REPLACEMENT VALUE OF SOYBEAN CURD RESIDUE FOR GROUNDNUT CAKE ON PERFORMANCE OF WEANER RABBITS

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SPS/12/MAS/00022

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BY

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SPS/12/MAS/00022

B. AGRICULTURE

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, BAYERO UNIVERSITY, KANO, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN ANIMAL SCIENCE.

November, 2016

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Prof. G.S Bawa and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

Signature **---------------------------------------**

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SPS/12/MAS/00022

CERTIFICATION

This is to certify that the research work of this dissertation and the subsequent write-up of by "Izzaddeen Saleh SPS/MAS/00022" were carried out under our supervision.

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APPROVAL PAGE

This dissertation has been examined and approved for the award of the degree of MASTER OF SCIENCE (ANIMAL SCIENCE)

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DEDICATION

This work is dedicated to my parents Alh. Balarabe Ahmad Kiyawa and Rabi'at Balarabe.

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ABSTRACT

Two Experiments were conducted to determine the performance of weaaner rabbits fed soybean curd residue based diets. In Experiment 1, a total of 30 weaner rabbits (8 weeks old) with average initial weight of 534.7g arranged in a completely randomized design were used. Soybean curd residue was used at 0, 25, 50, 75 and 100 % to replace groundnut cake. The results indicated that feed intake was significantly ($P<0.05$) affected by the dietary treatments. Rabbits on diets 5 and 4 had the highest values for feed intake, final weight and average daily weight gain, while those fed diet 1 had the least value. Rabbits fed diet 5 had the best cost of feed/kg weight gain, cost of feed/kg diet and FCR. Nutrients digestibility coefficients were not significant ($P>0.05$) for all the parameters except crude fibre which differed ($p<0.05$) significantly. Cut-up parts and visceral organs measurement showed significant differences ($P<0.05$) in some parameters (heart, lungs and dress weight) while others (dressing percentage, head, thigh, rack/rib, skin, liver, small intestine, large intestine, kidney, stomach, forelimb and hind limb) showed no significant ($P>0.05$) differences. Values obtained from haematological studies varied significantly ($P<0.05$) for Hb, RBC, PCV, WBC, MCH and MCHC, while TP and MCV were not affected. In Experiment 2, six experimental diets were formulated; diet 1 served as a control with no soybean curd residue. Diet 2 contained soybean curd residue supplemented with 0.2% lysine and 0.2% methionine. Diet 3 contained soybean curd residue with 0.2% Lysine and 0% methionine. Diet 4 contained 0.2% methionine + 0% lysine. Diet 5 contained soybean curd residue with 0% lysine + 0% methioine, while diet 6 contained lysine and methionine at 0.2 % levels respectively. A total of 30 weaner rabbits were used, in a completely randomized design (CRD). Feed intake was higher for rabbits fed diet 6 while the least value was recorded in those fed diet 5. Final weight was higher for rabbits on diet 2. However, average daily weight gain was highest for rabbits on diet 6, similarly for FCR. Rabbits fed diet 2 had the best cost of feed/kg weight gain. Mortality was not recorded for any of the dietary treatment group. Nutrients digestibility coefficient were not significant ($P>0.05$) for all the parameters except crude fibre which differed ($p<0.05$) significantly. Cut-up parts and visceral organs measurement showed significant ($P<0.05$) difference in some parameters (heart, lungs, stomach and dress weight) while others (dressing percentages, head, thigh, rack/rib, skin, liver, small intestine, large intestine, kidney, forelimb and hind limb) showed no significant ($P>0.05$) differences. Values obtained from haematological studies varied significantly ($P<0.05$) for Hb, RBC, PCV, WBC, and MCHC while TP, MCH and MCV did not differ ($P>0.05$) significantly among the treatment groups. It was concluded that soybean curd residue can replace groundnut cake at 100% in diets for growing rabbit production without deleterious effect. Rabbits fed diet 2 (lysine 0.2% + methionine 0.2%) was found to be better for all the performance parameters considered in this study.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The majority of the world's estimated 1.3 billion poor people live in developing countries where they depend directly or indirectly on livestock for their livelihoods (World Bank, 2008 and FAO, 2009a). Globally, livestock contributes about 40% of the agricultural gross domestic products (GDP) and constitutes about 30% of the agricultural GDP in the developing world (World Bank, 2009). These estimates highlight the important contribution of livestock to sustainable agricultural development.

The contribution of food from animal origin to the world population is well documented (Randolp *et al.,* 2007; Bwibo *et al.,* 2003 and Ndolovu, 2010). Livestock products accounts for almost 30% of human protein consumption (Steinfields *et al.,* 2004)

Growing population, Urbanization and Economic growth in developing countries are contributing to growing demand for livestock and livestock products (Delgado *et al.,* 1999 and Hall, 2009).

Globally, human population is expected to increase from around 6.5 billion to at least 8.2 billion by 2050 (Rosegrant *et al.,* 2009). More than 1 billion of this increase will occur in Africa (Swanepoel *et al.,* 2010)

Soybean is one of the most important legumes in the world. In 2010, the annual world output of soybean exceeds 261 million tons of which 1.5 million were in Africa. An FAO, (2009b) report indicated that Japan imported soybean amounting to 3.5 million tons in 2009. Nigeria is the largest producer of soybean in sub-Saharan Africa, followed by South Africa (IITA, 2009). Soybean curd residue (SCR) is the main surplus material from soybean products and it is often regarded as waste. About 1.1 kg of fresh soybean curd residue (SCR) is produced from every kilogram of soybeans processed into soymilk or tofu (Khare *et al,* 1995). In Japan, about 700,000-800,000 tons of SCR are disposed off annually as by-products of tofu production (Shuhong, *et al,* 2013 and Mizumoto *et al*., 2006). SCR is a loose material consisting of a good source of nutrients, including protein, oil, dietary fiber, minerals, along with un-specified monosaccharide and oligosaccharides. By-products from tofu processing, sometimes known as soybean-curd lees or tofu-cake, are left over when tofu (soybean curd) is made from soybeans. The filtrate, contains protein and fat, and is made from milled and boiled soybean mash, is called soymilk, while tofu wastes are the soybean curd residue.

Protein supplementation is often important to improve livestock performance, and this needs to be done with respect to the requirements of the animal in addition to the balance of other nutrients available. Soybean meal, groundnut cake and fish meal have been widely and successfully used as conventional protein sources for livestock. However, the prices of these protein sources have been escalating continuously in recent times, whilst availability is often erratic. The problem has been worsened due to the increasing competition between humans and livestock for these protein ingredients as food. According to Odunsi, (2003) the rapid growth of human and livestock population, which is creating increasing needs for food and feed in the less developed countries, demands that alternative feed resources must be identified and evaluated.

Food and Agricultural Organization (FAO), (2011) has estimated an annual five to seven percent (5-7%) growths rate for meat consumption, such increases cannot be met easily by large animals because of their production cycle. This may however be met by short cycle animals such as rabbits, poultry and pigs. Increased rabbits production could bridge the supply-demand gap of protein.

Rabbits play an important role in the supply of animal protein to the Nigerian populace (Amaefule *et al.,* 2005). They are efficient converters of feed to meat and can utilized up to 30% crude fiber as against 10% by most poultry species (Egbo *et al.,* 2001). Rabbits can utilize unconventional feed stuff (Igwebuike *et al.,* 2001) and diverse forage materials.

1.2 PROBLEM STATEMENT

Shortages of feed resources often impose major constraints on the development of animal production in the tropics and sub-tropics. Considerable quantities of crop residues and agro-industrial by-products (by-product feedstuffs) are generated every year in most developing countries. These are suitable for feeding livestock, however, because of lack of technical-know-how they are lost or underutilized (Aregheore and Chimwano, 1991).

In rabbit meat production, as in other animal species, feeding costs represent the largest part of the production costs. Depending on mainly the investment costs, they amount 60-70% of the total costs. In view of being competitive with those animal productions, a reduction of the feeding costs is of primarily importance (Maertens, 2009). Cost effectiveness is of central importance in ration formulation and evaluation of raw materials as costs must always be considered (Robert, 2008).

Animal protein intake is dismally low in lesser-developed countries (LDC's) than in developed countries (DC's). The FAO (2009) recommends a minimum of 70g of protein daily per caput, out of which at least 35g (50%) should come from animal proteins, but the average Nigerian consumes less than 10g of protein with only 3.2g of this amount from animal protein. In Africa, Nigeria has the highest number of under-five mortality. These deaths occur because of low animal protein intake (Abu *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 within the country. Fast-growing livestock such as rabbits possess a number of features that might be of advantage in the small holder subsistence – type farming in developing countries.

One hundred and ninety-three (193) MPhil and PhD theses spanning 1969-2006 in department of Animal Science, University of Ibadan, Nigeria were collated and analyzed. Of this number only 6 (3%) involved rabbits for research. Two theses were in the area of nutrition, two on rabbits processing and consumer acceptance and the remaining two were in the area of reproductive physiology (Abu *et al.,* 2008). And also a study by Abdussamad *et al.* (2012) revealed that out of 1261 papers presented at Nigerian Society for Animal Production from 1998-2007, 431 involved poultry while only 187 involved rabbits research. The use of rabbits is low compared with other livestock and poultry. Rabbit production can provide impoverished urban population and the resource-poor rural dwellers the opportunities to meet part of their total protein intake and earn additional income (Abu *et al.,* 2008)

The rabbit (*Oryctolagus cuniculus*) appears to be the most sustainable because of affordable or low-cost management requirements, small-bodied size, short generation interval, fecundity; rapid growth rate, ability to utilize forage and agricultural by-products, genetic diversity, and adaptation over a wide range of ecological environments. (Abu *et al.,* 2008)

1.3 JUSTIFICATION

To meet the increasing demand for animal protein, emphasis needs to be given to non-conventional sources such as easily managed rabbits as against the conventional sources such as cattle, sheep, goat, pig and poultry that would require more capital, space and time (Berepubo *et al.,* 1995; Yusuf *et al.,* 2010). To make rabbits rearing more viable as a small scale business, Alawa *et al.* (1990) have advocated the development of alternative feeding materials that would be relatively cheaper when compared with commercial feed or convention feed.

The production of soybean products has been increasing throughout the world, and there has been a corresponding increase in the quantity of soybean curd residue (SCR) being thrown out. The dumping of SCR has become a problem to be solved due to its contamination to the environment. SCR is rich in fiber, fat, protein, vitamins, and trace elements. It has potential for value added processing and utilization; options that simultaneously hold the promise of increased economic benefit as well as decreased pollution potential for the environment. (Shuhong *et al.,* 2013)

In view of the above, there is need to explore more areas in rabbits production and nutrition so as to boost the consumption of dietary protein of animal origin in Nigeria as well reduce the cost of feeding through alternative protein sources.

1.4 OBJECTIVES

The main objectives of the study is to evaluate the performance characteristics of rabbits fed soybean curd residue with or without supplementation of lysine and or methionine while the specific objectives are to:

1. examine the carcass characteristics and hematological parameters of rabbits fed soybean curd residue with or without supplementation of lysine and or methionine
2. determine the nutrient digestibility by rabbits fed soybean curd residue with or without synthetic lysine and or methionine
3. determine the cost effectiveness of using soybean curd residue with or without synthetic lysine and or methionine in rabbits diets

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 IMPORTANCE OF RABBITS PRODUCTION

Rabbits have a potential as a meat producing animals in the tropics due to their characteristics such as small body size, short generation interval, rapid growth rate and ability to utilize forages and agricultural by-products. The wastes from products grading before selling at the market such as vegetable wastes, are well utilized as feed resource for rabbits, and the manure from the animals could be used as an organic fertilizer for crops. Rabbits could contribute significantly to solving the problem of meat shortage (Mikled, 2005; Lebas, 1983; Taylor, 1980). Production systems with small or large ruminants usually need a long time to give a saleable product and with high cost, especially for feeds. Agricultural by-products, foliages, cassava root meal, rice bran can be used as dietary ingredients for rabbits (Lukefahr and Cheeke, 1991; Ha *et al*., 1996; Ruiz-Feria *et al.*, 1998). The demand for human food from animal products such as meat, eggs and milk is continually increasing (Delgado *et al*., 1999). Iraqi (2003) noted that the consumers of today pay great attention to the health aspects of the food, such as low fat content and organic origin and that meat from rabbits has low cholesterol level, high protein/energy ratio and relatively rich in essential fatty acids. Rabbits utilize waste products more effectively thus offering an alternative to other producing species for the improvement of protein supply to the human population and the realization of monetary income by putting into effective use the waste materials that are inedible for human (Iraqi, 2003; Schlolaut,1985).

It is claimed that there are few traditional/social taboos concerning the eating of rabbit meat (Mamattah, 1978).

Owen, (1981) and Nuhu, (2010) reported that the rabbits could be an alternative food source, particularly for people in developing countries. Rabbits manure has been experimentally fed to rabbits and ruminants and has been used to produce methane gas as household source of alternative energy. The animals are also use in the experiments involving nutrition, medical research and testing products (Trujillo *et al.,* 1991). In addition they are sold as pets.

Moreki, (2007) observed that the reasons for raising rabbits are manifold and that rabbits are important source of food, particularly in Europe and Asia. Moreki, (2007) reported that rabbits produce white meat that is fine grained; high in protein, low in fat and highly palatable. It is low in cholesterol and can be substituted for poultry in most recipes. High quality rabbit skins are used in fur garments (clothing, hats), to cover bicycle seats and their use could spark a village industry craft projects. Another significant use of rabbits is in cosmetics, medical and pharmaceuticals research laboratories. Rabbits are also raised for show or as pets (Moreki, 2007).

In 1994, world's rabbit production was estimated to be 1.5 million tons per annum (Moreki, 2007). The leading rabbits producing countries in Africa are Morocco and Nigeria and these are reported to produce 20000 to 99000 tons meat per year (Moreki, 2007).

Abu *et al.* (2008) reported that animal protein intake is dismally low in lesser-developed countries than in developed ones. They noted however, Nigeria with a population of about 140 million, the highest in Africa, has the highest number of under-five mortality. These deaths occur as a result of low animal protein intake. Micro-livestock such as rabbits, guinea pig, grass cutter, giant rat and pigeons have been suggested as a rapid means of obtaining animal proteins. The rabbits appear to be the most suitable means of producing high quality animal protein for the expanding populations of the lesser-developed countries like Nigeria. The attributes of rabbits include affordable or low-cost management requirements, small-bodied size, short generation interval, fecundity; rapid growth rate, ability to utilize forage and agricultural by-products, genetic diversity, and adaptation over a wide range of ecological environments (Abu *et al.,* 2008). Nigeria was estimated to have up to 1.7 million rabbits (Resource Inventory and Management (RIM), 1992).

2.2 THE DIGESTIVE TRACT OF RABBITS

Domestic rabbits (*Oryctolagus cuniculus*) are herbivores, concentrate selectors, and are classified as hindgut (caecum and colon) fermenters (McNitt *et al*., 1996). Since there are no mammalian enzymes to break down the cellulose components of their plant-based diets, rabbits as well as other herbivores have a symbiotic microbe population (primarily Bacteroides).

Due to smaller body size and higher metabolic rate than horses, rabbits rely on other adaptations for forage utilization (Cheeke, 1987). In rabbits, the microbial population is found in the caecum. The rabbit caecum is very large, compared with the rest of the gut (Stevens and Hume, 1995) and forms a spiral that fills the abdominal cavity. The caecum (Jenkins, 1999) has a capacity that is 10 times that of the rabbits's stomach, about 40% of the gastrointestinal tract.

Instead of completely fermenting fibre, rabbits utilize a mechanism to sort out indigestible fibre and expel it from the body, a process that is a specialized feeding strategy that overcomes poor-quality protein (Pond *et al*., 1995). This sorting mechanism occurs as digesta enter the rabbits's large intestine and muscular contractions facilitate the separation of fibre and non-fibre (protein, soluble carbohydrates, etc) fractions.

A series of peristaltic (move fibre through colon) and anti-peristaltic waves (move fluid and non-fibre components to caecum for fermentation) separate out non-fibre fractions for further fermentation in the caecum (Cheeke, 1987; Carabano and Piquer, 1998); particle size and density aid separation (Cheeke, 1994). The fibre components are voided from the body (day, or hard, faeces) about 4 hours after consumption of the diet (Cheeke, 1994). After fermentation of the non-fibre components in the caecum, a pellet is formed (called a cecotrope, also soft, or night, faeces) that is voided from the body approximately 8 hours after consumption of the diet (Pond *et al.*, 1995). A neural response (Jenkins, 1999) or the strong odour of VFA (Stevens and Hume, 1995) in the cecotrope seems to stimulate its consumption directly from the anus. This practice of consuming cecotropes is called coprophagy (Gillespie, 1998). In natural settings, coprophagy usually occurs during the night, opposite of feed intake and the voiding of hard faeces, in a circadian rhythmic pattern (Carabano and Piquer, 1998; Jenkins, 1999), and is an integral part of the rabbits's digestion process (Cheeke, 1994). Due to their small body size, if allowed to consume a diet ad libitum, rabbits will daily eat an amount that approximates 5% of their body weight in dry matter and drink about 10% of their body weight in water (Okerman, 1994). Even at this intake, if a rabbits was to consume only low-quality forages, there would be insufficient energy and nutrients to meet its metabolic requirements. However, if rabbits at maintenance are fed a high-quality pelleted diet for ad libitum consumption, they will become obese (Brooks, 1997).

When allowed to select their own diet in a natural habitat, rabbits select the most tender, succulent plant parts or the plant parts that are most nutrient-dense and lowest in available cell walls.

Some researchers refer to animals that practice this type of eating behaviour *concentrate selectors*, a practice that allows the animal to meet the dietary requirements for their high metabolic rate (Cheeke, 1994). Rabbits have high feed intake (65-80 g/kg BW) and fast feed transit time (19 hours), which enable them to consume lower-quality forages and still meet nutritional requirements (Gidenne, 1992). Most problems seen in rabbits production involve the gastrointestinal tract. Enteritis is the primary gastrointestinal disorder, and it often results in diarrheoa (Milon, 1996).

2.3 RABBIT MEAT COMPOSITION

Rabbits meat is very nutritious and a rich source of protein, energy, minerals and vitamins. Relative to other common meats, rabbit's meat is low in fat, sodium and cholesterol (Nelson, 2011). Fielding (1991) stated that rabbits meat is especially high in protein and low in fat and that, the fat in the meat is mainly unsaturated that is of high quality than saturated fat that is common in other meats. The values of 27 and 25.82 % Protein, 8 and 7.15 % fat for rabbit meat were reported by Woollotfarms (2012) and Fatsecret (2014). Rao *et al*. (1987) reported that rabbit meat 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 rabbits, Mohamed (1989) reported the meat composition as 77.34% moisture, 21.55% protein, 2.73% ether extract and 1.63% ash.

2.4 NUTRIENT REQUIREMENTS OF RABBITS

Rabbits have a high feed intake of 65 to 80 g/kg body weight and rapid transit rate of feed in the digestive system to meet the nutritional requirements (Caravano and Piquer, 1998). The amount of feed consumed and the nutrient requirements vary with the age of the rabbits and can be categorized into four age groups which are the young rabbits 4-12 weeks of age or fattening, lactating does, pregnant does and maintenance or non-producing rabbits (Sandford, 1996). Rabbits sleep during the day and consumption of feed takes place mostly in the late afternoon and early evening (Nakkitset, 2007).

2.4.1 Crude Protein Requirement of Rabbits

Protein is perhaps the most frequent nutrient lacking in rabbits 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; Kellems and Church, 2006). Rabbits are animals with rapid growth requiring good protein quality and all essential amino acids because of this reason, microbial protein from the soft faeces cannot even support the requirement for maintenance (NRC, 1977). Normally, producing rabbits such as lactating or pregnant does or growing and fattening rabbits, have a higher protein requirements than non-producing ones. Protein intake and growth performance of rabbits have been presented in many research papers (FAO, 1997). For rabbits the recommended crude protein level in the dry matter of the 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). Although rabbits have a microbial ecosystem for fermentation in the ceacum which is similar to the system in the rumen, the major protein and essential amino acids sources are true protein coming from the feed. Non-protein nitrogen such as urea cannot successfully replace the true protein because this source of nitrogen either degrade or is absorbed too early and cannot be utilized by the micro-organism in the ceacum (FAO, 1997). Cheek (1994) reported that urea is converted to ammonia in the rabbits gut and when absorbed, result in toxicity and cause liver or kidney lesions (Nikkitset, Mikled and Ledin, 2008). Lysine and methionine are usually the amino acids that are found to be deficient in rabbits ration (Gillespie, 1998). While there is some bacterial protein synthesis in the caecum, it is not enough to meet the essential amino acid requirements of rabbits. Carregal and Nikuma (1983) used diets with increasing crude protein levels, 14.3, 17.2 and 21.4%, as they found no significant difference among groups of rabbits with regard to body weight, feed intake or feed conversion efficiency. Abdella *et al*. (1988) conducted an experiment and observed that there were 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) using mash diets containing crude protein ranging from 11.63 to 26.85% reported that the diets containing 20.74% crude protein recorded the highest final live body weight and live weight gain. 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.

He further reported that when essential amino acids were added to protein supplements such as cotton seed meal, rapeseed meal, horsebeans, and peas, growth rates similar to those achieved with soya bean and fish meals were attained. According to Pond *et al*. (1995) dietary protein quality is particularly important for rapidly growing weanling rabbits, which may not have well developed caecal fermentation. 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).

2.4.2 Metabolizable Energy Requirement of Rabbits

The energy needed for growth is usually supplied by carbohydrate and to a lesser degree by fat. The growing rabbits, like the breeding doe can to a certain degree adjust the feed intake according to the energy content of the feed offered. The energy requirement is therefore presented as energy content/kg feed. According to FAO (1997) the energy requirement is between 2,200 to 3,200 kcal DE/kg of feed, base on age and production stage, lactating and growing rabbits needing more energy than non-producing rabbits. Rabbits adjust their feed intake as a function of their dietary energy concentration (Partridge, 1989). According to Partridge (1989), this regulation of intake to achieve constant daily energy intake is only possible at a dietary digestible energy (DE) concentration above 2250kcal/kg. Several factors influence the energy requirements of rabbits (Kellems and Church, 2006). These include productive function (growth, lactation, maintenance, etc), age, sex, body size and environment (temperature, humidity, and air-movement). As temperature decrease, the rabbits requires more energy to maintain normal body temperature (Gillespie, 1998), and to compensate for this increased energy, either the intake level of feed must be increased or the energy content of the ration must be increased. High starch diets are often incompletely digested in the small intestine of the rabbits due to rapid transit time (McNitt *et al.,* 1996). Incomplete chemical digestion of the starch results in the availability of starch for microbial fermentation (Stevens and Hume, 1995). Excess starch in the gut results in an extremely rapid growth of microbes. If toxin-producing microbes (primarily *clostridium spiroforme*) are in residence, high level of starch may leads to enteritis and possible death (Tisch, 2006). As a result of potential incomplete starch digestion, low-energy grains are preferred (Cheeke, 1994). Grains processed too finely can lead to rapid bacterial fermentation of the starch and cause enterotoxaemia. Thus, a coarse grind is recommended. About 3% fat is recommended in rabbits diets; dietary fat is well utilized by rabbits and improves diet palatability and increases energy level without causing carbohydrate overload of the hindgut (Pond *et al*., 1995). Average maintenance requirement determined in growing rabbits is about 100kcal DE/kg$^{0.75}$ (Maertens, 1992). Fed on energy-concentrated foods, rabbits can satisfy their requirements, but this is not possible on forages alone because forages are usually dilute sources of energy (Fielding, 1991); hence when fed only on forages they cannot obtain as much energy as those fed on concentrate foods such as maize grains or cereals bran.

2.4.3 Crude Fibre Requirement of Rabbits

Rabbits use crude fibre less efficiently due to faster rate of passage of digesta and small holding capacity compared to grazing ruminants. Rabbits are therefore more selective in their diets than ruminants (Lebas *et al.,* 1986). Chemical composition and form of fibre not only affect its susceptibility to digestion but can also influence feeding habits. Nuhu (2010) reported an experiment, which compared oat husk with barley straw and pure cellulose in rabbits's diets, and concluded that daily feed intake increased as the crude fibre content of the diet was increased from 3.9 to 27.0 %. The optimal level of crude fibre for growing rabbits is 13 to 14% (Lebas *et al.,* 1986). According to Maertens, (1988) although fibre is not considered a real nutrient in rabbits because of its low digestibility (average dietary digestibility is less than 20%), it is considered a nutrient to maintain the gut motility.

Cell-wall constituents from feedstuffs having low lignin content or young plants have a considerable higher digestibility than highly lignified sources, 40-70% versus 5-20% respectively. It is not clear what the minimum fibre intake for prevention of diarrhoea in rabbits should be.

Research reports from Blas *et al*. (1994) and Gidenne and Jehl, (2000) examined the effect of low fibre diets to rabbits, and observed that a sharp decrease in fibre level from 19-9% in the diet doubled the risk of digestive trouble. The population of cellulolytic bacteria decreased in the caecum, and the microbial ecology system in the caecum became unbalanced, which may cause death from diarrhoea.

Feeding rabbits with a diet low in fibre and high in energy or a finely ground concentrate diet; can result in high mortality due to intestinal disorders, such as enterotoxaemia (Lukefahr and Cheeke, 1991). The risk of destabilization of the caecal flora is higher if the increased ileal starch flow is not accompanied with a similar increase of fibre intake (Gidenne and Perez, 1996).

Aduku, Dim and Aganga, (1998) fed weaner rabbits peanut meal, sunflower meal and palm kernel meal diets containing 14.84, 23.24 and 38.89 % crude fibre respectively and observed that feed consumption was significantly ($P<0.05$) higher with palm kernel and sunflower meal diets than with the peanuts diet. This was attributed however, to the rabbits having to compensate for their energy requirements. In the same experiment they found feed-to-gain ratios to be significantly ($P<0.05$) poorer on the palm kernel and sun flower meals diets than on peanut meal diet. Differences in weight gain and final body weight for the three diets were however not significant ($P>0.05$) though the diet with lower fibre content had higher weights gains than the one with higher crude fibre content. The optimum level of crude fibre for growing rabbits is 13-14% (Lebas *et al*., 1986).

2.4.4 Fat Requirements of Rabbits

About 3% fat is recommended in rabbits diets (Pond *et al.,* 1995). Dietary fat is well utilized by rabbits and improves diet palatability and increases energy level without causing carbohydrates overload in the hindgut (Pond *et al.,* 1995). McClure, (2011) discovered that rabbits require 1 to 2 % fat for maintenance, 2 to 4 % for growth and finishing, 2 to 3.5 % for gestation and 2.5 to 3.5 for lactation. NRC (1977) reported a preference by rabbits of a diet with 5 % corn oil over one with no added fat and a distinct preference for a diet with 10 % added corn oil over one with 20 % oil added. NRC (1977) also observed that essential fatty acid deficiency in rabbits has been demonstrated which include reduce growth, loss of hair and changes in the somniferous tubules, impaired sperm development and increased accessory gland weight.

2.4.5 Vitamin Requirement of Rabbits

Rabbits require water-soluble (B group and C) as well as fat-soluble vitamins (A, D, E and K). According to Lukerfahr and Cheeke, (1991), the major vitamins needed in rabbits diets are vitamins A, D and K and that protein and carbohydrate dietary sources, fed in good variety, may largely meet the minerals and vitamins requirements. Micro-organisms in the digestive system synthesized sizeable amounts of water soluble vitamins which are utilized by the rabbits through caecotrophy. Vitamin K and the B complex vitamins are not required in the diet, since they are synthesized through coprophagy and fermentation in the caecum or hindgut; likewise vitamin C (Lukefahr and Cheeke, 1991). Under practical conditions, the B-complex vitamins are not dietary essential for rabbits; however, under stress situation and at high performance levels, deficiency can occur (Ismael, 1992)

Vitamin A deficiency and toxicity have been demonstrated but precise requirements have not been determined. The vitamin A requirement for growth and lactation in rabbits was observed by Murphy and Norman, (2004) to be 6,000 and 10,000 IU/kg respectively and that any dietary requirements for vitamin D is likely much lower than for other species. The authors also reported that the only practical problem encountered with vitamin D in rabbit nutrition is toxicity: 2300 to 3000 IU of vitamin D/kg is detrimental. Vitamin E deficiency has been demonstrated, but recommendations are based primarily on old data or probably not of practical concern in rabbit nutrition because it is synthesized in the caecum, and no requirements studies have been conducted. Under practical conditions, B-complex vitamins deficiencies have been demonstrated. Addition of B vitamins to commercial rabbit feeds has not shown benefits. Under practical conditions, the B-complex vitamins are not dietary essentials for rabbits; however, under stress situations and at high performance levels deficiencies can occur (Ismael, 1992).

Gillespie, (1998) has indicated that the use of iodized salt at the rate of 0.5% of the diet will supply the needed sodium, chlorine and iodine for rabbits. Rabbits can synthesize vitamin C, so it is not a dietary essential. In commercial diets, it is advisable to include a vitamin mixture that provides at least moderate concentrations of vitamin A and E to ensure that no deficiency occurs. Vitamin C supplementation is recommended for rabbits under stress (Murphy and Norman, 2004, Verde and Piquer, 1986).

2.4.6 Minerals Requirement of Rabbits

Studies on the calcium and phosphorus requirements of growing rabbits have shown that they need these minerals much less than lactating does. The rabbit requires minerals in low amounts, but these compounds are still essential for normal function. A balanced diet normally supplies enough minerals, but lactating and pregnant does may need additional minerals to produce milk, tissues and bones for the kittens (FAO, 1997). Macro minerals such as sodium, potassium, calcium, magnesium and phosphorus are present at large levels in animal’s body and are required in smaller amounts in the diets (Dairy herd, 2009). Ash residue is generally taken to be a measure of the mineral content of the original food and it tends to vary depending on the type of feed (Onwaka, 2005).

Pond *et al.* (1995) stated that the major mineral element of concern in rabbits diet formulation are calcium (Ca) and phosphorus (P), and that the other minerals are usually provided in adequate amount by the ingredients used plus the addition of trace-mineralized salt. Studies on calcium and phosphorus requirements of growing rabbits have shown that they need these minerals much less than lactating does. The amounts excreted through the milk are significant. However, excess of calcium (>40g/kg) or phosphorus (>19g/kg) induce significant alteration of fertility and prolificacy or higher proportion of stillbirths. Low or unbalanced phosphorus levels can increase urinary calcium loss and restrict growth rate and protein efficiency. Total dietary phosphorus intake ranging from 0.45 to 0.76 % did not affect any of the doe's reproduction performances (Lebas and Jouglar, 1990). The Ca:P ratio does not seem to be critical for rabbits (Lebas *et al,* 1998) and is usually 2:1. However, rabbit can tolerate much higher ratios. Copper sulphate which is often used as a non-nutritive feed additive aids in preventing enteritis (Pond *et al*., 1995). Fielding (1991) stated that rabbits are born with high levels of iron in their livers, sufficient for their pre-weaning growth.

2.4.7 Water Requirement of Rabbits

Water consumption is very important for the feed intake in rabbits. In normal condition the consumption of water is around 100ml to 600ml/day or 50ml to 100ml /kg BW (Nakkitset, 2007). Verdelhan, Bourdillon, Morel-Saives and Audoin (2004) observed that the feed intake of rabbits was significantly reduced when water consumption was restricted. Water is normally considered a nutrient, although its properties and functions are quite different from those of other nutrients found in feeds. Water is the major component of the rabbits's body, making up to 70% of the lean body mass (Maertens, 1992). The author further indicated that rabbits will die more rapidly from water deprivation than from food deprivation and that restricting drinking water or limiting drinking time leads to reduced feed intake that is directly proportional to the amount of water being consumed. Maertens (1992) also reported that water and feed consumption varies with changes in environmental temperature and humidity. As the temperature rise above 20^0c day and night, feed intake tends to drop while water consumption increases. At high temperatures (30^oc and above), feed and water intakes decline, affecting the performance of growing and lactating animals (Fernandez-Carmona, Cervera and Blas, 1996). According to Pond *et al.* (1995) water plays an essential role in a number of functions vital to animal such as digestion, nutrient transport, waste excretion and temperature regulation. One of the most important properties of water in nutrition is its remarkable ability to dissolve substances (Pond *et al.;* 1995). Animals need more water to serve as a media for transporting substances contained in feed round the body and to dissolve substances that cannot spontaneously adsorbed by the body of rabbits (Siregar, 1994).

2.5 SOYBEAN CURD RESIDUE

Soybean curd residue (Tofu cake) a is by-product of tofu (soybean curd) industry and has been used as animal feed at the farm level, due to its high content of protein and carbohydrate (Chiou *et al.,* 1998; Amaha *et al.,* 1999). Tofu cake is available in two forms, wet and dried. Wet tofu cake usually cannot stand to organic microbial decomposition, so that dried form is better for long time storage (Hernaman *et al.,* 2010). Tofu cake can be an alternative to replacing the expensive concentrate as an additional feed. Dried tofu cake can be made using fresh tofu cake which needs to dry in the oven (110-1700C) for about 10 hours (Owen and Amakiri, 2010). Rojik (2010) and (Tanwiriah *et al.,* 2005; Adrian, 2005), have studied the possibility and the effect of tofu cake as an additional feed in rabbits and Muscovy duck respectively and it was concluded that tofu cake can improve the performance of growing rabbits.

2.6 SOYBEAN CURD RESIDUE COMPOSITION

The main components of SCR are ruptured cotyledon cells and the soybean seed coat, which is rich in cell wall polysaccharides. Characterization of this byproduct, including the protein, oil, dietary fibre, and mineral composition, along with unspecified monosaccharides and oligosaccharides, is repored in the literature (van der Riet *et al.,* 1989; O'Toole, 1999; Surel and Couplet, 2005). Soybean curd residue is rich in cellulose, and it accounts for approximately 50% of the dry weight in soybean with very few calories. It is a good dietary fiber, which cannot be digested in the small intestine but can be fermented by microbes in the large intestine. It is reported that dietary fiber in SCR can reduce blood fat (Shuhong, *et al,* 2013). Soybean curd residue has high quality protein, especially essential amino acids. It is well-documented that SCR contain about 27% crude protein (dry basis) with good nutritional quality and a superior protein efficiency ratio, which shows a potential source of low cost vegetable protein for human consumption. Soya saponins constitute a group of nonvolatile, amphiphilic molecules found in a wide variety of legume seeds, such as soybeans, peas, lentils, and lupins (Shuhong, *et al,* 2013). Soybean and soy-based food products are major dietary sources of soya saponins (Shuhong, *et al,* 2013). Soya saponins mainly exist in the soybean cotyledons cells, and it will be left in the SCR after soybean products processing. They were reported to have immune stimulatory, antiviral, hepatoprotective, and antitumorigenic properties (Shuhong, *et al,* 2013; Gurfinkel and Rao, 2003)

2.7 SOYBEAN CURD RESIDUES AS ANIMAL FEED

Feeding tofu cake as additional feed for local male sheep gave a significant increment on the water consumption ($P < 0.01$). Data experiments shows that dried tofu cake as an additional feed successfully increase the local male sheep's water consumption. If there were water content in feed or additional feed, the sheep will need less water than usual due to sheep can absorb the water from any source include feed or additional feed to fulfill their water needed (Tilman *et al.,* 1991).

Moon *et al*. (1999), observed no significant difference in antler productivity of Sika deer (*Cervus nippon*) when fermented SCR was fed. However, there were some positive results in a weight gain of deer and circumference of antler. In another study, Abe (2001) reported that dry matter intake (DMI), daily gain, carcass weight and marbling score (BMS) of loin eye was higher for the total mixed ration (TMR) feeding group with SCR than for control group in Japanese black beef cattle.

Kyoung *et al.,* (2012) determined the effect of dietary soybean curd residue (SCR) on the growth performance and carcass characteristics in Korean native cattle, Hanwoo steer it was observed that dry matter intake (DMI) and average daily gain (ADG) were significantly higher in SCR groups than animals on the control group. Dietary SCR improved growth rate of cattle without any meat quality deterioration.

A 15-week experiment was conducted by Ahmad and Diab (2008) to evaluate the use of okara meal (soybean by–product) in practical diets for all-male monosex Nile tilapia, *Oreochromis niloticus* (30.1±0.1 g). It was concluded that, partial or complete replacement of okara meal for HFM–protein in diets did not affect fish body composition of dry mater, protein or fat levels compared to the control treatment. In addition, okara meal could serve as a complete replacement for fish meal in practical diets for all-male monosex Nile tilapia.

2.8 ANTI-NUTRITIONAL FACTORS

Compounds that interfere with the intake, availability, or metabolism of nutrients in the animal are referred to as anti-nutritional factors. Their biological effects can range from a mild reduction in animal performance to death, even at relatively small intakes. The subject is complicated by the fact that different species and ages react in different ways to the presence of anti-nutritional factors (CAES, 2016). Anti-nutritional factors may occur as natural constituents of plant and animal feeds, as artificial factors added during processing or as contaminants of the ecosystem (Njidda and Ikhimioya, 2012). The raw grain of soybean contains several anti-nutritional factors in variable amounts. Some of them are not important in monogastric animals, because they are not considered harmful for these species.

Proper processing of soybeans requires precise control of moisture content, temperature and processing time to destroy the anti-nutritional factors (CAES, 2016). Both over and under-toasting of soybean meal can result in a meal of lower nutritional quality. Under heating produces incomplete inactivation of the anti-nutritional factors and over-toasting can reduce amino acid availability (lysine).

According to Nityanand (1997) anti-vitamin activities against vitamins A and D have been observed in soyabean, against vitamin E in kidney bean (*Phaseolus vulgaris),* against vitamin K in sweet clover and against pyridoxine in linseed cake. Akinmutimi, (2004) reported that most processing methods employed in improving the food value of non-conventional or alternative feedstuffs do not completely eliminate anti-nutritional factor substances, but only reduce their concentrations to tolerable levels in feedstuffs. It is a common practice in feeding trials to use the weights of some internal organs like liver and kidney as indicators of toxicity. Nuhu (2010) reported that if there are toxic elements in the feed, abnormalities in weights of liver and kidney would be observed. The abnormalities will arise because of increased metabolic rate of the organs in an attempt to reduce these toxic elements or anti-nutritional factors to non toxic metabolites. Healthline (2014) gave spleen as one of such organs, which was reported to be responsible for purifying and storing the blood as well helps the immune system which recognize and attack foreign antibodies and diseases.

The accepted limit of ANFs as reported by Amata (2010) for alkaloids was 640 mg/100g, 475 mg/100g for tannins, 186 mg/100g for saponins, 341.2 mg/100g for trypsin inhibitors, and 25 mg/100g for phytic acid while 15 mg/100g was reported for oxalate and 1.12 mg/100g for phenol. The limits of 35mg/100g was reported by Heuze, Trans, Bastianelli, Hassoun and Renaudeau (2014) for hydrocyanic acid, 23-46 mg/100g was reported by Tripathi and Mishra (2007) for glucosinolates and 25-40 was reported by Njidda and Ikhimioya (2012) for Nitrates. However, Jurgens (1997) observed that plants contain thousands of compounds or ANFs which may be regarded as a class of compounds which are generally not lethal but may diminish animal productivity. The most important anti-nutritional factors to monogastric animals are:

2.8.1 Protease Inhibitors: Protease inhibitors can inhibit the activity of proteolytic enzymes and can cause a decrease in digestive efficiency, inadequacy in dietary sulfur amino acids. As a consequence of inhibition of proteolytic enzymes the animals tend to react to the presence of protease inhibitors by secreting more digestive enzymes, which results in pancreatic hypertrophy. In poultry and swine, trypsin inhibitors significantly reduce the digestibility and utilization of amino acids. At least five trypsin inhibitors have been identified. However, the principal protease inhibitors present in raw or under processed soybeans are the Kunitz factor and the Bowman-Birk factor; the latter is more resistant to the action of heat, alkali and acid. Their average levels in raw soybeans are 1.4 and 0.6%, respectively (Jurgens, 1997)

2.8.2 Lectins: These are glycoproteins noted for their capability to agglutinate erythrocytes and bind sugar components. Lectin content in beans ranges from one to three percent. Lectins are not broken down in the gut, attach to mucosa cells damaging the intestinal wall and reducing the absorption of nutrients. Heat treatment is very effective and necessary in the inactivation of lectins (Nityanand, 1997).

2.8.3 Goitrogenic factors: These, similarly, are glycosides belonging to the isoflavinic group, some of which like genistin; have goitrogenic activity resulting in enlargement of the thyroid gland and a reduction in the activity of thyroxine secreted by the thyroid itself (Makker and Becker, 1999)

2.8.4 Tannins: These are complex polymeric phenols having molecular weight greater than 500 are natural constituents of many plants, and grouped into two forms-hydrolysable and condensed tannins (Nityanand, 1997). Hydrolysable tannins are potentially toxic and cause poisoning if large amounts of tannin-containing plant material such as leaves of oak (Quercus *spp*.) and yellow wood (*Terminalia oblongata)* are consumed (Njidda and Ikhimioya, 2012). Makker and Becker (1999) reported that tannins can inhibit the activities of rumen microbes, form complexes with protein, cellulose, hemicelluloses, lignin and starch and interfere with their optimum utilization in the digestive tract and systems. Protein sources of plant origin containing high amounts of tannins and in particular hydrolysable tannins should be used with caution (Becker and Makker, 1999). Ranjhan (1999) reported that soaking and washing removes substantial amount of tannins and this is usually accompanied by some loss of dry matter. Tannins have been found to affect digestibility and therefore rate of utilization of dietary nutrients in animals (Njidda and Ikhimioya, 2012)

2.8.5 Saponins are bitter in taste and hence reduce palatability; they are also haemolytic and alter the permeability of cell membranes and produce toxic effects on organized tissues when ingested. Lucerne, white and red clovers, mahua seed cake and soyabean are rich sources of saponins. Soaking and washing in water is quite effective in removing a greater proportion of saponins (Nityanand, 1997). Saponins have been reported to cause depressions in feed intake (Njidda and Ikhimioya, 2012). According to Rajhan (2001) ruminants can breakdown saponins but monogastrics cannot. Although saponins appear in low levels they can decrease feed palatability.

2.8.6 Phytates: (salts of phytic acid) are found in almost all feeds of plant origin. The phytates are present in association with protein and generally high in protein feeds e.g. groundnut cake, soyabean cake and sesame cake. Phytic acid possesses high chelating ability and in plants, it is found as phytates of many minerals which are mostly not available to monogastrics as they lack the enzyme phytase. The use of the enzyme phytase can make minerals such as phosphorus available to monogastrics (Nityanand, 1997). Phytic acid complexes with certain minerals such as calcium, phosphorus, magnesium, copper, iron and zinc reducing their bioavailability. Levels of phytate in soybeans range from 1.0 - 2.3 percent.

2.9 FEED INTAKE, WEIGHT GAIN, FCE AND MORTALITY OF RABBITS FED CONCENTRATES IN THE TROPICS

Nuhu (2010) reported the effects of feeding graded levels of cassava root meal on the performance of fryer rabbits under tropical condition. The experiment showed that rabbits could tolerate up to 30% cassava root meal diet without adverse effects on feed intake and rate of growth. The 45% cassava root level, however, gave poor growth and utilization efficiency and this was blamed on the hydrogen cyanide level in the diet. The results are showed that daily feed intake, daily weight gain, feed conversion efficiency and mortality ranged from 20.02-79.92g, 16.72-18.53g, 3.06-4.78g and 12.50-25.00% respectively.

Farinu *et al*. (2008) evaluated the nutritive potential of pigeon pea grain and leaf meals on growth performance of pre-pubertal rabbits in the tropics. Eighteen weaner rabbits were randomly allocated to experimental diets 1, 2 and 3, containing 0% pigeon pea, 15% pigeon grain meal and 15% pigeon pea leaf meal respectively, in replacement of maize offal as the main energy source. The final liveweight (1375.1 g for diet 1, 1487.5 g for diet 2 and 1347.38 g for diet 3); daily weight gain (11.6 g for diet 1, 13.00 g for diet 2 and 11.21 g for diet 3); and FCE values of 6.50, 5.20 and 5.31 for diets 1, 2 and 3, respectively were not significantly ($p>0.05$) affected by the dietary treatments. It was concluded that 15% pigeon pea grain meal inclusion in rabbit's diet with maize offal rather than maize, as the main energy base, resulted in better performance of weaner rabbits.

A feeding trial was conducted using weaner rabbits by Ayers *et al*. (1996) to evaluate hybrid poplar (HP) (*Populus spp*.) leaves as animal feed under tropical conditions. Ten New Zealand white weaner rabbits were each assigned to treatment 0, 10, 20, or 40% HP foliage. A diet with 40% Alfalfa Meal (AM) was the control. There was no difference in growth rates of rabbits on the various diets, even though digestibilities were lower in those on diets with HP than those in the AM control. Greater gut fillin rabbits on the HP-containing diets associated with the higher feed intakes with these diets, may compromise accuracy of the weight gain data.

Eustace *et al*. (2003) used 24 weaner rabbits to assess their performance using varying dietary cyanide levels (0mg 250mg 500mg 750mg). Daily weight gain, daily feed intake and feed efficiency significantly ($p<0.05$) reduced as the cyanide level increased. The results showed that dietary cyanide had negative impact on growth performance. Initial weight (766.67-779.17g), Final weight (1329.17- 1630.00g), Daily feed intake (54.56-68.08g), Daily weight gain (9.74- 16.64g) and FCE is 4.85-5.77. In the same study, the resulting cholesterol level values reported were 74.33 mg/dl, 106.75mg/dl, 53.67mg/dl and 104.00mg/dl, respectively, showing that dietary cyanide had negative impact on blood cholesterol level.

Okorie (2003) carried out a six-week experiment to determine the effect of palmitic acid fortified maize wet milling by-product on the performance of weaner rabbits. Forty eight (48) weaner New Zealand White and Dutch breed of rabbits were assigned to four dietary treatments of 0, 25, 30 and 50% levels of the palmitic acid fortified maize wet milling by-product. The growth rate of rabbits on the 25% diet was higher followed by the 0 and 30% diets. Nevertheless, those on 50% showed a depressed growth rate, which could be due to the unpalatability of the by-product at the 50% level. The animals showed a higher feed intake at the 25% level and 0% level ($p>0.05$) and the feed intake decreased from the 30% level to the 50% level of inclusion. The data obtained in the experiment showed a strong promise for the palmitic acid fortified maize wet-milling by-product as a good source of feedstuff for rabbits.

Hasanat *et al*. (2006) used cross-bred New Zealand white meat type rabbits in a 128- day trial to study the effect of concentrate supplementation on growth of rabbits under rural conditions. Dietary treatment 1 was a conventional diet, while treatment 2 was conventional diet plus concentrate. All animals had free access to locally available green grasses. The results obtained were: initial weight (g), T1 = 1055.83 and T2 = 994.98; final weight (g), T1 = 1426.66b and T2 = 1911.66a; weight gain (g/d) T1 = 5.30b and T2 = 13.02a. The results showed that, average daily live weight and final weight gain were significantly ($p<0.01$) higher in T2 than in T1 group. It could therefore be inferred that supplementation of concentrates in addition to conventional feeding may improve growth performance of rabbits under rural conditions.

According to Lei, Li. and Jiao (2004) the best growth performance was obtained with diets containing 16 to 20 % CP. There were no significant (P>0.05) differences in total DM, DE, ME, CP and fibre intake due to breed or sex and no interactions between foliage, breed and sex with the exception of concentrate intake, which was higher for NZW rabbits. Since the NZW rabbits consumed more concentrate than the crossbred rabbits, intake of CP and fibre was higher for the NZW rabbits. This results in significantly (P<0.05) higher daily gain for NZW than for the crossbreds. The higher intakes may explain part of the difference in growth rate, but probably the NZW rabbits, being selected for meat production, are also more efficient in metabolizing and using the nutrients for tissue growth. The best FCR was found in the group fed water spinach, 3.6 g DM/g LWG, and the worst in the group fed mimosa, 5.2 g DM/g LWG (P<.001). There was an interaction between foliage and breed for FCR (P<0.05). Sex had no significant

(P>0.05) effect on growth rate or FCR. Growth rates of 14.0g/day have been reported for rabbits fed water spinach *ad libitum* as a sole feed (Samkol, 2005), about 18.1g/day with broken rice (Phimmasan, Kongvongxay, Chhay and Preston, 2004) and 31.4g/d when supplemented with molasses block and concentrate at 2 and 3 % (DM) of body weight respectively (Chat, *et al*., 2005)

2.10 EFFECT OF NUTRITION ON BIOCHEMICAL AND HAEMATOLOGICAL COMPONENTS OF RABBITS

Blood is a complex fluid containing a large variety of dissolved suspended inorganic and organic substances (Stewart, 1991) or specialized circulating tissues and cells suspended in the intercellular fluid substance. Blood circulates in the arteries, veins and capillaries of man and animals (Stewart, 1991). Its primary function is to transport oxygen from respiratory organs to body cells distributing nutrients and enzymes to cells and carrying away waste products, thereby maintaining homeostasis of the internal environment. The cellular elements of the blood that supply oxygen are the red blood cells, the white blood cells protects against foreign organisms and antigens, while platelets initiates coagulation (Merck Veterinary Manual, 2005). The various functions of blood are made possible by the individual and collective actions of its constituents – the biochemical and haematological components. Generally, both the biochemical and haematological blood components are influenced by the quantity and quality of feed and also the level of anti-nutritional elements or factors present in the feed (Akinmutimi, 2004).

Biochemical components are sensitive to elements or factors present in the feed (Akinmutimi, 2004), including elements of toxicity. They can also be used to monitor protein quality of feeds. Haematological components of blood are also valuable in monitoring feed toxicity especially with feed constituents that affect the formation of blood (Oyawoye and Ogunkunle, 1998). Roberts, Daryl, Peter and Victor (2000) reported that low level haemoglobin (Hb) of treatment diets could imply that dietary proteins were not of high quality. Diets containing poor protein would usually result in poor transportation of oxygen from the respiratory organs to the peripheral tissues (Roberts *et al*., 2000). Reduction in the concentration of PCV in the blood usually suggests the presence of a toxic factor (e.g. haemagglutinin) which has adverse effect on blood formation (Oyawoye and Ogunkunle, 1998). High WBC count is usually associated with microbial infection or the presence of foreign body or antigen in the circulating system. Reduction in PCV and RBC values are indicative of low protein intake or mild anaemia. High blood urea levels are associated with poor protein quality or excess tissue catabolism associated with protein deficiency (Merck Veterinary Manual, 2005). There is evidence in literature that haematological characteristics of livestock suggest their physiological disposition to the plane of nutrition (Madubuike and Ekenyem, 2006). Reduction in packed cell volume and red blood cell values are indicative of low protein intake or mild anaemia (Lindsay, 1977). Blood chemistry constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feed and feeding (Esonu, Emenelom, Udedibie, Herbert, Ekpor, Okoli and Iheukwumere, 2001; Iheukwumere and Okoli, 2002).

Blood chemistry studies are usually undertaken to establish the diagnostic baselines of blood characteristics for routine management practices of farm animals (Tambuwal, Agaie and Bangana, 2002; Onyeyilli Egwu, Jiike, Pepple and Ohaegbulem, 1992; Aba-Adulugba and Joshua, 1990).

The haematopoietic system is an important index of physiological and pathological status in animals and man since it is the one which becomes exposed to a high concentration of toxic agents first (Merck Veterinary Manual, 2005). Total serum protein has been reported as an indication of the protein retained in the animal body (Akinola and Abiola, 1991; Esonu *et al*., 2001), while total blood protein and creatinine contents have been shown to depend on the quantity and quality of dietary protein (Iyayi and Tewe, 1998; Awosanya, Joseph, Apata and Ayoola, 1999; Esonu *et al*., 2001). Muscle wasting has been shown to be the source of excess creatinine in the blood of animals and is normally due to creatinine phosphate catabolism during this process (Bell, Enslie-Smith and Patterson, 1992). Increased serum urea concentration may suggest an increase in activities of urea enzymes ominthine, carbonyl transferase and orginase, which may also indicate kidney damage (Ajagbonna, Onifade and Suleman, 1999). Normal range of blood sugar level indicates that animals are not surviving at the expense of body tissues (Ologhobo, Apata, Oyegide and Akinpelu, 1992). Merck Veterinary Manual (2005) reported that the number of neutrophils in the blood increases rapidly when acute infection is present, hence a blood count showing this increase is useful in diagnosis of infections. The manual reported further that eosinophils which normally are scarce increase in numbers in certain chronic diseases, such as infection with parasites and also in allergic reactions.

2.11 HAEMATOLOGICAL AND BIOCHEMICAL VALUES OF RABBITS

A 12-week feeding trial to evaluate the blood biochemistry and haematology of rabbits fed sun-dried, ensiled and fermented cassava peel based diet was conducted by Ahamefule *et al*. (2006) in Nigeria. It was observed that the haematological values obtained for rabbits fed sun-dried, ensiled and fermented cassava peel based diets, except PCV and WBC, fell within normal stipulated ranges. This is a good indication that sun-drying, ensiling and fermentation could be used to reduce hydrogen cyanide (HCN) to a non-lethal level in cassava peels for rabbit nutrition. The results obtained in the trial for PCV, WBC, neutrophils, lymphocytes and eosinophils, ranged from 42-75%, 5.80-7.30 x10^3/dl, 37.50-43.25%, 56.50-60.75%, and 1.25-2.00% respectively.

Ogbuewu, Okoli and Lioeje (2008) carried out a 16-week feeding trial to determine the effect of dietary neem leaf meal (NLM) 0, 5, 10, and 15% on serum biochemical constituents of buck rabbits. The results of the trial suggested that buck rabbits could tolerate 5-15% dietary levels of NLM without deleterious effects. The results obtained showed that TP, globulin, albumin and cholesterol ranged from 3.00-6.90 g/dl, 1.50-5.10 g/dl, 0.90-1.80 g/dl and 56.50-174.60 mg/dl respectively.

Ahamefule *et al*. (2008) carried out a research to assess the haematological and biochemical profile of weaner rabbits fed raw or a processed pigeon pea seed (PSM) meal based diets at 20% inclusion level in the tropics. The summary of the haematological and biochemical components of the rabbits fed the various diets showed that haemoglobin, PCV, WBC, neutrophils, eosinophils, lymphocytes, TP, globulin and albumin ranged between 5.53-8.40 g/dl, 19.6-28.5 %, 5.0-6.8 (x10^3), 55.3-72.6 %, 8.3-11.0 %, 33.0-37.0 %, 2.9-5.3 g/dl, 1.10-2.70 g/dl, and 1.64-4.20 g/dl respectively. The conclusion drawn from the study was that most haematological and biochemical values obtained were out of the normal physiological range for rabbits. Raw or processed pea generally caused remarkable changes in the haematological and biochemical profile ofthe weaner rabbits when incorporated at 20% level in the feed.

Merck Veterinary Manual (2005) reported normal physiological ranges of haematological components for rabbits as 5-12.5, 1.6-10.6, 0.05-0.5, 1.2-7.2, 30-85, 1-4, 30-48, 5-8, 10-17, 33-50, 58-67, 17-24 and 29-37 for WBC (x10^9/L), lymphocytes (x10^9/L), Eosinophils

($x10^9$/L), Neutrophils ($x10^9$/L), lymphocytes (%), Eosinophils (%), Neutrophils (%), RBC ($x10^{12}$/L)9, Hb (g/dl), PCV (%), MCV (fl), MCH (pg) MCHC (pg), respectively.

2.12 DIGESTIBILITY VALUES OF RABBITS FED CONCENTRATES IN THE TROPICS

Iyeghe-Erakpotobor *et al*. (2005) evaluated concentrate, grass and legume combinations on performance and nutrient digestibility of grower rabbits under tropical conditions. The results showed a high digestibility of dry matter, crude protein, crude fibre and ether extract indicating that the rabbits were able to utilize nutrients in the high forage and low concentrate combinations used for growth. They concluded from the study that any of the combinations of concentrate, grass and forage would be adequate for grower rabbits. They reported results of apparent digestibility, dry matter (DM), ether extract (EE), crude fibre (CF) and crude protein (CP) ranged from 59-72%, 68-80%, 45-55%, and 59-74% respectively.

Eustace *et al*. (2003) assessed the response of rabbits fed varying levels of dietary cyanide and reported the apparent digestibility of rabbits as shown in. The results showed a low nutrient digestibility with a consequent reduction in growth rate and feed conversion as cyanide concentration increased beyond 250 mg. Based on the results of this study, diets formulated for rabbits should contain no more than 250 mg cyanide per kg in diet. The results for (DM), crude protein (CP), crude fibre (CF) and ether extract (EE), ranged from 67.55-74.96 %, 57.66-66.26 %, 33.37-48.53 %, and 83.07-90.66 % respectively.

A study was carried out to determine the digestibility of weaner rabbits fed graded levels of soyabean cheese waste/maize offal diet and brachiaria grass hay by Iyeghe-Erakpotobor *et al*. (2006) and reported digestibility coefficients for dry matter, ether extract, crude protein and crude fibre as 63-77 %, 65-77 %, 69-79 % and 45-71% respectively. Dry matter and ether extract digestibility values were similar for the control, and significantly higher than 100 and 50% SBW treatments. Crude protein digestibility was similar for the control and all the experimental groups. This could indicate a high efficiency in crude protein utilization. It is concluded from this study that soybean cheese waste/maize offal diet compared favorably with the standard rabbits meal fed to rabbits in nutrient digestibility.

Bamikole *et al*. (2005) investigated the potential of mulberry leaves in rabbit production where the nutrient digestibility of the rabbits was monitored. The percentage of concentrate in the rations was incrementally replaced with mulberry leaves: 100:0, 75:25, 50:50, 25:75, 0:100. The results obtained for nutrient digestibility for dry matter, crude protein crude fibre and ether extract, were 75.67-82.33 %, 76.33-84.00 %, 79.67-88.67 % and 55.65-80 % respectively. The results indicated that the levels of DM, CP and CF were not significantly ($P>0.05$) different among the diets, except for EE. The values of EE significantly declined as the percentage of concentrate offered decreased. It could be concluded that the high levels of nutrients intake and digestibility confirm the high nutritive value of mulberry leaves and their potential as forage that can support rabbit production.

Ayers *et al*. (1996) conducted a feeding trial using weaner rabbits to evaluate black locust and hybrid poplar (HP) leaves as animal feed under tropical conditions and reported nutrient digestibility values indicated values ranging from 54.76-78 %, 8.40-26.28 % and 55.72-64.3 % for crude protein, acid detergent fibre and dry matter respectively. Nutrients digestibility values were lower in diets with hybrid poplar leaf meal than in the alfalfa (control). The reduced crude protein digestibility with increasing dietary hybrid poplar leaf meal is likely due to effects of anti-nutritional factors.

2.13 CARCASS CHARACTERISTICS OF RABBITS UNDER TROPICAL CONDITIONS

Amata and Bratte (2008) carried out an experiment to determine the effect of feeding graded levels of *Gliricidia sepium* leaf meal (GLM) on organ weights of 25 weaner rabbits allotted to five dietary treatments containing 0 (control), 5, 10 15 and 20% GLM. The conclusion from the experiment indicated that beyond 10% GLM in rabbit's diets, there would be probably increases in detoxification activities in the liver and kidneys of the rabbits. The results obtained were heart, kidney, liver and lungs that ranged from 4.75-5.99 g, 6.52-10.95 g, 30.36-42.84 g and 5.18-6.36 g respectively.

Okorie (2003) conducted an experiment to assess the effect of palmitic acid fortified maize wet-milling by-product on the performance of weaner rabbits and reported the following carcass yield. Dressing percentage and breast weight were lower ($p<0.05$) for the 50% inclusion of the palmitic acid fortified maize wet-milling by-product, while the inclusion of the by-product increased ($p>0.05$) the viscera weight. The results of the experiment showed that palmitic acid fortified maize wet-milling by-product could improve carcass yield of rabbits. The results obtained were weight of the animal, dressing percentage, liver, kidney, and heart weights that ranged from 1200-1311 g, 72.6-76.2 %, 2.79-3.28 g, 0.7-0.8 g, and 0.88-1.05 respectively.

In an experiment to study the effect of different feeding systems on the carcass characteristics of New Zealand white rabbits, Biya *et al*. (2008) reported carcass characteristic values. T1 represented rabbits which were fed with concentrate alone.T2 rabbits had 25% replacement of concentrate.T3 had 50 vegetable cuttings on DM basis.T4 had 25% concentrate and 75% vegetable cuttings on DM basis and T5 had 100% vegetable cuttings on DM basis.The results showed that T2, which had 25% replacement of concentrate with vegetable cuttings produced the highest dressing percentage compared to the other treatment groups. The results of the slaughtered weight, carcass weight, dressing percentage, pelt, head, liver, kidney, heart plus lungs plus spleen, obtained from the experiment ranged from 1595.17-2290.00g, 571.66-1197.36 g, 45.31-52.27 %, 10.08-11.58 %, 7.75-8.77 %, 2.33-3.63 %, 0.84-1.26 %, and 1.07-1.16 % respectively.

CHAPTER THREE

3.0 MATERIALS AND METHODS

Experiment 1: Replacement Value of Soybean Curd Residue for Groundnut Cake

3.1 EXPERIMENTAL SITE

The experiment was conducted at National Agricultural Extension and Research Liaison Service (NAERLS) Skill Acquisition Farm, Ahmadu Bello University (A.B.U) Samaru, Zaria. The farm is located at latitude $11^0$9’45”N and longitude $7^0$38’8”E at an altitude of 610m above sea level (Ovimaps, 2014). Zaria is a Local Government Area of Kaduna State. The climate in the area is divided into two: dry and rainy seasons. The dry season is usually from November to March and the temperatures recorded are within an average of 28^0C towards the end of the dry season. The rainy season is usually from April to October. The daily mean maximum temperature reaches a peak in April and a minimum occurs between December and January. The area enjoys a tropical savannah climate with the annual total rainfall of about 1099mm (Adamu, 2008) and a population of 408,198 based on the 2006 census.

3.2 SOURCE OF SOYBEAN CURD RESIDUE

The soybean curd residue used in the experiments was collected from local Wara (Tofu) producers at Samaru. It was sun dried to reduce moisture content.

3.3 PROXIMATE ANALYSIS AND ANTI-NUTRIENT

The analysis of the soybean curd residue and feed samples was carried out according to procedures described by AOAC (2000). Quantitative determination of oxalates, phytates, tannins, saponins and cyanogenic glycosides were carried out using the method of AOAC (1990).

Table 3.1: Percentage Chemical Composition of Soybean Curd Residue

Parameter	Percentage
Moisture	11.49
Crude protein	29.11
Crude fat	4.27
Crude fibre	23.77
Nitrogen free extract	27.72
Ash	3.64
Energy	2396.55Kcal/kg

Source: proximate analysis

3.4 MANAGEMENT OF EXPERIMENTAL ANIMALS AND DATA COLLECTION

A total of 30 weaner rabbits (8 week old) of 534.7g average initial weights were used for the study. Each treatment consists of 6 rabbits and each rabbit was a replicate. The rabbits were assigned randomly in a completely randomize design. They were housed individually in wire cages of 40 x 60 x 60cm dimension. Feed and water were provided *ad libitum*. The cages had wire screen base, which allows feaces and urine to pass into collection grid. The rabbits were allowed one week adjustment period before the feeding trial commences. Ivomectin was administered at 0.2mls per rabbits as prophylactic measure against endo and ecto parasites. The drinkers were washed on daily basis before water supplied. The rabbits were weighed weekly. The performance was monitored in terms of feed intake, weight gain and feed to gain ratio.

3.5 CARCASS EVALUATION

At the end of 8-week feeding trial, carcass evaluation was carried out. Three (3) rabbits representing the average of their treatment groups were selected and fasted for 24 hours prior to slaughter to clear the gut. They were bled by severing the jugular vein with the aid of a sharp knife and the fur was removed by skinning. The internal organs and the gut were removed and weighed individually. The skinned carcass were cut and weighed. The weights of the cuts and the internal organs were expressed as a percentage of live weight.

3.6 EXPERIMENTAL DIETS

Five experimental diets were formulated to meet the nutritional requirement of rabbits. The diets contained 20% crude protein and 2739.7kcal ME/kg for diets 1,2,3,4 and 5. Soybean curd residue was included at 0, 25, 50, 75, and 100.0% as replacement for groundnut cake in the diets. The gross composition of the experimental diets is presented in Table 3.2.

Table 3.2: Gross Composition of the Experimental Diets

Ingredients	Percent Replacements of Soybean curd residue for Groundnut cake				
	0	25	50	75	100
Maize	54.80	51.45	48.10	44.76	31.35
G/nut Cake	31.15	26.72	22.28	17.83	00.00
SCR	00.00	07.78	15.57	23.36	54.60
Wheat offal	10.00	10.00	10.00	10.00	10.00
Bone meal	02.50	02.50	02.50	02.50	02.50
Limestone	01.00	01.00	01.00	01.00	01.00
Premix*	00.25	00.25	00.25	00.25	00.25
Salt	00.30	00.30	00.30	00.30	00.30
TOTAL	100	100	100	100	100
Calculated Analysis					
Metabolizable Energy (Kcal/kg diet)	2853.10	2810.40	2767.70	2725.10	2541.10
Crude protein (%)	20.00	20.00	20.00	20.00	20.00
Crude fibre (%)	4.66	5.25	6.84	8.44	14.82
Calcium (%)	1.37	1.38	1.40	1.41	1.46
Phosphorus (%)	0.88	0.85	0.82	0.79	0.66
Methionine (%)	0.27	0.28	0.29	0.30	0.35
Lysine (%)	0.77	0.72	0.67	0.62	0.43
Cost/kg diet (N)	74.98	69.65	64.32	58.98	37.58

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

3.7 HAEMATOLOGICAL EVALUATION

Blood samples (2mls) were collected from rabbits for haematological indices assay. After the jugular vein was severed, a sample bottle containing Ethylene Diammine Tetraacetic Acid (EDTA) was used to collect blood sample. Blood samples were analyzed for total protein (TP), haemoglobin (Hb) concentration; red blood cell counts (RBC), white blood cell count (WBC), and pack cell volume (PCV) as described by Ewuola and Egbunike (2008) . The analysis was carried out at the Clinical Pathology Laboratory, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria.

3.8 DIGESTIBILITY STUDY

At the end of the experiment, three rabbits were selected from each treatment and were housed individually in separate cages for faecal and urine collection. The trial lasted for 7 days. Plastic sheet was placed under each cage to allow for faecal and urine collection. During the collection, fur and feed were removed from the faeces on the plastic sheet on daily basis. Daily feed intake per rabbits was recorded during the period. Urine samples collected was transferred into 25ml bottles containing 5mls of tetraoxosulphate (VI) acid (H_2SO_4). Faecal samples of the rabbits were then bulked, oven-dried at 70^0C for 72 hours and then weight. Nutrient digestibility was calculated using the formula below:

$$ND = \frac{\text{Nutrient supplied in feed – amount of nutrient in faeces) x 100}}{\text{Nutrient supplied in the feed}}$$

ND = Nutrient digestibility

Experiment 2: Effect of Lysine and or Methionine Supplementation on Performance of Weaner Rabbits Fed Soybean Curd Residue Based Diets

3.9 EXPERIMENTAL DIETS

Six experimental diets were formulated; diet 1 served as a control with no soybean curd residue. Diet 2 contained soybean curd residue supplimented with 0.2% lysine and 0.2% methionine. Diet 3 contained soybean curd residue with 0.2% Lysine and 0% methionine. Diet 4 contained 0.2% methionine + 0% lysine. Diet 5 contained soybean curd residue with 0% lysine + 0% methioine, while diet 6 contained lysine and methionine at 0.2 % levels respectivelty. The gross composition of the experimental diets is presented in Table 3.3.

Table 3.3: Composition of Experimental Diet

Ingredients	Diets					
	1	2	3	4	5	6
Maize	55.39	32.70	32.00	32.00	31.35	45.05
G/nut cake	30.16	00.00	00.00	00.00	00.00	16.50
SCR	00.00	52.85	53.75	53.75	54.60	24.00
Wheat offal	10.00	10.00	10.00	10.00	10.00	10.00
Bone meal	02.50	02.50	02.50	02.50	02.50	02.50
Limestone	01.00	01.00	01.00	01.00	01.00	01.00
Premix*	00.25	00.25	00.25	0.25	00.25	00.25
Salt	00.30	00.30	00.30	00.30	00.30	00.30
Lys	00.20	00.20	00.20	00.00	00.00	00.20
Meth.	00.20	00.20	00.00	00.20	00.00	00.20
Total	100	100	100	100	100	100
<u>Calculated Analysis</u>						
Metabolizable Energy(Kcal/kg)	2847.4	2558.1	2555.8	2555.8	2554.1	2715.7
Crude protein (%)	20.00	20.00	20.00	20.00	20.00	20.00
Crude fibre (%)	4.64	14.44	14.64	14.64	14.82	7.05
Calcium (%)	1.37	1.46	1.46	1.446	1.46	1.41
Phosphorus (%)	0.66	0.88	0.66	0.66	0.66	0.83
Methionine (%)	0.46	0.55	0.35	0.55	0.35	0.50
Lysine (%)	0.95	0.62	0.63	0.43	0.43	0.90
Cost/Kg diet (N)	78.75	42.55	39.16	40.96	37.58	70.22

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

3.10 MANAGEMENT OF EXPERIMENTAL ANIMALS AND DATA COLLECTION

A total of 30 weaner rabbits (8 weeks old) of 561.7g average initial weight were used for the study. Each treatment consisted of five rabbits and each rabbit served as a replicate. The rabbits were assigned in a completely randomize design. Management was done as did for Experiment 1.

3.11 CARCASS EVALUATION

Same procedure was used as in Experiment 1.

3.12 HEAMATOLOGICAL EVALUATION

Same procedure was used as in Experiment 1.

3.13 DIGESTIBILITY STUDY

Same procedure was used as in Experiment 1.

3.14 DATA ANALYSIS

Data obtained from the experiments was subjected to analysis of variance (ANOVA) using the General Linear Model Procedure (SAS, 2002). Differences between means among the dietary treatments were separated using Duncan multiple range test.

The data obtained was analyzed using the following model:

$Y_{ijk} = \mu + O_i \; P_j + e_{ijk}$

Where:

Y_{ij} = individual observation

μ = overall mean

O_i = effect of i^{th} levels of soybean curd residue

P_j= effect of j^{th} lysine and or methionine

e_{ijk} = random error

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Experiment 1: Performance of Weaner Rabbits Fed Replacement Levels of Soybean Curd Residue (SCR) For Groundnut Cake

Results on performance of weaner rabbits fed graded level of SCR as replacement for GNC were presented in Table 4.1. The results indicate that all the parameters considered were significantly (P<0.05) affected by the dietary treatments. Rabbits fed diet 4 (75.0% SCR) and Diet 5 (100% SCR) were statistically similar (P>0.05) with respect to final weight, daily weight gain and daily feed intake values. However, those fed diet 3 (50.0% SCR) and diet 1 (0.0% SCR) were significantly (P<0.05) different. Animals on diet 2 (25% SCR) were statistically similar (P>0.05) with those on diet 1 (0.0% SCR) and diet 3 (50% SCR) for most of the parameters. For feed conversion ratio, rabbits fed diet 1 (0.0% SCR) and diet 2 (25.0% SCR) did not differ (P>0.05) significantly; likewise those on diet 4 (75.0% SCR) and diet 5 (100% SCR), but difference exists between the two groups. Similarity (P>0.05) also exist between animals fed diet 2 (25.0% SCR), diet 3 (50.0% SCR) and diet 4 (75.0% SCR). The cost of feed /kg weight gain was affected for the entire treatment groups with diet 1 (0.0% SCR) had the highest (₦495.1) while diet 5 (100% SCR) had the least (₦ 176.2). Mortality was not recorded in all the treatments.

Table 4.1: Performance of weaner rabbits fed replacement levels of soybean curd residue (SCR) for groundnut cake

Parameters	Percent Replacements of Soybean curd residue for Groundnut cake					SEM
	0	25	50	75	100	
Initial weight (g)	535.80	534.20	534.70	536.30	532.70	74.7
Final weight (g)	1087^{c}	1140^{bc}	1212^{b}	1329^{a}	1404^{a}	53.2
Daily weight gain (g)	9.84^{c}	10.82^{bc}	12.10^{b}	14.16^{a}	15.55^{a}	0.79
Daily feed intake (g)	64.67^{d}	66.61^{cd}	68.76^{bc}	70.93^{ab}	72.38^{a}	1.33
Feed conversion ratio	6.60^{a}	6.25^{ab}	5.74^{bc}	5.07^{cd}	4.69^{d}	0.76
Feed cost/kg gain(₦)	495.10^{a}	435.10^{b}	369.10^{c}	299.20^{d}	176.20^{e}	23.53
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

^{abcd} Means on the same row with different superscript are significantly ($P<0.05$) different, g= gram, SEM = standard error of mean

4.1.2 Nutrient Digestibility by Weaner Rabbits Fed Replacement Levels of Soybean Curd Residue for Groundnut Cake

The results of nutrients digestibility of weaner rabbits fed soybean curd residue as replacement for groundnut cake are shown on Table 4.2. The results indicated that all the parameters considered were not affected significantly ($P>0.05$) by the test material except crude fibre which differ at ($P<0.05$) significantly among treatments. The values of crude fibre for rabbits on diet 1 (67.3%), diet 3 (72.4%) and diet 5 (72.7%) did not differ statistically between each other but statistically different ($P<0.05$) with those on diet 4 which recorded the highest value. In other words, animals on diet 2 and diet 4 (70.8 and 80.2% respectively) differ significantly ($P<0.05$) between each other but statistically similar with other treatments.

Table 4.2: Nutrient Digestibility (%) of Weaner Rabbits Fed Replacement Levels of Soybean Curd Residue for Groundnut Cake

Parameters	Percent Replacement of Soybean curd residue for Groundnut cake					SEM
	0	25	50	75	100	
Dry matter	62.8	60.2	70.5	74.0	66.4	7.07
Crude protein	75.7	73.1	77.5	79.9	74.5	3.98
Crude fibre	67.3[ab]	65.8[b]	72.4[ab]	75.2[a]	72.7[ab]	4.03
Ether extract	78.7	76.8	80.8	83.4	82.0	3.22
Ash	64.6	60.3	68.3	71.4	65.5	3.98
Nitrogen free extract	62.3	57.2	67.8	71.2	61.1	7.59

[abcd] Means on the same row with different superscript are significantly ($P<0.05$) different. SEM = standard error of mean

4.1.3 Haematological Parameters of Weaner Rabbits Fed Graded Levels of Soybean Curd Residue as Replacement for Groundnut Cake

Results for haematological parameters of weaner rabbits fed graded level of SCR as replacement for GNC are presented on Table 4.3. The results indicated that all the parameters considered were significantly ($P<0.05$) affected by the test ingredient except total protein (g/dl) and mean corpuscular volume (fl). Heamoglobin values for animals fed diet 2 (25.0% SCR) recorded the highest value (12.80 g/dl) and was statistically superior ($P<0.05$) than those on diet 1 (0.0% SCR) and diet 5 (100% SCR). Parked cell volume and red blood cell of the animals followed similar trend. Rabbits fed diet 1 (0.0% SCR) had the highest value of white blood cells (5.2 $x10^9/l$), followed by those fed diet 3 (4.10 $x10^9/l$). They were statistically different ($P<0.05$) from rabbits on diet 2 (50% SCR), diet 4 (75% SCR) and those fed diet 5 (100% SCR) with 2.60, 2.20 and 3.17 values respectively. Highest value for Mean corpuscular heamoglobin (pg) (20.47) was recorded for rabbits fed diet 5 (100% SCR) and was statistically different ($P<0.05$) from animals fed diet 3 (75.0%) which is the least (19.72). Mean corpuscular heamoglobin concentration (g/dl) followed similar trend except that the least (32.83) was recorded for rabbits fed diet 2 (25.0%SCR).

Table 4.3: Haematological Parameters of Weaner Rabbits Fed Graded Levels of Soybean Curd Residue as Replacement for Groundnut Cake

Parameters	Percent Replacements of Soybean curd residue for Groundnut cake					SEM
	0	25	50	75	100	
TP (g/dl)	6.70	5.80	6.00	6.70	6.00	0.487
Hb (g/dl)	10.97^{bc}	12.80^{a}	12.17^{a}	12.00^{ab}	9.97^{bc}	0.741
RBC (x 10^{12}/L)	5.40^{bc}	6.47^{a}	6.17^{ab}	6.00^{ab}	4.87^{c}	0.380
PCV (%)	33.00^{bc}	39.00^{a}	36.67^{ab}	36.00^{ab}	29.67^{c}	2.241
WBC(x10^{9}/L)	5.20^{a}	2.60^{c}	4.10^{ab}	2.20^{c}	3.17^{bc}	0.518
MCH (pg)	20.35^{ab}	19.97^{ab}	19.72^{b}	20.01^{ab}	20.47^{a}	0.309
MCHC (g/dl)	33.23^{ab}	32.83^{b}	33.18^{ab}	33.33^{ab}	33.58^{a}	0.256
MCV (fl)	61.22	60.29	59.43	60.04	60.96	0.905

^{abcd} Means on the same row with different superscript are significantly (P<0.05) different. PCV= packed cell volume, Hb=haemoglobin level, WBC=white blood counts, TP=total protein, SEM = standard error of Mean

4.1.4 Carcass Characteristics of Weaner Rabbits Fed Graded Levels of Soybean Curd Residue as Replacement for Groundnut Cake

Results for carcass characteristics of weaner rabbits fed graded levels of soybean curd residue as replacement for groundnut cake are presented in Table 4.4. The result showed that all the parameters considered were not significantly affected (P>0.05) by the dietary treatments except for live weight, slaughter weight, dress wt, heart and lungs which differed (P<0.05) across their treatment means. Rabbits fed diets 3, 4 and 5 were not significantly different (P>0.05) in terms of live weight, lungs and heart, while treatment 1 differed significantly (P<0.05) in terms of heart values.

Table 4.4: Carcass Characteristics of Weaner Rabbits Fed Graded Levels of Soybean Curd Residue as Replacement for Groundnut Cake

Parameters (% unless otherwise stated)	Percent Replacements of Soybean curd residue for Groundnut cake					SEM
	0	25	50	75	100	
Live weight (g)	1106[c]	1165[bc]	1270[ab]	1293[ab]	1388[a]	61.70
Dress weight (g)	682.06[b]	732.7[b]	773.3[b]	803.0[ab]	910.0[a]	57.80
*Dressing %	61.70	62.80	61.10	62.20	65.50	04.07
Expressed as % of carcass weights						
Thigh	16.80	15.20	13.50	13.40	13.80	3.72
Rack/Rib	28.48	27.71	26.00	26.24	27.26	2.94
Forelimb	7.54	7.21	6.86	6.71	7.40	0.79
Hind limb	13.77	12.69	14.10	13.07	14.55	2.04
Head	8.12	7.35	7.71	7.55	8.03	0.71
Skin	8.14	8.34	7.89	7.18	9.35	1.06
Liver	3.96	3.54	3.75	3.52	4.08	0.76
Lungs	0.69[c]	0.79[bc]	1.11[ab]	1.26[a]	1.17[a]	0.16
Heart	0.04[bc]	0.39[c]	0.55[ab]	0.60[a]	0.67[a]	0.06
Small intestine	7.85	6.62	7.51	6.01	6.84	1.04
Large intestine	8.60	8.81	9.32	8.07	7.65	1.22
Kidney	1.37	1.44	1.11	1.18	1.31	0.25
Stomach	7.10	6.94	7.06	6.10	5.02	0.79

[abcd] Means on the same row with different superscript are significantly ($P<0.05$) different, g = gram, SEM = standard error of mean. * Express as % of live weights

4.1.5 Experiment 2: Performance of Weaner Rabbits Fed Soybean Curd Residue with Lysine And Or Methionine Supplementation

Performance of weaner rabbits fed soybean curd residue with lysine and or methionine supplementation is presented on Table 4.5. All the parameters observed were significantly (P<0.05) affected by the test material. Rabbits fed diet 2 recorded the highest final weight (1473g) followed by those on diet 6 (1466g) while the least was observed for rabbits fed diet 5 (1206g). Rabbits on diet 5 differs significantly (P<0.05) from the remaining treatments except those on diets 3 and 4 which were statistically similar (P>0.05). Result on daily weight gain indicates no significant variation (P>0.05) between rabbits on diets 2 and 6 but differ significantly (P<0.05) with other treatment groups. Similarly, there was no significant difference between animals fed diet 3 and 5 (P>0.05), likewise those fed diets 1 and 4. Daily feed intake shows highest value (P<0.05) for rabbits fed diet 6 (75.74g) than the rest of the treatments, those fed diets 5 had the least value (67.59g). Animals fed diet 3, 4 and 5 did not differ (P>0.05) significantly with respects to feed conversion ratio, so also those fed diets 1, 2 and 6; rabbits on diest 2 and 4 had the least value (4.46 each). In terms of feed cost /kg weight gain, rabbits fed diets 3, 4 and 5 were not affected (P>0.05) significantly while those fed diets 1 and 6 were significantly (P<0.05) affected. Rabbits on diet 2 had the highest value (₦189.9) although has no significant difference (P>0.05) with animals fed diets 4 and 5. Mortality was not recorded for any of the treatments.

Table 4.5: Performance of Weaner Rabbits Fed Soybean Curd Residue with Amino Acid Supplementation as Replacement for Groundnut Cake

Parameters	Diets						SEM
	1	2	3	4	5	6	
Initial weight (g)	561.00	561.20	561.80	560.40	563.00	562.00	30.94
Final weight (g)	1351^{bc}	1473^{a}	1220^{d}	1306^{cd}	1206^{d}	1466^{ab}	59.00
Weight gain (g/day)	14.44^{b}	17.01^{a}	12.07^{c}	13.52^{bc}	11.74^{c}	17.08^{a}	0.94
Feed intake (g/day)	72.56^{bc}	74.80^{ab}	69.96^{cd}	72.80^{abc}	67.59^{d}	75.74^{a}	1.52
Feed conversion ratio	5.09^{bc}	4.46^{c}	5.83^{a}	5.46^{ab}	5.58^{a}	4.46^{c}	0.33
Feed cost/kg gain(₦)	397.60^{a}	189.90^{d}	228.20^{c}	223.60^{cd}	217.00^{cd}	312.90^{b}	16.59
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

^{abcd} Means on the same row with different superscript are significantly ($P<0.05$) different. g= gram, SEM = standard error of mean

4.1.6 Nutrient Digestibility of Weaner Rabbits Fed Soybean Curd Residue with Lysine And Or Methionine Supplementation

Result of nutrients digestibility of weaner rabbits fed graded level of SCR as replacement for GNC were presented on Table 4.6. The result indicated no significant difference ($P>0.05$) between treatment means for all the parameters except crude fibre (CF) which differs across the treatments. Rabbits fed diet 3 had the highest value for crude fibre digestibility and differ significantly ($P<0.05$) with those fed diet 5.

Table 4.6: Nutrient digestibility of weaner rabbits fed soybean curd residue with amino acid supplementation as replacement for groundnut cake

Parameters	Diets						S.E.M
	1	2	3	4	5	6	
Dry matter	75.7	79.8	81.4	72.8	70.5	75.8	5.94
Crude protein	77.5	80.5	82.9	78.7	76.1	79.1	3.66
Crude fibre	70.7^{ab}	70.4^{ab}	73.2^{a}	65.3^{ab}	63.8^{b}	68.7^{ab}	3.89
Ether extract	83.9	82.8	84.4	80.6	78.8	82.8	3.05
Ash	63.0	66.3	69.4	62.6	58.3	63.9	7.36
Nitrogen free extract	64.1	70.8	74.2	65.3	60.2	66.9	7.01

^{abcd} Means on the same row with different superscript are significantly ($P<0.05$) different, S.E.M = standard error of mean

4.1.7 Haematological Parameters of Weaner Rabbits Fed Soybean Curd Residue With Lysine And Or Methionine Supplementation

Result for haematological parameters of weaner rabbits fed SCR with lysine and or methionine supplementation is shown on Table 4.7. The results indicated that significant differences ($P<0.05$) exist between the treatment means except for MCV, MCH and TP which shows no significance variation ($P>0.05$) statistically between the treatment groups. Rabbits fed diet 5 had higher Hb value (13.8g/dl). Rabbits fed diet 5 were statistically similar ($P>0.05$) with those on diets 6, 3 and 2 but different ($P<0.05$) with those on diet 1 (10.97g/dl) which is the least. RBC and PVC follows similar trend. Rabbits on diet 1 showed higher value (35.75g/dl) for MCHC and differ significantly ($P<0.05$) from those fed diet 5 which is the least (34.52). Rabbits fed diets 2, 3, 4 and 6 indicated no variation ($P>0.05$) between the treatment means.

Table 4.7: Haematological Parameters of Weaner Rabbits Fed Soybean Curd Residue with Amino Acid Supplementation as Replacement for Groundnut Cake

Parameters	Diets						SEM
	1	2	3	4	5	6	
TP (g/dl)	7.00	7.00	7.70	7.70	6.80	7.24	0.445
Hb (g/dl)	10.97^{c}	13.17^{ab}	13.00^{ab}	11.97^{bc}	13.80^{a}	12.58^{ab}	0.721
RBC (x 10^9/l)	5.87^{c}	7.17^{ab}	7.00^{ab}	6.40^{bc}	7.47^{a}	6.78^{ab}	0.374
PCV (%)	30.67^{c}	37.67^{ab}	37.00^{ab}	34.00^{bc}	40.00^{a}	35.87^{ab}	2.202
WBC (x10^9/l)	3.17^{bc}	4.10^{ab}	2.70^{bc}	5.20^{a}	2.60^{c}	3.55^{bc}	0.519
MCHC	35.75^{a}	34.96^{bc}	35.14^{b}	35.23^{ab}	34.52^{c}	35.09^{bc}	0.275
MCH	18.68	18.36	18.58	18.70	18.48	18.55	0.231
MCV	52.26	52.53	52.89	53.09	53.55	52.88	0.721

^{abcd} Means on the same row with different superscript are significantly (P<0.05) different. PCV= packed cell volume, Hb=haemoglobin, WBC=white blood counts, TP=total protein, SEM = standard error of mean

4.1.8 Carcass Characteristics of Weaner Rabbits Fed Soybean Curd Residue with Lysine And Or Methionine Supplementation

Table 4.8 presents the results for carcass characteristics of weaner rabbits fed soybean curd residue with amino acid supplementation as replacement for groundnut cake. All the parameters observed were not affected (P>0.05) significantly by the test material except for live weight, dress weight, skin, lungs, heart and stomach. Rabbits fed diet 1 shows higher values (1404, 925, 10.55 and 2.32) and significantly (P<0.05) differ with respects to live weight (g), dress weight (g), skin (%) and lungs (%) respectively, while those on diet 4 had the least (1121, 697.7 and 0.48) in terms of live weight (g), dress weight and heart respectively. Values for stomach were statistically similar (P>0.05) for diets 2, 3, 4, 5 and 6; rabbits on diet 2 had the least value while those on diet 4 had the highest. With respects to lungs and heart, animals fed diet 1, 2 and 3 differ (P<0.05) significantly with those fed diets 4 and 5. Rabbits fed diet 6 were similar (P>0.05) with all other treatment groups.

Table 4.8: Carcass Characteristics of Weaner Rabbits Fed Soybean Curd Residue with Amino Acid Supplementation as Replacement for Groundnut Cake

Parameters	Diets						SEM
	1	2	3	4	5	6	
Live weight (g)	1404^{a}	1285^{ab}	1307^{ab}	1121^{c}	1180^{bc}	1259^{bc}	64.4
Dress weight (g)	925.0^{a}	788.3^{b}	818.0^{ab}	697.7^{b}	748.7^{b}	795.1^{b}	59.1
*Dress %	66.60	62.30	63.30	63.10	64.10	63.90	3.77
Express as % of carcass weights							
Thigh	14.90	14.50	14.50	17.80	16.30	15.60	3.48
Rack/Rib	28.36	27.10	27.34	29.58	28.81	28.24	2.719
Forelimb	8.44	7.90	7.75	8.58	8.25	8.18	0.726
Hind limb	15.61	15.16	14.13	14.83	13.75	14.70	1.892
Head	9.08	8.76	8.60	9.17	8.40	8.80	0.651
Skin	10.55^{a}	9.09^{ab}	8.38^{b}	9.34^{ab}	9.54^{ab}	9.38^{ab}	0.986
Liver	5.13	4.80	4.57	5.01	4.59	4.82	0.699
Lungs	2.32^{a}	2.17^{ab}	2.23^{a}	1.75^{c}	1.85^{bc}	2.06^{abc}	0.169
Heart	0.76^{a}	0.64^{ab}	0.69^{a}	0.53^{bc}	0.48^{c}	0.62^{abc}	0.067
Small intestine	7.84	8.51	7.01	8.85	7.62	7.97	0.954
Large intestine	8.65	10.32	9.07	9.60	9.81	9.49	1.134
Kidney	1.81	1.61	1.68	1.87	1.94	1.73	0.231
Stomach	6.24^{b}	8.10^{a}	7.14^{ab}	8.14^{a}	7.98^{a}	7.52^{ab}	0.768

[abcd] Means on the same row with different superscript are significantly (P<0.05) different, g = gram, SEM = standard error of mean. * Express as % of live weights

4.2 DISCUSSION

4.2.1 Performance of Weaner Rabbits Fed Graded Level of Soybean Curd Residue (SCR) As Replacement for Groundnut Cake

Results on the performance of rabbits fed replacement levels of SCR showed that there was a significant ($P<0.05$) difference among the treatments. The highest final body weight observed in rabbits on diet 4 (75%SCR) and diet 5 (100%SCR) respectively could be ascribed to higher feed intake and a better feed conversion ratio, while the lower values obtained in rabbits on diet 1 and 2 containing 0.0%SCR and 25.0%SCR respectively could be due to poorer feed conversion ratio and relatively low feed intake compared to other treatments groups. The poor performance for rabbits on diet 1 may probably be due to low fibre in the diet being lower than 14% recommended by Ikurior and Kem, (1998) for growing rabbits. The final weight values obtained in this study were lower than the values (1860g-2028g) reported by Hamed and Azza (2013), Ubwa *et al.* (2014) and Bouatene *et al.* (2011); but higher than 0.78 kg to 1.1 kg reported by Ironkwe and Amaefule (2012) and similar to results of Jiya *et al.* (2011). This shows that soybean curd residue is a potential feed ingredient for rabbits.

The higher weight gain obtained in rabbits fed 75%SCR agreed with the findings of Feng *et al.* (2007) who reported that dietary fermented SCR improved the growth performance of piglets. Kim *et al.* (2005) also reported feeding pigs with soybeans meal increase average daily weight gain and feed conversion efficiency. The increase in daily weight gain in this experiment could be due to increase in feed intake (Table 4.1) as reported by Lei *et al.* (2004) with increase SCR level of inclusion. The higher weight gain could also be partly due to a better protein quality from soybean curd residue as reported by

Shunong *et al.* (2013). Soybean curd residue is a good source of nutrients including protein, oil, fibre (Van der Riet *et al.,* 1989 and O'Toole, 1999). Feng *et al.* (2007) reported that soybean curd residue has growth-promoting effect. The lower body weight gain for rabbits on diets 1 and 2 was due to the relatively lower feed intake as compared to other treatments groups. The values obtained from this work compared favorably with the values (11.21g) reported by Farinu *et al.* (2008), 9.74-16.64g by Iyayi *et al.* (2003) and 14.8-15.9g obtained by Nikkiset (2007). However, the daily weight gain values obtained in this study was lower than values (35.5-39.7g) of Ayers *et al.* (1996), 21.3-22.6g by Okorie (2003), 18.1g by Phimmasan *et al.* (2004) and 31.4g obtained by Chat *et al.* (2005). The differences in breed could be attributed to these variations. This is consistent with Lei *et al.* (2004) who found that New Zealand White rabbits consumed more feed and thereby more CP and CF than the cross breed rabbits.

The highest average daily feed intake were observed for rabbits on diet3, 4 and 5 (50, 75, and 100%SCR) respectively. The higher feed intake could be attributed to a better palatability of the diets compared to the control group. The control group could be less palatable which may have resulted in the rabbits taking lesser amount of the diet. This agreed with Kyoung *et al.* (2012) who reported that SCR has a subtle flavor and savory test making it palatable for animals.

Rabbits showed significant ($P<0.05$) differences for feed conversion ratio. The lower the feed conversion ratio, the better feed utilization. The best FCR was obtained for rabbits on 100%SCR diet. The poorer value was observed in rabbits fed diet 1 (0.0%SCR) probably due to higher chance for feed wastage was high in rabbits with no or less SCR inclusion in their feed. This could be as a result of the less palatability of their diet as

SCR is believed to add palatability as reported by Kyoung *at al.* (2012). This could facilitate selective feeding which will ultimately add to feed wastage and that would count on the quantity of feed offered which will lead to increase in the value of FCR. The values obtained from this experiment can be compared with values (5.2-6.5) reported by Farinu *et al.* (2008) and that (4.85-5.77) of Iyayi *et al.* (2003). It was also similar to values (4.39-6.64) reported by Osakwe and Nwose (2008). It was however higher than values (2.9-3.12) of Okorie (2003) and values (3.34-3.62) of Ubwa *et al.* (2014) as well as values (2.96-4.37) reported by Omage *et al.* (2009).

It was observed that rabbits fed 100%SCR had lower cost per kg weight gain values. Similarly the values differ ($P<0.05$) significantly and increase with decreasing level of inclusion of SCR. FCR and feed cost per kg weight gain value decrease as levels of SCR increases in the diets. This support the report of Odunsi (2003) that prices of conventional protein sources are escalating due to competition, and that, alternative feed resources should be identified and evaluated. The cost decreased as the levels of groundnut cake decreased in the diet. Dilaga and Adiwinarti (2011) concluded that tofu cake (SCR) is relatively cheaper feed resource considering its nutritive value. The authors also stated that provision of tofu cake does not cause any physiological disorder to male sheep.

4.2.2 Nutrient digestibility of weaner rabbits fed graded levels of soybean curd residue as replacement for groundnut cake

In all the parameters observed, only crude fibre showed significant ($P<0.05$) difference. Rabbits on diet 4 (75%SCR) had the highest value for crude fibre digestibility. This may be the optimum level for efficient nutrient utilization. The values for nutrient digestibility obtained from this study can be compared with values reported by Ayers *et al.* (1996), Iyayi *et al.* (2003), Bamikoke *et al.* (2005), Iyaghe-Erakpotobor *et al.* (2005), the values contrast with Iyaghe-Erakpotobor *et al.* (2006) in terms of crude fibre digestibility probably due to a little variation in the diets. The values are also lower than the values reported by Adedeji *et al.* (2013).

4.2.3 <u>Haematological parameters of weaner rabbits fed graded levels of soybean curd residue as replacement for groundnut cake</u>

The PCV, Hb and RBC values of rabbits fed graded levels of SCR ranged from 29.67-39%, 9.97-12.8g/dl and 4.87-6.47x10^{12}/l respectively. However, the highest value was observed for rabbits fed 25%SCR and the least values was obtained for rabbits fed 100%SCR. It appears that there is more efficient erythropoiesis in rabbits on diet 2 (25%SCR) as this may be responsible for higher PCV values compared to other group. The ranges of Hb values (9.97-12.80 g/dl) observed being within normal ranges for rabbits indicates the normal physiological relationship of haemoglobin with oxygen in the transport of gasses to and from the tissue of the body (Njidda *et al*., 2006). The values were all within the normal ranges (PCV 30-50, Hb 8-17.5, TP 5.4-7.5, RBC 4-8, WBC 5-12) and (PCV 33-50, Hb 10-17, RBC 5-8, MCV 58-67, MCH 17-24, MCHC 29-37, WBC 5-12.5) reported by Hillyer (1994) and Mercks Veterinary Manual (2005). However, rabbits on diets 2 and 4 (25% and 75%SCR) showed poor results in terms of WBC while those on diets 1 and 3 (0.0% and 50%SCR) seemed to be the best. The fact that WBC values for both groups fall within the normal ranges indicated a normal antibody production which help in maintaining strong disease resistance. This is evident by the fact that no mortality was recorded during the experiment. MCH and MCHC were highest (P<0.05) for rabbits on diet 5 (100%SCR) while those on other treatments showed no difference (P>0.05) statistically. WBC values for rabbits fed diets 2 and 4 (25% and 75%SCR) were lower than those reported by Olabanji *et al.* (2007). MCV and TP does not show any significant differences (P>0.05) in all the treatment groups. The values obtained for MCV and MCH were in agreement with Omoikhoje *et al.* (2006). All other haematological values obtained from this study were within the range reported by Olabanji *et al.* (2007), Mercks Veterinary Manual (2005), Hillyer, (1994) and Ahmefule *et al.* (2008)

4.2.4 Carcass Characteristics of Weaner Rabbits Fed Graded Levels of Soybean Curd Residue as Replacement for Groundnut Cake

There was a significant (P<0.05) impact on the live weight, dress weight, lungs and heart. The higher percentage of dress weight, lungs and heart obtained for rabbits fed diet 4 and 5 (75%SCR and 100%SCR). This also cut across other prime carcass cuts evaluated. The dressing percentage value obtained were lower than values (72.6-76.20%) reported by Okorie, (2003) but higher than the values (45.5-52.6%) reported by Biya *et al.* (2008). The intestines were heavier in rabbits on the control diet followed by those on diet 2 (25%SCR) and keep on increasing. This could be due to feed retention in the intestines as reported by Bennagadi *et al.* (2001) that a lower content of fibre cause slowing down of the digesta transit resulting in a longer retention time. The control group had the lowest crude fibre content, and the crude fibre was found to increase with increasing level of SCR (Table 3.2). That's why the intestinal weights were also increasing as level of crude fibre increases. The values for head were similar with that of Biya *et al.* (2008). The values obtained for carcass from this research can be compared with that of Olabanji *et al.* (2007).

4.2.5 Performance of Weaner Rabbits Fed Soybean Curd Residue with Lysine And Or Methonine Supplementation

Results on the effect of SCR supplemented with amino acids on final weight (Table 4.5) shows that there was significant ($P<0.05$) different among the treatment groups. Higher final body weight was observed for rabbits on diet 2, followed by those on diets 6 and 1. This could be due to higher feed intake and better feed conversion ratio. The poorest value for final body weight was obtained from rabbits fed diets 3, 5 and 4. This could be due to poorer feed conversion ratio and lower feed intake. Another reason could be due to lack of either or both of the essential amino acids. According to Rutz (2002), when organism cannot obtain sufficient amount of essential amino acid from the diet, it catabolizes body protein to obtain that amino acid. Addition of limiting nutrient in the diet promotes animal growth. Diets 3 and 5 had lesser methionine, and rabbits on these diets showed least performance in terms of final weight and daily gain. This conforms to the conclusion drawn by Yesmin *et al.* (2013), that final body weight as well as daily and weekly body weights gains were improved significantly with addition of methionine. The results from the present study do not agree with Bouyeh (2012) who reported that supplementation of lysine and methionine did not have effect on body weight gain, but there was effect on FCR.

Weight gain and feed intake as well feed conversion ratio was higher for animals on diet 6 followed by those on diet 2. For FCR, rabbits on diets 3 and 5 had the poorest values. This may be attributed to lowest level of methionine in the diets. Methionine in the diet increases feed conversion efficiency (Sonbol *et al.,* (1992). Bhatt *et al.* (1997) also stated that methionine supplementation results in better feed conversion in growing rabbits. Yesmin *et al.* (2013) also agreed with the result.

Feed cost was highest for rabbits fed 1 followed by those fed diet 6. The lowest cost of feed per kg was observed for those on diet 2. The cost was higher in treatments in which GNC was included in the diets.

4.2.6 Nutrient Digestibility of Weaner Rabbits Fed Soybean Curd Residue Supplemented With Lysine And Or Methionine

The results for nutrients digestibility of rabbits fed SCR in which amino acids were supplemented as replacement for GNC were presented on Table 4.6. There was an improvement in terms of nutrient digestibility of the rabbits. Rabbits fed diet 3 had higher crude fibre digestibility compared to other dietary treatment. The higher crude fibre digestibility was compared with report of Abaza and Umar (2011) who observed similar result when corn cobs was supplemented with enzyme in the diet of growing rabbits. Although nutrient digestibility was improved, the actual reason of improvement is not clear yet because digestibility is influenced by many factors.

4.2.7 Haematological Parameters of Weaner Rabbits Fed Soybean Curd Residue Supplemented With Lysine And Or Methionine

Hematological constituents reflect the physiological responsiveness of animal to its internal and external environment, which includes feed and feeding (Esonu *et al*., 2001). Table 4.7 showed the hematological indices of rabbits fed SCR diets in which amino acid supplemented as replacement for GNC. The normal PCV indicates the absence of normocytic anaemia which is reportedly characterized by normal MCV and MCH and only detected by a decreased number of RBC or PCV (Coles, 1986). The result was corroborated by the normal RBC which further elucidated the absence of hemolytic anaemia and depression of erythrogenesis. The normal hemoglobin concentration for all the experimental rabbits is probably an indication that SCR supplemented with amino acid supported hemoglobin synthesis, which according to Sirosis (1995) is among other factors, primarily affected by protein intake. The result suggests absence of microcytic hypochromic anaemia, which is due to iron deficiency and its improper utilization for the formation of haemoglobin. Blood constant (MCV and MCH) were similar ($p>0.05$) among the treatment groups but fell within the normal physiological range reported by Hillyer (1994) and Mercks Veterinary Manual (2005) for clinically healthy rabbits. The result suggests that all the rabbits irrespective of the treatment had normocytic and normochromic red cell, suggesting that the inclusion SCR supplemented with lysine and methionine in feed did not affect iron utilization by the rabbits. However, the values obtained for MCV and MCH in this study were lower than 86.60 (fl) and 29.57 (pg) respectively reported by Ukorebi (2011) in growing rabbits fed herb based diets. The observed similarities in red blood cell indices partly agree with the report of Ogbuewu *et al*. (2013) who fed growing rabbits with ginger powder. The results from the study shows no significant ($P>0.05$) differences between the rabbits fed dietary treatments in terms of MCV and MCH, Total protein was also not significant. The non significant result for total protein reported was also reported by Weissman *et al.,* (2008) although the authors reported higher values (52.3-55.3) than the values obtained from this study. Hb, RBC and PCV were significantly ($P<0.05$) higher in rabbits fed diet 5 while the lowest values were observed for rabbits fed diet 1. White blood cell was higher in rabbits fed diet 4 and the least was recorded in those fed diet 5. The least value for MCHC was also observed for rabbits on diet 5 while the highest value was recorded for those on diet 1. The values obtained from this study are within the ranges reported by Atansuyi *et al.,* (2012) and Ogbuewu *et al.,* (2013).

4.2.8 Carcass Characteristics of Weaner Rabbits Fed Soybean Curd Residue Supplemented With Lysine And Or Methionine

Of all the amino acids, lysine is the only one that plays a metabolic role almost exclusively to add protein for meat deposition (Champe and Hervey, 1997). Live weight, dress weight, lungs and heart had higher values in rabbits fed diet 1. The values were reported to be increasing with higher content of lysine in the diet. Gomes *et al.,* (1992) reported improved performance when lysine supplementation was increased from 5.5 to 8.5 g/kg. However, those fed diets 2, 4 and 5 were similar (P>0.05) with respect to stomach and skin weights while those on diet 1 and 3 were similar for lungs and heart.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Two experiments were conducted to determine the performance of weaaner rabbits fed soybean curd residue based diets. In Experiment 1, total of 30 weaner rabbits were used in a completely randomized design. Soybean curd residue was used to replace 0.0, 25.0, 50.0, 75.0 and 100% groundnut cake. Anti-nutritional factors in soybean curd residue were significantly removed by 86.94, 88.05, 69.36, 30.49 and 52.90 % for Phytate, Trypsin inhibitor, Cyanide, Tannins and Oxalate respectively. The results also indicated that feed intake was significantly ($P<0.05$) affected by the dietary treatments. Rabbits on diets 5 and 4 had the highest values for feed intake, final weight gain and average daily weight gain, while those fed diet 1 recorded the least value. Rabbits fed diet 5 had the best cost of feed/kg weight gain, cost of feed/kg diet and cost of feed/kg weight gain as well as FCR. Nutrients digestibility coefficients were not significant ($P>0.05$) for all the parameters except crude fibre which differs ($p<0.05$) significantly. Cut-up parts and visceral organs measurement showed significant ($P<0.05$) difference in some parameters (heart, lungs and dress weight) while others (dressing percentage, head, thigh, rack/rib, skin, liver, small intestine, large intestine, kidney, stomach, forelimb and hind limb) showed no significant ($P>0.05$) differences. Values obtained from haematological studies varied ($P<0.05$) significantly for Hb, RBC, PCV, WBC, MCH and MCHC. Also TP and MCV did not differ ($P>0.05$) significantly among the treatment groups.

In Experiment 2, total of 30 weaner rabbits were used for the study, six experimental diets were formulated; diet 1 served as a control with no soybean curd residue. Diet 2 contained soybean curd residue supplimented with 0.2% lysine and 0.2% methionine. Diet 3 contained soybean curd residue with 0.2% Lysine and 0% methionine. Diet 4 contained 0.2% methionine + 0% lysine. Diet 5 contained soybean curd residue with 0% lysine + 0% methioine, while diet 6 contained lysine and methionine at 0.2 % levels respectivelty arrenged in a completely randomized design (CRD). Feed intake was higher for rabbits fed diet 6 while the least value was observed for those fed diet 5. Final weight was higher for rabbits on diet 2. However, average daily weight gain was highest for rabbits on diet 6, so also FCR. Rabbits fed diet 2 had the best cost of feed/kg weight gain. Mortality was not recorded for any of the dietary treatment group. Nutrients digestibility coefficient were not significant (P>0.05) for all the parameters except crude fibre which differed (p<0.05) significantly for both experiment. Cut-up parts and visceral organs measurement showed significant (P<0.05) differences in some parameters (heart, lungs, stomach and dress weight) while others (dressing percentage, head, thigh, rack/rib, skin, liver, small intestine, large intestine, kidney, forelimb and hind limb) showed no significant (P>0.05) differences. Values obtained from haematological studies varied (P<0.05) significantly for Hb, RBC, PCV, WBC, and MCHC while TP, MCH and MCV did not differ (P>0.05) significantly among the treatment groups. Rabbits fed diet 2 (lysine 0.2% + methionine 0.2%) was found to be better for all the performance parameters considered for this study.

5.2 CONCLUSION

In Experiment 1, rabbits fed diet 5(100%SCR) had higher feed intake, weight gain, final weight, and feed conversion ratio. The cost of feed/kg was also better. It was concluded that SCR can replace GNC at 100% level to improve growth, feed intake, feed conversion ratio, and had better cost of feed per kg weight gain; with no health hazard.

In Experiment 2, rabbits fed diet 2 (lysine 0.2% + methionine 0.2%) was found to be better for all the performance parameters considered in this study. Cost of feed/kg weight gain was cheaper for diet 2.

5.3 RECOMMENDATION

This study recommends that 100% SCR can be used as replacement for GNC. Growing rabbit fatteners can save cost on conventional ingredient by replacing the costly groundnut cake with cheaper soybean curd residue.

The study also recommends that about 0.2% lysine + 0.2% methionine be incorporated in the tropical growing rabbits diet in which soybean curd residue replaced groundnut cake.

Though it is not possible to give a generally valid recommendation as the availability and suitability of the raw materials and their relative cost effectiveness can differ significantly, however, it is recommended that further research should be carried out on the use of SCR for better performance on rabbits

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Appendix

Appendix 1: Anti-nutrients in raw soybean and soybean curd residue

Parameters (mg/100g)	Raw soybean	Soybean curd residue	Percent reduction (%)
Phytate	52.65	6.86	86.94
Tripsin inhibitor	69.03	8.34	88.05
Cynide	2.48	0.17	64.91
Saponin	2.84	0.87	69.36
Tannin	0.96	0.48	30.43
Oxalate	1.55	0.73	52.90

Fig. 1: Processing Channels of soybean curd which in turn gives the by-product as residue.

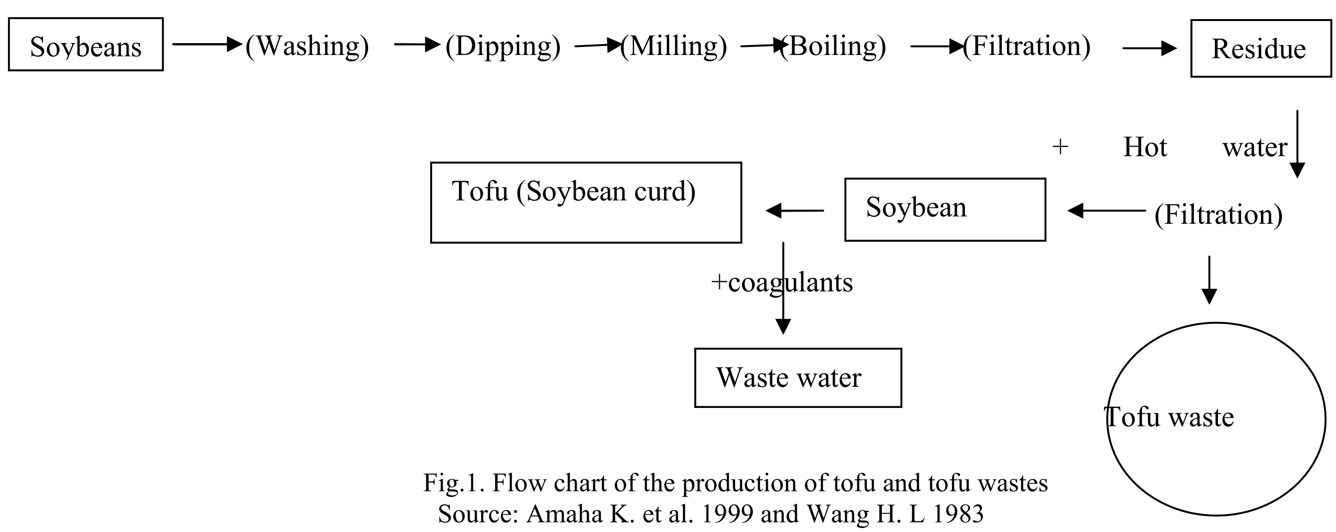

Fig.1. Flow chart of the production of tofu and tofu wastes
Source: Amaha K. et al. 1999 and Wang H. L 1983