REPLACEMENT VALUE OF GRASSHOPPER MEAL (*Orthoptera caelifera*) FOR FISH MEAL IN THE DIETS OF BROILER CHICKENS

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DECLARATION

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

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CERTIFICATION

This is to certify that the research work for this dissertation and subsequent write-up by (Abdullahi Abdu Muhammad SPS/15/MAS/00007) was carried out under my supervision.

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APPROVAL PAGE

This dissertation has been examined and approved for the award of M.sc in Animal Science.

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DEDICATION

I dedicated this project work to my family and my parents (Alhaji Muhammad Abdullahi Fagge and Hajiya Hauwa Muhammad)

TABLE OF CONTENTS

CHAPTER FOUR

Abstract

The study evaluated the growth performance, carcass characteristics and haematological indices of broiler chickens fed diets containing graded levels of grasshopper meal (GHM) as replacement for fish meal. A total of one hundred and sixty day-old Marshal broiler chicks were raised on floor pens in deep litter system and fed varying levels of grasshopper meals at 0, 25, 50 and 100 %. The birds were randomly allotted to four dietary treatments replicated four times with ten birds per replicate in a completely randomized design. Feed and water were provided *ad libitum* and the experiment lasted for eight weeks. The results of the starter phase showed that there was no significant (p>0.05) differences in liveweight gain (LWG), final body weight (FBW) and feed conversion ratio (FCR). However, significant (P<0.05) differences was in feed intake of the birds. At the finisher phase, significant (P<0.05) differences were recorded in liveweight gain (LWG), final body weight (FBW) and feed conversion ratio (FCR) of the birds. The results of carcass characteristics showed significant (P<0.05) differences in the weight of all the carcasses except the thighs across the treatments. On the contrary, organs characteristics presented no significant (P>0.05) differences in all the organs. The result of the analysis of blood chemistry parameters revealed significant (P<0.05) differences in creatine, albumin and globulin levels. Similarly, significant (P<0.05) differences was recorded in values for mean corpuscular volume while there were no significant (P>0.05) differences in the other blood parameters measured. It was concluded that 50% levels of grasshopper meal could replace fish meal in the diets of broiler chickens at both starter and finisher phases without adverse effect on birds' performance. There was reduction in feed cost with increasing level of GHM at up to 100%. Therefore, inclusion of 50% GHM in diets of broiler chickens is recommended.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Broiler chickens are domestic fowls kept primarily for meat production. Poultry birds are one of the major means of alleviating malnutrition in Africa, especially the third world countries like Nigeria with recorded protein deficiency especially of animals source (Apantaku, Oluwalana & Adepegbe, 2006). According to Adejimi , Hamzat, Raji, and Owosibi (2010) poultry products provide the fastest means of bridging the protein deficiency in most tropical countries because of its short generation interval and higher acceptability in rural and urban areas. Hence, the best alternative to meet the nutritional needs of growing population like Nigeria (Falayi, 2009). This resulted in increase in poultry egg and meat production. Unfortunately, the effort is challenged by the increasing high feed cost, thereby, affecting the expansion of poultry industries in Nigeria (Food & Agriculture Organization, FAO, 1990).

Profitable management of broiler chicks requires knowledge of their nutritional requirements at various stages of growth. This types of information is necessary towards achieving maximum biological and economic efficiency in the use of feed resources, since the rapid expansion of the livestock industry depends to a large extent on the availability of good quality feed at reasonably cheap prices, particularly for monogastric animals species such as poultry and pigs whose performance depends on the use of concentrated balanced ration (Duru, 1993). Hassan (2002) stated that in commercial poultry production, the major setback is the feed cost, which accounts for about 75 to 80% of the total cost of production. The cost of feed ingredients has been steadily increasing due to the growing number of poultry farms and feed compounding mills. Hence, poultry farmers have been searching for alternative feed ingredients to the conventional ones in order to cut the high cost of feed. Poultry farmers need to learn how to compound feed using available local feed ingredients. According to Emenalon and Udedible (1998) one way out of this predicament is the development of dietary formulations, which allow locally available ingredients to be used, this will reduce dependence on imported feedstuff. One option is the search for alternative feed ingredients among the leguminous seeds as valuable protein sources for animals to minimize the use of soybean and groundnut that become too costly. Fish meal is one of the feed ingredients and is rich in protein content, usually marked at 65% protein (CP) but the CP content varies from 57 to 77% depending on the species of the fish used (Aduku, 1985).

According to Ahmed (1987) the importance of fish meal as feedstuff has been on the decline in many countries including Nigeria, because of relatively high cost, non-availability and at times, adulteration by feed supplies which leads to heavy losses in poultry stocks. Additionally, the feed ingredient contaminates easily with diseases like Salmonellosis, fowl cholera etc.

Grasshoppers are abundant in the Northern part of the country at affordable price and will serve as a very good substitute for fish meal, both in terms of cost, and quality. A strong economic incentive therefore, exists for finding an alternative animal protein source for poultry feed in order to reduce the cost of feed and maximize the returns from poultry farming (Esonu, Iheukwumere, Iwuji, Akanu & Nwugo, 2003).

According to Nazneen, Islam, Lieder and Hamid, (1995) Grasshopper meal (GHM) has a high proportion of crude protein (537.60g per kg dry matter), ether extract (158.6g per kg dry matter) is therefore, a potential protein source for poultry feed; provided the price is reasonable. Plant proteins are usually low in lysine and Methionine, which are critical in poultry diet, to prepare poultry diet certain amounts of animal proteins sources like fish meal, blood meal and meat meal must be added to the diet in order to balance the deficiencies of the essential amino acids. Fish meal remains the only source of animal protein being used to overcome the deficiencies (Hassan, Sani, Maiunguwa & Rahama, 2009).

Research efforts are being geared towards evaluating alterative, good quality renewable protein sources that can replace scarce, expensive and elusive conventional protein sources used in poultry nutrition. Once of such alterative is insects. Among the edible insects, grasshoppers can be utilized as animal feed. However, a research should be conducted to find out which inclusion level of GHM could be best for the selected poultry bird. Next, it is to evaluate whether the results are comparable with other formulated diets having protein source, to establish the suitability of GHM as an alternative protein source for poultry (Das & Mandals, 2014).

Anankware, Fening, Osekre and Obeng-Ofari (2014) reported that insects including the order Orthoptera (grasshoppers) provide a more sustainable source of protein for animal feed. Hence, there is an urgent concerted need to conduct research on the identification, distribution, conservation and economic potential of neglected and under-utilized insect species in Africa, to enable us identify and modernize the readily available and accessible alternative food and feed to help solve the problem of feed and food insecurity and malnutrition. On the content issues that need to be resolved include efficient production methods, transformation and inclusions in animal feed.

Jose-Maria, Barroso and Agugliaro-Manzano (2013) reported that to include insects as a feed ingredient in the feed chain, additional research is recommended for its feeding value, inclusion levels in diets and functional properties of the feed ingredients.

A grasshopper has great potential as a protein source in broiler diets without causing any physiological disorder as reflected in the haematological analysis. Therefore, grasshoppers could be a good source of cheaper protein compared to fish meal in animal ration (Adeyemo & Longe, 2008). In line with this, Chinese World Poultry, CWP, (2007) reported that GHM as a protein source can be added to poultry feed at a rate of 15% with no adverse effects on performance of the birds.

Table 1: Comparative Proximate Composition for Fish Meal and Grasshopper Meal

Nutrients (%)	Fish Meal	Grasshopper Meal
Dry matter	93.63	94.9
Moisture content	8	5.1
Crude protein	65.00	64. 51
Either extract	10.1	12.0
Ash	20.16	13.6
Crude fibre	1.40	17.0
NFE	3.73	5.49
Calculated Analysis		
ME (kcal/kg)	2860	1917
Calcium (%)	4.40	0.55
Phosphorus (%)	3.35	0.12
Sodium (%)	-	0.1
Potassium (%)	0.44	0.73

Source: Olaleye (2015)

Table 2: Comparative Amino acids Composition for Fish Meal and Grasshopper Meal

Nutrients	Fish Meal	Grasshopper Meal
Lysine	7.85	5.87
Histidine	2.22	4.24
arginine	5.82	7.62
aspartagine	9.35	9.32
Threonine	4.55	4.08
Serine	4.55	5.22
glutamine	13.3	15.21
Proline	4.35	5.02
Glycine	5.90	4.78
Alanine	6.34	5.29
Leucine	0.70	1,79
Valine	5.65	3.47
Methionine	2.84	1.96
Isoleucine	4.85	4.21
Tyrosine	7.35	5.30
phenylalanine	4.35	4.50

Source: Olaleye (2015)

1.2 PROBLEM STATEMENT

The increasing cost of feed resources in livestock production has been identified as a serious impediment to meeting the demand for animal protein particularly in developing countries (Adejinmi, Adejinmi & Adeleye, 2000). This continually recurring challenge has compelled the search for alternatives to the expensive grains and protein concentrates. This interest had resulted in animal nutritionist searching for alternatives that could help to reduce the cost of feeding without negatively affecting the performance of the birds. Replacement of expensive feed ingredients with cheap and available substitutes represents a suitable strategy of reducing feed cost and encouraging poultry production. Several researches were carried out in the search for alternatives to conventional feed in poultry diets and results of some of these efforts were not established (Adeyemo & Longe, 2008).

1.3 JUSTIFICATION FOR THE STUDY

The high cost of conventional feed ingredients such as maize, millet, soybeans, groundnut cake, fish meal and others arising from the competition between man and animals has contributed immensely to the current high cost of poultry feed. Poultry farmers will appreciate any ingredient that is cheap and can harness production sustainability (Adeyemo & Longe, 2008).

Insect meals could potentially replace 25 to 100% of the soybean meal and fish meal in animal feed. Grasshoppers emerged as an interesting protein source for broiler chickens because it resulted in a number of meat quality parameters, such as higher antioxidant potential, longer shelf life and increased protein and decreased cholesterol content (Houndonougbo, Brah & Issa, 2018).

Grasshoppers are available in the Northern part of Nigeria at affordable price and will serve as a very good substitute for fish meal, both in terms of cost, availability and quality (Kekeocha, 1985). However, high level of inclusion in the diet, especially of monogastric can decrease feed intake and cause other adverse effects. Hence, the need to explore the extent to which this meal could be incorporated in the diets of broiler chickens to support their satisfactory performance. (Ojewola, Okonye & Okoho, 2005)

1.4 OBJECTIVES OF THE STUDY

The main objective of this study was to investigate the optimum replacement value of GHM for fish meal in the diets of broiler chickens. The specific objectives were to:

i. Determine the effects of replacing fish meal with GHM in the diets of broiler chickens on performance (feed intake, live weight gain, feed conversion ratio).
ii. Evaluate the effects of replacing fish meal with GHM in the diets of broiler chickens on carcass and internal organs characteristics.
iii. Assess the effects of replacing fish meal with GHM in the diets of broiler chickens on haematology and serum biochemical indices.
iv. Examine the cost benefit of substituting fish meal with GHM in the diets of broiler chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 THE ROLES OF POULTRY IN FOOD PRODUCTION

Chicken meat and eggs are the best source of quality protein, and are highly needed by the many millions of people who live in poverty. In sub-Saharan Africa (SSA) and South Asia malnutrition (poor nutrition) and under nutrition (inadequate nutrition) are closely associated with poverty. These conditions affect the immune system. The HIV/AIDS epidemic sweeping through countries in SSA stems partly from extreme poverty and, with it, poor nutrition. A recent survey of several countries found that 34 percent of the people surveyed in South Asia and 59 percent in SSA were suffering from severe energy deficiency (Smith & Wiseman, 2007). Both groups obtained 67 percent of their energy from staple foods (cereal grains, grain legumes, starchy roots and tubers) containing small quantities of only low-quality protein. Their average per capita egg consumption was only 42 per year, compared with a global average of 153. Stunting and wasting in children under five years of age, and slow mental development were seen mainly in rural areas of SSA. Eight out of ten of those affected were among the poor. Diseases such as kwashiorkor and marasmus, both seen in underweight children, are associated with inadequate dietary energy and protein. Pregnant and lactating women and young children are particularly vulnerable. In SSA, only 8 percent of dietary energy comes from animal protein, compared with an average of 17 percent in all developing countries, and 28 percent in China.

Chicken meat and eggs a valuable source of protein and almost all of the essential Nutrients Chicken meat and eggs provide not only high-quality protein, but also important vitamins and minerals. Worldwide, 2 billion people depend on rice as their staple food. Most eat polished white rice stripped of many essential fats, the B complex vitamins and several minerals. Other cereal grains are usually deficient in critical nutrients. For example, maize (corn) is a staple food in some regions, but the niacin it contains is unavailable. Maize consumption without supplements causes pellagra. Invariably the protein content of grains is low and of poor quality. Net protein utilization (NPU) is an index of protein quality, calculated by multiplying protein digestibility by biological value. NPU of grains is generally less than 40. Rice is the exception, with NPU of about 60, but it is low in protein (7.5 percent). NPU of chicken eggs is 87. Generally, cereals lack the most important amino acids for humans – lysine, threonine, the sulphur-bearing amino acids (methionine and cysteine) and occasionally tryptophan. Eggs and chicken meat are rich in these essential amino acids. Eggs are also high in lutein which lowers the risk of cataracts and macular degeneration, particularly among people living in developing countries. In the least developed countries, the projected increase in egg consumption between 2005 and 2015 is 26 percent, compared with only 2.4 percent in the most developed countries (Windhurst, 2008). Corresponding annual projections for poultry meat are 2.9 percent and 1.6 percent, respectively (FAOSTATS).

The advantages of chickens meat and eggs compared to other animal proteins In developing countries, the diet of people living in cities usually contains more animal protein than that of rural people, mainly because urban people are more prosperous, but also because they generally have access to a wider variety of foods at local markets. In low-income countries, commercially produced chicken meat is well placed to satisfy the demands of a rapidly increasing affluent, middle class who can afford to pay for broiler chickens. Facilities and infrastructure for producing broiler chickens can be established quickly and soon start generating. Not only is chicken meat seen as a healthy meat, but also it is also the cheapest of all livestock meats. A major advantage of eggs and poultry meat as human food is that there are no major taboos on their consumption. In addition, a chicken provides a meal for the average family without the need for a refrigerator to store left-over. Meat from other livestock such as pigs and cattle is kept mainly for special festive occasions and celebrations, partly because of a lack of storage facilities (no refrigerator or electricity supply). Eggs can be purchased relatively cheaply and in small numbers. One egg is almost a meal in itself and when hard-boiled will last for several weeks. It could be taken to school safely by children for lunch.

Scavenging chickens provide cheap eggs and meat Scavenging family poultry provide much-needed protein and income, and contribute to food security for many families living in poor rural regions of developing countries. The eggs and meat produced by their own or neighbours' small poultry flocks are the only eggs and poultry meat that the majority of these families are ever likely to eat. This makes family poultry increasingly important as the world's population pushes towards 7 billion people. Furthermore, it is not difficult to improve the nutritional value of the

egg, to become a functional food. In conclusion**,** Poultry has a major role to play in developing countries. Produce is relatively inexpensive and widely available. The commercial poultry industry provides employment and is growing rapidly. To produce 1 kg of meat from a commercial broiler chicken only about 1.7 kg of feed is needed. Poultry production has a less detrimental impact on the environment than other livestock, and uses less water. Semi-scavenging backyard indigenous poultry are extremely important in providing income and high-quality protein in the diets of rural people whose traditional foods are typically rich in carbohydrate but low in protein. The vexed question of the cholesterol content of eggs and human health seems to have been exaggerated.

2.2 BROILER CHICKENS PRODUCTION AND MANAGEMENT

2.2.1 Broiler Chickens

Broiler chickens are domestic fowls kept primarily for meat production. Poultry birds are one of the major means of alleviating malnutrition in Africa, especially the third world countries like Nigeria with recorded protein deficiency especially of animals source (Apantaku *et al.* 2006). According to Adejimi *et al.* (2010) poultry products provide the fastest means of bridging the protein deficiency in most tropical countries because of its short generation interval and higher acceptability in rural and urban areas. Hence, the best alternative to meet the nutritional needs of growing population like Nigeria (Falayi, 2009). This resulted in increase in poultry egg and meat production. Unfortunately, the effort is challenged by the increasing high feed cost, thereby, affecting the expansion of poultry industries in Nigeria (FAO, 1990).

2.2.2 Poultry Housing

Poultry housing Improvements to poultry housing systems in developing countries have focused on providing an environment that satisfies the birds' thermal requirements. Newly hatched birds have a poor ability to control body temperature, and require some form of supplementary heating, particularly in the first few days after hatch. Many developing countries are located in tropical areas where minimal heating is required. Indeed, the emphasis in these countries – particularly for meat chickens – is on keeping the birds cool. International poultry breeding and feed companies operate in many developing countries and have established large-scale commercial farms in a significant number of them. The housing and equipment used make it possible to exert considerable control over the climate provided to the birds, but such houses are expensive to build and operate, and require a large turnover of birds to make them viable. Owing to the lower construction and running costs, medium- and small-scale commercial housing is popular in developing countries. By far the most prevalent poultry farming system in many developing countries is the small-scale scavenging system, which usually involves only very basic (if any) shelter for housing birds. Large-scale commercial farms: Commercial houses in developing countries are clear-span structures with litter on the floor for meat birds or cages for laying hens. The commercial chicken meat industry in some developing countries is vertically integrated, with single companies owning feed mills, breeder farms, hatcheries and processing plants. Arrangements typically involve agreements in which the farmer or landowner provides the housing, equipment and labour, while the company provides the chicks, feed, medication, transport and supervision. For controlled-environment housing of layers, multi-tier cage systems are common. Most large-scale commercial farms use controlled-environment systems to provide the ideal thermal environment for the birds (Glatz & Bolla, 2004). Birds' performance in controlled-environment sheds is generally superior to that in naturally ventilated houses, as the conditions can be maintained in the birds' thermal comfort zone. Achieving the ideal environment for birds depends on appropriate management of the poultry house. Modern houses are fully automated, with fans linked to sensors to maintain the required environment. Some commercial operators use computerized systems for the remote checking and changing of settings in houses. Forced-air furnaces and radiant heating are the main methods of providing heat to young chicks. Medium-scale commercial: In developing countries, most medium-scale commercial layer and chicken meat houses rely on natural air flow though the shed for ventilation (Daghir, 2001).

Ventilation is usually provided by prevailing breezes. Natural ventilation works best in poultry sheds where the long axis runs east to west, to avoid heating of the sidewalls by the sun during the morning and afternoon. Ventilation management: All poultry houses need some form of ventilation to ensure an adequate supply of oxygen, while removing carbon dioxide, other waste gases and dust. In commercial operations, minimum ventilation is often practiced in colder climates, but not generally in tropical ones (Glatz & Bolla, 2004). In large-scale automated operations, correct air distribution can be achieved using a negative pressure ventilation system. When chicks are very young, or in colder climates, the air from the inlets should be directed towards the roof, to mix with the warm air there and circulate throughout the shed. With older birds and in warmer temperatures, the incoming air is directed down towards the birds, and helps to keep them cool. Evaporative cooling pads can be placed in the air inlets to keep birds cool in hot weather. Tunnel ventilation is the most effective ventilation system for large houses in hot weather.

2.2.3 Broiler Management

The aim of management is to provide the conditions that ensure optimum performance of the birds (Bell & Weaver, 2001). Given reasonable conditions, broody hens are very successful at hatching their chicks, but good hatchability using artificial incubation (both large and small) relies on careful management of temperature, humidity, ventilation, position and egg turning. During incubation, the egg loses water vapour through its shell. The rate of water loss depends on both the shell structure and the humidity of the air surrounding the egg. The quality of the hatch also depends on the age and health of the breeder flock, and on the evenness and cleanliness of the eggs set.

Factors involved in broiler management involves monitoring poultry health; ensuring that the poultry house is maintained with appropriate brooding, rearing, growing and laying conditions; and ensuring that recommended vaccinations are given and appropriate feeding programmes are used. In developing countries, it is often difficult to achieve optimum performance from birds, owing to less-than optimal housing conditions and lack of quality feed, vaccines and trained staff.

Breed effects Owing to their superior production, commercial hybrids of high genetic merit are often used in developing countries, but are not well-suited to tropical environments. These birds are sensitive to changes in the diet and to high ambient temperature, and require skilled stockpersons to manage them. Indigenous poultry can cope better with the harsh conditions often prevailing in developing countries, and good management will improve their performance. This can be achieved by using good housing, protecting the birds from predators, and providing them with the environmental conditions that allow them to achieve maximum profitability.

Temperature effects, farmers need to compensate for undesirable climatic conditions by manipulating control systems or modifying the house to ensure that the welfare and environmental needs of the birds are satisfied. Environmental extremes (heat and cold stress, excessive or inadequate ventilation, poor air quality) can be managed if the design of the poultry house is appropriate for the conditions. Birds require adequate space, sufficient feed to meet their nutritional requirements, and an adequate supply of good-quality water. Use of a stringent quarantine programme to prevent disease is an essential element of good management, and farmers must be able to recognize disease and treat it as soon as possible. A suitable vaccination and medication programme is essential in commercial operations.

Effects of nutrition, managers need to ensure that the diets provided to birds in commercial operations meet the nutrient requirements of each age group and strain of chickens Small holder systems in developing countries typically place less emphasis on achieving maximum production, and more on maximizing profitability by using diets comprised mainly of local feedstuff ingredients, rather than imported feeds. Key management practices by farmers who mix their own feed include ensuring that micro-ingredients are kept cool, mouldy ingredients are not used, and storage facilities are weather- and rodent-proof.

Importance of good hygiene is an essential management task is to maintain clean sheds, surroundings and equipment. A clean shed improves health and limits parasites, dust and microbial contamination, while clean shed surroundings reduce vermin and fly loads. This is important not only for litter and manure management but also for biosecurity. Removal of residual feed from feeders is an important practice critical to the health of the flock. Another important management task is to sanitize sheds to minimize the risk of disease to incoming flocks of birds. Maintaining high flock health status is essential, and routine vaccination programmes for a number of diseases are typically in place, particularly in larger-scale operations. Some vaccinations are carried out at the hatchery, but it is essential that a proper vaccination schedule be established and that vaccination protocols are complied with.

Litter materials and management. Broiler litter is the material used as bedding in poultry houses to absorb faecal waste from birds and to make the floor of the house easy to manage. Common litter materials are wood shavings; chopped straw, sawdust, shredded paper and rice hulls, and a wide range of other materials are used in different regions around the world. Litter should be light, friable, non-compressible, absorbent, quick to dry, of low thermal conductivity and –very important – cheap. After use, the litter comprises poultry manure, the original litter material, feathers and spilled feed. The litter quality in a shed is determined by the type of diet, the temperature and the humidity. The recommended depth for litter is between 10 and 20 cm. Sawdust can result in high dust levels and respiratory problems. Dust particles in the litter capable of causing health problems in the birds are derived from dried faeces, feathers, skin and litter; their adverse effects arise because they carry or incorporate bacteria, fungi and gases.

Management of lighting: Poultry have seasonal and daily biological rhythms, both of which are mediated by light, particularly day length. For day length to exert its controlling effect, there needs to be a dark phase (night) when light levels should be less than 0.5 lux. Day length and light intensity during the breeder bird's life have an important role in development of the reproductive system. The difference in day lengths and light intensities between the rearing and the laying phases is the principal factor responsible for controlling and stimulating ovarian and testicular development (Lewis & Morris, 2006). The response to increases in day length and lighting intensity depends on the body weight profile during rearing, which in turn depend on the nutritional regime. The effects of light are predominantly on the rate of sexual maturation and egg production. The two types of artificial lighting commonly provided are incandescent and fluorescent. Incandescent globes are cheaper to install, but have lower light efficiency and a shorter life. Fluorescent lights are three to four times as efficient and last about ten times as long, but have variable performance in cold weather. The colour of the light rays has an effect on chickens' productivity. For example, green and blue lights improve growth, and lower age at sexual maturity, while red, orange and yellow lights increase age at sexual maturity, and red and orange lights stimulate egg production. Birds are calmer in blue light, so blue lights are recommended for use during depopulation in commercial operations. Lighting programmes for broilers: Lighting programmes for commercial broiler operations vary widely from company to company, and depend on the strain of bird used, the housing type (naturally ventilated versus controlled-environment), the geographical location and the season. Where light can be excluded from sheds, birds are typically reared under low-intensity (5 to 10 lux) lighting, to keep them calm and to prevent feather pecking. During early brooding, 25 lux is used to stimulate feeding.

Record keeping and meeting production targets are good management practices that allow the identification and solution of problems. When a problem is identified, the next step is to attempt to fix it. Identifying the cause of and fixing a problem is an important part of the farmer's knowledge base, and is likely to assist in preventing a recurrence of the problem (Barnett, Glatz, Almond, Hemsworth, & Parkinson, 2001). Records kept over time can help identify some of the possible causes of problems. One of the most useful record-keeping documents is a diary, which can be used in combination with record-keeping sheets to record major activities, problems identified, equipment repairs, deviations from equipment settings, and any staff issues. Records of production, growth, feed, egg weights, mortalities, treatments given, and response to treatments should be maintained to assist investigations of sub-optimal performance. In all production systems, signs of ill health can be detected when poultry reduce their food and water intake; reduce production or growth; undergo a change in appearance, behaviour or activity level; or have abnormal feather condition or droppings.

2.3 FISH MEAL

Fish meal is a commercial product mostly made from fish that are not intended for human consumption. Fish meal is made from bones and offal left over from fish caught by commercial fisheries. Fish meal takes form of powder or cake. This form is obtained by drying the fish or trimmings and then grinding it. If the fish used is a fatty fish it is first pressed to extract most of the fish oil. Fish by-products have been used to feed poultry, pigs and other farm animals. Fish meal can be made from almost any type of seafood, but is generally manufactured from wild caught, small marine fish that contain a high percentage of bones and oil, and are usually deemed not suitable for direct human consumption. The processing is made by cooking, pressing, drying and grinding of fish or fish waste into a solid. Most of the water and some or all of the oil is removed (Miles & Chapman, 2005).

2.4 GRASSHOPPER MEAL

Hassan *et al.* (2009) stated that broiler chickens fed 100% level of inclusion of grasshopper as a replacement of fish meal attained weight gain of 1.02kg in fish meal attained weight gain of 1.02kg in 5weeks. This could be as a result of higher crude protein content of grasshopper meal. Feed intake was also found to be higher due to the higher crude fibre content in diet with 100% level of inclusion of grasshopper meal. Feed conversion efficiency was found to be higher in 10% level of inclusion of grasshopper meal. Thus indicating that grasshopper meal has slightly lower feed conversion efficiency compare to fish meal. Feed cost in 100% level of inclusion of grasshopper meal was found to be highest because of cost of transportation of grasshopper meal from Jigawa state while they conducted their research in Kaduna state which they conducted their research in Kaduna state which has less availability of the insect. During their experimental period mortality was only recorded in 0% inclusion level of grasshopper meal. In their proximate analysis of composition of grasshopper meal, it was revealed that the dry matter 94.23, crude protein 53.58, crude fibre 9.21 fat/oil 26.52, Ash 4.31, N.F.E 6.40%.

Hassan *et al.* (2009) concluded and recommended that grasshopper meal can replace significant quantity of fish meal in broiler ration. Grasshopper could be turned into a money-spinning livestock feed ingredient. The study recommended that poultry farmers should form co-operative societies to enable them procure the grasshopper meal in large quantities so as to reduce the high cost involved in procuring the meal especially for the states that are far away from the grasshopper sources. The poultry farmers should be taught how to compound their poultry locally as this will go a long way in reducing the cost feed which forms about 80% of the total cost of production in the poultry industry.

Hassan *et al.* (2009) stated that the chicks that are used in the experiment were divided into three (3) treatments and each treatment was replicated twice with 22 chicks per replicate, making a total of 140 day-old broiler birds and the feeding trial lasted for 5 weeks. Grasshopper meal was included at 0, 50 and 100% in the diets as replacement of fish meal. In recent studies (Ghosh, Haldar & Mandal 2016) identified that grasshopper; *O. hyla* species retain about 54% moisture in their body and proximate compositions such as crude protein, fat carbohydrate, nitrogen free extract, crude fibre and ash content as percentage of dry matter. These are crude protein 64, carbohydrate 28 nitrogen free extract 19 and fat 2.58%. Further analysis disclosed that the amino acids content include; alanine 1.76, arginine 1.91, As part ate and as paragine 1.90 cystine 3.57 glutamic acid and glutamine 30.01 glysine 3.53, 0.56 histidine 1.12 isoleucine 2.85 leucine 2.53 lysine 4.29 methionines 0.97, cystine 3.57, histidine 1.12 isoleucine 2.85, leucine 2.53 lysine 4.29 methoinine 0.97, proline 0.39 serine 6.23%. Threonine 3.75 tryptophan 0.52, tyrosine 1.51 valine 0.19%, phenylalanine not detectable. Fatty acids include: caprylic acid 0.003 lauric acid 0.006, myristic acid 0.503 palmtoleic acid 0.015, heptadenaoic acid 0.044, (is-10- heptadenaoic acid 0.044, stearic acid 0.487 acid 0.470, arachidic acid 0.061, gama linoleic acid 0.007, heneicosanic acid 0.005 Cis-11-eicosenic acid 0.010%. linolenic acid 0.29, heneicosanoic acid 0.005, behenic acid 0.035, C is -8 11, 14 eicosatrience acid

0.001, arachidonic acid 0.014, ligxaenioc acid 0.025. minerals and vitamins include; iron 16.19 Zinc 17.34 manganese 2.30 magnesium 84.84, copper 4.36 phosphorus 0.75 niacin (vit-B3) 29.59 ascorbic acid (vit-A) 0.12%. Anti-nutritional factors include: tanin 2.316, oxalate 0.474, phytin P.O. 031, phytin 0.109.

Ghosh *et al.* (2016) concluded and recommended that the short-horned grasshopper species *O. hyla hyla* is rich in protein, amino acids, fat, fatty acids and carbohydrate and low in anti-nutritional factors is suitable for use as a protein rich feed supplement in fish and animals diets.

Ramos-Elorduy, Camacho and Pino-Moreno (2012) stated that the grasshopper species Orthoptera have a high nutritive value specially those belong to the family *Acriditae* that generally allows higher content of the different parameters studied; and also, were the most utilizing by people improving significantly the peasant diet because as it was shown generally provide more quantity of the student nutrients.

Ramos-Elorduy *et al.* (2012) recommended that it is important to do additional research about these edible insects, as well as new methods of gathering efficiently, production, food technology processing and marketing.

Ojewola and Udom (2005) reported that grasshopper has DM content of 91.67, 28.13 CP, 2.38 crude fibre CF, 9.97 ash, 4.18% ether extract EE and 1618 Kcal/g gross energy GE. Anand, Ganguly and Haldar (2008) reported that protein content of acridids ranges from 60 to 66 4.5-7 kcal/g, fat 6-7.5, Carbohydrate 3.6-7.5% and mineral contents. Anand *et al.* (2008) recommended that grasshopper because of their high nutritional and ubiquitous presence; grasshopper present a potential sustainable food resources in animal nutrition. Also, harvesting food acridids from croplands will minimize the use of pesticides for management of pest grasshopper and reduce the environmental pollution. Bernard, Allen and Ultrey (1997) identified that the EE content of grasshopper meal is 4-55% on a dry matter basis and that it may vary substantially within a species depending on developmental stage. Many insects accumulate fat during larval development, and two of the commonly utilized in 200s are larval forms, mealworm larval and wax moth larval. The authors concluded that if these larvae constitute a substantial part of the diet, they may present a disproportionately high fat content, leading to excess energy intake relative to other essential nutrients.

Njidda and Isidahomenl (2010) fed rabbits diet containing 0, 1.25, 2.50, 3.75 and 5% grasshopper meal and observed that carcass characteristics showed significant differences among treatments ($P<0.05$) for slaughter weight carcass weight, dressing percentage skin pelt, tail fact and abdominal fat. Also, the slaughter weight and carcass weight were better in groups receiving 2.5% grasshopper meal (50% fish meal replacement).

Jose-Maria *et al.* (2013) stated that adult larval and pupil forms of insect are consumed naturally by will birds and free range poultry. The species of grasshopper are naturally consumed by world birds and free-rang poultry. In general, feeding experiments with various species of grasshopper have shown positive results, without adding amino acids. Thereby the conclusion of 15% grasshopper meal in broiler chicken feed does not affect growth (Wang, Zhai, Zhang, Zhang & Chan, 2005). The result coincide with reports by other researchers, which did not find differences in growth indices between broilers that were fed the control diet, cricket-based diet, *Anabrux simplex* (Finke, Park & Boye, 1985) or *Gryllus testaceus* (Wang *et al*. 2005) or with grasshopper (Ojewola, Okonye & Okoho, 2005). Similar results were obtained by Finke *et al.* (1985), even with high levels (28%) of substitution.

Jose-Maria *et al.* (2013) concluded that development of mass-rearing systems for insects the current economic crisis and the increase in food prices, provides interesting perspectives for the use of insects for different purposes such as animal nutrition, agriculture, to obtain essential oils or biodiesel. Moreover, insect culturing does not compete with food resources or land use and maximize the benefits of waste management by using "waste nutrients" for insect growth. Additionally, insect utilization contributes to the natural recycling of nutrients. Therefore, we believe that the coming years will see a significant increase in scientific production related to the use of insect meal in animal feed or other purposes. To make use of insects as feed ingredient on a large scale it is important to increase the scale of insect productions further with continuous quantity and quality but it should be decrease the cost prices of insect rearing further in order to be competitive with currently used protein sources.

Jose-Maria *et al.* (2013) recommended that the use of insect meal in animal feeding indicate that insects have great potential in animal. Feeding as protein source, insects have adequate profile of amino acids, depending on the insect species. The most frequent limiting amino acids are histamine, lysine and tryptophan, which could be incorporated into the diet. Moreover, it is necessary to evaluate the amino acid profile or to improve the profile through genetic methods. To include insects as a feed ingredient in the feed chain additional research is recommended on its feeding value, inclusion levels in diets, and functional properties of the feed ingredient. The use of insects as a sustainable protein rich feed ingredient in diets is technically feasible and opens new perspectives in animal feeding.

Ojewola and Udom (2005) stated that one hundred and fifty (150) unsexed day-old broiler chicks of Anak strain were randomly divided into 5 treatment groups, each having 3 replicates of 10 chicks in a completely randomized designed (CRD). The control diet(1) contained imported fish meal (Danish) 2,3,4 and 5 contained imported fish meal (Danish) 2,3,4 and 5, local fish waste meal crayfish waste meal and grasshopper meal, respectively. The grasshopper meal contained 357.60g kg^{-1} CP (crude protein), 158. 6g kg^{-1}.

Ojewola *et al.* (2005) discovered that the percentage either extracts was highest (15.86) for grasshopper meal. However, source mode of harvesting, processing and observed in composition and gross energy content all the test ingredients. Grasshopper meal, whose protein content is mostly chitin, could also have enhanced the birds' performance. According to Ramaa Chandran (1987) chitin is known to have a growth promoting effect at low levels by producing glucosamine during its digestion through chitinase enzyme secreted by intestinal bacterial. Furthermore, of bifido bacterium, thus stimulating improved gain, (Spreen, Zikakis & Austin, 1984). The feed-to-gain ratio shows that the diets were equally efficient in weight gain and this favours complete substitution o Danish fish meal with grasshopper meal. Similarly, observation had been documented (Olomu & Nwachukwu, 1977).

This is an indication that the test ingredients used in this trial are not in any way harmful to the birds. It is also an indication that satisfactory animal protein could be prepared from locally sourced grasshopper meal as a complete substitute for fish meal in the diets of broiler chickens.

Ojewola *et al.* (2005) concluded and recommend that the nutritive quality of soybean meal-based rations could be improved by the inclusion of the various animal protein sources in broiler ration and there is need to supplement cereal based rations with meal with grasshopper meal did not hamper productive performance in broilers, their production and utilization in feed formulation could be encourage. This is expected to bring about a reduction in the price of poultry meal products to a level affordable by majority of consumers. It is further expected that such replacements would reduce competition between man and animals for fish as feed ingredient with a consequent reduction in the market price of fish.

Melo, Marillia, Rocha and Maria Jose (2011) found that grasshopper contains 71.5 CP, 5.75 lipids, 2.50 minerals, 3.89 CF and 16.36% NFE on a DM basis. These findings indicate that the protein context of grasshopper varies widely (28.13 to 53.38%) probably due to stage of growth and locality. Further he stated that the availability of insects may change according to biotic and biotic conditions of the environment, example in Botswana, grasshoppers and crickets are available for 10 months, i.e. from August to may and absent in winter month of June and July.

Moreki, Tiroesele and Chiripasi (2012) concluded that due to high nutritional value and ubiquitous presence, insects are a potential value and ubiquitous presence, insects are a potential sustainable food resource in animal nutrition. It appears that the utilization of insects as alternative sources of protein is feasible in Botswana, especially under smallholder poultry production practiced by resource-poor farmers who cannot afford expensive compounded poultry feeds. Therefore, producing feeds using locally available ingredients will reduce the cost of production. Furthermore, promoting cultivation and improved preservation techniques will ensure a regular and good source of income for people who grow these insects not only for their utilization in poultry feeds but also for their own consumption. As insects are generally easy to cultivate, it is important to conduct further investigation on new methods of gathering producing and processing.

Harrinder, Trans, Heize and Ankers (2014) reported that in an early study in the Philippines, locust meal was not a efficient but was as palatable as fishmeal when fed to broilers. More recent studies have tried replacing a part of fishmeal with locust and grasshopper. Lynda (2016) stated that insect meals could potentially replace between 25 and 100% of the soymeal or fishmeal in animal feeds. Grasshoppers emerged as an interesting protein sources for broilers, as they result in a number of meat quality parameters, such as higher antioxidant potential, longer shelf life increased protein and decreases cholesterol content.

Lynda (2016) concluded that in order for insect meals to be a significant part of the animal diets produced by the feed industry, the researchers said there was a need for cost effective, mass insect rearing facilities, a regulatory framework and sanitation procedures for safe use of bio-wasted and managing diseases, heavy metals and pesticide. They also called for more studies evaluating insect meals as livestock feed, life cycle studies to measure the environmental impact of using insects as animal feed and data on the feed conversion efficiency of various insects, to make informed decisions.

Njidda and Isidahomen (2010) reported that they conducted an experiment to evaluate the effect of replacing fish meal with grasshopper meal on haematology, blood chemistry and carcass characteristics of growing rabbits. Forty rabbits aged 6-10 weeks were randomly assigned to the dietary treatments in a complete randomized design with eight rabbits per treatment. The rabbit were fed with diets containing 0,1.25, 2.50, 3.75 and 5% grasshopper meal in diets designated as T1 (control), T2, T3, T4 and T5, respectively. The experimental diets and clean drinking were supplied *ad libitum* throughout the experimental period of nine weeks. Njidda and Isidahomen (2010) reported that the blood chemistry; the albumin values showed no significance difference (P>0.05) among treatments and the values fell within the normal range of 2.5 to 4.0g/d/. The globulin values (1.02 to 2.02 g/d1) showed significant differences (P<0.0.5) among treatments. The value for T1, T2, T3, T4 and T5 were lower. The blood glucose was within the rage 4.2-8.9 mm01/1. Serum creatinine levels were within normal range and did not differ (P>0.05) among treatment groups. The values obtained for animals on diets T1, T2 and T3 were indication that dietary protein was well utilized by the rabbits. The results of the carcass characteristics shows that the slaughter weight and carcass weight were highest in rabbits fed diet T3 containing 2.5% grasshopper meal (50% fish meal replacement). There were significant differences ($P<0.05$) among treatments for skin pelt tail and fact, with T2 having the highest value for skin pelt and tail. The dressing percentage may be related to the higher fat content recorded with the carcass which ranged from 45.75 to 70.03% with the highest in T2 (70.03) and lowest in T5 (45.75%). The study revealed that there was a relationship between dressing percentage and abdominal fat of carcass. Values obtained for heart, lungs, kidneys and liver weights showed non-significant differences ($P>0.05$) among treatment groups. It is a common practice in feeding trials to use kidneys as indicators of toxicity. In the study, the liver and kidney weights in rabbits of different treatment groups suggest that the test diets did not contain any appreciable toxin. Njidda and Isidahomen (2010) conduced that growing rabbits could tolerate up to 2.5% grasshopper meal (50% replacement of fish meal) in their diets without adverse effects on their blood and carcass characteristics.

Olaleye (2015) in related studies conducted a research to assess the effects of grasshopper in the diet of *clarias garlepinus* fingerlings to substitute fishmeal with grasshopper meal in the formulation of *clarias gariepias* fingering feed. Different diet (those containing only fishmeal and those containing grasshopper meal at various inclusion levels) were formulated using different treatments which include feed containing both fishmeal and grasshopper meal. Fingerlings weighing 15-20g were used for 48 hours. Five different diet were tried with two replicates for each treatment for a period 56 day fish in all treatments were fed 5% of their body weight daily split into two feeding frequency and the weight were recorded bi-weekly. The feeding rate was adjusted weekly based on body weight. Water quality parameter such as temperature and PH were monitored. The data obtained from the trials were subjected to one-way analysis of variance and statistical different between the means were separated using Turkey-HSD at 95% degree of confidence using SPSS 15.0 statistic package.

Olaleye (2015) concluded that and discovered that the nutrients composition shows that grasshopper meal has high crude protein of 64.51%. This is a very high value that could completely replace fish meal in feed. The calcium content is greater than those obtained from soya beans meal and groundnut cake.

The phosphorus (P) content is low due to low ash content. The sodium (Na) content compares favourably with that of soybean meal and yellow maize which has being used to replace fishmeal obtained by different researchers. The potassium (K) compares favourably with that of fishmeal. In this study treatment 2 (20% fishmeal and 10% grasshopper meal) has the highest weight gain. Average daily weight gain (ADG), specific growth rate (SGR) protein efficiency ratio (PER) and high feed conversion ratio (FCR) compared to other treatments despite the fact they were of the same crude proteins levels (45% cp). High weight gain protein efficiency ratio, feed conversion ratio, Average daily weight gain and highest growth rate was recorded from fish fed treatment 3 (15% fish meal and 15% grasshopper meal). Treatment 5(30% grasshopper meal) have a lower weight gain, protein efficiency ratio, faced conversion, specific growth rate and average daily weight gain when compared with treatment 1,2, and 3. Olaleye (2015) concluded that grasshopper meal has been shown to contain most of the essential amino acids in higher proportion than other proteins feedstuff like blood meal, groundnut cake and soya bean meal. The growth performance for *clarias garipinus* fed with five different diet containing grasshopper meal at varying inclusion level was monitored for 56 days in net hapas installed in concrete tank. The overall best performance was obtained in treatment 2 and 3 respectively. This is an indication of the potentials of *clarias garlepinus* to achieve optimal growth. Olaleye (2015) recommended that the nutrients compassion of grasshopper and its quality makes it a good dietary supplement in fish production and recommended that more studies should be carried out on other conventional feedstuff of least cost for growth performance of *clarias garipines* and possibly other aquaculture fish.

Amza and Tamiru (2017) stated that 25% of fish meal can be replaced with grasshopper meal without adverse effects and for some specie inclusion up to 40% is recommended. Also insect meals that contain high oil as 36% oil which can be used for the preparation of biodiesel. However, high content of oil could decrease fibre digestion in the rumen in such a way that it creates unfavourable condition for optimum rumen fermentation. Therefore such species of insect should be defatted to ensure normal rumen fermentation. Moreover insects meals that contain high levels of ash and hence their high levels if inclusion in the diet, especially of mono-gastric, can decrease its intake and cause other adverse effects.

Amza and Tamiru (2017) concluded that it is possible to come up with concrete conclusion that insect meals are valid, cost effective and highly nutritive alternative source of animal potentially utilized as a supplement and or sole sources of nutrients particularly protein meeting the overall nutrient requirements of various animal species. According to the current reviews, various insect species have 30 to 70% of protein on DM basis and rich in fats minerals and vitamins content and have efficient food conversion factor compared to conventional fish and unaffordable for small scale farmers engaged in livestock rearing. The palatability of the diets containing insect meals is good and can replace soybean and fishmeal in the diet of poultry, fish and pig based on feeding studies. However, it is important to note that insect meals compared to fishmeal contain lower concentration of methionine and ca which has to be considered when for mutating diet based on insect proteins it appears that grasshopper meal could be added into the diet of broilers at 2.5% of fishmeal can be replaced with grasshopper meal without any adverse effect and for some species inclusion up to 40% is recommended.

Amza and Tamiru (2017) recommended that there is need for establishing regular effective well optimized mass insect rearing facilities for a defined quality of animal product. To use insects as alternative sustainable protein rich ingredient in poultry fish and pig diets, it requires production of insect at large scale up on undertaking utilization of bio-wastes and organic side streams to different stakeholders, there is need in developing countries to establish intensive insect rearing to enhance livestock productivity ultimately ensuring food security. Co-ordinated responsibilities should be established. First the government should create awareness on how to establish insect rearing farms up on utilizing of locally available insects species bio wastes and organic side streams to different stakeholders engaged in livestock rearing and collaborate working with various governmental and non-governmental such those working in agriculture, livestock resource, Fishery developments, health and environment. For obtaining safe insect meals in animal feed, setting up of sanitation procedures on bio-waster disease management, application of heavy metals and pesticides needs to be considered. While feeding insects' meal to livestock we should also consider its impacts on animal and human health point of view. To reduce environmental effect of protein rich animal feed derived from plant and animal sources, should be encouraged as substitute or supplementation.

In related studies Park, Jozefiak and Margrete (2015) stated that in recent years much attention has been devoted antimicrobial peptides (AMPS) present in insects called nature antimicrobial or antibiotics due to the increasing global problem of bacterial fungal certain parasitic and viral resistance to antibiotics. AMPs mechanism of insect does not induce bacterial resistant and involves the destruction of the bacterial cell envelope.

Yi *et al.* (2013) stated that there are possibilities of using in agriculture including animal nutrition as well as the pharmaceutical industry.

Cickova and Diener (2011) stated that some insects from the order *Diptera* have a great ability to utilize organic waste material that contain moisture (60-80%) converting it to valuable insect protein in such a way that they reduce the accumulation of poultry manure by 50% and reduce bacterial growth in the manure that results in a reduced odour development and the growth suppression of significant pathogens.

Adeyemo and Longe (2008) stated that grasshopper meal was fed to broilers for 1-28 day as a substitute for fishmeal resulted in higher body weight gain, feed intake and feed conversion. He recommended that 50% of fish meal could be replaced by grasshopper meal 1.7% of fishmeal could be replaced by grasshopper meal 1.7% in the diet.

Alegbeleye, Obasa, Olude, Otubu and Jimoh (2012) reported that in African grasshopper meal was used to replace fish meal (weight basis) resulted without any adverse effect on growth and nutrient utilization at the same protein level in the diet. The inclusion 25% decreased digestibility, performance, a little shrinkage in gills, and reduction in ovarian steroid genesis which may reduce fertility.

Yen *et al.* (2010) reported that not all insects are safe to use in animal feed. Just as it applies for plant and animal food products. Some insects cause allergic reactions, botulism, parasitizes and food poisoning and stated that for example the pupae of the African silkworm (*Anaoheve nata*) contains a thiaminase and can cause thiamine deficiency and responsible for a seasonal ataxic syndrome.

In related studies, Balogun (2011) stated that deserts locust meal (*Schistocerca gregaria*) could replace up to 25% dietary protein in *C. garepinus* juveniles without significant reduction in growth chitin may have contributed to reduced performance when greater rates were used.

Ahmad, Birnin-Yauri, Bagudu and Sahabi (2013) reported that grasshopper offer has been subjected to proximate analysis produced moisture 1.83 ± 0.29, ash 28.17± 0.29, crude lipid 24.70± 0.75, crude fibre 10.2± 0.29%, lysine 6.39, threonine 3.94 mg/100g, cystine 1.19 mg/100g, valine 4.53mg/100g, methionine 2.34 mg/100g isolevcine 3.33mg/100g, leucine 8.73mg/100g tyrosine 3.22mg/100g phenylalanine 6.93 mg/100g. Non-Essential amino acid. histidine 4.32mg/100g, arginine 7.83mg/100g, asparticacid 10.35mg/100g, serine 4.26 mg/100g, glutamicacid 12.66 mg,/100g, proline 3.40mg/100g glycine 3.94mg/100g, alanine 4.02 mg/100g.

Ahmad, *et al.* (2013) concluded that crude fibre content in the grasshopper 10.2+0.29 could fibre content in the grasshopper 10.2+0.29 could play physiological role in the body maintaining an internal distension for proper peristaltic movement of the intestinal tract. A low diet could lead to constipation which might bring discomfort to the body system with running stool. Diets with high fibre content have content have been used for weight control and fat reduction, as they give sense of satiety even when small food is eaten.

Sani *et al.* (2014) report that they conducted studies with dried grasshopper; the wings were removed and discarded then ground to powder and subjected to analysis. The proximate analysis for moisture, ash and crude fibre were carried. Also crude fat, protein content and analysis of anti-nutritional factors, mineral composition was carried out.

Sani *et al.* (2014) discovered that the dried grasshopper (*Zonocerous variegatus*) contain composition of moisture 5.33± 1.16 ash 11.50±3.04 crude lipid 49.33± 2.08 crude fibre 2.03±1.01 crude protein 2.19±0.87 carbohydrate 29.61±4.21%. Anti-Nutrients compositions are oxalate 11.25±5.20 mg/100g, phytic Acid 2.18 ± 0.24mg/100g, tannin 3.90±0.1 mg/100g. mineral composition are sodium (Na) 0.02±0.00 mg/kg, potassium (K) 0.04± 0.01/kg, calcium (Ca) 1.12±0.07 mg/kg, magnesium (Mg) 0.57± 0.07mg/1kg manganese (Mn)-mg/kg, iron (fe) 1.84± 0.05mg/kg copper (CU) 0.20±0.01kg, Zinc (Zn) 1.63± 0.01mg/kg, lead-mg/kg.

According to Sani *et al.* (2014) the moisture content was higher than previous report. High moisture content leads to the risk of microbial deterioration and spoilage of food substances. The grasshopper was rich in fat. Fats are essential in daily human diets as they increase the palatability of food by absorbing and retaining their flavours. These are also vital structural and biological functioning of the cell and help in the transport of nutritionally essential fat-soluble vitamins. Crude fibre content varies with species; this might be due to different exoskeletons and structure. Anti-nutritional factors like those that tannin was observed to be very low compared to other obtained results; oxalate was very high, while phytic acid is higher compared to other similar research findings. These might be due to different species used. The mineral composition of the grasshopper species *Zonocerous varvgatus* showed that calcium, iron and zinc are more abundant compared to magnesium and copper. Values of copper sodium and potassium are moderate while manganese and lead were not detected. Copper, sodium and potassium were low compared to other researches but the values of calcium, magnesium, iron and zinc were higher.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

The study was conducted at the Poultry Unit, Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano. Kano is positioned on latitude 11.99^0 N and longitude 8.51^0 (Global Positioning system, GPS, 2018). It is in the semi-arid area of North-western Nigeria. Annual rainfall ranges between 787 and 1320mm. Average minimum and maximum temperatures are 21.5 ^{0}C and 30.9 ^{0}C (climate-Data-org, 2018). Humidity ranges between 17 and 64%. The wind direction is West to East and East to West. The mean monthly sunshine hours vary from 220.1 to 266.6 kWh/m^2 day (Kano State Government, KNSG, 2004). The vegetation comprises of trees, shrubs and grasses. These include: *Acacia militia, Adonsonia spp, Khanya senegalensis.* Predominant livestock include: cattle, sheep, goats, domestic fowls, ducks, pigeons, guinea fowls, camels and donkeys (FAO, 2009).

3.2 EXPERIMENTAL DESIGN

The experiment was carried out in a completed randomized design (CRD) comprising of four treatments (0, 25, 50 and 100% inclusion levels; coded A, B, C, and D respectively). Each treatment was replicated four times with ten chickens per replicate.

3.3 SOURCE OF EXPERIMENTAL BIRDS

A total of 160-day-old Marshal broiler chicks were purchased from one of the reputable poultry chicks suppliers in Nigeria.

3.4 SOURCE AND PROCESSING OF EXPERIMENTAL FEED INGREDIENTS

Feed ingredients for the diets formulation (maize, soya bean meal, groundnut cake, fish meal, limestone, bone meal, premix, salt, lysine and Methionine) were purchased from reputable feed raw material industries and open local markets in Kano state. Whereas grasshoppers were obtained from Gumel central market, Jigawa state, irrespective of their species. The wings and appendages were removed and sun-dried by spreading on a concrete floor for 10 days with regular turning to ensure proper drying and prevent mouldiness. The dried samples were ground into powder using mortar and pestle. Experimental diets were milled at Baba Grains Mill, Sabuwar Gandu, Kano. These samples were taken to laboratory for proximate analysis at the Department of Animal Science Bayero University, Kano.

Table 3: Composition of the Experimental Broiler Starter Diets (23% CP)

Ingredients	A	B	C	D
Maize	49.50	50.00	50.50	51.50
Soybean meal	36.63	36.13	36.00	34.00
Rice bran	5.00	5.00	4.50	4.00
Groundnut cake	3.00	3.00	2.50	4.00
Fish meal	3.47	2.60	1.74	-
Grasshopper meal	-	0.87	1.73	5.47
Bone meal	1.60	1.60	2.20	2.22
Premix*	0.35	0.35	0.35	0.35
Salt	0.25	0.25	0.35	0.35
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Nutrients				
ME(kcal/kg)	2887.07	2869.09	2869.57	2847.31
CP(%)	23.59	23.53	23.23	23.49
CF (%)	4.62	4.74	4.79	5.20
EE (%)	5.29	5.34	5.25	5.31
Ca (%)	1.04	0.75	0.78	0.90
P (%)	1.75	0.72	0.80	0.75

**Vitamins-Minerals Mixture = Vit. A: 8,500,000 IU; Vit D3: 1,500,000IU, Vit E: 10,000mg, Vit K: 1,500mg, Calcium pantothenate: 5000mg: Vit B1(thiamine): 1,600mg, Vit B2(riboflavin): 4000mg, Niacin: 20,000mg, Vit B6 (pyridoxine): 1,500mg, Vit B12: 10mg, Folic acid: 5oomg, Biotic H2: 750mg, chlorine chloride: 175,000mg, Manganese : 40,000mg, Iron: 20,000mg, Zinc: 30,000mg, Copper: 3,000mg, Iodine: 1,000mg, Cobalt : 200mg, antioxidant: 1,250mg. ME = metabolizable energy, CP=crude protein, CF= crude fiber, EE= Ether Extract, Ca= calcium, P = phosphorus*

Table 4: Composition of the Experimental Broiler Finisher Diets (20% CP)

Ingredients	A	B	C	D
Maize	59.00	59.50	59.91	59.95
Soybean meal	23.99	23.10	23.10	23.06
Rice bran	5.50	6.40	6.30	6.30
Groundnut cake	3.00	3.00	3.00	2.50
Fish meal	5.31	3.98	2.50	-
Grasshopper meal	-	1.33	2.50	5.40
Bone meal	2.50	2.40	2.00	2.20
Salt	0.25	0.25	0.25	0.20
Premix*	0.25	0.25	0.25	0.20
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Nutrients				
ME (kcal/kg)	2964.62	2960.87	2963.29	2934.52
CP (%)	20.43	20.16	20.04	20.06
CF (%)	4.17	4.37	4.58	4.98
EE (%)	5.37	5.54	7.16	5.81
Ca (%)	1.36	1.23	1.14	1.04
P (%)	0.90	0.83	0.75	0.71

**Vitamins-Minerals Mixture =Vit. A: 8,500,000 IU; Vit D3: 1,500,000IU, Vit E: 10,000mg, Vit K: 1,500mg, Calcium pantothenate: 5000mg: Vit B1(thiamine): 1,600mg, Vit B2(riboflavin): 4000mg, Niacin: 20,000mg, Vit B6 (pyridoxine): 1,500mg, Vit B12: 10mg, Folic acid: 5oomg, Biotic H2: 750mg, chlorine chloride: 175,000mg, Manganese : 40,000mg, Iron: 20,000mg, Zinc: 30,000mg, Copper: 3,000mg, Iodine: 1,000mg, Cobalt : 200mg, antioxidant: 1,250mg. ME= Metabolizable energy, CP = Crude protein, CF= Crude Fiber, EE= Ether Extract, Ca= Calcium, P= Phosphorus.*

3.5. MANAGEMENT OF THE EXPERIMENTAL BIRDS

The experimental broiler birds were managed in a deep litter house which was partitioned into sixteen pens as experimental units. Each treatment was replicated four times with ten birds per replicate. Two weeks before the arrival of the chicks, the brooding house and all the equipment for the experiment were thoroughly cleaned, washed and disinfected using Soklin detergent and Izal disinfectant suspension at dose rate of 40 ml in 5 litres of water. These practices were continued throughout the experimental period. Brooding facilities included: brooder guards, litter materials, hovers or brooder boxes, feeders, drinkers and heaters. The brooding equipment was assembled with the brooder box in the middle and the heaters radiating from it. The water fountain were set between the feeders but near the edges of the hovers. The whole arrangements were enclosed by a chick guard of ceiling of about 80 cm high and 1.3 m away from the brooder box. The guard was moved back little everyday and then completely removed after ten days. On arrival, the birds were provided with glucose; 8 g per litres of water and chicks formula in the drinking water; 5 g to each 5 litres of water. The chicks' formula was for 3 days consecutively. The room was well prepared and heat was supplied using 200 watts electric bulbs. Additionally, charcoal was used to provide heat especially during power outbreak. The heat maintained a suitable brooding temperature at 33^0C for the chicks. Feed and water were provided *ad libitum*. The birds were dewormed with piperazine. The following vaccinations were adopted:

Table 5: Vaccination Schedule for the Experimental Birds

Name of vaccines	Dosage(g/l)	Route of administration	Age(day/days)
Newcastle Disease Vaccine (Intraocular)	0.08/2	One drop in each eye	1
Gumboro (1st dose)	0.08/2	In drinking water	10
Newcastle Disease Vaccine (Lasota1st dose)	0.08/2	In drinking water	17
Gumboro (2nd dose)	0.08/2	In drinking water	24

3.6.0 DATA COLLECTION

3.6.1 Feed Intake

The amount of feed for each day was recorded for each experimental unit before being offered to the birds. The amount of feed left in the feeders was deducted from the feed in the previous day as feed intake for the day.

Feed intake was recorded on replicate basis and the values recorded were used to compute the average weekly feed intake. The average weekly intake was divided by the number of birds in the replicate and further divided by seven to obtain the average feed intake per bird per day.

$$\text{Feed intake} = \frac{\text{Feed supplied(g)} - \text{left over feed(g)}}{\text{Number of birds}}$$

3.6.2 Liveweight Gain

The weight of the birds in each replicate was measured at the beginning of each weighing week with the aid of a Camry digital weighing scale and Camry mechanical weighing scale. The weight was recorded as the initial body weight and at the end of each week, the body weight was weighed and recorded as final body weight. The initial body weight was deducted from the final body weight to obtain the body weight gained for the week.

Liveweight gain (g) = Final weight (g) – Initial weight (g)

3.6.3 Feed Conversion Ratio

The feed conversion ratio (FCR) of the birds was calculated as the ratio between feed intake and body weight gain.

$$\text{FCR} = \frac{\text{feed intake}}{\text{liveweight gain}}$$

3.6.4 Carcass Measurements

At the end of eight weeks feeding trial, two birds per replicate were randomly selected and weighed for carcass and internal organ measurement. The birds were starved over night and slaughtered by severing the jugular veins, scalded in warm water for a minute and defeathered manually as described by Hann and Splindler (2002). The defeathered birds were weighed and eviscerated with the head, neck, shank and viscera removed to obtain the dressed weight. The weights of primal cuts such as thighs, breast, wings, back and drumsticks, weights of organs such as heart, empty gizzard, lungs and liver were taken and expressed as percentages of the dressed weight.

$$\text{Dressing percentage} = \frac{\text{Dressed weight}}{\text{Liveweight}} \times 100$$

3.6.5 Blood Samples Collection

At end of eight week of the feeding trial, two birds per replicate were randomly selected and slaughtered. 10 ml was collected in two parts in a labelled specimen bottles for haematological and biochemical studies using sterilized syringes and needles. The first part 5 ml was transferred into a plastic tube containing ethylenediamine tetraacetic acid (EDTA) which was immediately taken to laboratory for haematological studies. The second part 5 ml were transferred into anti-coagulant free plastic tube for serum blood chemical analysis. The tube containing the blood sample for biochemical analysis were placed in a slanting position at room temperature for clotting. The samples were centrifuged at 3000 rpm for 10 minutes to determine the concentration of total protein (Njidda & Isidahomen, 2010)

3.6.6 Haematological Analysis

Packed cell volume (PCV) was determined by microhaematocrit method (Coles, 1986). The haemoglobin concentration was determined by the cyanomethaemoglobin method (Schalm, Jain & Corol, 1975; Coles, 1986). Red blood cells (RBC) and white blood cells (WBC) were determined by the haemocylometer method according to the Schalm *et al.* (1975). Leucocytes differential counts and platelets were determined as described by Archetti *et al.* (2008). Blood constituents (mean cell volume, mean cell haemoglobin and mean cell caemoglobin concentration were determined using appropriate formulae as described by Ahamefule, Edouk, Usman, Amaefule and Oguike (2006). Mean corpuscular volume (MCV) was calculated by multiplying the PCV by 10 and dividing by RBC count, and mean corpuscular Haemoglobin concentration (MCHC) was calculated by multiplying the haemoglobin concentration by 100 and diving by PCV value. Serum and total protein were determined by Burette method (Kohn & Allen, 1995), while albumin was determined using BCG (Bromocresol green) method (Peter, Biamonte & Doumas, 1984) and Globulin according to Coles (1986).

3.6.7 Cost Benefit Analysis

The cost of the experimental feed ingredients was recorded in accordance with the prevailing prices during the feed formulation for the experimental diets. The cost of each experimental diet, average cost of feed consumed (₦/kg) and the cost per liveweight gain were calculated as follows:

Total Feed Cost (₦) = Total Feed Intake x Feed Cost

Total feed intake (kg) = Average Feed Intake/2 × 56

$$\text{Feed Cost per kg body weight (₦)} = \frac{\text{total feed cost}}{\text{Total weight gain}}$$

$$\text{Total weight gain (kg)} = \frac{\text{total feed cost}}{\text{Feed cost per kg body gain}}$$

3.6.8 Mortality Rate

Mortality rate was determined as number of dead chickens per day throughout the experimental period. Then, mortality rate was calculated as:

Mortality rate = number of dead birds/number of days

Percentage mortality = number of dead birds/total number of birds stocked × 100

3.7 PROXIMATE ANALYSIS

Proximate composition of the experimental diets (crude protein, crude fibre, Ether extract, Ash and moisture) and GHM were determined by Standard method of Association of Official Analytical Chemist (2005).

3.8 DATA ANALYSIS

The data generated from this research were subjected to one-way analysis of variance (ANOVA) using General Linear Modal (GLM) procedure of statistical Analysis System (SAS, 2008). Mean separation was compared using Least Significance Difference (LSD).

3.8.1 Experimental Model

$Yij = \mu + Ti + Eij$

Yij = overall observation of the effect of GHM on the ith .

μ= population mean

Ti = effect of ith GHM level(s) of inclusion (0, 25, 50 and 100%)

Eij = Experimental error

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Proximate Composition of GHM and Experimental Diets

Result of the proximate analysis of GHM is presented in Table 4.1 The moisture content is 5.31%, 94.69% dry matter, 65.15% crude protein , 9.21 % crude fibre, 4.18 % ash , 14.46 % ether extract and 7.0 % Nitrogen free extract.

Table 6: Proximate Composition (%) of GHM

Parameters (%)	Grasshopper Meal
Moisture	5.31
Dry matter	94.69
Crude protein	65.15
Crude fibre	9.21
Ash	4.18
Ether Extract	14.46
Nitrogen free Extract	7.0
Minerals (%)	**Grasshopper Meal**
Calcium	1.12
Phosphorous	0.75
Potassium	0.04
Sodium	0.02
Magnesium	0.57

4.1.2 Proximate Compositions of the Experimental Broiler Starter Diets

Result of the proximate composition of starter diets is presented in Table 4.2. The crude protein content for the starter diets was almost similar across the treatments. However, diets D recorded the lowest value of crude protein. The crude fibre obtained was higher in diets D, followed by B, C and A respectively. Diets D had the lowest value of ether extra, followed by diets B and A while diets C recorded higher value of ether extract. The values for ash were almost similar in A and C and higher than those in B and D. However, D had the least value for ash content followed by B. Dry matter were almost similar and higher in A and C diets while B and D had almost similar and lower dry matter content. Diet D had the highest value of Nitrogen free extract, followed by B, A while C had the lowest value of Nitrogen free extract.

Table 7: Proximate Composition of the Experimental Starter Diets

Parameters (%)	A	B	C	D
Moisture	10.70	11.38	10.84	11.29
Dry matter	89.30	88.62	89.16	88.71
Crude protein	22.81	22.64	22.78	22.50
Crude fibre	6.94	7.08	7.01	7.23
Ether extract	8.74	8.55	8.79	8.51
Ash	9.11	8.75	9.13	8.19
NFE	52.28	52.98	52.29	53.57

GHM = Grasshopper meal, NFE= Nitrogen Free Extract

4.1.3 Proximate Composition of Experimental Broiler Finisher Diets

Result of the proximate composition of broiler finisher diets is presented in Table 4.3. It showed the crude protein content for the finisher diets was slightly higher in C and B followed by D and A respectively. The values for crude fibre were almost similar across all the diets. However, diet C had lower value of crude fibre. Diet C recorded higher value for ether extract followed by diets D, B and A respectively. The values obtained for ash were almost similar in diets A, B and D while diets C had higher value. Diet B recorded lowest value of dry matter followed by diets C, A while diet B recorded higher value of dry matter. Diets C recorded lower value of nitrogen free extract while the nitrogen free extract value was almost similar across diets A, B and D.

Table 8: Proximate Composition of the Experimental Broiler Finisher Diets

Parameters (%)	A	B	C	D
Moisture	10.76	11.39	10.89	10.71
Dry matter	89.24	88.61	89.11	89.29
Crude protein	19.74	19.93	20.02	19.89
Crude fibre	7.52	7.24	7.13	7.27
Ether extract	6.88	6.96	7.73	7.01
Ash	7.53	7.69	8.11	7.41
NFE	58.33	58.18	57.01	58.42

GHM= Grasshopper meal, NFE=Nitrogen Free Extract

4.1.4 Performance of the Experimental Broiler Chickens at Starter Phase (0-4 weeks)

The performance of broiler chickens fed starter diets containing GHM is presented in Table 4.4. There was significant ($p<0.05$) difference was observed in feed intake and final body weight across the treatments. Liveweight gain was not significantly ($p>0.05$) affected by the dietary treatments. However, diet C had higher final weight gain while diet D had better feed conversion ratio. Mortality was recorded in treatments A, B, and D. No mortality was recorded in treatment C.

Table 9: Growth Performance of the Experimental Broiler Chickens at Starter Phase (0-4 weeks)

Parameters	A	B	C	D	SEM	P-Values
IBW (g/)	40.86	44.13	46.33	43.70	36.75	0.67
FBW (g)	666.27^{d}	674.88^{c}	699.91^{a}	689.47^{b}	178.17	1.51
FI (g/b/d)	35.43^{c}	39.12^{d}	38.94^{a}	35.82^{b}	0.70	5.39
LWG (g/b/d)	22.34	22.53	23.25	23.06	0.00	0.37
FCR	1.59	1.74	1.67	1.55	0.00	23.63
MP (%)	2.5	2.5	0.00	2.5	0.00	0.001

IBD= Initial Body Weight, FBW= Final Body Weight, FI= Feed intake, LWG= Live Weight Gain, FCR= Feed Conversion Ratio.MP=Mortality Percentage. ^{a,b,c,d}. Means in the same row having different super scripts are significantly different ($P<0.05$), GHM = Grasshopper Meal, SEM = Standard Error of Means, P-Value= Probability Value.

4.1.5 Performance of the Experimental Broiler Chickens at Finisher Phase

growth performance of broiler chickens fed diets containing graded levels of GHM is presented in Table 4.5 from 5-8 weeks. Liveweight gain, daily weight gain and feed conversion ratio were significantly ($p<0.05$) affected by dietary treatments. Liveweight gain was significantly higher ($p<0.05$) in the birds fed diet C while A had the lowest liveweight gain. There was no significant difference ($p>0.05$) on average feed intake in all the treatments. However, birds on A had highest feed intake. Mortality was recorded in all the treatment groups.

Table 10: Growth Performance of the Experimental Broiler chickens at Finisher Phase (5-8 weeks)

Parameters	A	B	C	D	SEM	P-Value
IBW (g)	666.27^{d}	674.88^{c}	699.91^{a}	689.47^{b}	0.00	2.10
FBW (g)	1369.03^{d}	1433.90^{b}	1495.9^{a}	1426.92^{c}	0.00	6.67
FI (g/b/d)	132.05	126.18	128.47	137.58	36.75	0.67
LWG (g/b/d)	25.10^{d}	27.11^{c}	28.43^{a}	26.34^{b}	0.00	3.92
FCR	5.26^{d}	4.65^{b}	4.55^{a}	5.22^{c}	0.00	21.33
MP (%)	2.5	2.5	2.5	2.5	0.00	0.001

IBD= Initial Body Weight, FBW= Final Body Weight, FI= Feed intake, LWG= Live Weight Gain, FCR= Feed Conversion Ratio.MP=Mortality Percentage.
^{a,b,c,d}. Means in the same row having different super scripts are significantly different ($P<0.05$), GHM = Grasshopper Meal, SEM = Standard Error of Means, P-Value= Probability Value.

4.1.6 Haematological Parameters of the Experimental Broiler Chickens

The result on haematological parameters of the experimental chickens fed GHM is presented in Table 4.6. There was significant difference ($p<0.05$) in the values recorded on mean corpuscular volume (MCV). On the contrary, no significant ($p>0.05$) difference observed in red blood cell (RBC), white blood cell (WBC) and packed cell volume (PCV). Likewise, no significant ($p>0.05$) difference observed in haemoglobin (HGB) and mean corpuscular haemoglobin (MCHC).

Table 11: Haematological parameters of the Experimental Broiler Chickens

Parameters	A	B	C	D	SEM	P-Values
HGB (g/dl)	14.4	15.00	15.25	13.65	1.59	0.32
PCV (%)	29.10	29.40	27.70	27.10	10.38	0.12
MCH (pg)	69.15	71.15	73.35	70.95	2.98	1.00
MCHC (g/dl)	49.5	50.95	55.35	50.85	2.51	2.58
MCV (fl)	138.95[a]	137.35[b]	132.15[d]	132.8c	3.43	3.28
RBC (x 10^{12}/L)	2.09	2.14	2.10	2.06	0.07	0.02
WBC (x 10^{9}/L)	804.5	810.5	159.8	134.65	73.17	0.70

GHM = Grasshopper Meal, SEM = Standard Error of Mean .HB: Hemoglobin, PCV: Packed Cell Volume, MCH: Mean Corpuscular hemoglobin, MCHC: Mean Corpuscular Hemoglobin Concentration, MCV: Mean Corpuscular Volume, RBC: Red Blood Cell, WBC: White Blood Cell

4.1.7 Blood Chemistry of the experimental Broiler Chickens

The results of blood chemistry of broiler chickens fed GHM is presented in Fig. 1 The result showed significant ($p<0.05$) differences in creatine, albumin and globulin levels. While no significant ($p>0.05$) difference in the glucose levels. However, the result revealed higher glucose level in diet A.

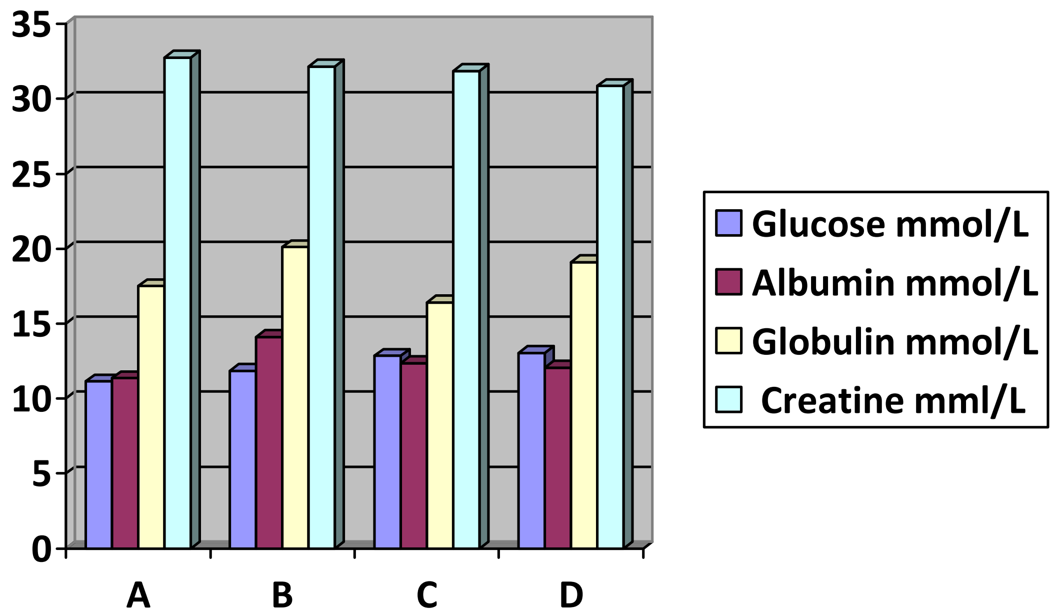

Fig. 1: Blood Chemistry of the Experimental Broiler Chickens

4.1.8 Carcass Characteristics Of The Experimental Broiler Chickens

The result of carcass measurements is presented in Table 4.8. There was significant ($p<0.05$) differences in head, shanks, wings, drumstick and breast muscle while there was no significant ($p>0.05$) in thighs. However, chickens on diet A presented highest values in head, shanks, wings, thighs, drumstick and breast muscle. Diet C had the least value of head, shanks, wings and drumstick while diet D had the least value of breast muscle.

Table 12: Carcass characteristics of the Experimental Broiler Chickens (expressed as percentage of carcass weight)

Parameters	A	B	C	D	SEM	P-Value
Live weight (g)	2000	2100	2250	2050	0.01	1.50
Bled weight (g)	1750	2055	2205	2005	0.03	1.70
De-feathered weight (g)	1710	2015	2160	1965	0.03	1.33
Dressed weight (g)	1540	1850	2010	1810	0.02	0.04
Carcass weight (g)	1240	1600	1670	1575	1.12	0.64
Dressing Percentage	62.00	76.19	74.22	76.83	0.00	0.09
Head (%)	5.50^{a}	3.66^{c}	3.45^{d}	4.25^{b}	0.02	43.33
Shanks (%)	8.93^{a}	6.65^{b}	5.47^{c}	5.68^{d}	0.02	165
Wings (%)	15.26^{a}	11.06^{c}	9.88^{d}	11.77^{b}	0.12	47.6
Thighs (%)	19.35	12.78	14.21	15.79	87.36	1.42
Drumstick (%)	19.44^{a}	16.01^{b}	12.51^{d}	13.94^{c}	0.10	93.68
Breast muscle (%)	28.05^{a}	24.97^{b}	22.44^{c}	21.52^{d}	0.02	16.94

a,b,c,d. Means in the same row having different super scripts are significantly different (P<0.05)
GHM= Grasshopper Meal, SEM= Standard ErrorMean, P-Value= Probability Value

4.1.8 Organs Characteristics Of The Experimental Broiler Chickens

Result of organ characteristics of broiler chickens fed diets containing graded levels of GHM is presented in the Table 4.9. The result showed no significant differences ($p>0.05$) in lungs, heart, liver, spleen, empty gizzard and proventriculus. However, the lungs and proventriculus of birds on diet C presented higher values. The empty gizzard and liver of diet D and the spleen, heart and intestines of diet A presented highest values. Diet A had the highest value of heart weight while diet C had the least value of heart weight. Moreover, diet B presented the highest value of liver while diet C had the least value.

Table 13: Organs Characteristics of the Experimental Broiler Chickens

Parameters % BW	A	B	C	D	SEM	P-Value
Lungs	0.88	0.88	0.89	0.77	0.02	1.33
Heart	0.60	0.51	0.49	0.54	0.00	0.003
Liver	1.83	2.10	1.60	1.78	0.46	1.42
Spleen	0.16	0.07	0.08	0.13	0.02	0.001
Empty gizzard	2.17	1.80	1.92	2.43	0.03	2.50
Proventriculus	0.56	0.46	0.73	0.57	0.01	3.00
Intestines	6.66	5.62	5.51	4.83	0.00	1.15

[a,b,c,d]. *Means in the same row having different super scripts are significantly different ($P<0.05$)GHM= Grasshopper Meal, SEM= Standard Error Mean, P-Value= Probability Value*

4.9.1 Cost Benefit Analysis for the Experimental Broiler Chickens at Starter Phase (0-4 weeks)

Result of cost benefit analysis at the starter phase is presented in Table 14. The result showed no significant difference in (₦/kg) in feed cost (FC), feed cost per kg weight gain (FC/kg gain), total feed cost (TFC). Diet A recorded highest value of feed cost while diets C and D recorded the least value of cost feed. Similarly, feed cost per weight gain recorded the highest value in diet A while diet C recorded the least value. Likewise, total feed cost recorded highest value in diet A while diet C had the least value.

Table 14: Cost Benefit Analysis of the Experimental Broiler Chickens at Starter Phase (0- 4weeks)

Parameters	A	B	C	D
TFI (kg)	4.69	4.63	4.69	4.86
FC (₦/kg)	150.95	148.56	141.39	141.80
TFC(₦)	707.96	687.83	663.31	689.15
TWG (kg)	1.25	1.26	1.30	1.29
FC/kg gain (₦)	566.37	545.90	510.24	543.22
Cost saving (₦)	-	20.47	56.13	32.15

TFI= Total Feed Intake, FC= Feed Cost, TFC=Total Feed Cost, TWG=Total Weight Gain, FC/kg=Feed Cost per kilogram Body Weight Gain

4.9.2 Cost Benefit Analysis for the Experimental Broiler Chickens at Finisher Phase (5-8 weeks)

Result of cost benefit analysis at finisher phase is presented in Table 15. The result showed no significant difference in feed cost across the treatment groups. Diet B recorded the highest value of feed cost while diet D recorded the least value. However feed cost per weight gain recorded the highest value in diet A while diet D recorded the least value. On the contrary, total feed cost recorded highest value in diet B while diet D had the least value.

Table 15: Cost Benefit Analysis of the Experimental Broiler Chickens at Finisher Phase (5-8weeks)

Parameters	A	B	C	D
TFI (kg)	4.69	4.63	4.69	4.86
FC (₦1kg)	152.81	155.39	144.59	132.13
TFC(₦)	716.81	719.46	678.13	642.15
TWG (kg)	1.33	1.39	1.45	1.38
FC/kg gain (₦)	538.86	517.59	467.67	465.33
Cost saving (₦)	-	21.27	71.19	73.53

TFI= Total Feed Intake, FC= Feed Cost, TFC=Total Feed Cost, TWG=Total Weight Gain, FC/kg=Feed Cost per kilogram Body Weight Gain

4.2 DISCUSSION

4.2.1 Proximate Compositions of Grasshopper Meal

The result of the nutrients composition showed that GHM had high crude protein (65.15% CP) content. This very high value could completely replace fish meal in broiler chickens diets. The values compares favourably with the result obtained by Olaleye (2015) which was 64.51% CP. Similarly, the value of GHM crude protein compares favourably with that of fish meal obtained by Okonye and Nnnaji (2004) which was 68.47% CP. However, the value for crude protein obtained in this study was within the range recommended by National Research Council, NRC, (1994). However, the crude protein level of GHM reported in this study differed from the findings of Michael and Kalopo (2017) who reported crude protein value of grasshopper was 57.60% CP and that of Myer (2008). The difference in the crude protein of the GHM according to Houndonougbo *et al.* (2018) could be due to the sex, stage of maturity, season, geographical location, method of harvesting, processing and storage. The ether extract was 14.46%, which agrees with the findings of Olaleye (2015) who reported that GHM had 14.46% ether extract. The values of the ether extract of GHM were greater than that obtained in fish meal (Okonye & Nnnaji, 2004). This is good as it is being used as component of encapsulation of feed nutrients meant for broiler to prevent loss of water soluble nutrients such as proteins and amino acids because of its insoluble property in water (Lopez-Alverado, Langdon, Teshima & Kana-Sawa, 1994). The crude fibre was high due to the fact that grasshoppers have an exoskeleton composed of chitin (Okonye & Nnaji, 2004). The nitrogen free extract was 7.0%, which is the small amount of carbohydrate that could be digested easily because of its solubility as reported by Falayi, (2009). The dry matter of GHM is very high 94.69% with low moisture content of 5.31%. This implies quick drying of the feed compared to dry matter of fish meal 90.0% and moisture content 10% (Eyo, 2001).

The calcium content was 1.12 % that agrees with the findings of Haruna (2003) who reported the calcium content of GHM was greater than those obtained from soybean meal and groundnut cake. It compares favourably with that of blood meal and less than that of fish meal. The phosphorous content was 0.7%, which is low due to low ash content. The sodium content was 0.02% which agrees with the findings of Muftau and Olorede (2009) who reported that the sodium of GHM compares favourably with that of soybean meal and yellow maize which has being used to replace fish meal obtained by different researchers. The potassium content was 0.04%, which compare favourably with that of fish meal obtained by CWP (2007). The above nutrients composition of GHM and its quality makes it a good dietary supplement in the diets of broiler chickens.

4.2.2 Performance of the Experimental Broiler Chickens at Starter Phase

The birds fed diets C and D recorded a higher weight gain than the birds in diets A and B. This could be as a result of higher feed intake of diet C and D and the higher crude protein content of these diets. This findings agrees with the findings of Rosenfeld, Gernat, Marcano, Murillo, and Flores (1997) who reported that GHM constitute a high protein rich concentrate that can be used as a protein supplement for broiler chickens and that of weight gain was as a result of the feed digestibility and palatability, while Oluyemi and Roberts (1979) indicated that adequate nutrient intake like protein and energy level in the diets of broiler chickens enhance proper growth and weight gain.

The birds in treatments B and C showed a high feed intake than the birds on diets A and D. The high feed intake in diet C could be as a result of the higher crude fibre content in the diet, as birds tend to consume more fibrous feed to satisfy their energy requirements. This agrees with the findings of Ranjhan (2001) and Sunusi, Garba, Saidu, and Ali (2013a) that birds on higher fibre diets tend to consume more of the feed to meet their requirements for growth and development.

Feed efficiency was found to be higher in birds on treatments A and C compared to birds on diet A .The feed conversion efficiency is an indicator of efficiency of feed utilization and a form of basis for quick check on profitability of a broiler farm (Kekeocha, 1983). The percentage mortality was 2% at the starter phase because of coccidiosis outbreak in the pens. It developed from damp litter materials, which were wet as a result of accidental fall of drinkers during placement after refilling; despite that the wet litters were removed immediately. Reo-Cocciforte (Anticoccidial Soluble Powder) 1gm per litre in drinking water for 5 consecutive days was used to control the outbreak. The mortality percentage recorded was not more than 5%, which was minimal as reported by Yassin, Velthuis, Boerjan and Van Riel (2009).

4.2.3 Performance of the Experimental Broiler Chickens at Finisher Phase

The result of the finisher phase showed linear increase in weight gain with increasing levels of GHM of up to 50%. However, at 100% level of inclusion, the weight gain declined. The increase in liveweight gain was as a result of better quality essential amino acid when GHM and fish meal were combined and the secretion of chitinase enzyme called glucosamine by intestinal tract bacteria that promotes liveweight gain (Ramos-Elorduy *et al*. 2012) while the declining in weight gain at 100% could be due to high fat content of GHM, which decreases fibre digestion and causes adverse effects in monogastric animals as reported by (Veldkemp, Duinkerken, Lakemond & Van Boekel 2012).

There was higher feed intake in diet A than the birds in diets B and C. This could be due to high crude fibre content and chitin material, which influence feed intake as birds tend to consume more fibrous feed to satisfy their energy requirement. This agrees with the findings of Ranjhan (2001) that birds on higher fibre diets tend to consume more of the feed to meet their requirements for growth and development.

Feed conversion ratio was higher in diet A and D. This was as the result of better-combined feed utilization of GHM and fish meal. This is in agreement with the findings of Hassan *et al*. (2009) who reported that the control diet had higher feed conversion efficiency. Mortality recorded was 2 % at the finisher phase in which three birds died at a result of sudden change in weather of the day, which resulted to heavy hazy dust and extremely low temperature. This is in line with the findings of Minka and Ayo (2014) who reported that mortality rate was recorded on birds exposed to cold-dry (harmattan) season because of low ambient temperature and the development of pulmonary hypertension due to cold stress, and high levels of dust particles. The percentage mortality was not more than 5%, therefore, the percentage was minimal as reported by Yassin *et al.* (2009).

4.2.4 Haematological Parameters of the Experimental Broiler chickens

The values recorded on mean corpuscular volume (MCV) were affected by the experimental diets. Observation showed the haematological indices of the birds fed GHM diets were not adversely affected by the experimental diets. This indicated that the replacement ingredient was of good quality, which agreed with the findings of Clarke and Myra (1975), and Nnamani (2007) that red blood cells count is an indication of feed quality. Anaemia is a very serious pathological condition in human and animals which may be caused by severe loss, extensive haemolysis of red blood cells and inadequate red blood cells production (Koinarski, Angelov & Lalev, 2001) and nutrients deficiencies (Njidda & Isidahome , 2010) among others. Jain (1993) reported that erythrocytes (RBC) and leucocytes (WBC) of animals in good health varies among species according to their condition of health. The packed cell volume was not significantly ($p>0.05$) affected by experimental diets. This could be related to the effect of ambient temperature of the experimental house. According to report by Yahar, Straschnow and Playnik (1997) that low ambient temperature of rearing chickens are associated with significant hypovolemia (and thus high PCV) because they did not lose fluid for heat dissipation by panting in contrast to high ambient temperature. Haematological results on haemoglobin (HB) mg per 100 ml, packed cell volume (PVC) 25-45% and mean cell haemoglobin (MCV) 90-140 per mg/100ml indicated that the experimental diets did not produce any deleterious effect on the parameters. This was because all the values fell within the normal range for mature broiler chickens as reported by Banerjee (2007), Muhammad and Oloyede (2009); Tewe and Egbunike (1992); Post, Rebel and Huurne (2007).

4.2.5 Blood Chemistry of the Experimental Broiler Chickens at Finisher Phase

The result revealed significant differences in creatine, albumen and globulin levels except in glucose, which was not affected by the experimental diets. Blood chemical values obtained in the present study were within the normal ranges recommended by Mitruka and Rawnsly (1997) and Banerjee (2007). The significant difference in creatine, albumen and globulin could be due to high level of crude protein in GHM especially when combined with fish meal which agrees with the findings of Ramos-Elorduy *et al*. (2012) who reported that GHM and fish meal when combined resulted to the secretion of chitinase enzyme (glucosamine) by intestinal tract bacteria promoted liveweight gain of birds.

4.2.6 Carcass Characteristics of the Experimental Boiler Chickens

There was no significant difference observed in liveweight, bled weight, defeathered weight and dressed weight while significant was observed in head, thighs, shanks, wings, drumsticks and breast muscle across the treatments. This agrees with the findings of Sunusi *et al.* (2013b) who reported that the results of carcass characteristics in final liveweight, plucked weight, carcass weight and dressing percentage showed no significant ($p>0.05$) differences. Thus, this indicates that GHM does not have any adverse effect in the carcass characteristics of broiler chickens. However, no significant differences ($p>0.05$) were observed in thighs this agrees with the findings of Sun, Long and Liu (2012) who reported that significant differences were observed in carcass characteristics with exception of thighs. This probably occurred.

4.2.7 Organs Characteristics of the Experimental Broiler Chickens

The values obtained for lungs, heart, liver, spleen, empty gizzard, proventriculus and intestines in this study showed no significant differences ($p>0.05$) among the treatment groups. The weight of heart, kidney and liver is an indicator of toxicity. Bone (1979) reported that, if there is toxic element in the feed, abnormalities in weights of liver, kidney and heart would be observed. The abnormalities aroused because of increased metabolic rate of the organs in an attempt to reduce these toxic elements or anti-nutritional factors to non-toxic metabolites. In this study, the liver weight does not contain any appreciable toxin.

4.2.8 Cost Benefit Analysis for the Experimental Broiler Chickens at Starter Phase (0-4 weeks)

The values recorded for cost benefit analysis for the experimental birds at starter phase showed no significant difference in feed cost (FC), feed cost per kg weight gain (FC/kg gain), total feed cost (TFC) among all the treatment groups which is in consonance with the findings of Sunusi *et al.* (2013a) who reported that no significant difference was observed in feed cost, total feed cost ad cost per weight gain. This result indicated that GHM could replace fish meal in broiler chickens diets with no adverse effect in feed cost associated with raising broiler chickens.

4.2.9 Cost Benefit Economic Analysis for the Experimental Broiler Chickens at Finisher Phase (5-8 weeks)

The values recorded for cost benefit analysis for the experimental birds at finisher phase showed no significant difference in feed cost (FC), feed cost per kg weight gain(FC/kg gain), total feed cost(TFC) among all the treatment groups. However, diet D recorded the least cost of feed (₦/kg) which was better than diet A. This is in line with the report of Hassan *et al.* (2009) who reported that the cost and return analysis showed that 100% GHM diets gave the highest return. This is due the reason that GHM is cheaper than fish meal.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The need to improve the performance of broiler chickens while at the same time, reducing the cost of feeding through the use of local cheaper feed ingredients is immense in poultry production. The present study was designed to determine the effects of replacing fish meal with GHM in the diets of broiler chickens on performance (feed intake, liveweight gain and feed conversion ratio), haematology, carcass and organs characteristics. A total of 160 day-old Marshal broiler chicks were purchased from one of the reputable poultry chicks suppliers in Nigeria. The experiment was carried out in a completed randomized design (CRD) comprising of four treatments (A, B, C, and D). Each treatment was replicated four times with ten chickens per replicate.

Inclusion of GHM at 0, 25, 50 and 100 % in the diets of broiler chickens during the starter phase significantly ($p<0.05$) improved the performance of the birds. At the end of the finisher phase, birds fed diet C showed significant differences ($p<0.05$) better than those birds on diets A, B and D. This showed the birds could tolerate up to 50 % level of inclusion without adversely affecting the performance of the birds.

Inclusion of GHM of up to 50 % revealed a reasonable result in this study. Thus, the replacement of 50% fish meal with GHN in the diets of broiler chickens is recommended to broiler chickens producers in order to maximize their profit.

5.2 CONCLUSION

The result obtained in the present study showed that 50 % GHM could replace fish meal in the diets of broiler chickens at both starter and finisher phases without adverse effects on growth performance and carcass yield. It was established that inclusion of grasshopper meal at up to 100% led to reduction of feed cost by 13.65%.

5.3 RECOMMENDATIONS

The inclusion of GHM of up to 50 % in diets of broiler chickens is recommended. Further research should be carried out to examine the intermediate levels of the tested GHM diets.

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