}	1.56±0.77^{d}	2.94±0.77^{c}	6.82±0.77^{a}	0.98±0.77^{de}	2.78±0.77^{c}	4.72±0.77^{b}	5.71±0.77^{ab}
Progesterone (M)	0.10±0.17^{e}	0.31±0.17^{d}	0.49±0.17^{d}	0.85±0.17^{bc}	0.13±0.17^{de}	0.18±0.17^{d}	1.01±0.17^{b}	2.15±0.17^{a}

^{abcde}Means with different superscripts within the same row are significantly (P<0.05) different. ng/ml: nanogram per milliliter, F:Female, M:Male

CHAPTER FIVE

5.0 DISCUSSION

5.1 PERFORMANCE OF RABBITS

5.1.1 Effect of Forage level on performance of rabbits

The observed increase in total weight gain and average daily gain of rabbits fed 20% forage than those fed 40% forage could be attributed to proper utilization of the feed by the rabbits in that group. This finding is in agreement with the report of El-Gendy (1999b) who fed lupin (*Lupines albus*), but disagrees with Tangendjaja *et al*. (1990) who reported 40% *Leucaena leucocephala* replacement for concentrate as ideal to support growth without adverse effect. The rate of gain in this study agrees with the daily growth rate of 5-10g reported by Iyeghe-Erakpotobor *et al*. (2001) during the grower phase of rabbits and growth rates of 10 to 12g/day with fresh lablab with molasses or sugar cane though lower than growth rate of 28.9g/day for rabbits fed alfalfa with molasses blocks reported by Linga and Lukefahr (2000). The result is also lower than the range of 10-20 g/day for weight gain of rabbits reported by Lukefahr and Cheeke (1990) in the tropics.

The general increase in feed intake of rabbits fed 40% forage could be attributed to increased fibre content of the diets. It is also possible that a reduction in metabolizable energy value could have resulted in the rabbits' increased feed intake to meet the energy deficient. The observed increase in feed intake and feed to gain ratio with increased level of forage inclusion at 40% is in line with the report of Taiwo *et al*. (1999), who attributed this to the rabbits' tendency to eat more of a diet containing high crude fibre and ash content. However, Nworgu *et al*. (1999) reported that an increase in the percentage of forage meal in the diet reduced feed intake of rabbits, while Scapinello *et al*. (2000)

stated that inclusion of cassava leaves and stem hay up to 20% in rabbit diets did not affect the general performance. Rabbits can also tolerate up to 40% of broom grass (*Thysanolaena mnxima*) in their diets without adverse effect on the growth performance (Rohilla and Bujarbaruah, 2000).

The non significant (P>0.05) difference in daily feed cost, total feed cost and feed cost per kg gain observed in this study agrees with the findings of Iyeghe-Erakpotobor (2012) who fed groundnut and sole lablab forage or mixed to rabbits and observed similar feed cost and feed cost per kg gain for forages fed. Higher saving/kg gain was obtained on 20% forage meal level than 40% in this study, however, Iyeghe-Erakpotobor *et al*. (2012) reported savings/kg gain increased with increase in level of groundnut haulms (15 to 45%) from ₦7.9 to ₦107.6. Higher savings/kg gain obtained for 20% forage level indicates that it is cheaper to use this level of forage meal in feeding rabbits as it would ultimately increase the profit margin of a rabbit enterprise over and above 40% inclusion level.

5.1.2 Effect of Forage type on performance of rabbits

Similar performance that was observed in rabbits fed the two forage types could be attributed to the palatability and the acceptance of these two forages by rabbits. The non significant effect of forage type supports the findings of Iyeghe-Erakpotobor (2012) who reported that forage type did not affect final weight, feed intake, weight gain, feed cost per kg of rabbits. Iyeghe-Erakpotobor *et al.* (2002) reported similar weight gain when rabbits were fed groundnut haulms, lablab and mucuna forages while Iyeghe-Erakpotobor *et al*. (2011) reported significantly higher feed cost/kg gain for rabbits fed groundnut than

lablab forage meal. Similarly Bawa *et al*. (2008), fed rabbits groundnut haulms and cowpea shells and obtained significant differences (P<0.05) in final weight, feed intake, weight gain and cost per kg gain between the dietary treatments

Similar weight gains by rabbits fed groundnut meal and lablab forage indicates the palatability and acceptance of the two forages by rabbits. The values obtained for weight gain of rabbits fed lablab (889.95g) and groundnut (847.56g) in this study is higher than the values (715.51, 603.46 and 605.10) reported by Omole *et al*. (2007), when rabbits were fed with sole *Stylosanthes guianensis*, *lablab purpureus* and sun flower forage meals respectively. Daily weight gain obtained in this study are lower than those reported by Iyeghe-Erakpotobor *et al.* (2011) who obtained daily gain of 12.16 g for rabbits fed groundnut forage meal and 13.02 g for those fed lablab forage meal. Aderinola *et al*. (2008) reported that average final weight, feed intake, daily weight gain and feed efficiency were significantly influenced by different diets and concluded that incorporation of *Centrosema pubescens* at 20% inclusion level gave better result than incorporation of *Calapogonium mucunoides.*

Feed conversion and feed cost obtained in this study agree with Iyeghe-Erakpotobor *et al*. (2011) who reported that feed conversion and feed cost were similar for both forages however feed cost/kg gain was higher on groundnut than lablab forage. In this study however, feed cost/kg gain was similar for both forage types. Saving/kg gain of ₦42.00 obtained for lablab over groundnut forage meal in this study is similar to Iyeghe-Erakpotobor (2012) who compared the feed cost/kg gain of rabbits fed lablab forage meal with groundnut forage meal and obtained savings/kg gain of $0.27 (₦40.50) for rabbits fed lablab forage meal than those fed groundnut forage. Iyeghe-Erakpotobor *et al*. (2011)

also obtained a saving of ₦30.12 per kilogram weight gain with lablab forage meal over groundnut forage. Higher savings/kg gain obtained on lablab over groundnut forage meal indicates that it would be cheaper to feed lablab to rabbits than groundnut on the long run. The problem of higher availability of groundnut haulms over lablab forage would however put groundnut forage at an advantage for use by farmers except if the rabbit farmer is a crop producer or lives in areas where lablab farming is commonly practiced like in the northern regions where more access to lablab forage is feasible. An alternative would be to encourage commercial production of lablab and groundnut forage meals for feeding rabbits.

5.1.3 Effect of Palm oil (PO) inclusion on performance of rabbits

The non significant difference (P>0.05) in all the performance of rabbits fed diets with or without palm oil could be an indication that the percentage of palm oil incorporated into the diets were not sufficient to show a significant effect. Lebas (1975) had earlier reported that addition of fat may not have any effect on performance of rabbits. Iyeghe and Ekpenyong (1990) also reported a non- significant increase in weight gains in rabbits fed palm oil at 3% and 5% of the diet. Feed intake of 61.85-64.73 g/day of rabbits in this study are similar with 63.89-82.46 g/day (Adejinmi *et al*., 2013) and 51.28-71.88 g/day (Attah and Ekpeyong, 1998) but higher than 44.61-47.30 g/day reported by Adeosun and Iyeghe-Erakpotobor (2012). Lower feed cost/kg gain and higher saving/kg gain obtained with rabbits without palm oil indicates the potential of reducing cost of producing rabbits on diets without palm oil.

5.1.4 Effect of Sex on performance of rabbits

Similarities in weight gain by both sexes observed in this study supports the finding of Ekpo *et al*. (2008) who did not observe any difference between the sexes in growth performance of rabbits fed unpeeled, peeled cassava tuber and cassava peel meals. Laxmi *et al*. (2009) also reported non-significant effect of sex on body weights of rabbits at ages 4, 8, and 16 weeks. Similarly, Nakkitset *et al*. (2007) observed no effect of sex on growth performance or feed intake when ruzi grass, head lettuce residue, Mimosa pigra and water spinach were fed to rabbits. Total weight gain, feed intake, average daily gain and total feed intake was slightly higher in male than in female and this is equally supported by Iyeghe-Erakpotobor (2012), who observed a non-significant difference in both sexes but a higher feed intake in males than females. The current results are different from the report by Lazzaroni and Biagini (2002) which show a higher feed intake by female than male rabbits.

Saving/kg gain of ₦49.59 obtained for female over male rabbits is close to ₦55.50 reported for female rabbits by Iyeghe-Erakpotobor and Adeyegun (2012). Feeding sole groundnut forage meal diet to male rabbits gave a saving/kg gain of $0.17 (₦ 25.50) than lablab forage meal diet while saving/kg gain was $0.88 (₦132.00) for female rabbits fed lablab forage over those fed groundnut forage meal diets (Iyeghe-Erakpotobor, 2012). Lower feed cost/kg gain and higher saving/kg gain obtained in female rabbits is an indication that there is a tendency of reducing cost of production when raising female rabbits than male rabbits.

5.1.5 Interaction effects of Forage level and Palm oil (PO) on performance of rabbits

There were significant improvements in total weight gain, average daily gain, feed intake and feed to gain ratio with supplementation of 20% forage meal with palm oil. This observation is in line with the report of Iyeghe and Ekpenyong (1990) that palm oil supplementation in rabbit diet improved growth performance by increasing weight gain; feed conversion, fat and crude fibre digestion. The significant difference ($P<0.05$) in feed: gain ratio is in agreement with the reports of Omole and Onwudike (1983) and Nuhu (2010) that showed significant difference ($P<0.05$) in feed:gain ratio in weaner rabbits fed cassava peel supplemented with palm oil, and when soya bean meal was replaced with moringa leaf meal in the diets of weaner rabbits. Improved performance of rabbits with inclusion of palm oil in the diet was reported to be as a result of the protein-sparing action of the oil which makes more protein available for tissue synthesis (Iyeghe and Ekpenyong, 1990).

Addition of palm oil in forage meal diets only improved the performance of rabbits at 20% level, and not at 40% level which had similar performance whether palm oil was supplemented or not, shown by similar weight gain, feed intake and feed to gain ratio. Similar feed intakes observed for 40% forage level with or without palm oil supplementation and 20% forage level supplemented with palm oil might indicate a dilution of energy supplied by palm oil with the additional forage because the same level of palm oil was added for the 20 and 40% forage levels. Adeosun and Iyeghe-Erakpotobor (2012) observed that inclusion of the same quantity of palm oil to varying levels of sugarcane peel (0, 10, 20, 30 and 40%) diets to reduce dustiness and increase energy level did not increase feed intake of rabbits.

Although there was no significant (P>0.05) interaction between forage level and palm oil supplementation on daily feed cost, total feed cost and feed cost per kg gain, supplementation of 40% forage meal diet with palm oil seems to have resulted in a higher cost. This is an indication that supplementation of high forage diets with palm oil might not improve performance and it would therefore be better to only supplement lower forage levels in order to improve performance.

5.1.6 Interaction effect of Forage level and Forage types on performance of rabbits

Alawa and Amadi (1991) had earlier reported that ability of rabbits to utilize highly fibrous diets may depend on the level of replacement, nature of the fibre source, age of rabbit and the length of adaptation period of their digestive system to the fibre source. Thus the higher feed intake observed in rabbits fed 40% groundnut meal might be as a result of increase in the fibre content of the diet with increased level of forages. However, this is contrary to the report of Nworgu *et al*. (1999) which showed a reduction in feed intake by rabbits on increased forage meal in the diet. The depressed feed intake by rabbits fed 20% groundnut haulms may be related to variation in the nutrient content of individual diets.

Rabbits fed 20% lablab had the highest weight gain compared to rabbits fed 40% groundnut forage meal which was the lowest amongst the groups. This finding agrees with Ngodigha *et al*. (1994) who observed that up to 50% of groundnut haulms can support weight gain of growing rabbits. Also Iyeghe-Erakpotobor *et al.* (2012), observed that weight gain of rabbits were unaffected by the level of groundnut forage and rabbits can be fed up to 45% groundnut forage meal. Daily gains of 14.14-12.17 g was obtained

with 0 to 20% lablab forage meal (Iyeghe-Erakpotobor and Yakubu, 2009) while Iyeghe-Erakpotobor and Adeyegun (2012) obtained daily gains of 9.34-10.72 g with 0 to 20% groundnut forage meal fed to growing rabbits. Fotso *et al*. (2000) reported that up to 42% of cassava leaf meal can be fed to growing rabbit with positive result. Similarly, Rohilla and Bujarbaruah (2000) revealed that rabbits can tolerate up to 40% of broom grass (*Thysanolaena maxima*) in their diets without adverse effect on growth performance.

5.2 CARCASS CHARACTERISTICS

5.2.1 Effect of Forage type on carcass characteristics of rabbits

The non significant difference (P>0.05) observed in carcass characteristics of rabbits fed groundnut and lablab forages agrees with Omole *et al*. (2007) who observed a non significant difference in the dressing percentage, liver weight and heart weight of rabbits fed *Stylosanthes guianensis* and *Lablab purpureus* forage. Amata (2010) also reported a non significant difference in the carcass characteristics of rabbits fed Gliricidia leaf meal (GLM). Similarly, Bawa *et al*. (2008) observed a non significant difference in the yield of heart, kidney and thigh but observed a significant difference for the pre-slaughter weight, carcass weight and dressing percentage when rabbits were fed groundnut haulms and cowpea shells. Wasem (2013) observed significant increase in the loin, head, neck and organs: heart, liver and lung of rabbits fed with 50% groundnut haulm.

5.2.2 Effect of Forage level on carcass characteristics of rabbits

The significant differences in live weight, slaughter weight, skin, liver, kidney and gastro-intestinal tract showed a trend in these parameters with 40% forage inclusion level

being higher than those fed 20% forage. The non-significant difference obtained in hind leg, fore limb and loin agrees with Adeosun and Iyeghe-Erakpotobor (2012) who reported similar dressing percentage, hind legs, fore legs, loin, chest, liver, kidney, lung and heart percentages for rabbits fed 0, 10, 20, 30 and 40% sugarcane peel diets, but disagrees with Abdu *et al*. (2012) who observed significant difference in the shoulder, thigh and loin when rabbits were fed carrot leaf meal at 0, 15, 30, 45 and 60% inclusion level.

The weight of 2.75-4.00 g obtained in this study for heart agrees with the 3.00-4.33 g reported by Nuhu (2010) however, weight of lungs (11.25-15.00g) obtained disagree with 9.00-13.10 g reported by Nuhu (2010) for lungs. The weights obtained for liver (28.75-38.00g) are lower than 32.33-44.00 g reported by Nuhu (2010), and 30.36-42.84 g by Amata and Bratte (2008). Kidney weight (11.00-15.50g) obtained is higher than 5.18-6.36 g reported by both Nuhu (2010) and Amata and Bratte (2008) who partially replaced gliricidia leaf meal for soya bean meal in the diets of weaner rabbits in the tropics.

5.2.3 Effect of palm oil (PO) on carcass characteristics of rabbits

Palm oil supplementation significantly ($P<0.05$) affected live weight, slaughter weight, skin, loin and kidney while dressing percentage, hind leg, head, liver, abdominal fat, heart, gastrointestinal tract weights were not statistically different. Peiretti *et al*. (2011), who observed that hind legs, fore legs, loin and abdominal wall, breast and ribs, head were not affected by oil type. The significant effect of palm oil supplementation on loin weight in this study disagrees with the result of Peiretti *et al*. (2011). Iyeghe- Erakpotobor *et al*. (2000) observed that palm oil supplementation at 0%, 3% and 5% did not

significantly affect carcass and organ yield. Fajimi *et al*. (1993), also observed a non significant difference in all the organs except gizzard when broilers were fed palm oil.

5.2.4 Interaction effects of Forage type and Palm oil (PO) on carcass characteristics of rabbits

Rabbits fed lablab forage supplemented with palm oil had significantly higher carcass parts and organs studied than those fed groundnut forage meal diets supplemented with palm oil. This might likely be because of better utilization of nutrients for tissue synthesis and growth by rabbits on lablab occasioned by the high crude protein content of 14.3-38% (Milford and Minson 1968; Karachi, 1997; Evans, 2002; Iyeghe-Erakpotobor and Yakubu, 2009). Groundnut forage on the other hand contains crude protein of 10.31% (Iyeghe-Erakpotobor and Adeyegun, 2012), Rabbits fed groundnut forage meal supplemented with palm oil had significantly ($P<0.05$) higher weight of skin and abdominal fat than those without palm oil which were similar with lablab forage meal fed rabbits with or without palm oil supplementation. The reason for the increase in abdominal fat weight of rabbits with groundnut forage could be that groundnut might have some hormonal properties.

5.3 HORMONE PROFILES

5.3.1 Effect of Age on hormone profile of rabbits

Serum concentration of progesterone in male and female rabbits significantly ($P<0.05$) increased as they aged. Shahnaz *et al*. (2000) observed that during the pre-pubertal phase; progesterone and estradiol remain at the basal level, however a few days before the onset

of puberty some fluctuations were observed. Progesterone and estradiol remain at the basal level of 0.1-0.6 ng/ml during the pre-pubertal phase of growth except for a small irregular rise nearing puberty (Shahnaz *et al*., 2000). Male progesterone levels were higher than the reported basal levels at 16 and 18 weeks of age. From progesterone and testosterone levels obtained in the 14th week of age, it would appear that the rabbits attained puberty around the 14th week of age. Baldwin and Stabenfeldt (1974) reported progesterone levels as 1.5, 13.3 and 3.3 ng/ml of plasma respectively in the periods prior to mating, mid pregnancy (Day 18) and at the end of gestation. Progesterone levels obtained in this study are higher at 14 weeks than 1.5 ng/ml reported prior to mating, and in the 16th and 18th week of age than 3.3 ng/ml reported for end of gestation.

5.3.2 Effect of forage type on hormone profile of rabbits

Higher serum progesterone level in male and female rabbits fed groundnut haulms than those fed lablab in this study might indicate that rabbits fed groundnut forage could have attained puberty earlier than those fed lablab forage meal. Similarly testosterone concentrations observed for both groundnut and lablab would indicate similar attainment of puberty in male rabbits. Testosterone is needed to initiate spermatogenesis at puberty and for the maintenance of this process in the adult (Castro *et al*., 2002). Environmental conditions, such as nutrition or environmental temperature can influence the hormonal profile of rabbits consequently the reproductive and productive performance of animals (Meshreky and Metry, 2000; Chiericato *et al.* 2001; Meshreky and Shaheed, 2003; Meshreky *et al*. 2007).

5.3.3 Effect of palm oil (PO) on hormone profile of rabbits

There were no significant differences (P>0.05) in testosterone and progesterone levels in female rabbits fed forage diets supplemented with PO and without PO. Significant difference (P<0.05) was observed in progesterone level in male rabbits, with rabbits fed palm oil supplemented diet having significantly higher progesterone than those without PO. Plasma androgen concentration increased in men and rats fed high fat diet (Clinton *et al*., 1997; Dorgan *et al*., 1997). In contrast, a reduction in fat intake caused a decrease in plasma testosterone level concentration (Hamalainen *et al*., 1984; Hanis *et al*., 1990; Perheentup *et al*., 1995). In this study however supplementation of palm oil did not affect testosterone levels in rabbits. Gronadzka-Ostrowska *et al*. (2002) fed three different dietary fats and observed that dietary fat type and feeding period, but not fat level significantly affected both testosterone production and testosterone uptake by target organs in male rats. Fitriyah *et al*. (2008) observed that feeding quail with 3% palm oil increased the level of testosterone.

5.3.4 Interaction effect of age and forage types on hormone profile of rabbits

Serum testosterone levels increased faster in males fed lablab forage than groundnut forage meal as they aged though rabbits fed both forage meals attained puberty around the 14^{th} week of age. On the other hand, faster increase in serum progesterone in female and male rabbits fed groundnut forage indicates that groundnut forage fed rabbits would attain puberty earlier than lablab forage fed rabbits. This is because of the fact that progesterone is required for steroid biosynthesis, follicular growth and ovulation responsible for changes associated with luteal phase of oestrus cycle, essential for

establishment and maintenance of early pregnancy (Hu *et al*., 2010). The range of testosterone (0.78-6.45ng/ml) obtained in this study is similar to the range of 0.5-10ng/ml reported by Moor and Younglai (1975). Progesterone levels obtained in this study are higher than 0.2-0.8 ng/ml during follicular phase and within the range of 4-20 ng/ml during luteal phase reported for the menstrual cycle (Progesterone EIA kit). Progesterone level in males was higher than basal levels of 0.1-0.6 ng/ml (Shahnaz *et al*., 2000) at 16 and 18 weeks of age for groundnut forage fed rabbits while it was higher only at 18 weeks of age for lablab forage fed rabbits.

5.3.5 Interaction effect of forage level and age on hormone profile of rabbits

A trend was established in serum progesterone and testosterone levels with increased level of forage and as the animal aged. The highest serum progesterone and testosterone levels were recorded in rabbits fed 40% forage at 18weeks of age while the lowest was recorded in rabbits fed 20% forage at 12 weeks of age. This could be attributed to the proper utilization of higher percentage of forage and subsequently its effect on hormone level. Patterson *et al*. (1992) reported that lower planes of nutrition delayed the onset of puberty by inhibiting maturation of the endocrine system. Testosterone levels were similar in 20 and 40% forage meals for all the ages though the rate of increase appeared to be slightly higher on 20% than 40% forage meal. Progesterone levels in female rabbits fed 20% forage were higher than basal level of 0.6 ng/ml (Shahnaz *et al*., 2000) at 14 weeks of age while even at 12 weeks the level was higher in rabbits fed 40% forage meal diets. In male rabbits, progesterone level was higher than 0.6 ng/ml at 18 weeks of age

for rabbits fed 20% forage whereas, in 40% forage meal diet fed rabbits it was higher from the 16th week of age.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary and Conclusion

The high cost of concentrate has contributed to high cost of rabbit feed. Therefore, relatively cheap and readily available feed will be appreciated by rabbit farmers. Forages are cheap, readily available, increases growth rate and the rabbits fed these forages reach puberty at the stipulated period and the attainment of puberty was not hindered by feeding of these forages.

The following conclusions were deduced from the results of this study:

- Lablab and groundnut meal can be fed to rabbits without adverse effects on their growth performance and carcass characteristics.
- The cost of feeding weaner rabbits could be lowered by supplementing concentrate diets with either groundnut or lablab forage meals.
- The result obtained in this study supports the need for supplementing rabbit concentrate diets with fibrous forage materials for optimum growth performance.
- Incorporation of forage meal in the diet of rabbits at 20% level of inclusion gave the best result in terms of weight gain.
- Addition of palm oil at a lower level had no effect on performance of rabbits but had a significant effect on some of the carcass characteristics of rabbits.
- Both male and female rabbits had a similar performance in this study.
- Testosterone levels were not affected by forage type, forage level or palm oil supplementation.

- Feeding of groundnut forage resulted in a significant increase in the serum progesterone level in both male and female rabbits.

6.2 Recommendations

From the results of these studies, it can be recommended that:

1. Lablab and groundnut forage can be used as rabbit feed by farmers since the performance of these two forage types compares favorably well with each other in terms of weight gain, feed intake and feed to gain ratio. Also, the cost of feeding any of these two forages compares favorably well.
2. Incorporation of forage into the diets of rabbits at 20% inclusion is therefore recommended.

6.3 Recommendations for further studies

The following are recommendations for further studies:

1. The effect of feeding solely concentrate, groundnut haulms and lablab
2. The effect of forage on Luteinizing hormone (LH), Follicle Stimulating Hormone (FSH) and Oestradiol.
3. Addition of palm oil to these feed ingredients at higher levels and its possible effect on steroid hormones.

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