# UTILISATION OF CRAYFISH WASTE AND POULTRY OFFAL AS REPLACEMENT FOR FISH MEAL IN CHICKEN DIET

**BY**

**Adebayo Rafiu, ASAFA**
**Bachelor of Agric. (Animal Science, OOU)**
**MSc. (Animal Science, Ibadan)**
**Matriculation Number: 64740**

**SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE**

**FACULTY OF AGRICULTURE AND FORESTRY**
**UNIVERSITY OF IBADAN, IBADAN**

**IN PARTIAL FULFILLMENT FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) IN ANIMAL SCIENCE**

# ABSTRACT

The escalating cost of dietary protein ingredients necessitates the search for alternatives in poultry production. The inclusion of Crayfish Waste (CW) and Poultry Offal (PO) in chicken feeds could reduce the cost of dietary proteins. The study evaluated the utilisation of CW and PO as dietary protein sources for chicken production.

Four experiments were conducted in a completely randomized design using three replicates of 10 birds each. Experiment I involved feeding of diets containing 100%, 75%, 50%, 25% and 0% Crayfish Waste Meal (CWM) as replacement for Fish Meal (FM) to 150 Day-Old Broiler Chicks (DOBC) at starter and finisher phases. In Experiment II, five diets in which Poultry Offal Meal (POM) replaced FM at 100%, 75%, 50%, 25% and 0% were fed to 150 DOBC at starter and finisher phases. In each of experiments III and IV, 180 DOBC and point-of-lay birds were respectively fed with broiler (starter and finisher) and layer diets containing CWM and POM as follows: 100% FM (control), 0:100(2), 25:75(3), 50:50(4), 75:25(5) and 100:0(6). The experiments lasted 9 and 13 weeks respectively. Parameters determined for birds included Crude Protein (CP), Ether Extract (EE), Crude Fibre (CF) and Energy of test ingredients, Body Weight Gain (BWG), Dry Matter Intake (DMI), Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER), Carcass Characteristics (CC), Blood Urea (BU), Total Protein (TP), Packed Cell Volume (PCV), Haemoglobin (Hb), weekly egg production and egg external parameters, using standard methods. Data were analyzed using descriptive statistics and ANOVA.

The CWM contained 35.0%CP, 12.9% CF, 3.9% EE, 1454 Kcal/kg ME. The POM contained: 51.9%CP, 1.8%CF, 6.2% EE, 2600Kcal/kg and FM; 65.1CP, 0.8CF, 6.0EE and 2860Kcal/kg. In Experiment I, BWG, DMI, FCR, and PER were not significantly different at the starter and finisher phases, respectively. In Experiment II, BWG, DMI, and FCR were similar among treatments at the starter phase. However at the finisher phase, BWG was significantly higher ($p<0.05$) for 75:25 broilers (977.5g) than others while DMI, FCR and PER were similar. At the starters phase of POM and CWM combinations, the DMI for Diet 5 (1.41kg) and 6 (1.18kg) were significantly ($p<0.05$) different. Birds fed diet 5 recorded the highest BWG (811.30g) which was similar to others but significantly ($p<0.05$) different from diet 6 (634.9g). At the finisher phase, the control birds consumed 2.98kg similar to diets 2 and 5 but differed significantly ($p<0.05$) from those on diets 3 and 4. The PER and FCR were similar both at the starter and finisher phases. Chicken fed 100% CWM recorded an eviscerated weight of 89.20% which was significantly ($p<0.05$) better than others. Treatment effects were similar for PCV and Hb. There were significant ($p<0.05$) differences between treatments for BU and TP. 50%POM:50%CWM (BU) and 75POM:25CWM (TP) differed significantly ($p<0.05$) from others. Egg external parameters gave similar result except for control which was significantly lower ($p<0.05$) than 50 POM:50 CWM.

Combination of poultry offal meal and crayfish waste meal was successfully used to replace fish meal at 100% level without adverse effect on production.

Key words: Crayfish waste, Poultry offal, Fishmeal, Chicken feed.
Word count: 499

## CERTIFICATION

I certify that this study was carried out under my supervision by Adebayo Rafiu ASAFA in the Department of Animal Science, University of Ibadan, Ibadan.

……... ……... ……………………………….

Supervisor

Professor A.D. Ologhobo

Animal Biochemistry and Feed Toxicology

Department of Animal Science

University of Ibadan

# DEDICATION

TO ALMIGHTY ALLAH



# ACKNOWLEDGEMENT

My heartfelt appreciation goes to Professor A.D. Ologhobo for the supervision of this work. It is noteworthy that I enjoyed the support of his entire family during my course, as well as the entire members of staff of Department of Animal Science, University of Ibadan, I pray that the Almighty God will continue to shower His infinite mercies on you.

It is with great gratitude that I acknowledge the contribution to this study of Mrs. Mopelola Omotoso for the support during the laboratory analysis, Mr.& Mrs. Adekunle Adenuga for the support on Layers' study, Mashaun Farm, Ikorodu for feed input support and the Rector, Lagos State Polytechnic where I work.

It is important that I acknowledge the moral support of the followings, Alhaji Y. Abisola Sunmola, Dr. & Dr.(Mrs.) B.B.A. Taiwo, Mr. & Mrs. Oyewole, Mr. M.A. Onigemo and other staff members of Department of Animal Production Tech., Lagos State Polytechnic, Trustee, Principal Officers and members of Animal Science Association of Nigeria; Dr. A.O.K. Adesehinwa, Dr. F.A.S Dairo, Prof. A.M. Bamgbose, 'Bukonla Anifowose, Yusuf Oso, Elder Toki, members of 'National Support Group' and all other friends and families that stood by me during the trying period. It is not possible to mention all the names.

I also use this opportunity to remember the contributions of Alhaji Asafa Olatunji Balogun (Dad), Mrs. Ayodele Asafa Balogun (Mum) and Mrs. Mojisola Oluwatoyin Asafa (wife), all of blessed memories for the work they started. May Almighty Allah grant them Aljanah.

The immense support of my immediate family is commendable; my wife, Mrs. Oladapo Asafa, children; Abdulsalam, Fatimah, Abdul Azeez and Azeezah, you are appreciated as well as and my siblings; Mrs. Amdalat Olabisi Odufade and Samsideen Olaitan Asafa. I equally appreciate the moral support of other members of the family of Asafa Olatunji Balogun, in-laws and relations.



**TABLE OF CONTENTS**

**LIST OF TABLES**

## LIST OF FIGURES

# CHAPTER ONE

## 1.0 INTRODUCTION

The increased industrialization and urbanization in Nigeria could contribute to an increase in volume and diversity of waste generated. Similarly, inadequate or defective management of these wastes would have a consequence on the environment resulting in pollution and increased environmentally induced diseases.

Wastes emanating from poultry processing and shrimping industries in Nigeria are mostly biodegradable and are usually dumped in the open on available land. The wastes being proteins putrify, gases such as ammonia, carbon dioxide among others are usually released during the process of biodegradation (Caires *et al.*, 2010). These gases contribute to the depletion of the ozone layer and the phenomenon has been a source of concern to the environmentalists because of its effect on the global warming. In addition, the decomposition of these wastes could have significant implications on public health resulting from the growth of deleterious micro-organism during the process (Ojewola, *et al.*, 2005).

Among the many problems confronting many developing nations, the issue of protein insufficiency in the diet of the citizenry is no less challenging. Owing to a combination of diverse socio-economic factors, the incidence of poverty has remained a constant companion of the people, accounting for the prevalence of nutritional deficiencies in the people's dietary framework (FAO, 2004). Ironically, insufficient protein intake among the citizenry frequently disables them from performing their socio-economic tasks at optimal levels. When the chips are down a vicious circle of poverty, malnutrition and underdevelopment is engendered as a result of the matrix between under productivity and undernourishment.

Generally speaking, a number of social and physiological problems have been traced to malnutrition as manifested in stunted growth among children, retarded mental development, low resistance to infectious diseases and reduced productivity (Adair and Kusawa, 2001). The interplay between nutrition and health is accountable for the established linkage between "protein malnutrition and socio-economic well being" (Ubdaonu and Nwawuchi, 1996). Unfortunately, available statistics indicate that Nigeria is one of the countries where protein intake of the people ranked among the lowest (FAO, 1998). For instance, it is estimated that on the average, Nigerians consume only about 7g of animal protein on daily basis as against the minimum requirement of 28g/caput/day (FAO, 1998). This further indicates a gross national shortfall of 75% (Ibe, 1999).

Furthermore, apart from the negative impact of insufficient protein intake on the nation's socio-economic health, the situation has also aggravated Nigeria's classification as an under developed country. This is because like education, per caput animal protein consumption has remained a global criterion for classifying countries as developed and under developed (Pellett and Ghosh, 1997).

Poultry production has been identified as one of the quick means of bridging the existing protein deficiency gap in Nigeria for the following reasons:

1. Poultry products (meat and eggs) provide an acceptable form of animal protein to most people throughout the world, with the exception of strict vegetarians (Smith, 1990).
2. There are very few or no religious or cultural taboos associated with poultry and its products as compared with pigs and cattle.
3. Poultry are adaptable to a wide range of climatic conditions.
4. They are highly productive.
5. Poultry are good and efficient feed converters, and
6. They have a short generation interval among others.

However, among the challenges of poultry production in Nigeria, scarcity and escalating cost of dietary ingredients constitute the highest. Feed has been estimated to contribute 70-80% of the total cost of rearing poultry (Singh, 1990). Also, Tewe (1997) reported that the cost of feeding ranged between 60-80% of the cost of production. The reported high cost of feed is linked to reliance on conventional feed resources. Fish meal has been relied upon for long as a source of dietary animal protein largely because of its balanced amino acid profile. Incidentally, the direct competition between man and poultry for fish has led to the scarcity, high cost and adulteration of fish meal.

In view of the above, re-cycling of agro-industrial wastes such as poultry offal and shrimp waste would not only reduce the environmental and health effect on the nation but would also help to reduce the high cost of dietary ingredients and feeding that are associated with intensive animal production systems. This is important in view of the increasing national population, which is not complemented with increased food production. This situation if unchecked could aggravate the national food security problem as livestock and man depend almost on the same sources of feed/food ingredients.

## 1.3 Objectives of the Study

The objective of this study is therefore to:

1. Determine the chemical composition of shrimp wastes and poultry offal respectively.
2. Establish the protein quality of shrimp waste meal and poultry offal meal.
3. Determine the replacement value for fish meal by different combination levels of shrimp waste meal and poultry offal meal on chicken.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 POULTRY NUTRITION

The main objective in feed formulation is to put together a combination of raw material resources that will provide a nutritionally balanced feed for different classes of livestock. Feed formulation therefore requires a clear understanding of the nutrient requirements of different classes of livestock in relation to age, production objectives and physiological state. In addition, the nutrient compositions of the available raw material resources need to be known (Ranjhan, 2000)

The nutrients required for metabolic and productive activities differ between classes of poultry and vary with age, sex and environment for the same species of bird. Also, genetic differences exist even within the species in quantitative requirement.

Once a good bird has been selected with high livability, high genetic potential to efficiently grow or lay eggs, prepared housing and management essential for a successful operation, the next thing is to procure the most efficient, nutritionally complete ration to suit the particular environmental condition (Ranjhan, 2000).

The first essential for the provision of correct, complete and balanced poultry ration is that it should contain the appropriate amount and proportion of energy and protein (Sainsbury, 1992). Energy is needed for the maintenance of all normal functions and any amount supplied over and above this basic need will be used for production.

Protein is required for the general body development in all-growing as well as laying birds. Also very important is the quality of protein, which is often determined by the amino acid composition of the protein. Methionine and lysine are important for their limiting properties. They are deficient in many feedstuffs and thus require supplementation in organic forms. The proteins richest in these amino acids are those derived from animal origin. For this reason, animal protein source is always included in chicks and broiler diets.

Vitamins and minerals are other essentials that are of paramount importance in poultry nutrition. They are required in small amount for normal growth and maintenance of poultry birds. They are well distributed in some feed ingredients, animal products and by-products and in some plant by- products.

## 2.2 NUTRIENT REQUIREMENT OF BROILER CHICKEN

Poultry birds obtain all they need for growth, tissue synthesis and maintenance from their feeds. Broilers like other classes of chicken have simple digestive system and their nutrient requirement changes significantly as they approach market age with the requirement for protein, amino acids, minerals and vitamins reducing in relation to energy (NRC, 1994). Male birds are said to require higher quantity of nutrients than the female, however, the difference seems to be little when the requirement is expressed as a percentage of the diet, (NRC, 1994).

There are at least 40 specific nutrients (chemical elements) that need to be in the diet to support life, growth and optimum reproduction. These consist of 13 important amino acids, 13 vitamins, 13 essential minerals, a fatty acid known as, linoleic acid, sufficient non-specific nitrogen that allow for production of non-essential amino acids and enough metabolizable energy to meet the energy needs for maintenance and production (Olomu, 1995).

Requirements vary according to the physiological condition and health status of the animal. It also differs among type, breeds, strains and birds of different ages of poultry (NRC, 1994). Highly productive animals require more nutrients in terms of quantity and quality than the non-productive ones, which are considered to be at maintenance.

### 2.2.1 ENERGY REQUIREMENT OF BROILER

Carbohydrates and fat represent the most efficient sources of energy in broiler diet (Daghir, 2008). The requirement for energy cannot be stated as precisely as the requirement for protein, amino acids, minerals and vitamins because good growth can be achieved with a wide range of energy levels (Olomu, 1995). It has been shown that the primary determinant of feed intake is the energy concentration of the diet (Olomu, 1995) and that as the level of metabolizable energy in the diet increases or decreases, feed intake changes inversely, although the rate of adjustment is not always sufficient to keep energy intake constant. Haq Nawas and Yaqoob, (2006) reported that the energy intake of chicks varies with the metabolic body weight and the composition of body gains (depending on age, sex and strain of the birds).

Aduku (1993) recommended energy levels of 2800 and 3000 KCal/kg ME for broiler starter and finisher respectively. However, National Research Council (NRC, 1994) recommended energy level of 3200 KCal/kg ME in both broiler starter and finisher ration. These recommendations are lower than the requirement in the temperate zones. The high energy diets required by temperate birds are usually prepared by supplementation with 2-5% fat (Haq Nawas and Yaqoob, 2006).

### 2.2.2 PROTEIN AND AMINO ACID REQUIREMENT OF BROILERS

The supply of dietary protein and essential amino acids can be considered as one of the most important determinants of growth in chicken (Ravindran and Bryden, 1999). Broilers require high protein level than layers and cockerels so as to ensure rapid tissue synthesis, resulting in fast growth.

NRC (1994) review on nutrient requirement of poultry indicated that protein requirement decreases with increase in age of birds. It thus recommended 23% crude protein for broiler starter of 0-3 weeks of age, 20% crude protein for 3-6 weeks of age, and 18% for broilers between 6-8 weeks of age (Table 1). Aduku (1993) reported similar values of 23% and 20% crude protein for broiler starter and finisher respectively. It is of importance that protein supplied to birds be of both plant and animal origin to ensure more balanced amino acids in the diet.

The most limiting amino acids in broiler ration are lysine and methionine (McDonald *et al*., 2010). Thus, supplementation of broiler ration with synthetic form of these amino acids is necessary. Leeson and Summers (2005) found the methionine and methionine + cysteine requirement of broiler starter under humid tropical condition to be 0.4% and 0.84% respectively. NRC (1994) gave the requirement for lysine and methionine for broiler starter and finisher to be 1.2%, 0.8% and 0.5%, 0.32% accordingly.

### 2.2.3 VITAMIN AND MINERAL REQUIREMENTS OF BROILERS

Vitamins and minerals play critical roles in the nutrition of broilers particularly at the early stages of their lives. Vitamin $D_3$ requirement of broiler chickens was reported to be 100 ICU/100kg of feed. Vitamin E requirement of broiler was put at 200, 80 and 80mg/kg for starter, grower and finisher diets respectively, (Roche, 1990). Oloyo and Ogunmodede (1991), reported that dietary biotin of 120mg/kg was required for the prevention of dermatitis, mortality due to fatty liver kidney syndrome and leg deformation in broiler chicken.

The principal minerals required in broiler diets are calcium and phosphorus (Pond *et al*, 1995). Calcium and phosphorus deficiency has been linked with weak or brittle bone. The requirements for some minerals are affected by level of other minerals. Examples are calcium and phosphorus, and sodium and potassium, which must be supplied from other sources than the normal ingredients (Daghir, 2008). Other micro-minerals are provided in ample amount by the usual natural ingredients used in formulating poultry feeds or included in commercial premixes (Olomu, 1995). The minimum requirement for vitamins and minerals as specified by NRC (1994) is as shown in the Tables 2 and 3 below.

**TABLE 1: PROTEIN AND AMINO ACID REQUIREMENTS OF BROILER CHICKEN (%)**

| Protein | 0-3weeks | 3-6weeks | 6-8weeks |
|---|---|---|---|
| Crude protein | 23.00 | 20.00 | 18.00 |
| **Amino acids** | | | |
| Arginine | 1.25 | 1.10 | 1.00 |
| Glycine+serine | 1.25 | 1.14 | 0.97 |
| Histidine | 0.35 | 0.32 | 0.29 |
| Isoleucine | 0.50 | 0.73 | 0.62 |
| Leucine | 1.20 | 1.09 | 0.93 |
| Lysine | 1.10 | 1.00 | 0.85 |
| Methionine | 0.50 | 0.38 | 0.32 |
| Methionine+cystinre | 0.90 | 0.72 | 0.60 |
| Phenylalanine+tyrosine | 1.34 | 1.22 | 1.01 |
| Proline | 0.60 | 0.55 | 0.48 |
| Threonine | 0.80 | 0.74 | 0.68 |
| Tryptophan | 0.20 | 0.18 | 0.16 |
| Valine | 0.90 | 0.82 | 0.70 |
| Phenylalanine | 0.72 | 0.65 | 0.56 |

*Source: NRC, 1994*

TABLE 2: **VITAMIN REQUIREMENT OF BROILER CHICKEN (UNIT/KG OF DIET)**

| Vitamins | 0-3weeks | 3-6weeks | 6-8weeks |
|---|---|---|---|
| **Fat-soluble vitamins** | | | |
| A (I.U) | 1,500 | 1,500 | 1,500 |
| D3(ICU) | 200 | 200 | 200 |
| E(I.U) | 10 | 10 | 10 |
| K(mg) | 0.50 | 0.50 | 0.50 |
| **Water-soluble vitamins** | | | |
| B12 (mg) | 0.01 | 0.01 | 0.007 |
| Biotin (mg) | 0.15 | 0.15 | 0.12 |
| Choline (mg) | 1300.00 | 1100.00 | 750.00 |
| Folacin (mg) | 0.55 | 0.55 | 0.55 |
| Niacin (mg) | 35.00 | 30.00 | 25.00 |
| Pantothenic acid (mg) | 10.00 | 10.00 | 10.00 |
| Pyridoxine(mg) | 3.50 | 3.50 | 3.50 |
| Riboflavin (mg) | 3.60 | 3.60 | 3.00 |
| Thiamin (mg) | 1.80 | 1.80 | 1.80 |

*Source: NRC, 1994*

**TABLE 3: MINERAL REQUIREMENT OF BROILER CHICKEN**

| **Macro nutrients** | **0-3weeks** | **3-6weeks** | **6-8weeks** |
|---|---|---|---|
| **Macro minerals** | | | |
| Calcium% | 1.00 | 0.90 | 0.80 |
| Choline % | 0.20 | 0.15 | 0.12 |
| Magnesium% | 600.00 | 600.00 | 600.00 |
| Non-phytase phosphorus | 0.45 | 0.35 | 0.30 |
| Potassium (%) | 0.30 | 0.30 | 0.30 |
| Sodium (%) | 0.20 | 0.15 | 0.12 |
| **Trace minerals** | | | |
| Copper (mg) | 8.00 | 8.00 | 8.00 |
| Iodine (mg) | 0.35 | 0.35 | 0.35 |
| Iron (mg) | 80.00 | 80.00 | 80.00 |
| Manganese (mg) | 60.00 | 60.00 | 60.00 |
| Selenium (mg) | 0.15 | 0.15 | 0.15 |
| Zinc (mg) | 40.00 | 40.00 | 40.00 |

*Source: NRC, 1994.*

## 2.3 NUTRITION OF LAYERS

There is the need to supply birds with the nutrients required in the order to maintain normal growth and reproduction and at the same time prevent development of nutritional disorders. The low level or absence of specific nutrients in the diet may lead to low production rate, nutritional deficiency symptoms and easy susceptibility to diseases. Oluyemi and Roberts (2001) reported the ideal layer as an active, lean and small bird that put all its effort in producing a lot of large eggs. Based on physiological function, a bird is not capable of producing more than 300 eggs in the first year. These workers also noted that birds infrequently and rarely exceed this level of production. However, in the tropics, production is much lower and has remained at 180 – 210 eggs in the first year although higher levels have been reported (Oyeleke, 1997).

### 2.3.1. ENERGY REQUIREMENT OF LAYERS

The energy requirement has been shown to be one of the most predominant factors determining the intake of other nutrient in the feed. It has been recognized that when the energy content of poultry is increased, the concentration of most of the other nutrients in the feed should be increased proportionately. This is attributed to the fact that birds eat to satisfy their requirement of energy (Smith, 1990).

Layers' diets may be classified as high energy with over 2860KCal of metabolizable energy per kg weight of feed, medium energy (2640 – 2860 kCal/ME/Kg) or low energy (2530 – 2640 kCal/ME/kg). High-energy diets may be used for small hybrid laying pullets so that they may produce the very large number of eggs in relation to their size. Smith (1990) also observed that the energy and the protein level in the feed govern feed consumed by a laying hen. Leeson *et al.,* (2001) noted that dietary forms and physical forms do not affect feed consumption but caloric density of the diet is the determining factor for feed intake and that the highest energy level significantly depressed feed intake when compared with birds fed with feed of lower caloric value.

Climate, as it has been recognized exerts a significant effect on growth, reproduction and other physiological functions of birds. The metabolisable energy (ME) required per bird varies with the temperature of the day. The metabolisable energy required per day during the hot season is lower than that of the cool season (Oguntunji and Alabi, 2010). Fetuga (1984) recommended levels between 2400 – 2600 kcal/ME/kg for laying hens in the tropics. This level is below that recommended by NRC (1994), which is 2900kcal/ME/kg of diet.

### 2.3.2 PROTEIN REQUIREMENTS OF LAYERS

Protein is important in the diet of layers especially for the production of eggs since an egg consist of 13 – 14 percent protein (Sainsbury, 1992). The amount of protein required for maintenance is relatively low, thus the requirement depends primarily on the amount needed for productive purposes.

### 2.3.3 AMINO ACID REQUIREMENT OF LAYERS

Baker, (2009) reported that amino acids were nutritionally significant in the diets of poultry. The essential amino acid, such as methionine, lysine, tryptophan are of great importance since they may serve as a limiting factor in the synthesis of a particular protein.

### 2.3.4 VITAMIN REQUIREMENTS OF LAYERS

Vitamin requirement is defined as the minimum amount per unit of body weight per day or per unit of feed, that will prevent the occurrence of clinical signs of deficiency, abnormal physiological characteristics and will satisfy the need for optimum performance in terms of those characteristics that are of economic significance (Leeson, 2007).

Some vitamins are essential in metabolism but may not be required in the diet, since they can be synthesized readily from other food constituents. An example of this is the production of niacin from tryptophan.

Housed layers are generally dependent on the vitamin present in their compounded feed in the correct amount and proportions and any interruption in their supply can give rise to most serious consequences, sometimes with striking rapidity. Vitamin E for example is essential for breeding stock for the good hatchability of their eggs. Poultry feed should contain up to 10mg/kg of added vitamin E but there is considerable variation between the needs of different classes of birds with the highest amounts required by breeders and young, fast-growing birds. Additionally, panthothenic acid is needed for normal growth and for good hatchability and the proper feathering of birds (Sainsbury, 1992). As confirmed by Bolukbasi *et al*, (2005), vitamin $D_3$ (cholecalciferol) is needed for normal egg production and for calcification of eggshell. Adequate vitamin $D_3$ in the diet of breeding hens is important not only for normal hatchability but also to provide a carry-over.

### 2.3.5 MINERAL REQUIREMENT OF LAYERS

Minerals are essential nutrients in layers' diet. For calcium and phosphorus, the young chick needs a minimum of 1 percent of the diet as calcium and 0.5 percent as available phosphorous, while laying hen needs about 3.5 percent of calcium (approximately 4.0g daily) since this is the main constituent of eggshell, (Daghir, 2008). Calcium and phosphorous should be added in the correct quantity and ratio either as steamed bone flour or as dicalcium phosphate, unless the diet contains at least 5 percent of fish or meat and bone meal. Iodine deficiency causes poor hatchability. Manganese forms a link in the chain of calcium metabolism of the bird and is required by breeding birds to ensure good hatchability of their eggs by layers to give good shell strength and by all growers to promote bone formation (Sainsbury, 1992). According to Daghir, (2008), layers require 30mg manganese, growing chicks and broilers, 30mg and breeding hens, 35mg. Others are available phosphorus, 0.45%; sodium, 0.16%; potassium, 0.4%; chloride, 0.12%; magnesium, 500mg; iron, 50mg; copper, 5mg; zinc, 50mg and selenium, 0.15mg.

## 2.4 FACTOR AFFECTING PERFORMANCE OF LAYERS

Primarily, the performance of a layer is estimated from its egg production and efficiency of feed utilisation for egg production. Some of the factors that may affect this include the following:

### 2.4.1 TEMPERATURE

This largely accounts for the differences in performance between those in temperate regions and those in the tropics hence it is regarded as a very important factor. Oluyemi and Roberts (2001) reported that in Nigeria, high environmental temperatures with lower relative humidity prevalent from the months of November to February tend to increase egg production. A fall in environmental temperature below the thermo-neutral zone (the environmental temperature range within which heat balance is maintained by physical means) on the other hand brings about uneconomical egg production. This is due to increased feed consumption to maintain body temperature and reduction in egg production and shell thickness (Oluyemi and Roberts, 2001). On the contrary, Smith (1990) reported that when birds were kept at 26$^{o}$C, their mean egg weight increased by 1g per week whereas when kept at 35$^{o}$C, the average eggs weight remained constant for a six-month period. According to the author, reduction occurs in the number of eggs produced by laying hens at high ambient temperature and that high ambient temperature produced eggs of lighter weight than similar birds kept at lower ambient temperatures.

On water intake, the effect of high ambient temperature modifies the water intake of laying hens. At increased ambient temperature, most birds will first double their water intake and then reduce their water intake to the levels they were consuming prior to the increase in ambient temperature (Oluyemi and Roberts, 2001). This decreased in water intake is associated with a decrease in food intake and a reduction in the rate of egg production.

### 2.4.2 BODY WEIGHT

Body weight of a laying hen influences egg production. Studies have shown that bird's weight increases steadily from the time she lays her first egg until it reaches a peak during the first year in lay. The weight drops only to increase again during the second or third year of lay and this is attributed to the accumulation of fat. Heavy strains of birds are commonly reared for egg production and are usually referred to as egg type bird (Oluyemi and Roberts, 2001). In under-weight as well as over-weight birds, egg production has been reported to be far less from being optimal. It was noted that as a fowl increases in body size, its feed utilisation decreases (Oluyemi and Roberts, 2001).

### 2.4.3 DISEASES

The occurrence of outbreak of disease is one of the major causes for financial losses in poultry industries. According to Oluyemi and Roberts (2001), infectious coryza affects birds of 2 – 4 months of age. It occurred mainly in the months of January and March. Few losses were recorded due to heat stroke during the hot spells. Other diseases such as Newcastle disease, which occurs at the middle of the rainy season (when a short drought occur or during early rains) usually lead to mortality of the birds and affect the performance of the survivors. Their performance is usually low resulting in low growth rate and subsequent low egg production. It is only in rare cases that complete recovery is possible.

### 2.4.4 NUTRITION

Apart from genetic effects, nutrition is one of the most important factors determining performance of a laying bird because nutrients are only used for egg production when maintenance and energy requirement have been met. Therefore, to obtain optimum performance in terms of egg production, adequate nutrition by providing a balanced diet is of utmost importance (Ranjhan, 2000).

The adequacy of nutrition is actually in terms of protein and energy levels. Researchers have reported a significant influence of dietary protein and energy levels in production of layers and that deficiency of some amino acids especially, methionine lead to laying of small sized eggs. Protein level not only affects rate of egg production and feed per dozen eggs laid, but also the egg weight (Yalcin *et al*, 2008). Reports from research also show that deficiency of linoleic acid leads to the laying of small-sized eggs. (FAO, 2004)

### 2.4.5 HOUSING

Housed birds are usually protected from the vagaries of weather. When birds are housed, it makes room for close observation of birds, which is very essential in order to maximize profit. The two common types of housing for layers are deep litter and battery cage systems. Lay *et al.*, (2011) reported no significant differences in egg production, feed efficiency, body weight gain and egg size for both housing systems. Nahashon *et al.,* (2011) suggested an optimum floor density of 18 and 12 birds/m$^2$ at 0 to 8 and 9 to 16 weeks of age, respectively, to achieve the highest possible feed conversion ratio for replacement pullets. Oluyemi and Roberts (2001) recommended the use of cage for layers due to numerous disadvantages associated with deep litter system.

## 2.5 BLOOD PARAMETERS

Blood parameters have been found to be an indication of whether animals are over supplied or under-supplied with nutrients, as well as for diagnosing the health and production status of animals. These blood parameters include: blood glucose, as indicator of energy status, total blood protein, blood urea nitrogen and heamoglobin as indictors of protein status and packed cell volume (PCV), as indicator of blood dilution (Frank *et al.*, 2010).

Serum proteins are sensitive to nutritional influences. Dietary protein depletion manifest as hypoproteinaemia or low serum protein level. Packed cell volume is the percentage of blood volume occupied by the packed red blood cell. According to Springer *et al.* (2010), insufficient intake of protein in both young and adult animal leads to a drop in PCV and total serum protein. The packed cell volume and total protein are also reported to be very useful in the evaluation of acute fluid and electrolyte alteration.

Sample of blood for serum analysis is usually decanted after centrifugation. Ethylenediamine-tetraacetic acid (EDTA) an anticoagulant should be added to the blood sample before use for plasma analysis. There are various ways used by earlier researchers on blood metabolite. Serum total protein was determined by buiret method (Reinhold, 1953), serum and plasma albumin by bromo-cresol green binding reagent method (Doumas and Briggs, 1972) and phosphotungstate for uric acid (Caraway, 1963).

Earlier studies by Oduguwa *et al.* (1996) reported that birds fed premix diet with high protein level has high protein level in the plasma and serum fraction. This is consistent with the earlier result of Oduguwa and Ogunmodede(1995). High level of transaminating enzymes causing high dietary vitamin $B_6$ was the reason adduced for the high protein level in the serum of bird fed on diet with premix of high protein content (Chen and Marlett, 1975; Saroka and Combs, 1986).

## 2.6 FACTOR AFFECTING PROTEIN UTILISATION

The ability of a protein to comply with a given physiological requirement is mainly a function of the availability and balance of amino acid in relation to the removal and synthesis of fibre protein. This might denote the protein quality. However, the biological efficiency of a dietary protein depends not only on the balance of available amino acid but also on the nitrogen and energy intake from the species and physiological state of the animal. The presence or absence of bacterial and fungal toxins, the rancidity of the associate fats, the content of vitamin and other essential intakes that accompany it in a diet affects the biological efficiency Guoyao Wu, (2009).

In essence, the determination of the biological efficiency of a protein which otherwise can be referred to as the nutritional value is the measurement of that particular protein source for a given class of animal as affected by various factors varying from anti-nutritional factor inherent on the protein to its digestibility (Poppi and McLennan, 2010).

### 2.6.1 FEED ENERGY AND UTILISATION OF PROTEIN

Protein is metabolized for production of energy less economically as a dietary constituent in the presence of carbohydrate or fat. Tornheim and Ruderman, (2011) pointed to the evidence of glucogenic nature of amino acid in which most amino acids can be converted into glucose, forming intermediates. A restriction in the energy value of the diet can therefore be associated with an increase in catabolism of labile protein in an effort of the animal to convert the caloric deficiency in the metabolic pool.

Blair (2008) emphasized the importance of balance between the energy producing and protein components of diet in protecting the integrity of body tissues under normal conditions. Conversely, increment in feed energy value permit improved utilisation of feed nitrogen for synthesis and conservation of body protein. Gous, (2010) demonstrated that lowering energy than conventional energy-protein levels can reduce final live weight though it is cheaper to do so. But there appears to be an optimum caloric intake associated with maximum nitrogen retention at various levels of dietary protein. This point to the fact that the calorie-protein ratio of the diet needs to be carefully adjusted if optimum utilisation of protein in a feed mixture is to be obtained.

### 2.6.2 PROTEIN UTILISATION AND AMINO ACID BALANCE

Only a very small part of the total body amino acid content is present as free amino acid and the concentration of free essential amino acids tend to be lower than that of many of the non-essential amino acids (Guoyao Wu, 2009). Therefore, it may be expected that the free amino acids content of the tissue may be modified by the dietary amino acid supply or by the rate of uptake for protein synthesis. There is obviously a relationship between the free amino acids in the tissue and the ability of dietary protein and amino acids to meet the requirement of an animal. An imbalance in the amino acid needed for specific protein synthesis at that point in time will probably lead to a decreased efficiency of utilisation of the amino acids component of the diet.

The varying values found in literature concerning the study of requirement of individual amino acid show that a balance in the amino acids relative to one another and the requirement of the animals might be a consideration. Kerr and Kidd, (1999) have shown that with a judicious adjustment of the amino acid, they could consistently use amino acid contents below the accepted recommendations. A well balanced diet is absorbed more rapidly than an unbalanced one, and amino acid may be transported more rapidly to the sites of protein synthesis in the former case (Gous, 2010).

## 2.7 MEASUREMENT OF PROTEIN QUALITY FOR MONOGASTRICS

Dietary protein serves to supply the needs of the animals in terms of essential amino acids and the materials necessary (amino group) for the synthesis of the amino acid individually regarded as non-essential. Methods used in protein quality evaluation can broadly be classified into chemical, micro-biological and biological.

### 2.7.1 PROTEIN EFFICIENCY RATIO (PER)

This method normally uses the growth of rats or chicken as a measure of the nutritional value of protein (McDonald *et al*, 2010). It is defined as the weight gained per unit weight of protein fed and may be calculated as:

$$PER = \frac{\text{Weight gained (g)}}{\text{Protein intake (g)}}$$

This formula showed that PER varied with the level of protein in the diet while the nitrogen intake will depend on the quality of protein. This index is also faced with the problem that it makes no provision for maintenance allowance for protein used, that is, PER of 2 is not twice as good as PER value 1. Furthermore, factors that influence total feed intake increase the variability of PER estimate.

### 2.7.2 NET PROTEIN RATIO (NPR)

The PER assay makes no allowance for maintenance, but assumes that all protein consumed is for growth (McDonald *et al*, 2010). In order to overcome this drawback, the weight loss of a second group or animals fed a protein free diet is induced in the calculation of NPR. This permits the evaluation of protein for their ability to support maintenance as well as growth.

$$NPR = \frac{\text{Wt. gained of test group (g)} - \text{Wt. loss of protein free group (g)} \times 100}{\text{Wt. of protein consumed by the test group (g)}}$$

### 2.7.3 GROSS PROTEIN VALUE (GPV)

The liveweight gain of chickens receiving basal diet containing 80g crude protein/kg (A) are compared with those chicken receiving basal diet plus 30g/kg of casein (A°). The extra liveweight gain per unit of supplementary test protein stated as a proportion of the extra liveweight gain per unit of supplementary casein is the gross protein value of the test protein i.e. GPV = $A/A^0$.

Where A = (g) increased weight gain/g test protein

$A^0$ = (g) increased weight gain/g casein

### 2.7.4 BIOLOGICAL VALUE (B V)

This is a direct measure of the proportion of the food protein, which can be utilized by the animal for the synthesis of body tissues and compounds. Biological value may be defined as the proportion of the absorbed nitrogen, which is retained by the body (McDonald *et al*, 2010). A balanced trial is conducted in which nitrogen intake, urinary and feacal excretion of nitrogen is measured along with the endogenous function of these two materials. The biological value is then calculated as:

$$BV = \frac{(\text{Faecal N - MFN}) - (\text{Urinary N - EUN})}{\text{Nitrogen intake - (Faecal N-MFN).}}$$

Where; MFN = Metabolic Faecal Nitrogen

EUN = Endogenous Urinary Nitrogen.

## 2.8 OTHER INDICES OF PROTEIN UTILISATION

### 2.8.1 SERUM TOTAL PROTEIN AND PROTEIN FRACTIONS

The total serum protein represents the sum of numerous different proteins many of which vary independently of each other. They consist of the various fractions of albumins and globulins (Chaney, 2006a). The change observed in total serum protein is usually as a result of the alteration of the albumin level (Fernández-Fígares, 1997). The influence of the dietary protein on serum protein components of the chick has received some attention.

Keyser *et al* (1968) observed a close relationship between dietary and serum protein concentrations. However, Fernández-Fígares, (1997) reported that serum albumin is probably not a very sensitive index of protein adequacy compared to body weights. This insensitivity could be complicated by elevation of serum protein levels above normal under some conditions in relatively undernourished individuals.

### 2.8.2 BLOOD URIC ACID CONCENTRATION

Uric acid is the end product of protein metabolism in avian species. It's precursors are aspartate and carbon dioxide, glycine, glutamine and the methyl group of methionine (Daghir, 2008). It has been shown that uric acid metabolism is influenced by the amount of protein and amino acid in the diet (Namroud, 2008).

The nutritive value of a protein is dependent not only upon its content of essential amino acid but the biological activity of this amino acid as well. Less nitrogen is thus incorporated into body protein and more is excreted as uric acid by chicks fed a poor quality protein as compared with that observed when a high quality protein is fed (Caires *et al.*, 2010). Uric acid metabolism in chicks (Swennen *et al*, 2010) is influenced by the amount of protein in the diet.

### 2.8.3 ENZYME ACTIVITY

The removal of the amino groups of most L-amino acids is promoted by group of enzymes called transminases. In these reactions called transamination, the ά-amino group is enzymatically transferred from the amino acid to the ά carbon atom of ά-ketoglutarate leaving behind the corresponding keto analog of the incoming amino acid and causing the animation of the ά-ketoglutarate to L-glutamate. Numerous transaminases associated with protein metabolism are subjected to a lot of variation depending on the type and quantity of protein in the diet (Lehninger, 2008).

The activities of glutamate pyruvate transaminase (GPT) and glutamate oxaloacetate transaminase (GOT) in liver was reviewed by Fernández-Fígares, (1997). He reported that the activity of GPT decreased linearly with the increasing biological value of the protein fed, whereas the enzyme GOT showed the highest activity with high quality protein. However the decrease in GOT activities was not maintained with proteins of poorer quality. High value of transaminases especially GPT and GOT may reflect liver damage (Hoffan and Solter, 2008) and this call for care in the interpretation of the values.

## 2.9 BROILER YIELD

The practicability of yield data collected is often open to question because of the rapid progress made by poultry industry in breeding, nutrition, management and processing procedure. In addition, some authors did not specify all the conditions under which the data were collected and reported. The factors earlier researchers found most responsible for variations in broiler yield were age, size, sex and conformation assuming uniform method of carcass separation.

Oluyemi and Robert (2001) stated that the carcass weight of dressed chickens is about 60-70% of the live weight. The dressed weight is often used as a measure of meat production in farm animals. It is known that marked change in body composition can be achieved by altering the protein and energy levels or sources in a ration. Ogunmodede (1980) showed that addition of palm oil to guinea corn ration improved dressed weight and total edible meat obtainable from broiler chickens compared with the ration of which guinea corn alone was the main dietary energy source.

The relative weight of body parts has been of major interest in recent years. The body parts are known as cut parts. Oluyemi and Robert (2001) classified chicken carcass into wholesale cut components as wings, legs (thigh and drumstick) back, breast, neck and giblets. The giblets consists of the gizzard, the heart, liver and in some cases the spleen and the kidney. Afifi and Rasheed (1966) stated that the giblet weight did not differ in two breeds when working with Fayomi and Rhode Island red, the weight ranged from 8.0 – 8.4%.

Abdominal fat laid down by broilers is dependent on interplay of factors both nutritional and non-nutritional. Lesson *et al.*, (1988) observed that higher protein levels resulted in proportional abdominal fat pad size. Female broilers have higher percentage of abdominal fats than male broilers and as dietary energy levels increase, the percentage of abdominal fat in broiler increased (Dozier *et al.* 2011).

## 2.10 POULTRY OFFAL MEAL

Poultry offal meal is the processed by-product from the poultry processing plants. It is made up of the processed edible and inedible parts (heads, viscera, feathers, beaks, blood, etc) from poultry processing (Fanimo, 1991). It is a protein-rich concentrate that can be stored for several months before being incorporated into animal feed (Ndifon, 1988).

Until recently, when its importance grew due to shortages in the supply of fish meal and the sky-rocketing cost of procuring other conventional protein supplements (Ndifon, 1988), very little was heard about this by-product, particularly in the tropics (Udedibie *et al*., 1987; Fanimo, 1991). Daghir (1975) attributed this to the fact that less than 5% of the total slaughtering of broilers and table birds are done through organized dressing system.

The composition of chicken offal is variable, depending on the nature and constituents of raw materials, the processing method adopted and duration of storage (Ndifon, 1988). This view was supported by Fanimo (1991) who reported the chemical composition as factor of the constituents, method of processing and storage. Amongst the earliest workers since its use as animal protein supplements in other parts of the world, more than three decades ago, were Naber and Morgan (1956). They estimated the composition as 57.20% crude protein, 13.10% ether extract, 1.50% crude fibre. 18.50% ash, 3.90% nitrogen Free Extract (NFE) and 94.20% dry matter. Much later, Bhargava *et al*. (1975) using 20 samples of POM reported a range of 63.88-76.60% crude protein, 7.93-18.27% ether extract, 0.82-4.97% crude fibre, 6.84-15.15% ash and 89.88-96.91% dry matter. They also reported a range of 1.41-4.93 mg/100g and 1.41-2.69 mg/100g for calcium and phosphorus respectively.

The values of 52.90% crude protein, 38.40% ether extract, 0.45% crude fibre, 4.70% ash, 3.55% NFE and 28.50% dry matter were reported by Ndifon (1988) for fresh offal which had 0.45% Ca, 0.80% P,45.10% true protein and 5290 Kcal ME/kg dry matter. He also reported the amino acid profile as, 6.40% alanine, 7.30% arginine, 5.60% histidine + $NH_3$, 3.20% isoleucine, 6.20% leucine, 4.40% lysine, 1.10% methoinine, 4.20% phenylalanine, 6.00% proline, 2.80% serine, 3.20% threonine, 2.20% tryptophan, 2.20% tyrosine, and 4.50% valine.

However, the stream-cooked fresh offal at $100^0$C for three different duration of time (12, 18 and 24 hours), pressed to remove the oil, dried and milled resulted in decreased proximate composition as the cooking time increased except for the NFE. The Ca content was unaffected while the phosphorous decreased upon cooking. The amino acid profile equally decreased with increasing processing time except for glutamic acid which followed no particular trend and, glycine and methionine which increased for the 12 hour processing and later decreased as the cooking continued (Ndifon, 1988).

Udedibie *et al*. (1987) reported values of 56.40% crude protein, 20.90% ether extract, 4.60% crude fibre, 7.70% ash, 0.78% Ca, 0.50% P and 3.18 KCal ME/kg for processed chicken offal meal. The range of 59.78-61.94% crude protein, 22.23-27.08% ether extract, 1.13-1.14% crude fibre, 2.06-2.14mg/100g Ca, 1.51-1.61mg/100g P and 87.96-92.31% dry matter were also reported by Lima (1988) while Fanimo (1991) reported 60.00% crude protein, 8.46% ether extract, 6.11% crude fibre, 14.40% ash, 11.03 NFE and 88.20% dry matter.

The amino acid composition (percent of dry matter) was reported by Fanimo (1991) as 2.63% arginine, 1.48% histidine, 2.67% lysine, 1.83% phenylalanine, 1.59% tyrosine, 3.37% leucine, 1.94% isoleucine, 0.92% methionine, 2.10% valine, 0.62% cystine, 2.41% alanine, 2.74% glycine, 6.07% glutamic acid, 1.82% serine, 1.82% threonine and 4.07% aspartic acid.

### 2.10.1 POULTRY OFFAL IN PIG RATION

The use of poultry offal for pigs as feed supplement has been widely reported in recent times (Edwards *et al*., 1979; Gruhu and Wunderlich, 1981; Knabe *et al*., 1989). Chicken offal was reported in the United Kingdom Ministry of Agriculture, Fisheries and Food Leaflet (1986) as one of the agro-industrial by-products that can be employed in pig feeding as a more cost effective way of producing pig meat.

Tibbetts *et al*. (1987) reported poultry offal silage (a mixture of heads, feet and viscera from broiler processing plant, ground and mixed with maize and dry molasses in *Lactobacillus acidophilus* culture) as an acceptable feed ingredient that can comprise up to 20% of the growing finishing pig diet. Udedibie *et al*. (1987) suggested in his work that poultry offal meal could be incorporated up to 20% in the grower pig rations with good results.

Poultry by-product meal from broiler has the potential of supplying 3 to 4% of the feed for subsequent lots of broilers (Escalona and Pesti, 1987). Potter and Fuller (1967), Jackson and Fulton (1971) and Narahari *et al*. (1981) have equally described poultry offal meal as a valid feed supplement for poultry. Poultry offal hydrolysate (POH) inclusion in the diets of 25 to 100kg live weight pigs was reported to reduce the daily feed intake (from 2.4 to 2.0kg/day) with a resultant linear reduction in growth rate (from 0.80 to 0.68kg/day). There was also no effect on the carcass characteristics as the level of inclusion increased (from 0 to 15% inclusion) (VanLuen *et al*., 1991).

In the work of Fanimo (1991) however, despite the reported low methionine content of poulrty offal meal, the performance of the pigs on its diet did not indicate the need for methionine supplementation of the diets. He reported that 100% replacement level of fishmeal with POM at both the weaner and grower phases are suitable. This was supported by the findings of Urlings *et al*. (1993) that fermented broiler by-products, comprising head, feet and viscera, significantly improved feed efficiency and carcass weight with pigs. It was therefore, concluded that poultry offal meal have tremendous potential for alleviating the problems of shortage of protein components of livestock feeds in Nigeria (Fanimo, 1991).

### 2.10.2 PROCESSING OF POULTRY OFFAL MEAL

The small scale processing, as reported by Ndifon (1987) include steam-cooking, pressing and dry at 95± 5.0$^0$C. The product was reported as having good keeping quality of up to two months. The amino acid of the processed chicken offal meal gave a chemical score of 0.77 for lysine being fairly high, with leucine (1.49) being the highest. The least stable was methionine and cystine (0.13). Phenylalanine + tyrosine and threonine + tryptophan (0.33) were also low when compared to whole hen's egg (FAO/WHO, 1973). Defatting the poultry offal meal resulted in a concentrate having as high as 81.40% crude protein, 4.82, 1.25 and 1.10mg/16gN as against the undefatted concentrate of 52.40% crude protein, 4.70, 0.95 and 0.75mg/16gN of available lysine, methionine and cystine respectively (Ndifon, 1988).

The other special methods of processing reported by Ndifon (1988) were centrifugal, meal production without cooking, solvent extraction, enzymatic treatment and chicken silage methods. The mechanical method of reducing the raw offal to meal and pressed liquor include heating, pressing, drying and grinding (Ndifon, 1988). The heating coagulates the protein, ruptures the oil depots and detaches physiological bound water. While the pressing removes a large fraction of the liquid from the mass and drying removes the appropriate amount of water from the wet material. The dried material is then ground to desirable granular form, which exposes large surface area for evaporative water losses and the mixing of antioxidants and binders before being stored and used.

The chicken offal meal used by Fanimo (1991) was processed by cleaning and cooking, cooling, drying, milling before storage. The raw offal was cleaned of residues and washed with water to remove dirt before being transferred into half-drums where wet-rendering method was applied. This entailed cooking the offal at the temperature of about $150^0$C for 3 to 4 hours. The broth was allowed to cool overnight before a substantial proportion of the liquid (especially oil) was decanted. The product was pressed to further expel the liquid and fried to reduce the moisture content until a brownish colour was obtained. The fried offal was then weighed and 2.5% of the measured weight added as salt (NaCI) as preservative. The material was further dried in the sun until about 90% dry matter was obtained. The meal was later ground and stored in plastic bags before being used.

## 2.11 SHRIMP FARMING

Shrimp is an aquatic animal found in streams, ponds and swamps. Some are found in slow-moving waters, others prefer swift streams and some blind ones dwell in caves. Shrimps generally are thigmotatic and try to get most of the body in contact with a surface. Many chemical substances unless concentrated will attract them. Most light sources will cause them to retreat though they are apparently attracted to red. Shrimps are consumed as human food and belong to phylum Arthropoda. The body is covered with exoskeleton composed of chitin, protein and lime. This bard protective covering is soft and thin at the joints between the somite, allowing flexibility of movement (Steffof, 2009)

The shrimp industry in Nigeria has grown significantly in the last few years (Fanimo *et al.*1996). Abohweyere (1984) reported that the available amount of shrimp in both offshore and Lagos Lagoon is estimated to be 300,000 tonnes per year and constitute the main parts of catches from fishermen and commercial shrimp trawlers As at 1990, the production of shrimps both in offshore and Lagos Lagoon amounts to 637,000 metric tons (Nigeria Agro Vet News, 1994). In year 2000, shrimp worth #5.58billion were exported from Nigeria and 43.35% revenue generated by Federal Government from fish production in 2001 came from shrimp and shrimp licenses (FDF, 2003).

Shrimp culture in Nigeria received attention once more when multinational oil corporations led by, Shell Petroleum Development Company of Nigeria (SPDC), first indicated interest in investing in commercial shrimp culture in the Niger-Delta (Business day, 2004). Recently, Sulalanka, a Sri Lanka consortium secured the approval of the Federal Government and FAO to commence inland culture of marine black tiger shrimp (Thisday, 2008). Research institutions like Nigerian Institute for Oceanography and Marine Research (NIOMR) consider investing in shrimp farming a top priority (Guardian, 2008) with the objective of boosting Nigeria's foreign exchange earnings through shrimp export.
There are different types of shrimp in Nigerian coastal water; these include Red Shrimp, Zebra shrimp, Pink shrimp and Brown shrimp (Livestock Farmer, 1994).

### 2.11.1 SHRIMP WASTE MEAL AND ITS UTILISATION

There is significant amount of waste generated from shrimp processing industry because of large percentage of animal heads, exoskeleton and soluble component lost during the various processing operations (Fanimo, *et al.*, 1996). Significantly, large amounts of shrimps are sold as peeled or unpeeled tail after cropping, deheading and washing. Some are chilled individually, quick-frozen or bulk frozen in blocks with water (Daniel *et al.*, 1992).

Ranjhan (2000) identified the by-products from marine and fisheries industry as follows: prawn shell and head waste 40000 tons, lobster waste 800 tons, fish waste 30000 tons, frog waste 5000 tons, shark liver residue 2000 tons and squall 10000 tons. He further reported that during processing, large quantity of shell of prawns and shrimp are left over and are available in the factories as waste and are sometimes dumped back into the river except for small quantity used in the preparation of poultry feed.

Shrimp Waste Meal (SWM) is basically the dried milled waste of the shrimp industry consisting of the heads, appendages and exoskeleton of the shrimp (Fanimo, *et al.*, 1996). The head alone represents 35-45% of the total shrimp production. Frank (1984) reported that SWM has an average of 46.7% protein and 27.8% mineral matter, while Ranjhan (2000) also stated that processed SWM has an average of 47% protein and 27.8% mineral matter indicating that shrimp waste meal is a substitute source of animal protein for poultry feeding. Fanimo, *et al.*, 1996 also indicated that shrimp waste meal is particularly rich in lysine, which makes it an ideal supplement for cereals.

### 2.11.2 PROCESSING AND STORAGE OF SHRIMP WASTE MEAL

Owing to the different processing methods employed, protein quality varies considerably. The quality also depends on the part of the animal that is being processed (Olutunde, 1997). Different processing methods like oven-drying, sun-drying, boiling and acid treatment have been used.

Shrimp wastes have poor storage life due to the activities of proteolytic enzymes and microbial degradation. For spoilage to be reduced, the various processing methods should ensure safety. Shrimp waste should be collected regularly and kept under refrigeration. Further processing without delay must be ensured to produce a stable product for later uses (Olutunde, 1997). Processed shrimp waste meal can retain good sanitary quality when stored for up to six months (Elizabeth *et al.*, 1993).

## 2.12 FISH MEAL

The word fishmeal refers to clean, dried, ground tissue of decomposed whole fish or fish cuttings, either or both, with, or without the extraction of part of the oil which have final protein content in excess of 58%. It must not contain more than 10 percent moisture (Meeker, 2009).

Good quality fish meal prepared from whole herring, menhaden, sardines and white fish containing 60-70% crude protein is one of the valuable animal protein feedstuff. It can also be prepared from fish waste consisting of tails, fins, heads, and guts from whole fish dressed for human consumption. As would be expected, this second type of fish meal is generally lower in crude protein content (Meeker, 2009).

The feeding value of the fish meal varies according to the method employed in drying and the type of raw material used. Common fish types used are those that have little food value such as the menhaden herring sardine, herring, haddock etc. (Ndifon, 1988). Fish meal from such sources will vary in protein content from 57 to

77% and generally have about 92 to 95% digestible protein. Fish meal is an excellent source of vitamins A, D and $B_{12}$, and has a good supply of calcium and phosphorous varying from 3 to 6% and 1.5 to 3.0% respectively (Ndifon, 1988).

The major role of fish meal in animal feeding is to extend supplies of vegetable protein by providing critical amount of supplemental lysine and methionine. The actual usage of this fish product can be considered to be determined by economics. Yamane *et al*. (1982) worked on the feeding value of fish meal in broiler feed and suggested that 2% dietary fish meal was adequate for satisfactory gains and feed conversion efficiency.

Due to its high protein content, and balanced amino acid and other nutrients, fish meal is a useful dietary ingredient for livestock. The inclusion of fish meal in diets has often caused higher growth rates than would be predicted from its nutrient composition. This is usually explained by assuming that fish meal contains one or more unidentified growth factors. Bjornstad *et al* (1974) worked on this area and their results indicated both an increase in growth and an improved utilisation of feed when fish meal was included in the diets but effects were not statistically significant. MacDonald *et al*. (2010) warned that the use of fish meal should be carefully considered with animals producing eggs which are vulnerable to taint development.

## 2.13 SAME SPECIES FEEDING OF ANIMAL BY-PRODUCTS IN POULTRY

Animal by-products was first introduced to the poultry industry in the 1880's in New England, where the residue from the waste water was air dried on platforms outside slaughterhouses (Denton *et al*., 2005). It has also been realized for many years that the performance of chickens on animal protein based diets are superior to their performance on vegetable protein based diets due to the calcium and phosphorous supplied by the bone in animal by-products (Waldroup and Adams, 1994), the abundance of B-complex vitamins, especially Vitamin B12 and higher concentrations of the amino acids- methionine and lysine (Parsons, 1998). It was reported (FDA, 1996) that poultry industry is still the major user of animal protein, using over 36% of all production of by-products. The primary advantages associated with the utilisation of meat bone meal (MBM) in broiler diets have been the high digestibility coefficients for the amino acids and inclusion of MBM in broiler diets at higher levels than traditionally used (up to 12.98% of high-ash and 17.76% of low-ash MBM) had no adverse effects on broiler performance. Other by-products of processed animal include meat meal, poultry meal, hydrolyzed feather meal, blood meal among others.

However, the outbreak of Bovine Spongiform Encephalopathy (BSE) in Europe in 1986 and its possible relation to the new variant Creutzfeldt-Jakob disease in humans, led to consumer concerns regarding BSE-related human illnesses. Epidemiological studies indicated that the feeding of meat- and bone meal to ruminants was responsible for this outbreak (Wilesmith *et al*., 1988). The agent responsible for this disease has not yet been completely identified. In theory such an agent can for example be a virus with unusual characteristics, a prion protein (an exclusively host-coded protein), or a virino (a small non-coding regulatory nucleic acid) (Traylor, 2005). Consequently, the European Union's scientific advisory body, the European Food Safety Authority (EFSA), concluded that animal by-products derived from animals that are not fit for human consumption should not enter the feed chain and that such materials should be properly handled and disposed after adequate processing, to prevent the possible spread of pathogens. This led to the ban on the use of animal by-products in feeding livestock in Europe. In response to the development, the United States of America in order to reduce the spread of BSE placed a ban on the import of live ruminants and ruminant MBM from the UK (since 1989) and all of Europe (since 1997).

Investigation (Cohen *et al*, 2001) revealed that there is no evidence of cross-infection of BSE between chicken and cattle even when they were experimentally inoculated. In view of this fact and given the enormity of wastes generated from livestock processing world over, rendering and processing of animal by-products into high-quality feeds are beneficial for feeding swine, poultry, and other species, converting products that otherwise have little or no value to a usable product.

The implications for not utilizing these resources as feed ingredients, not only for the cost of producing animal feeds but also for the cost of alternative disposal of these products, seriously impact economic, biosecurity, and environmental issues affecting society in general. The prohibitive energy costs associated with incineration eliminate this option. The inability to use rendered animal products increases \by approximately 5 to 10% the cost of producing animal feeds (Leeson, 2002). Whereas the use of these products has been banned in Europe, in North America the ban is only on feeding meat meals of ruminant origin to ruminants. Because of the low world demand, these products have been used to maximum advantage in poultry diets. Future use of these products may be restored in Europe, particularly for pigs and poultry (Leeson, 2002).

# CHAPTER THREE

## EEFECT OF CRAYFISH WASTE MEAL AND POULTRY OFFAL MEAL ON PERFORMANCE AND NUTRIENT RETENTION OF BROILER CHICKEN

### 3.1 INTRODUCTION

Poultry industry in Nigeria has been confronted with the challenges of high cost and scarcity of feed inputs. This stems from the direct competition between man and livestock.

Research efforts had been geared towards the use of locally available feedstuff such as agro-industrial by-products and farm wastes that may bring about the expected reduction in feed cost and consequently, poultry products. Fishmeal is one of the acceptable sources of protein for poultry feeds because of its adequacy in the composition of amino acids. However, the downturn in the economy of developing nations especially Nigeria have led to the rising cost of fish, owing to the high demand by its increasing population. As such, fishmeal has become less available with attendant exorbitant price value. Many authors have therefore researched into alternative sources of animal protein to ameliorate the situation. It is against this backdrop that the use of poultry offal and crayfish waste are being investigated as replacement for fishmeal. This study is therefore aimed at evaluating the potentials of crayfish waste meal as replacement for fishmeal in the diet of broiler chicken in trial 1 while trial 2 assesses poultry offal meal instead of crayfish waste similarly.

## 3.2 TRIAL 1: EFFECT OF CRAYFISH WASTE MEAL AS A DIETARY REPLACEMENT F0R FISHMEAL IN BROILER CHICKENS

### 3.2.1 MATERIALS AND METHODS

The study was carried out in the Poultry section of the Teaching and Research Farm of Lagos State Polytechnic, Ikorodu.

### 3.2.2 TREATMENT OF CRAYFISH WASTES

Crayfish wastes were collected from Universal Fisheries, Isolo Local Government Development Area, Lagos. A batch was drained and oven-dried at $65^{0}C$ for 24 hours followed by plate milling. Another batch was parboiled after collection, drained and oven-dried before milling. Proximate compositions of the samples were subsequently determined using the analytical methods of A.O.A.C (1996).

### 3.2.3 EXPERIMENTAL DIETS

Drained and oven-dried crayfish wastes which had the higher Crude Protein value (Table 8) was used with other feed ingredients to formulate five experimental diets. to meet the NRC (1994) nutrient requirement for broiler chicken (Tables 4 and 5) Five experimental diets were formulated to be iso-nitrogenous and iso-caloric with graded levels of crayfish waste meal replacing fishmeal as follows: 0%;100% (control), 25%;75%, 50%;50%, 75%;25% and 100%;0%. Each diet was fed for a period of 5 weeks for the starter phase and 4 weeks for finisher phase. Records of feed consumption and body weight were kept on weekly basis while body weight gain and feed conversion ratio (FCR) were estimated from the data collected.

**TABLE 4: COMPOSITION OF BROILER (STARTER) DIET CONTAINING CRAYFISH WASTE MEAL AS A REPLACEMENT FOR FISH MEAL**

| Ingredients | DIETS<br>100% FM | 75% FM 25% CWM | 50% FM 50% CWM | 25% FM 75% CWM | 100% CWM |
|---|---|---|---|---|---|
| Maize | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Wheat Offal | 7.00 | 8.10 | 9.00 | 9.85 | 10.50 |
| Maize Bran | 17.00 | 15.32 | 13.87 | 12.51 | 11.47 |
| Soya Meal | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Groundnut cake | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Fish Meal (65% CP) | 3.00 | 2.25 | 1.50 | 0.75 | 0.00 |
| Crayfish Waste Meal | 0.00 | 1.40 | 2.79 | 4.20 | 5.59 |
| Oyster Shell | 1.26 | 1.24 | 1.20 | 1.15 | 1.00 |
| Bone Meal | 1.20 | 1.15 | 1.10 | 1.00 | 0.90 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Broiler Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine Methionine | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Calculated Nutrient** | | | | | |
| Crude Protein (%) | 22.27 | 22.23 | 22.29 | 22.29 | 22.23 |
| Energy (kCal/kg) | 2813.30 | 2844.97 | 2776.42 | 2760.56 | 2748.61 |
| Available Calcium | 1.40 | 1.33 | 1.40 | 1.42 | 1.41 |
| Available phosphorus | 0.44 | 0.62 | 0.79 | 0.95 | 1.11 |
| Crude Fibre (%) | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 |
| Ether Extract (%) | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |

CWM = Crayfish waste meal

FM = Fish Meal

**TABLE 5: COMPOSITION OF BROILER FINISHER DIET CONTAINING CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISH MEAL**

| Ingredients | Diets 100% FM | 75% FM 25% CWM | 50% FM 50% CWM | 25% FM 75% CWM | 100% CWM |
|---|---|---|---|---|---|
| Maize | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| Wheat Offal | 5.60 | 5.99 | 6.35 | 6.65 | 6.85 |
| Maize Bran | 14.00 | 13.30 | 12.71 | 12.33 | 12.00 |
| Groundnut cake | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| Fish Meal(65%CP) | 2.00 | 1.50 | 1.00 | 0.50 | 0.00 |
| Crayfish Waste Meal | 0.00 | 0.93 | 1.86 | 2.79 | 3.72 |
| Oyster Shell | 1.27 | 1.25 | 1.20 | 1.00 | 0.90 |
| Bone Meal | 1.40 | 1.30 | 1.15 | 1.00 | 0.80 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Broiler Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Methionine | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Calculated Nutrient** | | | | | |
| Crude Protein | 19.36 | 19.36 | 19.36 | 19.36 | 19.36 |
| Energy (KCal/Kg) | 2844.85 | 2835.97 | 2829.27 | 2826.71 | 2823.52 |
| Available Calcium | 1.33 | 1.34 | 1.32 | 1.25 | 1.18 |
| Available phosphorus | 0.42 | 0.52 | 0.62 | 0.71 | 0.80 |
| Crude Fibre | 4.92 | 4.94 | 4.96 | 5.01 | 5.06 |
| Ether Extract | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 |

CWM = Crayfish waste meal

FM = Fish Meal

### 3.2.4 MANAGEMENT OF EXPERIMENTAL BIRDS

One hundred and fifty day-old broiler chicks were used for the study. 30 chicks were assigned to each dietary treatment, which was replicated thrice. The chicks were reared on a deep litter system with feed and water supplied *ad-libitum*. Prior to the arrival of the day-old chicks, the brooder house, feeders and drinkers were properly cleaned and disinfected with *Morigad* disinfectant. The house was partitioned into pens according to the design of the experiment. Wood shavings used as litter materials were spread on the floor of the pen at the height of 2.5cm. At the starter phase, the feeders were flat trays and fountain drinkers. Coal pots were provided in addition to electric bulbs (200 watts) as source of heat for brooding. Ventilation was adequate, the brooding temperature of 32 – 35$^0$C was maintained according to Oluyemi and Robert (2001).

Each diet was fed for a period of 5 weeks for the starter phase and 4 weeks for finisher phase. Records of feed consumption and body weight were kept on weekly basis while body weight gain and feed conversion ratio (FCR) were estimated from the data collected.

### 3.2.5 NUTRIENT RETENION TRIAL

Retention study was carried out during the eighth to ninth week of the experiment. Two birds from each replicate whose weights were close to the mean were selected for metabolic trial with facilities for feeding, water supply and collection of droppings. The birds were allowed to adjust for 4 days before feacal collection for three consecutive days. Known quantities of the diets were served to birds and the left over were properly accounted for.

The feaces were separated from feathers and oven dried at 60$^0$C for 48 hours. The dried samples were milled and stored for subsequent chemical analysis.

### 3.2.6 CARCASS QUALITY EVALUATION

At the end of the ninth week, two birds per replicate were slaughtered after they were starved overnight. The live weight, bled weight and dressed weight were taken. Eviscerated carcass was cut into prime cuts (thighs, drumsticks, wings, breast and back) and weighed. The abdominal fat and weights of the organs (liver, heart and gizzard) were also taken. The dressing out percentage was calculated as the proportion of hot carcass weight over live weight.

### 3.2.7 CHEMICAL ANALYSIS

The samples of the test diets as well as feacal output were analyzed for proximate constituents using the procedure of A.O.A.C (1996).

### 3.2.8 EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

The design of the experiment was a completely randomized design.

All data generated were subjected to analysis of variance using SAS statistical package (SAS, 2003). The design employed was completely randomized and significant treatment means were separated using Duncan Multiple Range test of the same software.

## 3.3 TRIAL 2: EFFECT OF POULTRY OFFAL MEAL AS A DIETARY REPLACEMENT FOR FISHMEAL IN BROILER CHICKENS' DIET

### 3.3.1 MATERIALS AND METHODS

The study was carried out in the Poultry section of the Teaching and Research Farm of Lagos State Polytechnic, Ikorodu.

### 3.3.2 TREATMENT OF POULTRY OFFAL

Poultry offal were collected from a broiler processing farm in Ikorodu, Lagos. They were boiled in a container for about 45minutes, allowed to cool and subsequently poured into a sac for draining. Further draining was achieved by pressing followed by oven-drying at $65^0$C for 48 hours. Dried poultry offals were subsequently crushed and fine-milled. A proximate composition of the poultry offal meal was determined using the analytical methods of A.O.A.C (1996).

### 3.3.3 EXPERIMENTAL DIETS

The poultry offal meal obtained from the process above was used with other feed ingredients to formulate diets to meet the NRC (1994) nutrient requirement of broiler chicken (Tables 6 and 7). Five experimental diets were formulated to be iso-nitrogenous and iso-caloric with graded levels of poultry offal meal replacing fishmeal as follows: 0%;100% (control), 25%;75%, 50%;50%, 75%;25% and 100%;0%. Each diet was fed for a period of 5 weeks for the starter phase and 4 weeks for finisher phase. Records of feed consumption and body weight were kept on weekly basis while body weight gain and feed conversion ratio (FCR) were estimated from the data collected.

**TABLE 6: COMPOSITION OF BROILER (STARTER) DIET CONTAINING POULTRY OFFAL MEAL AS REPLACEMENT FOR FISH MEAL**

| | Diets | | | | |
|---|---|---|---|---|---|
| Ingredients | 100% FM | 75% FM 25% POM | 50% FM 50% POM | 25% FM 75% POM | 100% POM |
| Maize | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Wheat Offal | 7.00 | 7.55 | 7.90 | 8.30 | 8.05 |
| Maize Bran | 17.00 | 16.21 | 15.61 | 14.97 | 14.97 |
| Soya Meal | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Groundnut cake | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Fish Meal (65%CP) | 3.00 | 2.25 | 1.50 | 0.75 | 0.00 |
| Poultry Offal Meal | 0.00 | 0.99 | 1.99 | 2.98 | 3.98 |
| Oyster Shell | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| Bone Meal | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine Methionine | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Determined Composition** | | | | | |
| Crude Protein | 22.26 | 22.24 | 22.28 | 22.29 | 22.32 |
| Energy (KCal/Kg) | 28125.5 | 2882.38 | 2752.48 | 2718.01 | 2691.88 |
| Available Calcium | 1.40 | 1.32 | 1.41 | 1.42 | 1.40 |
| Available phosphorus | 0.40 | 0.61 | 0.75 | 0.93 | 1.10 |
| Crude Fibre | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 |
| Ether Extract | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |

*FM = Fish Meal

POM = Poultry offal meal

**TABLE 7: COMPOSITION OF BROILER (FINISHER) DIET CONTAINING POULTRY OFFAL MEAL AS REPLACEMENT FOR FISH MEAL**

| Ingredients | Diets 100% FM | 75% FM 25% POM | 50% FM 50% POM | 25% FM 75% POM | 100% POM |
|---|---|---|---|---|---|
| Maize | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| Wheat Offal | 5.60 | 7.72 | 7.42 | 7.10 | 6.50 |
| Maize Bran | 14.00 | 11.71 | 11.85 | 12.01 | 12.45 |
| Soya Meal | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Groundnut cake | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| P.K.C. | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Fish Meal (65%CP) | 2.00 | 1.50 | 1.00 | 0.50 | 0.00 |
| Poultry Offal Meal | 0.00 | 0.66 | 1.33 | 1.99 | 2.65 |
| Oyster Shell | 1.27 | 1.27 | 1.27 | 1.27 | 1.27 |
| Bone Meal | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Methionine | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Determined Composition** | | | | | |
| Crude Protein | 19.30 | 19.36 | 19.36 | 19.35 | 19.36 |
| Energy (KCal/Kg) | 2844.79 | 2835.98 | 2829.26 | 2826.72 | 2825.52 |
| Available Calcium | 1.34 | 1.35 | 1.33 | 1.27 | 1.18 |
| Available phosphorus | 0.42 | 0.53 | 1.33 | 1.27 | 1.18 |
| Crude Fibre | 4.65 | 4.85 | 4.87 | 5.01 | 5.06 |
| Ether Extract | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 |

*FM = Fish Meal
POM = Poultry offal meal
PKC = Palm kernel meal

## 3.4 RESULTS

### 3.4.1 TRIAL I

#### 3.4.1.1 CHEMICAL COMPOSITION OF TEST INGREDIENT (CRAYFISH WASTE MEAL)

The results of chemical composition of crayfish wastes processed in different ways are presented in Table 8. Crayfish waste meal dried immediately after collection had 35.02% crude protein (C.P), 3.85% ether extract (E.E.) and 12.9% crude fibre (C.F.) whereas crayfish wastes parboiled before drying and milling had 29.59% CP 5.36% EE and 9.87CF respectively.

**TABLE 8: PROXIMATE COMPOSITION OF CRAYFISH WASTE MEAL**

| | Parboiled, Dried and Milled | Dried and milled |
|---|---|---|
| **Dry Matter (%)** | 80.40 | 81.30 |
| **Crude Protein (%)** | 29.59 | 35.02 |
| **Ether extract (%)** | 5.36 | 3.85 |
| **Crude fibre (%)** | 9.87 | 12.9 |
| **Energy** (KCal/Kg) | 1895 | 1454 |

### 3.4.1.2 PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISH MEAL

The performance characteristics of broiler chicken fed with crayfish waste meal as replacement for fish meal are shown on Table 9.

#### 3.4.1.2.1 Dry matter intake

At the starter phase, average dry matter intake was highest (1312.80g) in broiler chickens fed diet II (75%FM;25%CWM) and least (1209.20g) in diet III (50%FM;50%CWM) chickens. However, significant differences ($p>0.05$) were not observed between treatment means.

#### 3.4.1.2.2 Average body weight gain

The average body weight gain also increased marginally from 570.40g in chickens fed the control diet (100%FM) to 685.80g in those fed diet IV (25%FM;75%CWM). The broiler chickens fed diet V (100%CWM) recorded the least gain (552.50g) which was not significantly different ($p>0.05$) from others.

#### 3.4.1.2.3 Feed conversion ratio

Feed conversion ratio was highest (1.86) with broilers chickens fed diet II (75%CWM) followed by those fed diet III (1.97) while diet V (100%CWM) chickens recorded the least (2.34). The treatment means were not significantly ($p>0.05$) different from each other.

#### 3.4.1.2.4 Protein efficiency ratio

The trend in protein efficiency ratio was similar to that observed in feed conversion ratio which showed similarity ($p>0.05$) between treatments.

#### 3.4.1.2..5 Mortality

Mortality of birds were high at the starters phase ranging between 20 and 30% but not significantly different ($p>0.05$) between treatments

**TABLE 9: PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL**

| Variables [1] | Treatment 100% FM | 75% FM 25% CWM | 50% FM 50% CWM | 25% FM 75% CWM | 100% CWM | SEM |
|---|---|---|---|---|---|---|
| Av. Initial live weight (g) | 46.25 | 47.13 | 48.75 | 47.55 | 47.50 | 0.80 |
| Av. Final live weight (g) | 616.67 | 633.30 | 666.70 | 733.30 | 600.00 | 52.18 |
| Av. Weight gain (g) | 570.40 | 586.20 | 617.90 | 685.80 | 552.50 | 51.99 |
| Av. dry matter intake (g) | 1210.50 | 1312.80 | 1209.20 | 1263.60 | 1286.80 | 51.50 |
| Feed Conversion Ratio | 2.14 | 2.30 | 1.97 | 1.86 | 2.34 | 0.15 |
| Protein Efficiency Ratio | 2.11 | 2.01 | 2.29 | 2.43 | 1.93 | 0.18 |
| Mortality (%) | 20 | 25 | 20 | 20 | 30 | - |

[1] The treatment means were not significantly different from each other ($p>0.05$)

FM = Fish Meal

CWM = Cray fish waste meal

### 3.4.1.3 PERFORMANCE CHARACTERISTICS AND NUTRIENT RETENTION OF BROILER FINISHER CHICKENS FED CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISH MEAL

The performance characteristics and nutrient digestibility of broiler finisher chickens fed with CWM as replacement for FM are shown on Table 10.

#### 3.4.1.3.1 Dry matter intake

The average dry matter intake ranged from 1918.96g in broiler chicken fed diet IV (25%FM;75%CWM) to 2141.60g in diet V (100% CWM) chickens. There were no significant differences ($p>0.05$) between treatments means.

#### 3.4.1.3.2 Average body weight gain

Broiler chickens fed the control diet (100%FM) recorded the highest gain (787.30g) followed by those fed diet III (50%FM;50%CWM) while the least gain (679.00g) was by diet V (100%CWM) chickens. No significant ($p>0.05$) difference was observed between the treatment means.

#### 3.4.1.3.3 Feed conversion ratio

The feed conversion ratio was best (2.48) with chickens fed the control diet (100%FM) and progressively decreased with diet V (100%CWM) chickens recording the least (3.19). Differences between treatment means was however not significant ($p>0.05$).

#### 3.4.1.3.4 Protein efficiency ratio

Protein efficiency ratio followed similar trend with the feed conversion ratio. Diet I (100%FM) chickens had the highest value (2.09) followed by diet II (25%FM;75%CWM) while those fed diet V (100%CWM) was the least (1.64). There were no significant ($p>0.05$) differences between treatments means.

#### 3.4.1.3.5 Mortality

No mortality was recorded at the finisher phase.

### 3.4.1.4 CARCASS CHARACTERISTICS

The carcass characteristics of broiler birds fed with crayfish waste meal as replacement for fish meal are presented on Table 11. The chickens fed diet II (75%FM;25%CWM) recorded the best eviscerated weight followed by those that were fed diet IV (25%FM75%CWM). The two treatments were significantly ($p<0.05$) different whereas other treatment means were similar ($p>0.05$). The drumsticks which ranged between 17.52% (treatment II) and 16.34% (treatment V) of the eviscerated weight were also similar ($p>0.05$) between treatment means. The breast and back showed similarity between treatments except for chicken fed with diet III (50%;50%CWM) which was significantly heavier than those fed diet I (control) and diet II (25%FM;75%CWM) respectively.

The liver size percent of eviscerated weight ranged between 1.62% in chickens fed control diet and 1.79% (diet V chickens) and did not differ significantly ($p>0.05$) between treatments. The heart size was similar between treatments but for chickens fed diet V (50%FM;50%CWM) which was significantly ($p<0.05$) higher than others.

**TABLE 10: PERFORMANCE CHARACTERISTICS AND NUTRIENT DIGESTIBILITY OF BROILER FINISHER CHICKENS FED CRAYFISH WASTE MEAL AS A REPLACEMENT FOR FISH MEAL**

| Variables | Treatment<br>100% FM | 75% FM 25% CWM | 50% FM 50% CWM | 25% FM 75% CWM | 100% CWM | SEM |
|---|---|---|---|---|---|---|
| Av. Final live weight (g) | 1404.00 | 1391.50 | 1436.50 | 1436.00 | 1279.00 | 43.51 |
| Av. Weight gain (g) | 787.30 | 758.20 | 769.84 | 702.70 | 679.00 | 87.87 |
| Av. Dry matter intake (g) | 1945.90 | 2059.50 | 2110.50 | 1918.96 | 2141.60 | 41.05 |
| Feed Conversion Ratio | 2.48 | 2.75 | 2.76 | 2.86 | 3.19 | 0.35 |
| Protein Efficiency Ratio | 2.09 | 1.90 | 1.88 | 1.89 | 1.64 | 0.23 |
| Mortality (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **NUTRIENT RETENTION** | | | | | | |
| Dry matter Digestibility | 82.99 | 78.30 | 83.71 | 82.82 | 81.09 | 1.09 |
| Crude protein digestibility | $86.18^{a}$ | $72.90^{b}$ | $74.90^{b}$ | $79.74^{ab}$ | $71.01^{b}$ | 3.03 |

$^{abc}$: Means in the same row with different superscripts are significantly ($p<0.05$) different

FM = Fish Meal

CWM = Cray fish waste meal

**TABLE 11: CARCASS CHARACTERISTICS OF BROILER CHICKENS FED CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISH MEAL.**

| Parameters | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | 100% FM | 75% FM 25% CWM | 50% FM 50% CWM | 25% FM 75% CWM | 100% CWM | SEM |
| Live weight (kg/bird) | 1.375 | 1.300 | 1.400 | 1.475 | 1.300 | 0.05 |
| Defeathered weight (kg) | 1.200 | 1.200 | 1.300 | 1.275 | 1.050 | 0.06 |
| Defeathered weight (%) | 87.27$^{b}$ | 92.31$^{a}$ | 92.86$^{a}$ | 93.22$^{a}$ | 80.77$^{c}$ | 1.33 |
| Eviscerated weight (kg) | 1.00 | 1.125 | 1.050 | 1.175 | 975 | 0.04 |
| Eviscerated weight (%) | 72.73$^{bc}$ | 86.54$^{a}$ | 75.00$^{bc}$ | 79.66$^{b}$ | 75.00$^{c}$ | 1.66 |
| **Carcass relative composition (%)[1]** | | | | | | |
| Drumsticks | 12.73 | 17.31 | 12.50 | 13.56 | 11.92 | 2.05 |
| Wings | 9.82$^{ab}$ | 11.54$^{c}$ | 12.86$^{abc}$ | 11.53$^{bc}$ | 13.46$^{a}$ | 1.41 |
| Breast | 18.18$^{b}$ | 19.23$^{b}$ | 23.21$^{a}$ | 20.34$^{ab}$ | 19.23$^{ab}$ | 1.93 |
| Back | 16.36$^{a}$ | 13.46$^{d}$ | 14.29$^{bc}$ | 13.56$^{cd}$ | 15.39$^{ab}$ | 1.31 |
| Head | 5.46 | 5.77 | 3.57 | 6.78 | 3.85 | 1.35 |
| Neck | 7.27$^{a}$ | 6.54$^{b}$ | 3.57$^{c}$ | 6.78$^{b}$ | 7.69$^{a}$ | 1.63 |
| Thigh | 14.55$^{a}$ | 13.46$^{b}$ | 14.29$^{ab}$ | 15.25$^{ab}$ | 13.85$^{ab}$ | 0.68 |
| Gizzard | 2.19$^{a}$ | 2.36$^{ab}$ | 2.18$^{a}$ | 1.83$^{b}$ | 2.30$^{a}$ | 0.21 |
| Liver | 1.29 | 1.49 | 1.32 | 1.37 | 1.18 | 0.11 |
| Heart | 0.35$^{bc}$ | 0.45$^{bc}$ | 0.47$^{a}$ | 0.31$^{c}$ | 0.41$^{ab}$ | 0.07 |
| Abdominal fat | 1.40$^{d}$ | 0.64$^{d}$ | 2.22$^{a}$ | 1.22$^{b}$ | 0.82$^{c}$ | 0.62 |

$^{abcd}$ : Means in the same row with different superscripts are significantly ($p<0.05$) different

FM = Fish Meal

CWM = Cray fish waste meal

[1] Expressed as % eviscerated weight

### 3.4.2 TRIAL 2

#### 3.4.2.1 PROXIMATE COMPOSITION OF POULTRY OFFAL MEAL

The proximate compositions of poultry offal meal together with fish meal used for the study are presented on Table 12.

Poultry offal has 51.31% crude protein while fish meal contained 65% crude protein.

**TABLE 12: PROXIMATE COMPOSITION OF TEST INGREDIENTS**

| Composition | POM | FM |
|---|---|---|
| Dry matter (%) | 85.90 | 81.60 |
| Crude Protein (%) | 51.91 | 65.12 |
| Crude fibre (%) | 1.83 | 0.80 |
| Ether extract | 6.22 | 6.00 |
| Ash | 5.92 | 23.45 |
| ME (KCal/kg) | 2600 | 2860 |

POM = Poultry offal meal

FM = Fish Meal

### 3.4.2.2 NUTRIENT COMPOSITION DIETS CONTAINING CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL

The nutrient composition of experimental diets containing crayfish waste meal as replacement for fishmeal is presented in Table 13. Similarities in the proximate composition of the diets were observed.

**TABLE 13: NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS CONTAINING CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL**

| Nutrients % | 100% FM | 75% FM 25%CWM | 50% FM 50% CWM | 25% FM 75%CWM | 100% CWM |
|---|---|---|---|---|---|
| **Starter Diet** | | | | | |
| Crude Protein | 25.56 | 24.61 | 22.86 | 22.76 | 22.41 |
| Ether Extract | 3.24 | 4.12 | 3.98 | 3.63 | 3.50 |
| Crude Fibre | 4.81 | 6.20 | 6.91 | 6.12 | 6.60 |
| Calcium | 2.25 | 2.22 | 1.67 | 1.72 | 1.80 |
| Phosphorus | 1.37 | 1.58 | 1.64 | 1.53 | 1.53 |
| Metabolizable Energy (KCal/kg) | 2734 | 2761 | 2784 | 2782 | 2755 |
| **Finisher Diet** | | | | | |
| Crude Protein | 19.26 | 20.09 | 20.01 | 18.88 | 18.73 |
| Ether Extract | 0.72 | 1.62 | 0.66 | 1.13 | 0.55 |
| Crude Fibre | 2.53 | 3.04 | 3.38 | 3.29 | 14.84 |
| Calcium | 1.62 | 1.77 | 1.66 | 1.37 | 1.74 |
| Phosphorus | 1.03 | 1.21 | 1.09 | 0.96 | 0.83 |
| Metabolizable Energy (KCal/kg) | 2566 | 2559 | 2371 | 2444 | 2540 |

FM = Fish Meal

CWM = Cray fish waste meal

### 3.4.2.3 PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED POULTRY OFFAL MEAL AS REPLACEMENT FOR FISH MEAL

Presented in Table 14 are the performance characteristics of broiler starter chickens fed poultry offal meal (POM) as replacement for fish meal FM)

#### 3.4.2.3.1 Dry matter intake

The average dry matter intake of chickens fed with POM as replacement for FM increased as more poultry offal meal replaced fishmeal from 1210.60grammes in diet I (100%FM) to 1289.00grammes in those fed diet V (100%POM). It is however pertinent to note that there were no significant (p>0.05) differences in dry matter intake between the treatment means.

#### 3.4.2.3.2 Average body weight gain

The average body weight gain of broiler starters in the study which ranged between 603grammes for chickens fed diet II (25%POM) and 703.80grammes for those fed diet V (100%POM) did not significantly (p>0.05) differ as the level of replacement of fishmeal by poultry offal meal increased.

#### 3.4.2.3.3 Feed conversion ratio

With the feed conversion ratio, though broiler chickens fed diets IV (75%POM) and V (100%POM) respectively showed negligible superiority (1.83 and 1.84) over others, there were no significant (p>0.05) differences among treatment means.

#### 3.4.2.3.4 Protein efficiency ratio

Similar to the trend in feed conversion, protein efficiency ratio in the study was the highest (2.11) in broiler chickens fed diet IV (75%POM) while those fed diet I (100%FM) exhibited the least. No significant (p>0.05) difference was however observed among dietary treatments.

#### 3.4.2.3.5 Mortality

Percent mortality in the study was 20 in broiler chickens fed diets I (100%FM), III (50%POM) and IV (75%POM) respectively while those that received diets II (25%POM) and V (100%POM) recorded 25. There were no significant (p>0.05) differences among treatment means.

**TABLE 14: PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISHMEAL**

| Variables [1] | Treatment 100% FM 0% POM | 75% FM 25% POM | 50% FM 50% POM | 25% FM 75% POM | 0% FM 100% POM | SEM |
|---|---|---|---|---|---|---|
| Average Initial Live weight(g) | 46.25 | 47.50 | 46.25 | 47.25 | 47.25 | 0.65 |
| Average Final Live weight (g) | 616.67 | 650.00 | 666.70 | 750.00 | 750.00 | 49.44 |
| Average Weight Gain (g) | 570.42 | 603.00 | 619.90 | 703.70 | 703.80 | 49.37 |
| Average Dry Matter Intake (g) | 1210.60 | 1264.90 | 1279.30 | 1280.00 | 1289.00 | 78.93 |
| Feed Conversion Ratio | 1.95 | 2.20 | 2.10 | 1.83 | 1.84 | 0.26 |
| Protein Efficiency Ratio | 2.11 | 2.14 | 2.17 | 2.47 | 2.45 | 0.16 |
| Mortality (%) | 5.00 | 7.25 | 5.00 | 5.00 | 7.25 | 1.25 |

[1] The treatment means were not significantly different from each other ($p>0.05$)

FM = Fish Meal

POM = Poultry offal meal

### 3.4.2.4 PERFORMANCE CHARACTERISTICS AND NUTRIENT RETENTION OF BROILER FINISHER CHICKENS FED POULTRY OFFAL MEAL AS REPLACEMENT FOR FISHMEAL

Table 15 shows the performance characteristics and nutrient digestibility of broiler finisher chickens fed poultry offal meal as a replacement for fishmeal.

#### 3.4.2.4.1 Dry matter intake

The average dry matter intake for broiler chickens fed diet II (25%POM) ranked highest (2093.10g) followed by diet V (100%POM) chickens (2083.00g) while those fed diet IV (75%POM) consumed least (1991.14g). There were no significant ($p>0.05$) differences among treatment means.

#### 3.4.2.4.2 Average body weight gain

Average body weight gain of broiler chickens at this phase was best (977.5g) in those fed diet II (25%POM) and was significantly ($p<0.05$) higher than others. However, chickens fed control diet (100%FM) were similar ($p>0.05$) to those fed diets III and IV respectively.

#### 3.4.2.4.3 Feed conversion ratio

The broiler chickens fed diet II (25% POM) recorded the best feed conversion ratio (2.13) that was significantly ($p<0.05$) different from those fed diet V (100%POM) which was the least (3.56). However, chickens in other dietary treatments were similar ($p>0.05$) in feed conversion ratio.

#### 3.4.2.4.4 Protein efficiency ratio

The treatment means of protein efficiency ratio of broiler chickens in the study were similar ($p>0.05$) except for those fed diet II (25% POM) which was significantly ($p<0.05$) higher than others.

#### 3.4.2.4.5 Mortality

No mortality was recorded at the finisher phase.

### 3.4.2.5 CARCASS CHARACTERISTICS

The carcass characteristics of chicken fed POM as a replacement for FM is presented in Table 16. The eviscerated weight expressed as percent live weight ranged between 73.57 for diet IV (75%POM) chickens and 81.48 (diet III). There were no significant ($p>0.05$) differences between treatment means. Respective values for drumstick, back and thigh were only significantly ($p<0.05$) different between chickens fed the control diet (100%FM) and those of diet IV (75% POM) but others were similar. However, diet II (25% POM) chickens were significantly ($p<0.05$) different from those fed diet V (100% POM) in the values for breast and neck respectively whereas others were similar. There was no significant difference between treatment means for the wing values.

The gizzard and liver were respectively similar between treatments except for diet II (75% POM) chicken which recorded a significantly ($p<0.05$) higher values than others.

**TABLE 15: PERFORMANCE CHARACTERISTICS AND NUTRIENT DIGESTIBILITY OF BROILER FINISHER CHICKENS FED POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

| Variables | Treatment 100% FM 0% POM | 75% FM 25% POM | 50% FM 50% POM | 25% FM 75% POM | 0% FM 100% POM | SEM |
|---|---|---|---|---|---|---|
| Average Final live weight (g) | $1404.00^{b}$ | $1627.50^{a}$ | $1404.00^{b}$ | $1435.00^{b}$ | $1340.00^{b}$ | 52.08 |
| Average weight gain (g) | $787.30^{b}$ | $977.50^{a}$ | $737.34^{bc}$ | $685.00^{bc}$ | $590.00^{c}$ | 49.87 |
| Average Dry matter intake (g) | 1946.00 | 2093.10 | 1928.50 | 1991.40 | 2083.00 | 194.24 |
| Feed Conversion Ratio | $2.49^{ab}$ | $2.13^{b}$ | $2.63^{ab}$ | $2.93^{ab}$ | $3.56^{a}$ | 0.29 |
| Protein Efficiency Ratio | $2.09^{b}$ | $2.41^{a}$ | $1.98^{b}$ | $1.78^{b}$ | $1.46^{c}$ | 0.32 |
| Mortality (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | - |
| **NUTRIENT DIGESTIBILITY** | | | | | | |
| Dry matter digestibility | 82.99 | 81.13 | 81.16 | 82.29 | 80.50 | |
| Crude protein digestibility | 86.18 | 78.73 | 78.25 | 77.72 | 76.96 | |

FM = Fish Meal

POM = Poultry offal meal

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

**TABLE 16: CARCASS CHARACTERISTICS OF BROILER CHICKENS FED POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISHMEAL**

| Parameters | Treatment<br>100% FM 0% POM | 75% FM 25% POM | 50% FM 50% POM | 25% FM 75% POM | 0% FM 100% POM | SEM |
|---|---|---|---|---|---|---|
| Live weight (kg/Bird) | $1.375^{a}$ | $1.400^{a}$ | $1.350^{a}$ | $1.400^{a}$ | 1.175 | 0.04 |
| Defeathered weight (kg/bird) | 1.200 | 1.275 | 1.150 | 1.300 | 1.075 | |
| Defeathered weight (%) | $87.27^{c}$ | $91.06^{ab}$ | $85.19^{d}$ | $92.86^{b}$ | $91.49^{a}$ | 0.35 |
| Eviscerated weight (kg) | 1.000 | 1.050 | 1.100 | 1.030 | 0.925 | |
| Eviscerated weight (%) | 72.73 | 75.00 | 81.48 | 73.57 | 78.72 | 3.68 |
| **Carcass and organs relative composition (%)** | | | | | | |
| Drumsticks | $17.52^{a}$ | $19.24^{a}$ | $18.22^{a}$ | $13.60^{b}$ | $16.23^{ab}$ | 0.81 |
| Wings | 16.57 | 16.18 | 15.95 | 14.90 | 17.92 | 1.00 |
| Breast | $25.09^{ab}$ | $21.36^{b}$ | $22.80^{ab}$ | $23.64^{ab}$ | $27.03^{a}$ | 1.34 |
| Back | $22.53^{a}$ | $17.14^{b}$ | $15.92^{bc}$ | $13.60^{c}$ | $16.23^{bc}$ | 0.92 |
| Neck | $10.03^{a}$ | $11.41^{a}$ | $8.64^{b}$ | $8.63^{b}$ | $8.63^{b}$ | 0.57 |
| Thigh | $20.00^{ab}$ | $19.01^{ab}$ | $16.38^{bc}$ | $15.87^{c}$ | $18.92^{ab}$ | 0.80 |
| Gizzard | $3.02^{ab}$ | $3.52^{a}$ | $2.64^{b}$ | $2.49^{b}$ | $2.97^{b}$ | 0.15 |
| Liver | $1.79^{b}$ | $2.44^{a}$ | $1.77^{b}$ | $1.47^{b}$ | $1.75^{b}$ | 0.09 |
| Heart | $0.49^{c}$ | $0.61^{ab}$ | $0.64^{a}$ | $0.43^{c}$ | $0.51^{bc}$ | 0.03 |
| Abdominal fat | $0.84^{d}$ | $0.76^{b}$ | $1.40^{a}$ | $2.67^{c}$ | $0.32^{c}$ | 0.04 |

FM = Fish Meal

POM = Poultry offal meal

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

**TABLE 17: NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS CONTAINING POULTRY OFFAL MEAL AS REPLACEMENT FOR FISHMEAL**

| Nutrients % | **100% FM** | **75% FM 25% POM** | **50% FM 50% POM** | **25% FM 75% POM** | **100% POM** |
|---|---|---|---|---|---|
| **Starter Diet** | | | | | |
| Crude Protein | 25.26 | 23.81 | 22.41 | 21.36 | 20.31 |
| Ether Extract | 3.24 | 3.79 | 3.45 | 3.47 | 3.66 |
| Crude Fibre | 4.81 | 6.03 | 5.89 | 7.12 | 6.58 |
| Calcium | 2.21 | 1.94 | 2.23 | 1.88 | 1.88 |
| Phosphorus | 1.37 | 1.88 | 2.20 | 1.32 | 1.41 |
| Metabolizable Energy (KCal/kg) | 2734 | 2720 | 2765 | 2798 | 2832 |
| **Finisher Diet** | | | | | |
| Protein | 19.26 | 19.79 | 21.31 | 22.24 | 22.06 |
| Ether Extract | 0.72 | 0.76 | 0.82 | 0.87 | 1.09 |
| Crude Fibre | 2.53 | 1.89 | 2.41 | 1.01 | 1.11 |
| Calcium | 1.62 | 0.89 | 1.11 | 1.33 | 1.23 |
| Phosphorus | 1.03 | 0.89 | 1.01 | 1.32 | 1.21 |
| Metabolizable Energy (KCal/kg) | 2566 | 2534 | 2549 | 2557 | 2578 |

*FM = Fish Meal

POM = Poultry offal meal

## 3.5 DISCUSSION

## 3.5.1 Trial I

### 3.5.1.1 PROXIMATE COMPOSITION OF CRAYFISH WASTE MEAL.

The proximate composition of crayfish waste meal revealed that samples that were dried without parboiling recorded better value than those parboiled. This disparity could have been caused by heat treatment which probably denatured some of the protein in the samples that were parboiled. The 35.02% crude protein of un-parboiled crayfish waste used for this study is lower than 43.71% reported by Fanimo *et al.*, (1996) and 50.89% in tunnel-dried samples (Rosenfeld *et al.*, 1997) but similar to 35.2% reported by Ngoan *et al.*, (2000a). The nutritional value of crayfish waste is also affected by processing method and collection time. The head, which constitute about 70% of shrimp waste. is known to contain some bacteria which during storage can produce a dicarboxylic reaction turning amino acids to biogenic amines, resulting in depletion of the nutritional value with a possible toxic effect (Rosenfeld *et al.*, 1997). Samples used in this study were dried soon after collection to forestall the commencement of the activities of the spoilage bacteria. Therefore, immediate drying (without parboiling) produced a better result.

### 3.5.1.2 PERFORMANCE CHARACTERISTICS AND NUTRIENT RETENTION

The performance characteristics of broiler chickens fed with crayfish waste meal as replacement for fish meal showed no significant difference in dry matter intake at both the starter and the finisher phases. These findings are in agreement with Rosenfeld *et al.*, (1997) who replaced soyabean meal with crayfish waste meal up to 100% in broiler's diet and those of Oduguwa *et al.*, (2002) when they replaced fish meal with shrimp waste meal and reported no adverse effects on the broiler chicken.

The similarity in dry matter intake between treatments explains the non-significant difference in body weight gain as well as feed conversion ratio. Meyers (1986) reported that crayfish waste meal has a comparable amino acid profile with fish meal and when the feed is similar in composition, dry matter intake and gain would not be different. However, Fanimo *et al.*, (1996) reported a significant difference in body weight gain when more than 33% shrimp waste meal replaced fishmeal in chicken diet.

#### 3.5.1.3 CARCASS CHARACTERISTICS

Proteins form the structure of most of the body organs and tissues. If less protein is present in the ration, then less quantity will be deposited in these organs and tissues. Crayfish waste meal substituted for fishmeal did not have negative effect on eviscerated weight as well as carcass relative composition. The organs' weight also fell within reported range (Fanimo *et al*, 1996). Findings in this study agree with Rosenfeld *et al* (1997).

### 3.5.2 Trial II

#### 3.5.2.1 PROXIMATE COMPOSITION OF POULTRY OFFAL MEAL

The percent crude protein of POM in this study (51.31) is lower than 62.5 reported for broiler offal (Islam *et al*, 1994), 60.00 in chicken offal meal (Fanimo, 1996) and 56.00 in poultry visceral offal meal (Salami and Oyewole, 1997). The composition of POM is affected by the source or type of poultry and processing method. When the entire gastro-intestine and the contents are utilized, the composition would also depend on the constituents of the previous feed consumed by the birds. Skurray and Carroll (1978) observed differences in the chemical composition of hard and soft offal meals produced from different starting raw materials (offals) by the same 'dry-rendering' method. In this case, POM was processed by a modification of the wet-rendering method described by Nwokoro (1993).

#### 3.5.2.2 PERFORMANCE CHARACTERISTICS AND DIGESTIBILITY STUDIES

Results of performance characteristics of broiler chickens fed poultry offal as replacement for fish meal at the starter phase showed no significant ($p>0.05$) difference in dry matter intake, body weight gain, feed conversion ratio and protein efficiency ratio. It is well known that within a certain limit, birds fed *ad libitum* try to satisfy their energy requirements. Thus, the similarity in dry matter intake is a confirmation of the uniformity of contents of the test ingredients and there were no negative effect of POM on dry matter intake. This is in agreement with the findings of Udedibie *et al* (1988) in their study on laying hen and broiler chicken as well as Salami and Oyewole (1997) who fed poultry visceral offal meal to growing pullets.

Also, the similarity in the body weight gain, feed conversion ratio and protein efficiency ratio confirms the findings of Fuller (1956) who found that chicken offal meal produced a growth response equal to that of FM when used to supplement a simplified corn-soya ration. Similarly, Islam *et al* (1994) compared broiler offal with other protein-rich ingredients as replacement for FM and concluded that its dietary treatment was the best and the only one which totally and successfully replaced the costly FM of poultry diets.

### 3.5.2.3 CARCASS CHARACTERISTICS

The similarity observed in percent eviscerated weight as well as other cut parts in this study indicated that the dietary treatments were similar with each other. The values obtained are similar to those reported by Durunna *et al*, (2006). Also, the non-significant difference in the weight of liver and gizzard respectively indicate that poultry offal meal had no toxic or detrimental effect on the experimental chickens.

# CHAPTER FOUR

## PERFORMANCE CHARACTERISTICS, CARCASS CHARACTERISTICS, HEMATOLOGY AND BLOOD CHEMISTRY OF BROILER CHICKEN FED GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.

### 4.1 INTRODUCTION

Fishmeal is a conventional costly item which when added to the diet increases the poultry production cost (Islam *et al*, 1994). It is therefore imperative that alternative cheaper unconventional sources are sought. Poultry offal and crayfish waste used in trials 1 and 2 of the last study individually performed as much as fish meal. Reasonably, their combination at graded levels could result in a better performance than obtained in the last study. As such, all the dietary treatments in trials 1 and 2 (chapter 3) respectively was combined at graded levels with 100% FM diet as the control with the aim of arriving at a combination(s) that would perfectly replace fish meal in the diets of broiler chicken.

## 4.2 MATERIALS AND METHODS

The study was carried out in the Poultry section of the Teaching and Research Farm of the Lagos State Polytechnic, Ikorodu.

### 4.2.1 Management of Experimental Birds

One hundred and eighty day-old broiler chicks were used for the study. 30 chicks were assigned to each dietary treatment, which was replicated thrice. The chicks were reared on a deep litter system with feed and water supplied *ad-libitum*. Prior to the arrival of the day-old chicks, the brooder house, feeders and drinkers were properly cleaned and disinfected with *Morigad* disinfectant. The house was partitioned into pens according to the design of the experiment. Wood shavings used as litter materials were spread on the floor of the pen at the height of 2.5cm. At the starter phase, the feeders were flat trays and fountain drinkers. Coal pots were provided in addition to electric bulbs (200 watts) as source of heat for brooding. Ventilation was adequate, the brooding temperature of 32 – 35$^{0}$C was maintained according to Oluyemi and Robert (2001). Routine vaccinations were administrated as when due.

Six experimental diets were formulated to be iso-nitrogenous and iso-caloric with graded levels of crayfish waste meal and poultry offal meal replacing fishmeal as follows: 100%FM (control), 100%POM, 75%POM;25%CWM, 50%POM;50%CWM, 25%POM;75%CWM and100%CWM. Each diet was fed for a period of 5 weeks for the starter phase and 4 weeks for the finisher study. Records of feed consumption and body weight were kept on weekly basis while body weight gain and feed conversion ratio (FCR) were estimated from the data collected.

### 4.2.2 Serum collection

Blood was collected from two birds per replicate at the end of the experiment into sterile sample tubes without anticoagulant. The clotted blood was centrifuged for 15 minutes at 3,500 revolutions per minute. A clear fluid, which is the serum, was pipette out into a clean and sterilized bottle which was later taken for analysis.

The serum protein was analyzed using sigma assay kits, glucose were determined by o-Toluidine method using acetic acid (Dubowski, 1962) and cholesterol by the method to Roschlan *et al*., (1974).

**TABLE 18: COMPOSITION OF BROILER (STARTER) DIET CONTAINING GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.**

| Ingredients | Diets 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM |
|---|---|---|---|---|---|---|
| Maize | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Wheat Offal | 7.00 | 8.00 | 8.52 | 8.93 | 9.26 | 9.54 |
| Maize Bran | 17.00 | 14.97 | 14.17 | 13.45 | 12.86 | 12.43 |
| Soya Meal | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Groundnut cake | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Fish Meal (65%) | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Poultry Offal Meal | 0.00 | 3.98 | 2.98 | 1.99 | 0.99 | 0.00 |
| Crayfish waste meal | 0.00 | 0.00 | 1.40 | 2.79 | 4.20 | 5.59 |
| Oyster Shell | 1.26 | 1.26 | 1.24 | 1.20 | 1.15 | 1.00 |
| Bone Meal | 1.20 | 1.20 | 1.15 | 1.10 | 1.00 | 0.90 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| 25% Broiler Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Methionine | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Determined Composition** | | | | | | |
| Crude Protein (%) | 22.26 | 22.25 | 22.23 | 22.23 | 22.22 | 22.22 |
| ME KCal/Kg | 2813 | 2800 | 2783 | 2768 | 2754 | 2742 |
| Crude Fibre (%) | 3.77 | 3.20 | 3.26 | 4.63 | 4.78 | 4.24 |
| Ash (%) | 1.55 | 1.71 | 1.15 | 1.59 | 2.06 | 2.34 |
| Ether Extract (%) | 1.72 | 0.53 | 0.68 | 0.13 | 0.45 | 0.79 |

POM = Poultry offal meal

CWM = Crayfish waste meal

**TABLE 19: COMPOSITION OF BROILER (FINISHER) DIET CONTAINING GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.**

| | Diets | | | | | |
|---|---|---|---|---|---|---|
| Ingredients | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM |
| Maize | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| Wheat Offal | 5.60 | 6.50 | 6.90 | 6.90 | 6.90 | 6.85 |
| Maize Bran | 14.00 | 12.45 | 11.90 | 11.90 | 11.92 | 12.00 |
| Soya Meal | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Groundnut cake | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| Fish Meal (65%) | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Poultry Offal Meal | 0.00 | 2.65 | 1.99 | 1.33 | 0.66 | 0.00 |
| Crayfish waste meal | 0.00 | 0.00 | 0.93 | 1.86 | 2.79 | 3.72 |
| Oyster Shell | 1.27 | 1.27 | 1.25 | 1.20 | 1.00 | 0.90 |
| Bone Meal | 1.40 | 1.40 | 1.30 | 1.15 | 1.00 | 0.80 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Broiler Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Methionine | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Lysine Hcl | 0.15 | 0.08 | 0.15 | 0.15 | 0.15 | 0.15 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Determined Composition** | | | | | | |
| Crude Protein (%) | 19.36 | 19.35 | 19.35 | 19.36 | 19.36 | 19.36 |
| ME KCal/Kg | 2919 | 2909 | 2899 | 2884 | 2892 | 2889 |
| Crude Fibre (%) | 3.53 | 4.10 | 3.90 | 4.80 | 4.00 | 4.90 |
| Ash (%) | 1.11 | 0.99 | 0.00 | 1.31 | 1.15 | 1.03 |
| Ether Extract (%) | 0.98 | 1.47 | 1.48 | 0.80 | 0.96 | 1.20 |

POM = Poultry offal meal

CWM = Crayfish waste meal

## 4.3 RESULTS

### 4.3.1 PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.

The performance characteristics of broiler starter chickens fed with crayfish waste meal and poultry offal meal as replacement for fish meal are presented in Table 21.

#### 4.3.1.1 Average dry matter intake

The dry matter intake of broiler starter chickens at the trial showed significant ($p<0.05$) differences between treatment means. The broiler chickens fed diet V (25%POM;75%CWM) consumed the highest quantity of feed (1410.00g) which was similar ($p>0.05$) to those fed diets I and II but significantly ($p<0.05$) different from those fed diets III, IV and VI respectively. Though broiler chickens fed diet VI chickens (100%CWM) consumed the least quantity of feed (1183.40g), they were not significantly ($p>0.05$) different from those fed diets III and IV respectively.

#### 4.3.1.2 Average body weight gain

The average body weight gain of broiler starter chickens in the study ranged between 634.90g in broiler chickens fed diet VI (100%CWM) and 811.30g in those fed diet V (25%POM;75%CWM) Significant ($p<0.05$) differences were observed between these two treatments. Besides, chickens in other dietary treatments were similar in their average body weight gain.

#### 4.3.1.3 Feed conversion ratio

The average feed conversion ratio of broiler starter chickens was highest (1.65) in diet I chickens (100%FM) while those that were fed diet VI (100%CWM) recorded the least (1.87). It is pertinent to note that the differences observed between dietary treatments were not significant ($p>0.05$).

#### 4.3.1.4 Protein efficiency ratio

The protein efficiency ratio in the study closely followed the trend observed in feed conversion ratio. The broiler chickens fed diet VI (100%CWM) were the least efficient

(2.41) while those fed control diet (100%FM) were the best (1.65). There were no significant ($p>0.05$) differences among the treatment means.

#### 4.3.1.5 Mortality

The percent mortality at the starter phase was least (0.55) in broiler chickens fed diets I, II and III respectively while those that received diet VI (100%CWM) recorded the highest (2.20) value. There were no significant ($p>0.05$) differences for mortality among the treatment means.

### 4.3.2 Performance Characteristics of Broiler Finisher Chickens fed Graded Levels of Poultry Offal Meal and Crayfish Waste Meal as Replacement for Fishmeal

Presented in Table 22 are the performance characteristics of broiler finisher chickens fed a combination of poultry offal meal and crayfish waste meal as replacement for fish meal.

#### 4.3.2.1 Dry matter intake

The average dry matter intake of broiler chickens at the finisher phase was highest (2976.00g) in chickens fed diets I (100%FM) and V (25%POM;75%CWM) and the value was significantly ($p<0.05$) different from those that were fed diets IV (50%POM;50%CWM) and VI respectively. However, experimental chickens fed diets III and VI were not significantly ($p>0.05$) different in their dry matter intake.

#### 4.3.2.2 Average body weight gain

The average body weight gain of broiler finisher chickens in the study ranged between 1085.00g (diet VI) and 1251.00g (diet I). There was however no significant difference ($p>0.05$) between dietary treatments.

#### 4.3.2.3 Feed conversion ratio

The broiler finisher chickens fed diet IV (50%POM;50%CWM) ranked best with 2.41 which compares with 2.40 of control birds (100%FM). However, there were no significant differences ($p>0.05$) between treatment means in their feed conversion ratio.

#### 4.3.2.4 Protein efficiency ratio

Protein efficiency ratio of broiler finisher chickens indicated that those fed 100%FM (control) were the most efficient (2.17) which was closely followed by 50%POM;50%CWM (2.16). The least value of 1.95 was recorded by the chickens fed 100%POM (diet II). However, differences between the treatment means were not significant ($p>0.05$).

#### 4.3.2.5 Mortality

The broiler finisher chickens fed a combination of poultry offal meal and crayfish waste meal did not record any mortality.

**TABLE 20: PERFORMANCE CHARACTERISTICS OF BROILER STARTER CHICKENS FED GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.**

| | Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
| Average Initial weight (g) | 59.00 | 58.75 | 58.90 | 59.25 | 58.80 | 58.95 | 0.0 |
| Average final weight (g) | 853.00[a] | 850.67[a] | 785.75[ab] | 783.29[ab] | 870.33[a] | 693.89[b] | 30.1 |
| Average Weight Gain (g) | 793.00[a] | 791.70[a] | 726.80[ab] | 724.30[ab] | 811.30[a] | 634.90[b] | 28.5 |
| Dry Matter Intake (g) | 1308.70[abc] | 1331.10[ab] | 1233.70[bcd] | 1224.90[cd] | 1410.00[a] | 1183.40[d] | 31.9 |
| Average Feed Conversion Ratio | 1.65 | 1.68 | 1.70 | 1.70 | 1.74 | 1.87 | 0.08 |
| Average Protein Efficiency Ratio | 2.72 | 2.67 | 2.65 | 2.66 | 2.59 | 2.41 | 0.10 |
| Mortality (%) | 0.55 | 0.55 | 0.55 | 1.10 | 1.66 | 2.20 | 0.66 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

[abcd] : Means in the same row with different superscripts are significantly different ($p<0.05$)

**TABLE 21: PERFORMANCE CHARACTERISTICS OF BROILER FINISHER CHICKENS FED GRADED LEVELS OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS REPLACEMENT FOR FISHMEAL.**

| Variables | Treatment 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
|---|---|---|---|---|---|---|---|
| Average Final Live weight (g) | 2104.00$^{a}$ | 1965.00$^{a}$ | 1919.00$^{ab}$ | 1902.00$^{b}$ | 2035.00$^{a}$ | 1779.00$^{b}$ | 103.01 |
| Average Weight Gain (g) | 1251.00 | 1123.00 | 1133.00 | 1118.00 | 1164.00 | 1085.00 | 66.55 |
| Average Dry Matter Intake (g) | 2976.99$^{a}$ | 2970.00$^{a}$ | 2852.00$^{b}$ | 2681.00$^{c}$ | 2976.10$^{a}$ | 2757.00$^{bc}$ | 127.55 |
| Feed Conversion Ratio | 2.40 | 2.68 | 2.54 | 2.41 | 2.56 | 2.55 | 0.15 |
| Protein Efficiency Ratio | 2.17 | 1.95 | 2.05 | 2.16 | 2.02 | 2.03 | 0.08 |
| Mortality (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

### 4.3.3 Haematology of Broiler Chickens fed Graded Levels of Poultry offal Meal and Crayfish Waste Meal as Replacement for Fish Meal

Presented in Table 23 is the haematology of broiler chickens fed graded levels of poultry offal meal and crayfish waste meal as replacement for fish meal. The values for packed cell volume (PCV), haemoglobin (Hb) and red blood cells (RBC) were not significantly ($p>0.05$) different between treatment means. Diet III (75%POM;25%CWM) chickens recorded the highest values for PCV, Hb and RBC (36.00, 11.95, 3.10) while those fed diet II (100%POM) had the least (28.00, 9.30, 2.30) accordingly. However with MCV, MCHC and MCH, the highest values (125.49, 33.23, 41.74) were recorded by broiler chickens on diet V (25%POM;75%CWM) respectively. It is important to note that these haematology values did not follow a specific trend.

The total white blood count (WBC x $10^3$ u/l) in the study ranged between 10850 in experimental chickens fed diet II (100%POM) and 17650 for diet IV (50%POM;50%CWM). The latter was significantly ($p<0.05$) higher than other treatments. It is important to note that other dietary treatments were similar ($p>0.05$) in WBC mean values.

### 4.3.4 Serum Chemistry of Broilers Chickens fed Graded Levels of Poultry offal Meal and Crayfish Waste Meal as Replacement for Fish Meal

Summarized in Table 24 are the mean values of serum protein, chemical components and enzyme activities of broiler chickens fed graded levels of poultry offal meal and crayfish waste meal as replacement for fish meal. Results indicated significant ($p<0.05$) differences in serum total protein between dietary treatment III (75%POM;25%CWM) which had the least value (5.65g/dl) and those of II, IV and VI. However, the total protein values were similar in other dietary treatments. Though the blood albumin (g/dl) value was least (2.65) in chickens fed diet III (75%POM;25%CWM) and highest (2.90) with those fed diets II and V respectively, there were no significant ($p>0.05$) differences between the treatment means. For the globulin levels, broiler chickens fed diets II, and VI recorded 3.20g/dl respectively and were significantly ($p<0.05$) different from those of dietary treatments I, and III. However, the mean values of the former and latter did not differ significantly ($p > 0.05$) from those of treatment IV.

The mean blood urea value of broiler chickens that were fed diet IV (50%POM;50%CWM) was significantly ($p<0.05$) higher (19.00 mmg/dl) than other treatment means. It suffices to note that values for the other dietary treatments were not significantly different. Also, significant ($p<0.05$) differences were observed between dietary treatments I (control) and V (25%POM;75%CWM) in creatinine value (mg %), other treatment means were similar.

The serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT) were respectively, similar ($p>0.05$) between treatment means. A trend of linear increase was also observed in SGOT from treatments I (74.50) to VI (91.00).

**TABLE 22: HEMATOLOGICAL PARAMETERS OF BROILERS FED POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS A REPLACEMENT FOR FISHMEAL**

| Parameters | Diets 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
|---|---|---|---|---|---|---|---|
| PCV (%) | 29.00 | 28.00 | 36.00 | 32.50 | 34.00 | 35.50 | 3.48 |
| Hb (g/d1) | 9.65 | 9.30 | 11.95 | 10.30 | 11.30 | 11.70 | 1.13 |
| RBC (x $10^6$/u1) | 2.50 | 2.30 | 3.10 | 3.05 | 2.7 | 2.90 | 0.36 |
| MCV | 117.21 | 112.69 | 116.95 | 106.62 | 125.49 | 119.00 | 6.18 |
| MCHC % (g/100ml) | 33.27 | 33.21 | 33.19 | 33.23 | 33.23 | 33.29 | 0.08 |
| MCH (pg) | 38.99 | 40.73 | 38.56 | 35.43 | 41.74 | 39.60 | 2.01 |
| Total WBC (X$10^3$/u1) | $11850^{ab}$ | $10850^{b}$ | $13900^{ab}$ | $17650^{a}$ | $11600^{ab}$ | $11350^{ab}$ | 1749 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

**TABLE 23: SERUM CHEMISTRY OF BROILERS FED CRAYFISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL.**

| | Diets | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameters | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
| Urea (mm/01/1) | $9.45^{b}$ | $12.90^{b}$ | $11.15^{b}$ | $19.00^{a}$ | $12.10^{b}$ | $10.15^{b}$ | 1.12 |
| Creatinine (mg %) | $1.25^{a}$ | $1.00^{ab}$ | $0.95^{b}$ | $1.10^{ab}$ | $0.90^{b}$ | $1.10^{ab}$ | 0.08 |
| Total Protein (g/d1) | $5.90^{ab}$ | $6.10^{a}$ | $5.65^{b}$ | $6.00^{a}$ | $5.95^{ab}$ | $6.00^{a}$ | 0.09 |
| Albumin (g/d1) | 2.85 | 2.90 | 2.65 | 2.80 | 2.90 | 2.80 | 0.08 |
| Globulin (g/d1) | $3.05^{b}$ | $3.20^{a}$ | $3.00^{b}$ | $3.20^{a}$ | $3.05^{b}$ | $3.20^{a}$ | 0.03 |
| SGOT | 74.50 | 78.00 | 78.50 | 86.00 | 99.00 | 91.00 | 7.19 |
| SGPT | 13.00 | 12.00 | 11.00 | 16.50 | 12.00 | 13.50 | 1.73 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

### 4.3.5 Carcass Characteristics of Broiler Chicken Fed a Combination of Poultry Offal Meal and Crayfish Waste Meal as a Replacement for Fish Meal.

The carcass characteristics of broiler birds fed poultry offal meal and crayfish waste meal as replacement for fish meal are presented on Table 23.

The eviscerated weight expressed as percent live weight ranged from 76.26 to 89.20. Chickens fed diet VI (100% CWM) recorded a significantly ($p<0.05$) higher value than those fed other dietary treatments. However, there was no significant difference ($p>0.05$) between other dietary treatments.

The carcass relative composition (%) showed various significant differences ($p<0.05$) between treatment means without following a specific trend. The neck and back values were respectively highest (8.93, 21.42) in diet IV (50%POM;50%CWM) chickens. The values, though similar to those fed control diet (100%FM), were significantly ($p<0.05$) different from other dietary treatments. Also, the breast meat value for diet IV chickens was significantly ($p<0.05$) higher (24.00) than other dietary treatments but those fed diets III, IV and VI were respectively similar ($p>0.05$). In respect of the drumstick value, similarities were observed between chickens fed diets II, IV, V, VI and also those of I, III, IV, V accordingly.

The weight of the gizzard showed similarity between treatments except for dietary treatments III which was significantly ($p<0.05$) different from others. In the case of heart, it was treatment I (control) that differed ($p<0.05$) from others. There were no significant difference ($p>0.05$) in liver size between chickens fed diets I, II, III and IV respectively.

**TABLE 24: CARCASS CHARACTERISTICS OF BROILER CHICKEN FED A COMBINATION OF POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL AS A REPLACEMENT FOR FISH MEAL**

| Variables | Treatments<br>100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
|---|---|---|---|---|---|---|---|
| Live weight (kg) | 1.71 | 1.80 | 1.63 | 1.76 | 1.56 | 1.68 | 0.03 |
| Defeathered weight (%) | $83.58^{c}$ | $90.15^{b}$ | $95.38^{a}$ | $87.30^{bc}$ | $86.88^{bc}$ | $95.19^{a}$ | 1.28 |
| Eviscerated weight (%) | $76.26^{b}$ | $80.72^{b}$ | $81.54^{b}$ | $78.87^{b}$ | $80.42^{b}$ | $89.20^{a}$ | 1.63 |
| **Carcass relative composition (%)** | | | | | | | |
| Neck | $7.70^{ab}$ | $6.88^{b}$ | $7.55^{ab}$ | $8.93^{a}$ | $6.41^{b}$ | $6.71^{b}$ | 0.40 |
| Back | $19.62^{ab}$ | $18.90^{b}$ | $18.09^{b}$ | $21.42^{a}$ | $18.00^{b}$ | $14.41^{c}$ | 0.53 |
| Breast | $17.61^{cd}$ | $22.33^{b}$ | $18.86^{c}$ | $16.01^{c}$ | $24.00^{a}$ | $18.44^{cd}$ | 0.37 |
| Wings | $17.50^{cd}$ | $17.19^{d}$ | $18.87^{b}$ | $21.78^{a}$ | $18.21^{bc}$ | $16.24^{c}$ | 0.27 |
| Thigh | $17.31^{ab}$ | $18.91^{a}$ | $15.47^{b}$ | $16.08^{b}$ | $12.20^{c}$ | $13.42^{c}$ | 0.52 |
| Drumstick | $15.39^{a}$ | $13.92^{b}$ | $15.47^{a}$ | $14.29^{ab}$ | $14.32^{ab}$ | $13.42^{b}$ | 0.36 |
| Gizzard | $2.66^{b}$ | $2.55^{b}$ | $3.44^{a}$ | $2.51^{b}$ | $2.80^{b}$ | $2.86^{b}$ | 0.11 |
| Liver | $1.31^{bc}$ | $1.72^{ab}$ | $1.26^{bc}$ | $1.79^{ab}$ | $2.01^{a}$ | $1.07^{c}$ | 0.16 |
| Heart | $0.97^{a}$ | $0.42^{b}$ | $0.83^{a}$ | $0.43^{b}$ | $0.44^{b}$ | $0.44^{b}$ | 0.06 |
| Abdominal Fat | $0.43^{c}$ | $1.14^{b}$ | $1.29^{b}$ | $1.11^{b}$ | $1.85^{a}$ | $0.68^{c}$ | 0.11 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

## 4.4 DISCUSSION

### 4.4.1 PERFORMANCE CHARACTERISTICS

The broiler chickens fed with 100%CWM consumed a significantly less quantity of feed than others both at the starter and finisher phases thereby gaining the corresponding least weight. Conversely, diet V chickens (25%POM;75%CWM) which consumed most at the two phases also gained best, though not statistically significant. This result is in agreement with Ojewola *et al*, (2005) as well as Fanimo *et al*, (1996) who reported a reduced weight gain when increased quantity of shrimp waste meal was consumed by broiler chickens.

The non-significant differences that were observed in feed conversion ratio and protein efficiency ratio further indicated the extent of feed and protein utilisation respectively, because it relates protein intake to body weight gain.

### 4.4.2 BLOOD METABOLITES AND SERUM ENZYMES

Past and contemporary reports (Ikegwuonu and Basir, 1976; Olorode *et al*, 1996) revealed that blood is very vital to life and before any meaningful work can be done on the biology of birds, detailed haematology is imperative. This is because any abnormal variation in the haematology of the cell would affect the primary physiological function of the animal body. In this study, the non-significance of the results obtained for PCV, Hb, RBC, MCV, MCH and MCHC respectively between treatment means, is an indication of the uniform quality of the test diets and particularly that the values fell within the normal range as established by Mitruka and Rawnsley (1977) and Ross *et al* (1978). For the WBC, the significant difference observed treatment IV (50%POM;50%CWM) and others could be due to the interaction effect of different protein sources.

The total serum proteins represent the sum of different proteins which may vary independently of each other. They consist of the various fractions of albumins and globulins. These blood proteins have been used as indicators of protein nutrition. Keyser *et al*, (1968) observed a close relationship between dietary and serum protein concentrations. The total serum protein in the study was not significantly different between treatment means except for dietary treatment III (75%POM25%CWM) which was significantly lower than treatments II, IV and VI. Albumin fractions were not significantly different between treatments. The serum creatinine levels apart from being useful as an indirect measure of protein utilisation (Eggum, 1970) can also be used as an index of muscle wastage (Martin *et al*, 1981). The creatinine fractions in this study were also similar but for the control (100%FM) that was significantly higher than others. The values fell within the normal range for chickens (Mitruka and Rawnsley, 1977) which indicated adequate nutrition.

The results of serum Glutamic oxaloacetate trasaminase (SGOT) and Serum Glutamic pyruvic transaminase (SGPT) did not show significant difference between dietary treatments. It is however notable that the SGOT values increased marginally from treatment I (control) up to treatment V (25%POM;75%CWM) which is partly supported by the reports of Eggum (1976) on the activities of GPT and GOT in the liver that, the enzyme GOT showed highest activity with high quality protein whereas the GPT decreased linearly with increasing biological value of the protein fed.

### 4.4.3 CARCASS CHARACTERISTICS

The similarities in the carcass values between most of the dietary treatments indicate the uniformity of the diets. The breast muscles and drumstick are the most economically important portion of the carcass and also provide the greatest portions of edible meat in broilers (Smith and Teeter, 1987). The relative muscle weights of these two cuts were not significantly different which confirms the findings of Rosenfeld *et al*, (1997) when shrimp waste meal was used to replace soyabean meal and Salami and Oyewole (1997).

The sizes of the liver, gizzard, heart and abdominal fat respectively, were similar to earlier reports (Fanimo *et al*, 1996; Mohammed *et al*, 2009). The use of the proteins in the diets therefore is not considered a health risk.

# CHAPTER FIVE

## EFFECTS OF REPLACING FISHMEAL WITH POULTRY OFFAL MEAL AND CRAYFISH WASTE MEAL ON LAYING PERFORMANCE AND EGG QUALITY

### 5.1 INTRODUCTION

Sufficient protein nutrition has been hinged on the availability of meat and eggs. It is not only the availability but that they are affordable. An attempt therefore to find alternative to expensive feed ingredients will bring down the cost of feed and by implication the cost the products. With this, there would be increased hope of meeting the FAO (1998) recommendation of 65g of animal protein per caput per day. Poultry enterprise entails the production of meat and eggs. It is known that broiler production is about the former while eggs are derived from layers. The last study (chapter four) assessed the use of shrimp waste meal and poultry offal meal as replacement for fish meal in the diet of broiler chickens. It was assumed that some of the dietary treatments in the previous study would be distinctly better than others. If that had been true, these dietary treatments would subsequently be tested on laying birds. However, none of the dietary treatments in chapter four out-performed the other in the parameters considered. It was therefore reasonable that all the dietary treatments tested in the broiler study (chapter four) should be tried on the performance of layers. This study was therefore designed to assess the production performance and egg quality parameters in laying birds.

## 5.2 MATERIALS AND METHODS

### 5.2.1 EXPERIMENTAL SITE

The study was carried out on Adenuga poultry farm, Gberigbe near Ikorodu, Ikorodu Local Area, Lagos State.

### 5.2.2 TREATMENT OF TEST INGREDIENTS

Poultry offal collected from poultry processing farm was treated by wet rendering as described in Chapter 4.

Crayfish wastes collected from processing farm were dried and milled as described in Chapter 3 above.

### 5.2.3 EXPERIMENTAL DIETS

The above test ingredients were used together with other ingredient to formulate diets to meet the NRC (1994) nutrient requirement of layers.

### 5.2.4 MANAGEMENT OF EXPERIMENTAL BIRDS

One hundred and eight black harco pullets were randomly allotted to six experimental diets. Each dietary treatment was further divided into three (3) replicates of six birds each. Three (3) birds were housed in each unit of the battery cages equipped with feeders and nipple drinkers. The birds were offered the experimental diets and water adlibitum.

### 5.2.5 RECORDS OF PARAMETERS

**i. Average initial body weight:** This is the total weight of the birds per replicate at the beginning of the experiment.

**ii. Average final Body weight:** This is the total body weight of birds per replicate at the end of the 13$^{th}$ week.

**iii. Average Body weight change:** Final weight – initial weight. This was recorded at the end of the 13$^{th}$ week.

**iv. Average dry matter intake:** This was recorded as the total feed consumed per bird. Measurement was at the end of every week for the duration of the study.

**v. Dozen egg per kilogram feed:** Total dozen of eggs produced per one kilogram of feed consumed per number of birds, measured at the end of the study.

**vi. Percentage Hen day production:** Total number of eggs produced (expressed in percentage) per number of birds. This was recorded at the end of the study.

**vii. Egg number:** Total number of eggs produced per total number of birds in a treatment recorded at the end of the study.

### 5.2.6 MEASUREMENTS

Measurements of the egg quality traits were carried out within twenty-four hours after collection. Measurement of external quality traits of the eggs were carried out before the broken-out quality measurements were taken.

#### 5.2.6.1 Measurement of external quality traits

The following tests were carried out for all the eggs on an individual basis.

**i. Egg weight:** Individual egg weight was measured to the nearest 0.0g using a sensitive electronic balance.

**ii. Egg shape index:** For this purpose, egg length and breadth were measured to the nearest 0.01mm using a vernier caliper. Egg length was taken as the distance between the broad and narrow ends of the egg.

#### 5.2.6.2 Measurement of internal quality traits

Four eggs per treatment were randomly selected from the total eggs collected per week for measurement of internal quality of eggs and shell thickness. Albumen height was determined by using spherometer. The measurement was taken at the albumen widest expanse and midway between the yolk edge and the external edge of the thick albumen. Haugh Unit (HU) was determined by the formula below:

$$HU = 100 \log (H + 7.57 - 1.7 W^{0.75})$$

Where H = height of albumen (mm)

W = weight eggs (gram)

Immediately the inner content of eggs was evacuated from the shell, the thin membrane was carefully removed. The empty shell was air dried for a few minutes. Shell thickness was thereafter determined using micrometer screw gauge. It was taken at three points, the broad, equatorial and narrow ends; the average was recorded as shell thickness. Yolk index is a ratio of yolk height and yolk length.

### 5.2.7 STATISTICAL ANALYSIS

All data generated were subjected to analysis of variance using SAS statistical package SAS (2003). The design employed was completely randomized and significant treatment means were separated using Duncan Multiple Range Test of the same software.

Experimental design. The experiment was designed as a complete randomized design.

**TABLE 25: COMPOSITION OF LAYERS DIET CONTAINING CRAYFISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

| Ingredients | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM |
|---|---|---|---|---|---|---|
| Maize | 51.20 | 51.20 | 51.20 | 51.20 | 51.20 | 51.20 |
| Wheat Offal | 9.00 | 8.20 | 8.23 | 8.23 | 8.23 | 8.23 |
| Palm kernel meal | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Groundnut Meal | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 |
| Soya Meal | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Fish Meal (65%) | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Poultry offal meal | 0.00 | 2.65 | 1.99 | 1.33 | 0.66 | 0.00 |
| Cray fish waste meal | 0.00 | 0.00 | 0.93 | 1.86 | 2.79 | 3.72 |
| Lysine | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Methionine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Limestone | 8.25 | 8.20 | 7.95 | 7.70 | 7.57 | 7.50 |
| Bone Meal | 1.35 | 1.55 | 1.50 | 1.40 | 1.35 | 1.25 |
| Salt | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Composition (%)** | | | | | | |
| Crude Protein | 17.03 | 16.98 | 16.97 | 16.96 | 16.93 | 16.91 |
| ME (Kcal/kg) | 2600.48 | 2600.42 | 2597.35 | 2593.71 | 2539.81 | 2584.30 |
| Available Calcium | 3.55 | 3.52 | 3.50 | 3.50 | 3.50 | 3.53 |
| Available phosphorus | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 |
| Crude Fibre | 4.96 | 4.91 | 1.97 | 5.02 | 5.07 | 5.11 |
| Ether Extract | 3.95 | 4.15 | 4.10 | 4.04 | 3.99 | 3.93 |

POM = Poultry offal meal

CWM = Crayfish waste meal

FM = Fish Meal

## 5.3 RESULTS

### 5.3.1 PERFORMANCE CHARACTERISTICS

Presented in Table 27 are the performance characteristics of laying chickens fed combinations of crayfish waste meal and poultry offal meal as replacement for fishmeal.

The average weight gain ranged between 0.09kg in chickens fed diets II (100%POM) and VI (100%CWM) and 0.11kg .in those fed diets V (25%POM;75%CWM) and control (100%FM) respectively. There were no significant differences (p.>0.05) between the treatment means. Similarly, the dry matter intake were not significantly (p.>0.05) different. The least intake (0.75kg) was recoded by diet II chickens (100%POM) while those fed 100%CWM consumed most (0.78kg). The control diet (100%FM) was significantly (p.<0.05) more expensive (N42.33 per kilogram) than others. However, the cost of other diets were similar (p.>0.05). The Hen day production (%) ranged between 91.15 in chickens fed control diet (100%FM) and 88.16 in treatment IV chickens (50%POM;50%CWM). No significant differences (p.>0.05) were observed between treatment means. Also, the number of dozen eggs per bird which was highest (6.99) in chickens fed control diet and least (6.85) in diets II (100%POM) and III (75%POM;25%CWM) chickens respectively, were not significantly different (p.>0.05) between treatment means.

The egg weight recorded significant differences (p.<0.05) between the control chickens (55.49g) and those fed diet IV (50%POM;50%CWM) which weighed 53.88grammes. No significant differences (p.>0.05) were observed between other dietary treatment means.

**TABLE 26: PERFORMANCE CHARACTERISTICS OF LAYERS FED WITH CRAYFISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISHMEAL**

| | Diets | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameters | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
| Ave. Initial Live weight (Kg) | 1.51 | 1.50 | 1.49 | 1.49 | 1.51 | 1.49 | 0.01 |
| Ave. Final Live weight (Kg) | 1.62 | 1.59 | 1.59 | 1.59 | 1.62 | 1.58 | 0.01 |
| Ave. Weight Gain (Kg) | 0.11 | 0.09 | 0.10 | 0.10 | 0.11 | 0.09 | 0.01 |
| Dry matter Intake/bird /wk (Kg.) | 0.76 | 0.75 | 0.76 | 0.76 | 0.76 | 0.78 | 0.02 |
| Feed Cost (N)/Kg | $42.33^{a}$ | $34.54^{b}$ | $34.51^{b}$ | $34.47^{b}$ | $34.44^{b}$ | $34.40^{b}$ | - - |
| Feed Cost/bird/wk. (N) | 32.17 | 25.91 | 26.23 | 26.18 | 26.17 | 26.83 | |
| Egg Production (% Hen day) | 91.15 | 89.87 | 90.24 | 88.16 | 90.68 | 88.19 | 0.52 |
| No of dozen eggs/bird | 6.99 | 6.85 | 6.85 | 6.97 | 6.95 | 6.95 | |
| Mortality (%) | 0.00 | 5.05 | 5.05 | 0.00 | 0.00 | 0.00 | - - |
| Egg Weight (g) | $55.49^{a}$ | $55.02^{ab}$ | $54.16^{ab}$ | $53.88^{b}$ | $54.34^{ab}$ | $54.62^{ab}$ | 0.050 |

*POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

$^{abc}$: Means in the same row with different superscripts are significantly different ($p<0.05$)

### 5.3.2 EGG QUALITY PARAMETERS

The data on egg quality parameters of laying chickens fed combinations of crayfish waste meal and poultry offal meal as replacement for fishmeal are shown in Table 28.

The mean egg weight was similar (p.>0.05) among treatment means except for those of diet I (100%FM) which was significantly (p. < 0.05) heavier (55.49g) than diet III (53.88g) eggs. For egg length (cm), value ranged from 5.48 to 5.54. Differences among treatment means was not dietary related. Similarity (p.>0.05) was observed for layers fed diets I, V and VI as well as those of II, III and IV. Egg width (cm) for layers fed diet II (100%POM) was significantly (p. < 0.05) higher than others. However, other dietary treatments were similar (p. > 0.05). No significant differences (p.> 0.05) were observed among treatment means in the Egg surface area ($cm^2$).

The internal qualities of eggs laid by experimental birds were similar (p. > 0.05) among the treatment means. Yolk length (cm) ranged from 3.98 in diet IV (50%POM;50%CWM) to 4.04 in the control (100%FM) group. Similar trend was also observed with Yolk weight (g). Layers fed diet II (100%POM) recorded the highest Yolk height (1.74cm) while those fed diet V (25%POM;75%CWM) had the least (1.59cm). For Yolk index, the latter birds had the highest value (41.35) when those fed 100%CWM had the least (40.35). Noticeable differences in Albumen height (mm) and, like other parameters was not diet-influenced. The range was 7.93 (diet II) to 8.04 (diet V). The Egg shell thickness (mm)of experimental layers also ranged between 0.35 in diet IV and V birds respectively and 0.37 in those fed diet III (75%POM;25%CWM). The Haugh unit value was highest (98.24) in eggs of diet V while those of diet II (100%POM) recorded the least (97.78).

The weekly performance of experimental layers in egg quality parameters are further illustrated in figures 1 to 13.

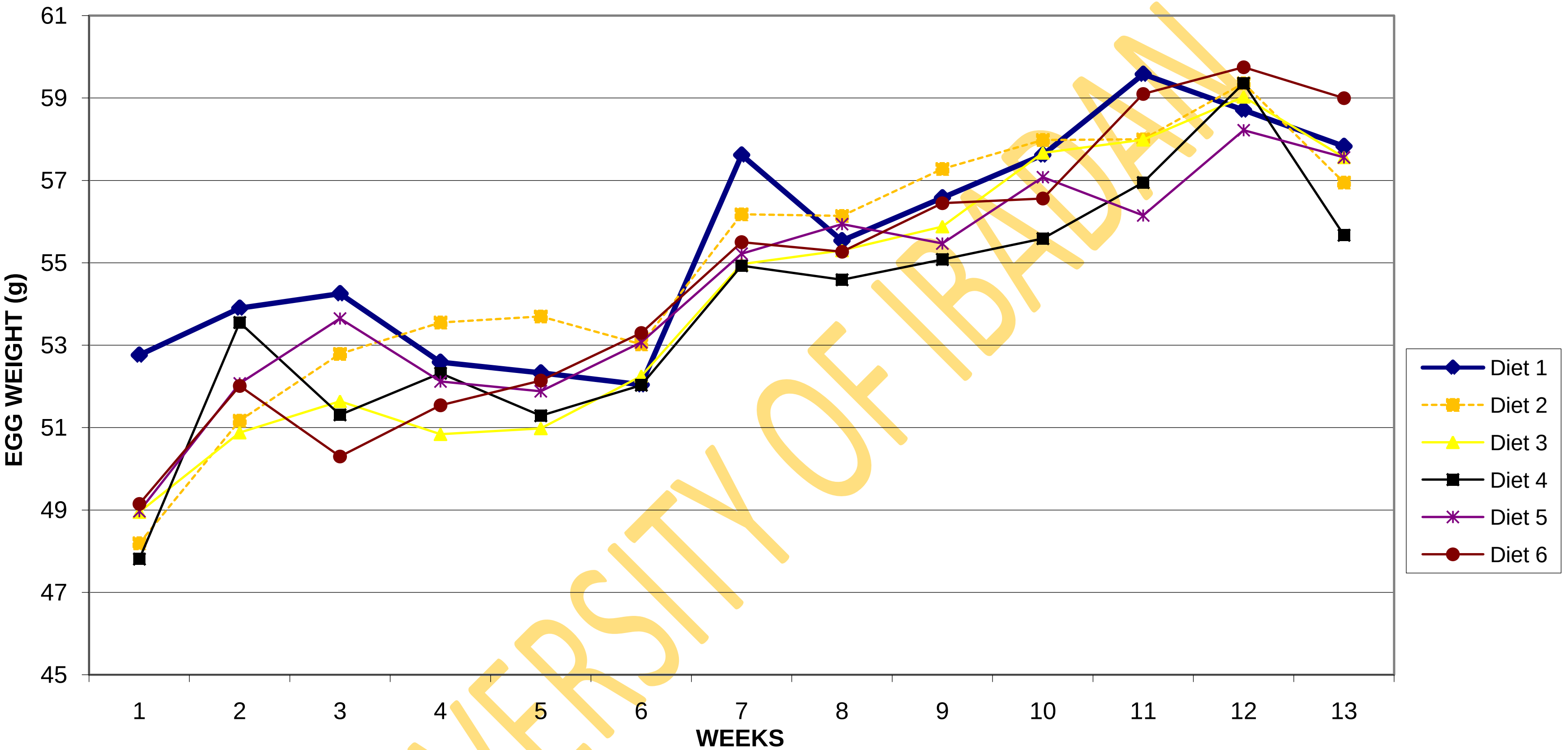


**FIG 1: EGG WEIGHT OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

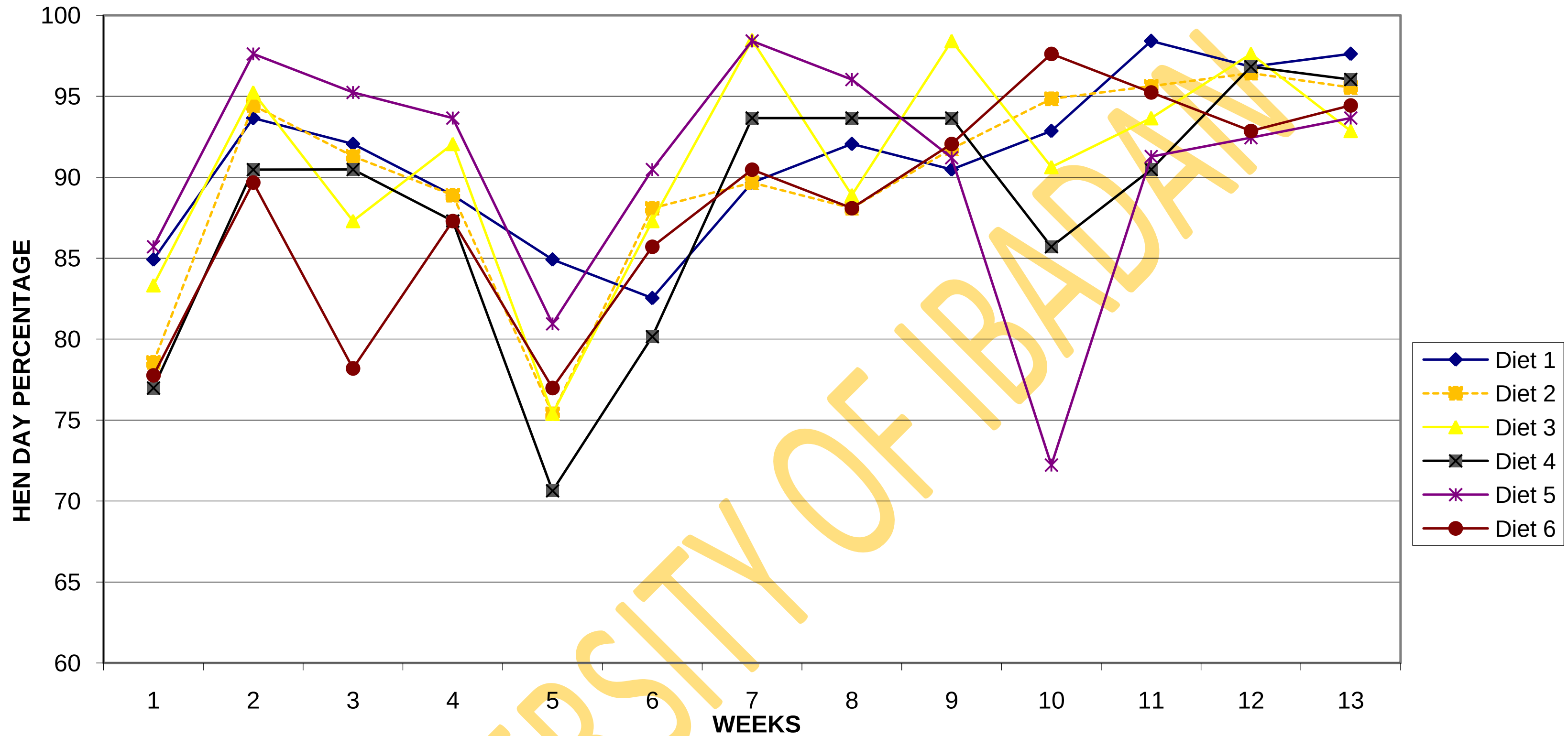


**FIG 2: HEN DAY OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

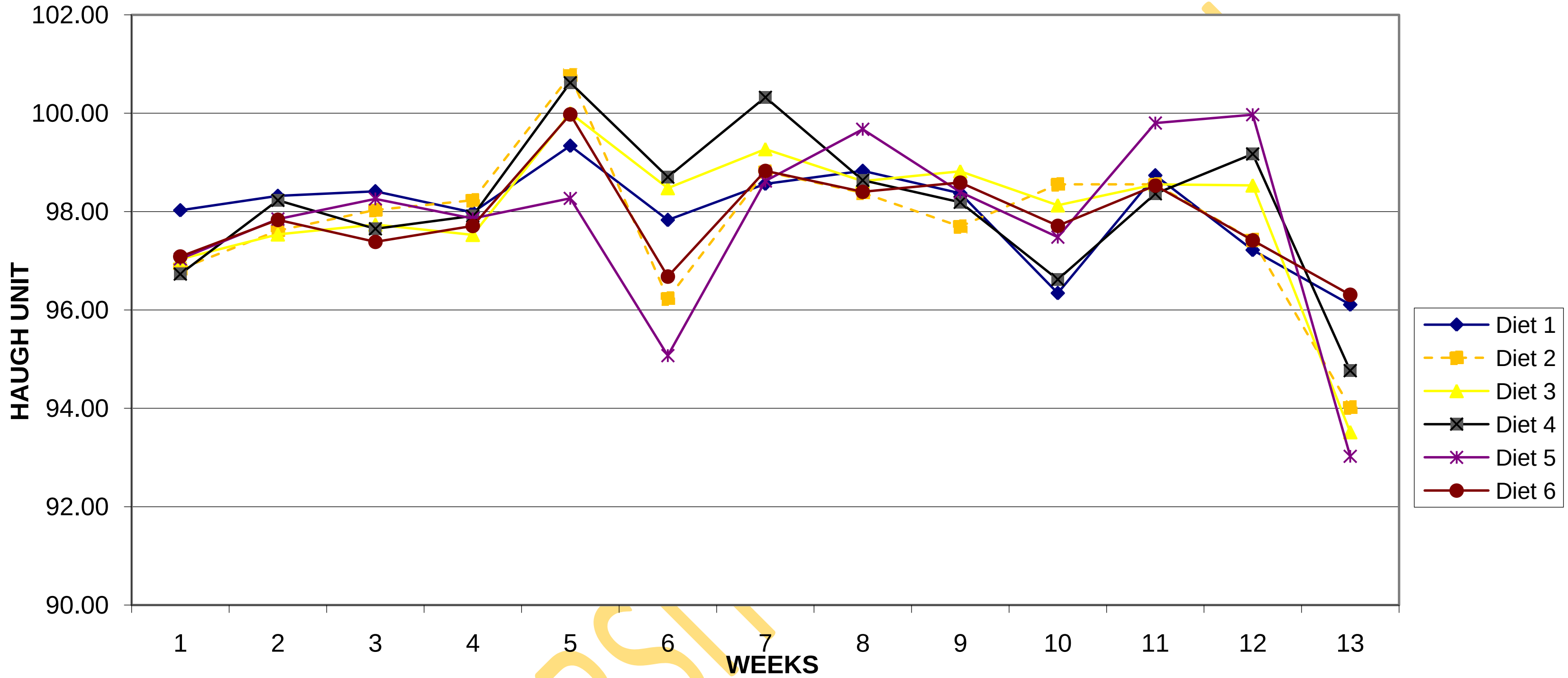


**FIG 3: HAUGH UNIT OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

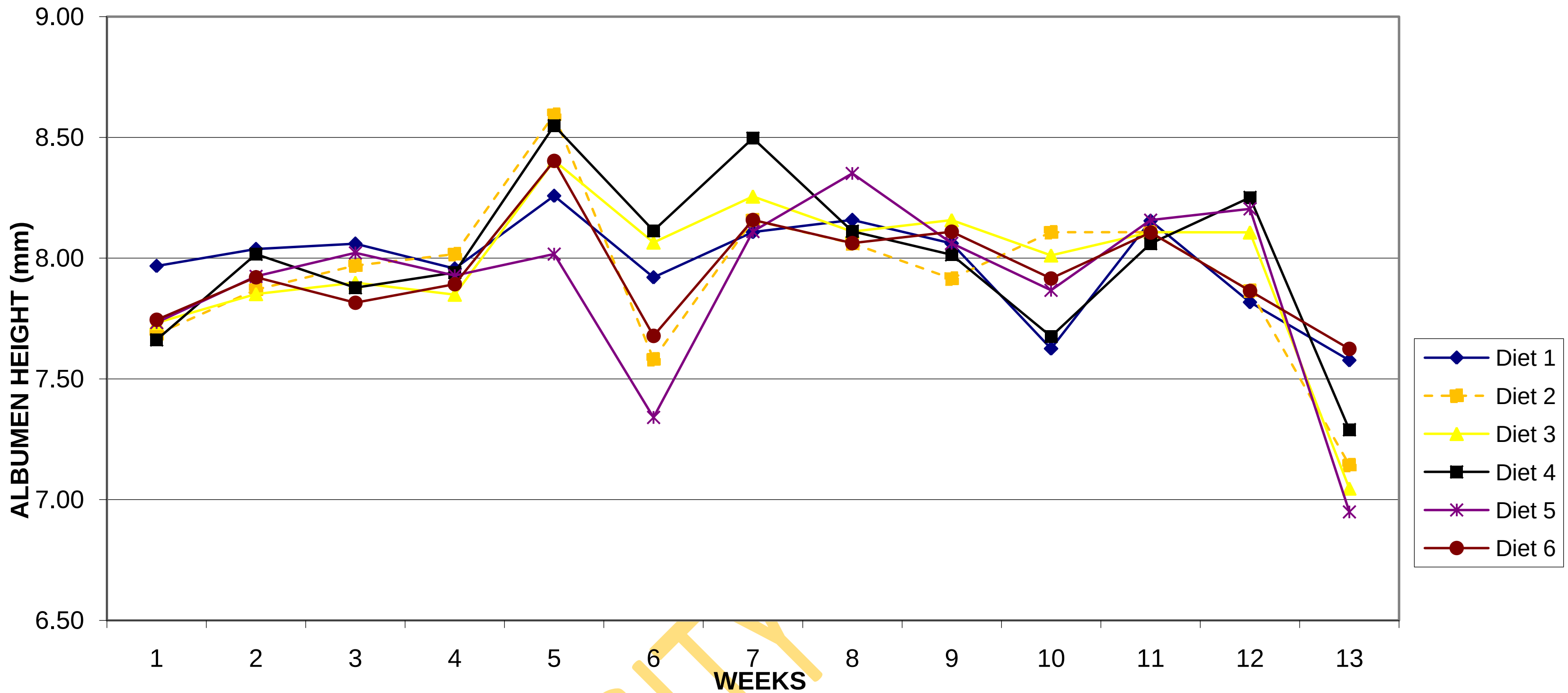


**FIG 4: MEAN WEEKLY ALBUMEN HEIGHT OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

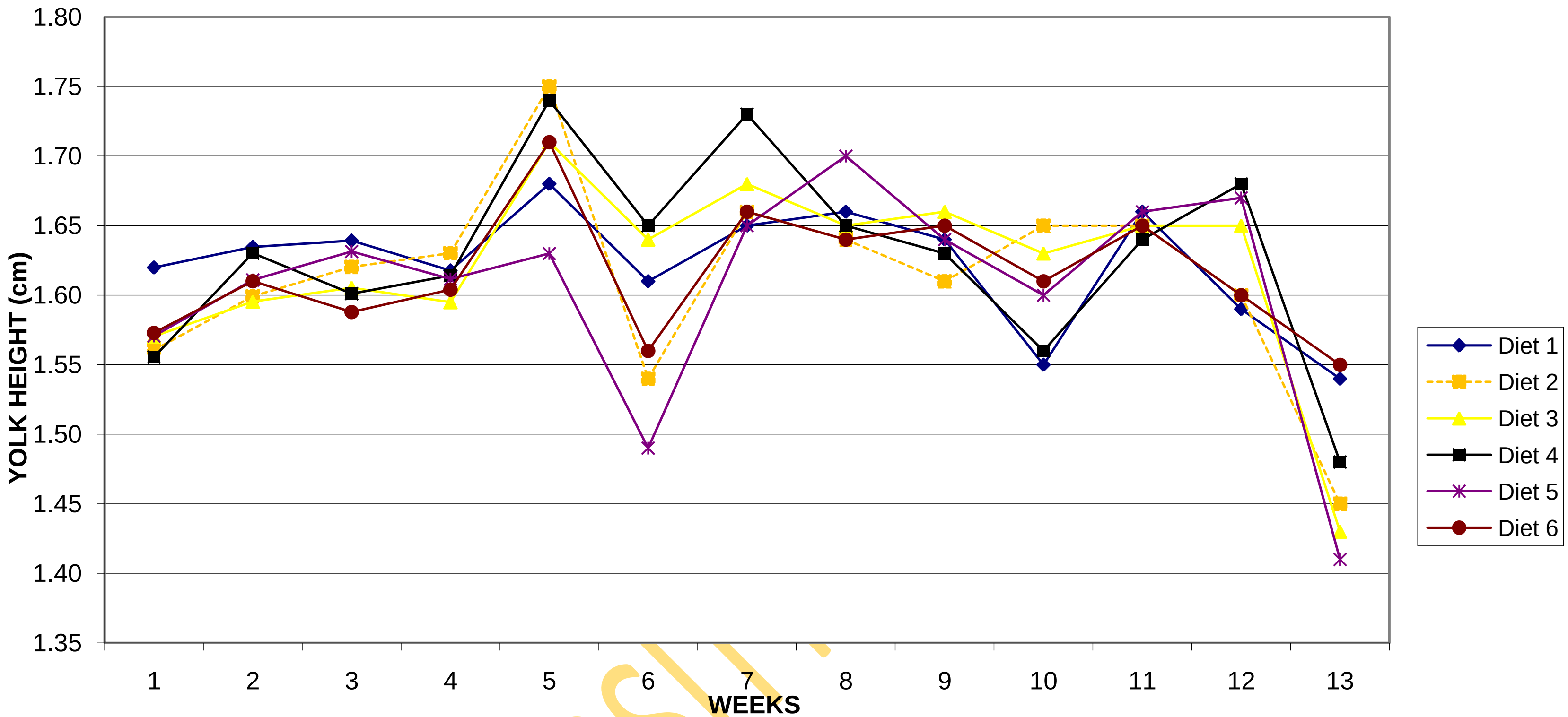


**FIG 5: MEAN WEEKLY YOLK HEIGHT OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

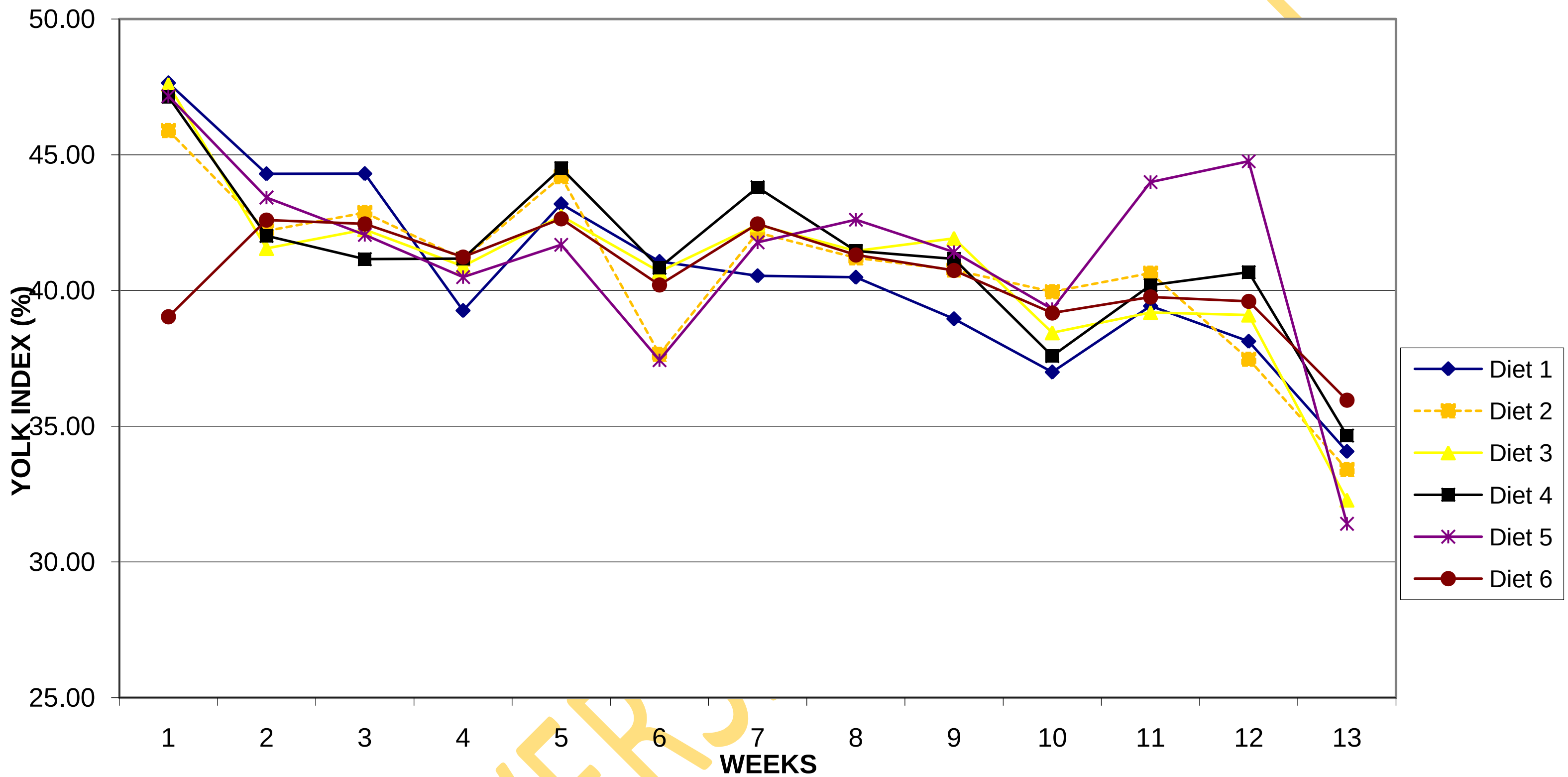


**FIG 6: MEAN WEEKLY YOLK INDEX OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

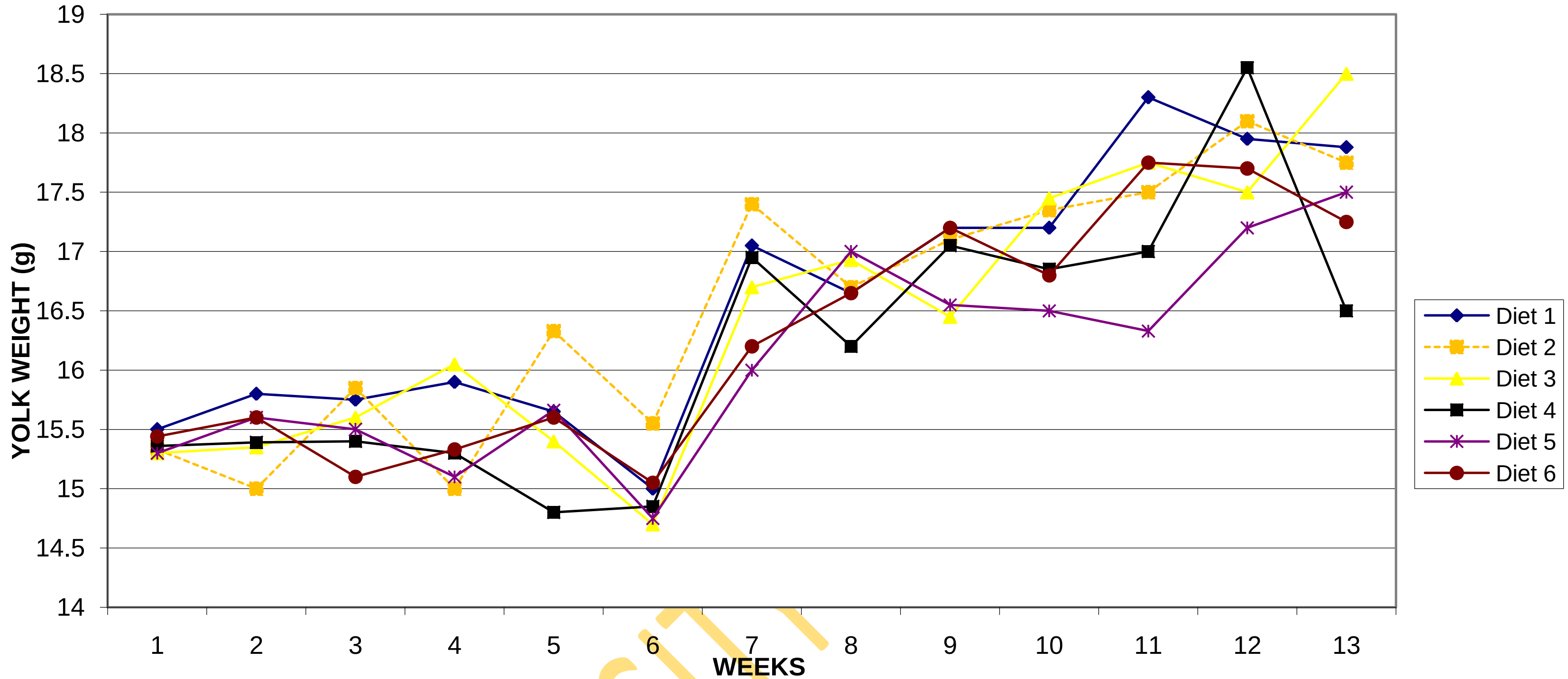


**FIG 7: MEAN WEEKLY YOLK WEIGHT OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

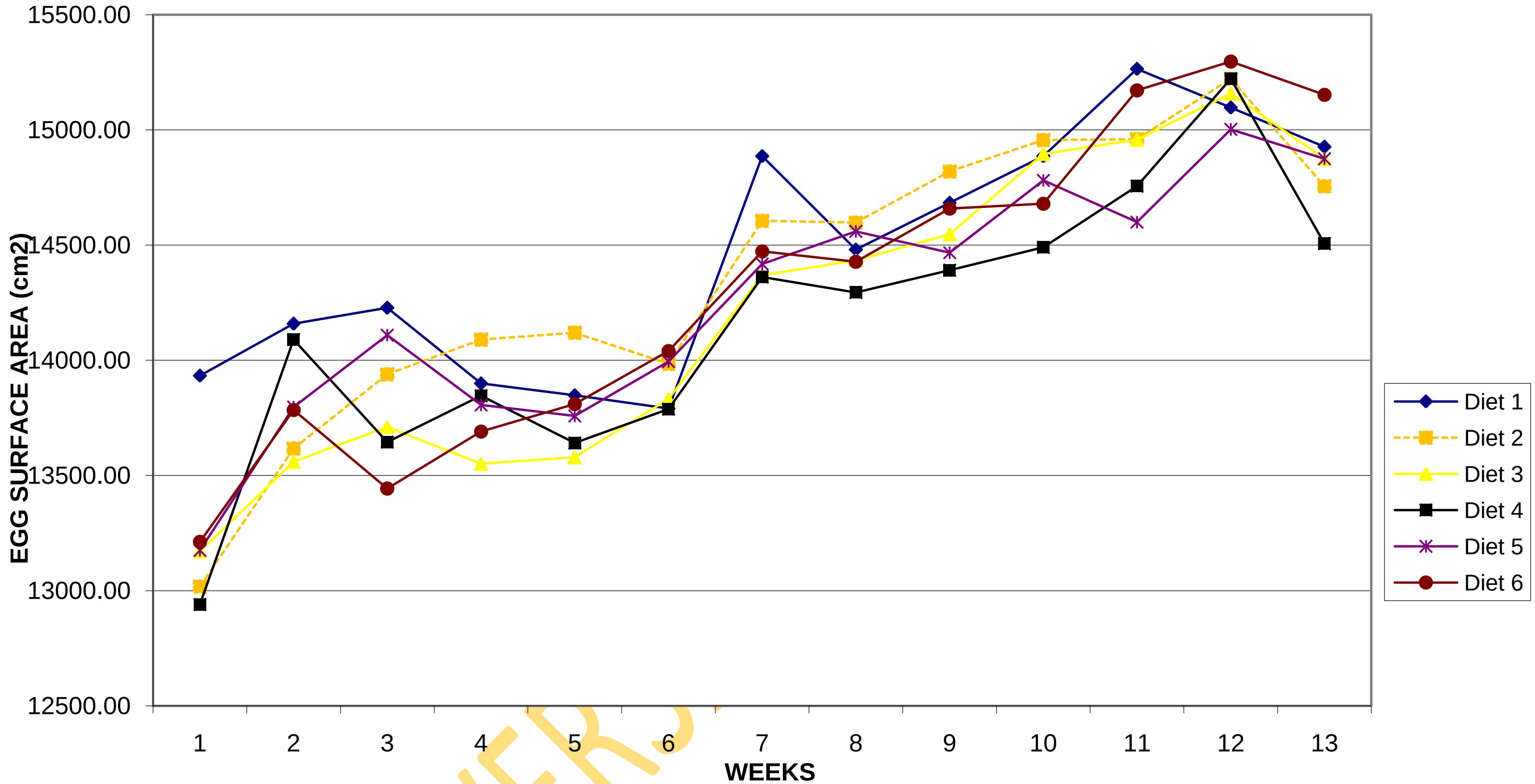


**FIG 8: MEAN WEEKLY EGG SURFACE AREA OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

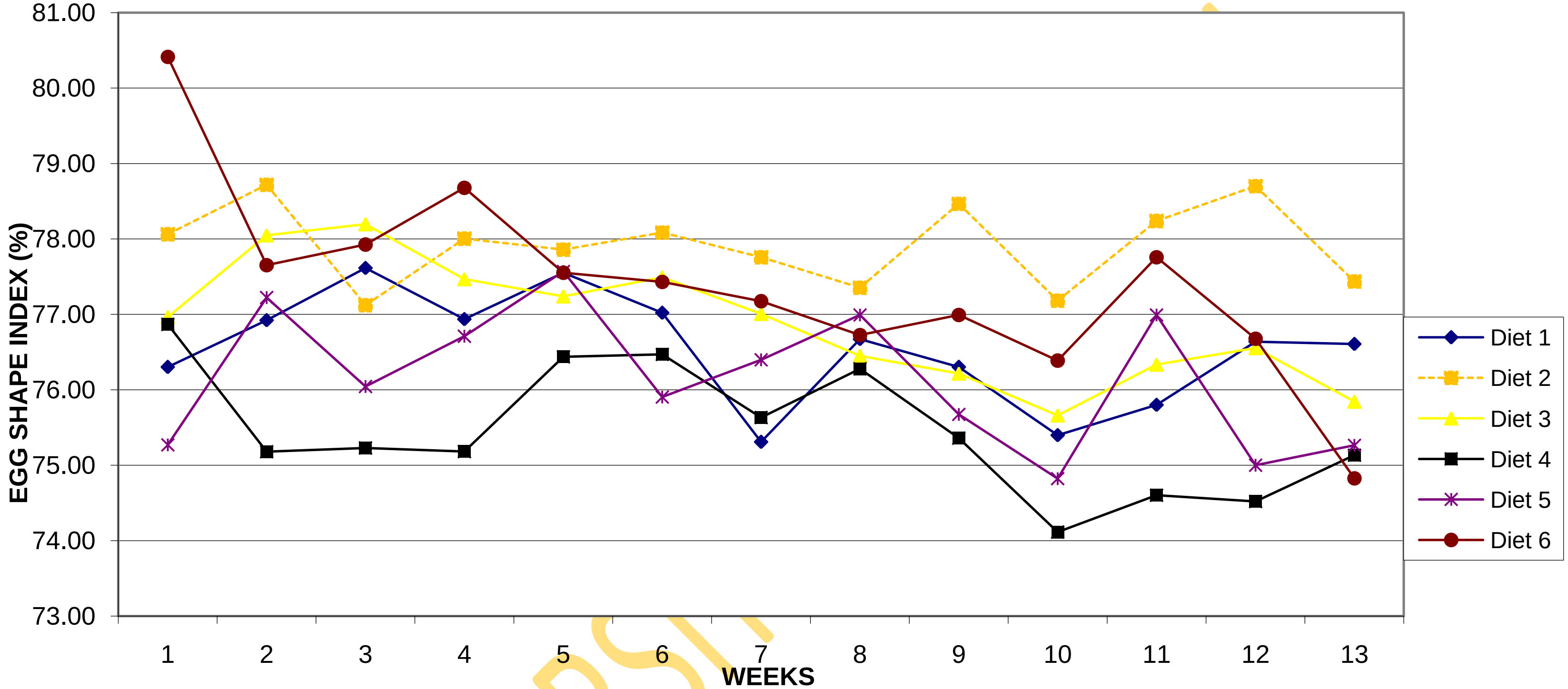


**FIG 9: MEAN WEEKLY EGG SHAPE INDEX OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

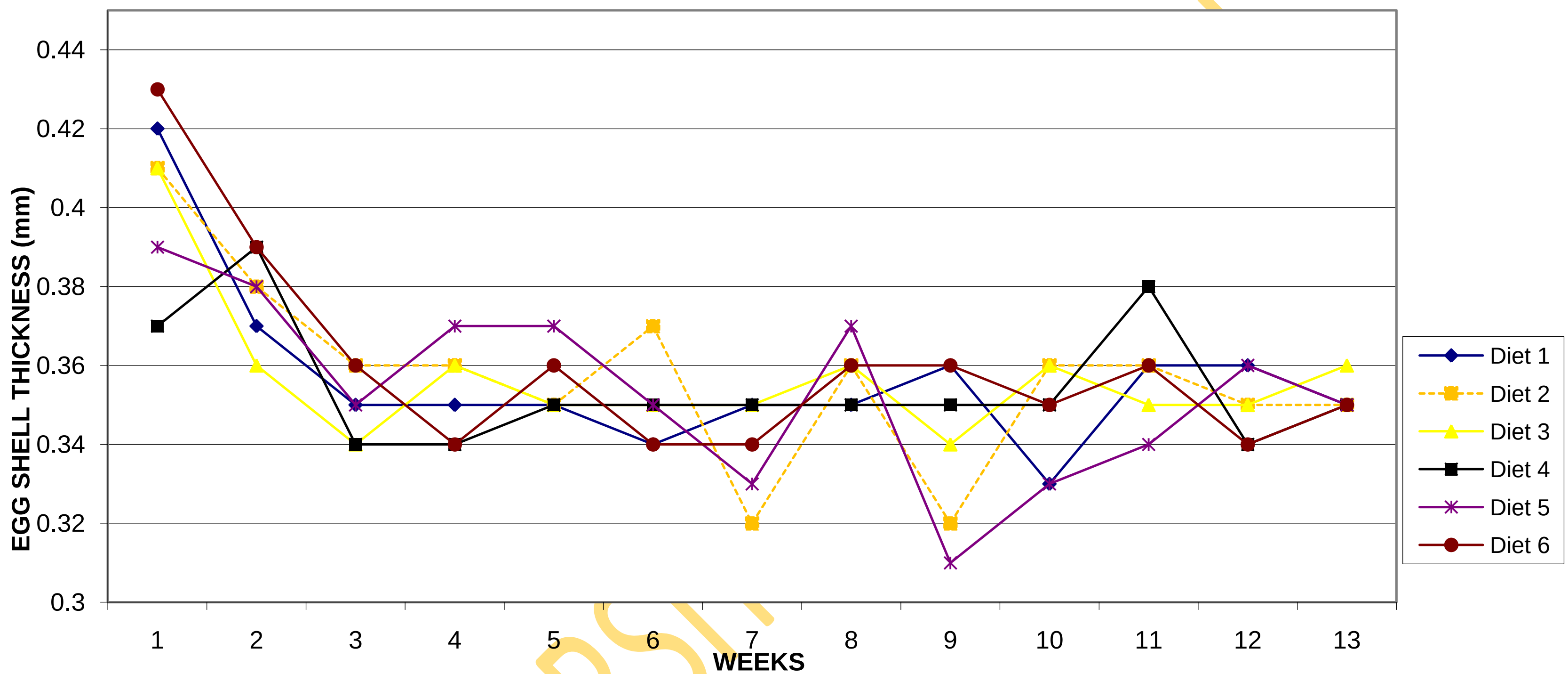


**FIG 10: MEAN WEEKLY EGG SHELL THICKNESS OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

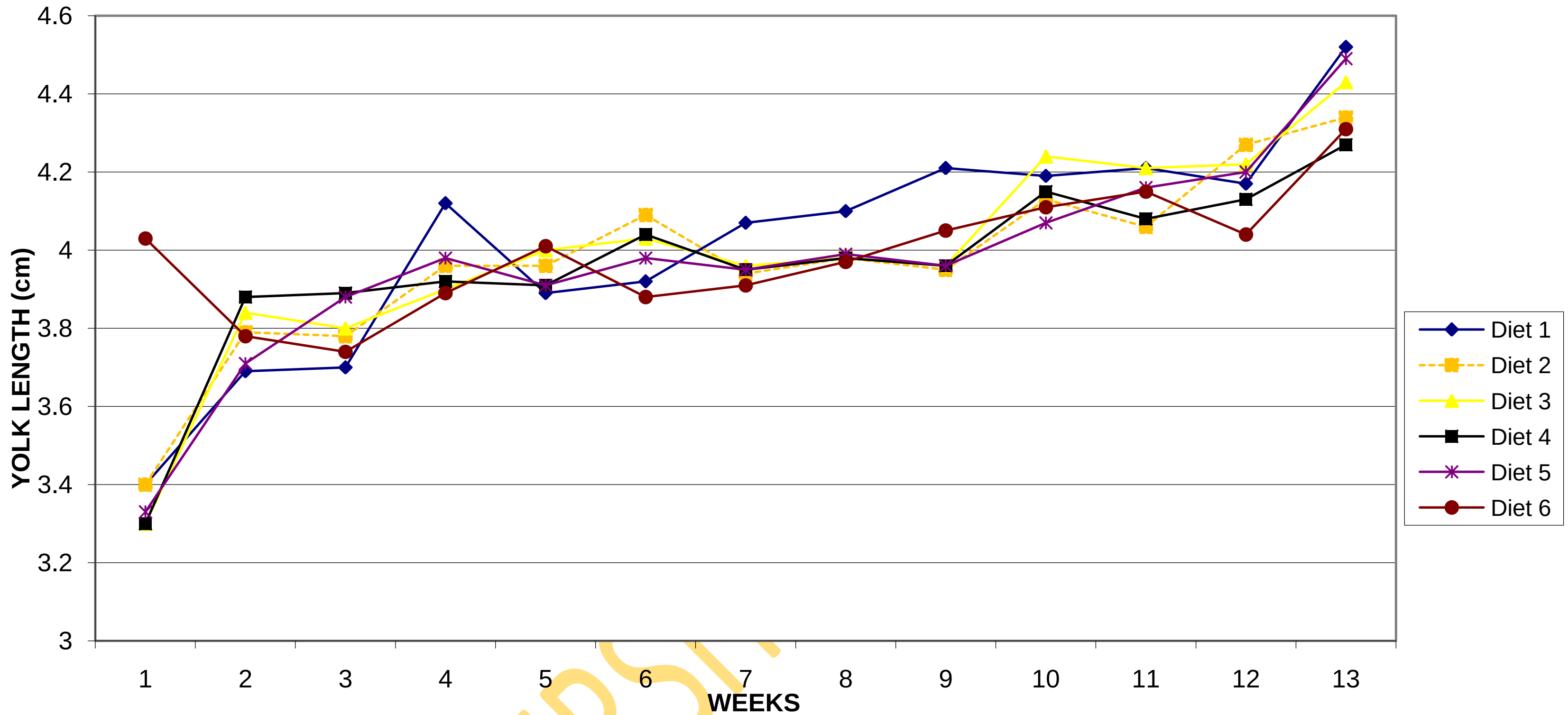


**FIG 11: MEAN WEEKLY YOLK LENGTH OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

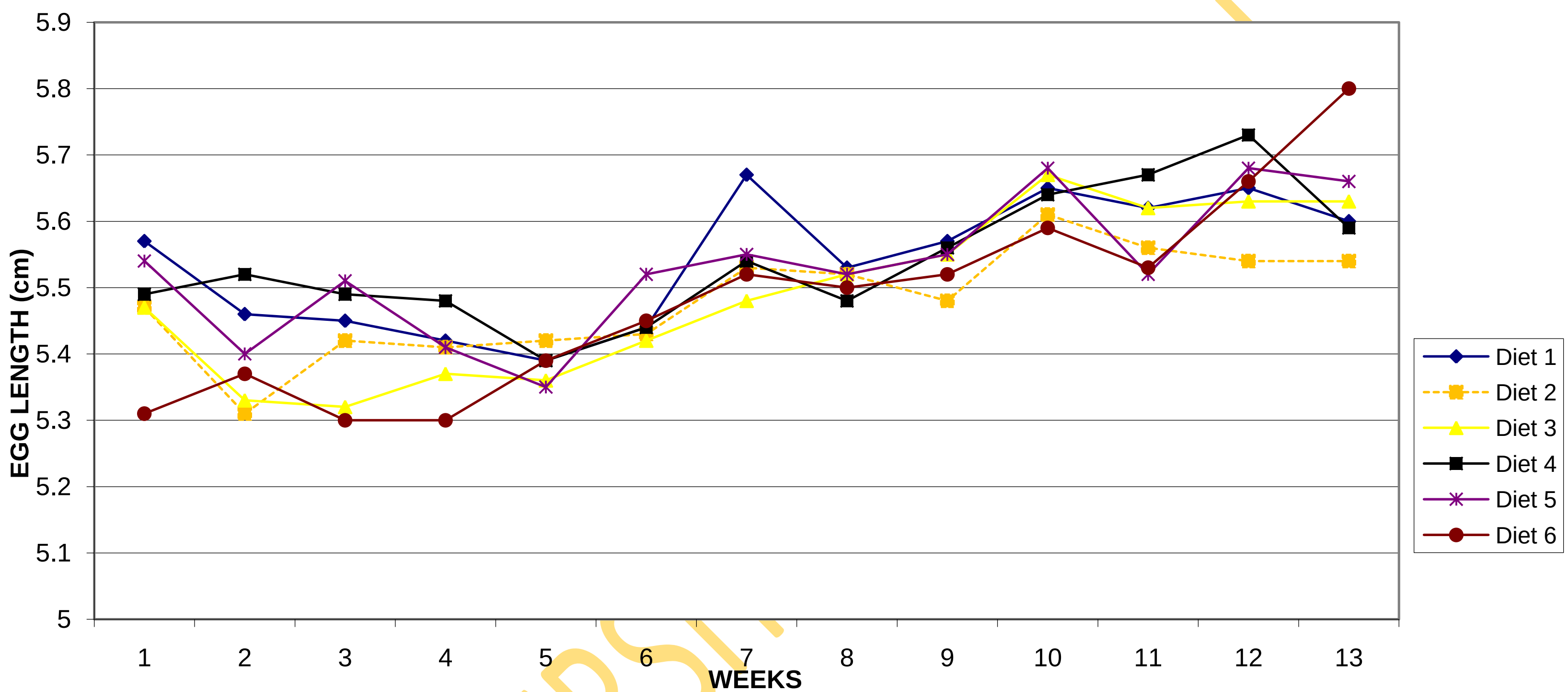


**FIG 12: MEAN WEEKLY EGG LENGTH OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

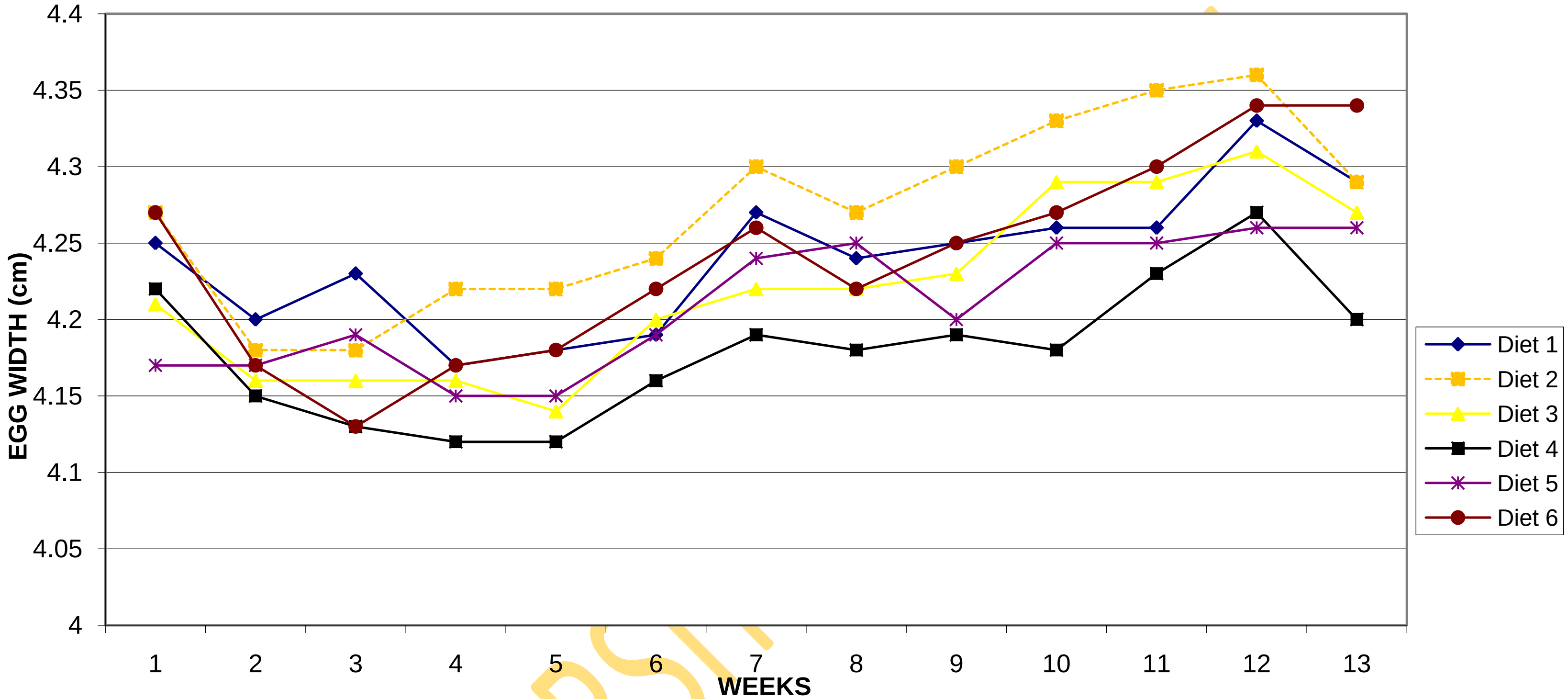


**FIG 13: MEAN WEEKLY EGG WIDTH OF LAYERS FED WITH CRAY FISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISH MEAL**

**TABLE 27: EGG QUALITY PARAMETERS OF LAYERS FED WITH CRAYFISH WASTE MEAL AND POULTRY OFFAL MEAL AS A REPLACEMENT FOR FISHMEAL**

| Parameters | Diets | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100% FM | 100% POM | 75% POM 25% CWM | 50% POM 50% CWM | 25% POM 75% CWM | 100% CWM | SEM |
| **External Qualities** | | | | | | | |
| Egg Weight | 55.49[a] | 55.02[ab] | 54.16[ab] | 53.88[b] | 54.34[ab] | 54.62[ab] | 0.050 |
| Egg Length (cm) | 5.54[a] | 5.48[b] | 5.49[b] | 5.49[b] | 5.54[a] | 5.53[a] | 0.006 |
| Egg Width (cm) | 4.24[b] | 4.27[a] | 4.22[b] | 4.18[b] | 4.21[b] | 4.24[b] | 0.001 |
| Egg Surface Area ($cm^2$) | 14468 | 14360 | 14203 | 14151 | 14257 | 14295 | 46.33 |
| **Internal Qualities** | | | | | | | |
| Yolk Length (cm) | 4.04 | 3.99 | 4.02 | 3.98 | 3.99 | 3.99 | 0.005 |
| Yolk weight (g) | 16.80 | 16.33 | 16.80 | 16.30 | 16.30 | 16.44 | 0.050 |
| Yolk Height (cm) | 1.62 | 1.74 | 1.63 | 1.64 | 1.59 | 1.63 | 0.008 |
| Yolk Ratio (%) | 30.27 | 29.71 | 31.08 | 30.26 | 29.99 | 30.14 | 0.188 |
| Yolk Index | 40.64 | 40.73 | 40.81 | 41.26 | 41.35 | 40.35 | 0.140 |
| Albumen Height (mm) | 7.98 | 7.93 | 7.97 | 8.00 | 8.04 | 7.95 | 0.016 |
| Egg shell Thickness (mm) | 0.35 | 0.36 | 0.37 | 0.35 | 0.35 | 0.36 | 0.001 |
| Unit Surface Shell Wt. ($mg/cm^2$) | 3.83 | 3.82 | 3.81 | 3.81 | 3.82 | 3.82 | 0.003 |
| Egg Shape Index | 76.54 | 77.92 | 76.88 | 75.46 | 76.14 | 77.40 | 0.360 |
| Haugh Unit | 98.01 | 97.78 | 97.98 | 98.15 | 98.24 | 97.88 | 0.069 |

POM = Poultry offal meal

CWM = Crayfish waste meal

SEM = Standard error of means

[abc]: Means in the same row with different superscripts are significantly different (P<0.05)

## 5.4 DISCUSSION

The absence of significant differences in the mean values obtained for most of the performance characteristics among treatment means implied that nutrients were similarly and effectively utilized for all diets. The hen-day production falls within the range reported in the tropics (Oluyemi and Roberts, 2001). The sustainance of body weight in all the dietary treatments is a corroboration of the good nutrient utilisation in all the diets.

The haugh unit which is an index of protein utilisation as well as the quality of laid eggs was not affected by dietary treatment. This observation reveals that the use of poultry offal meal and crayfish waste meal as replacement for fish meal in the diet of layers did not produce bad quality eggs during the laying period.

# CHAPTER SIX

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Four experiments were conducted to assess the replacement value of fishmeal by poultry offal and crayfish waste in poultry ration.

The first and second studies evaluated the potential of crayfish waste and poultry offal respectively in the replacement of fish meal on broiler chickens individually. At the third experiment, graded levels of crayfish waste meal and poultry offal meal were combined to replace fish meal in the diets of broiler chicken. Performance characteristics, nutrient digestibility, carcass characteristics, serum metabolites and haematology of birds were assessed. In experiment four, crayfish waste and poultry offal were combined at graded levels to replace fish meal in layers diets. External parameters and internal qualities of eggs as well as performance characteristics were evaluated.

In trial one, results indicated that;

- Crayfish wastes that were dried immediately after collection had the highest crude protein content.
- There were no significant difference between treatment means in performance and carcass characteristics as well as nutrient digestibility at both the starters and finisher phases.

In trial two;

- All dietary treatments were similar in performance characteristics at the starter phase.
- At the finisher's, chickens fed 75%POM;25%FM showed superiority over others in body weight gain. No significant difference was recorded with other parameters monitored.

In experiment three:

- Chickens fed 75%CWM;25%POM consumed more feed and gained more than those fed100%CWM.
- Chickens fed 100%CWM recorded a significantly higher eviscerated weight than others.

- Blood chemistry and haematology were within recommended range and did not significantly differ between dietary treatments.

In experiment four;

- Layers fed combination of crayfish waste and poultry offal meals at various levels performed as much as those that were fed fish meal (control) in performance characteristics, egg external parameters and haugh unit.

Therefore it can be concluded that combination of poultry offal meal and crayfish waste meal can successfully be used to replace fish meal in the diet of chicken (broiler and layers) without adverse effect on performance.

It is hereby recommended that poultry offal meal and crayfish waste meal should be used individually or in combinations to replace fish meal in the diet of chicken (broiler and layers) without adverse effect on performance.

# REFERENCES

Abohweyere, P.O. (1984): Population dynamics of Marine Shrimp resources. Annual Report of Nigeria Institute of Oceanography and): Marine Research. Pg 33.

Adair, L.S. and Kusawa, C.W. (2001). Early growth retardation and syndrome X: Conceptual and methodological issues surrounding the programming hypothesis. In; R. Martorell and F. Haschke, eds., Nutrition and Growth, New York.

Aduku, A.O. (1993). Tropical Feedstuff Analysis Table .Pp. 1 -2

Afifi, M.A. and Rasheed, A.A (1966). Slaughter and carcass studies on 12 week old Fayoumi and Rhode Island red birds. Poultry Science 61: 1131-1136

A.O.A.C. (1996). Association of Official Analytical Chemistry. Official methods of analysis, 16th ed. Gaitesburg;

Baker, D.H. (2009). Amino acid requirement of layers – a review. Amino Acids. 37(1): 29-41

Bhargava, K.K. and O'neil, J.B (1975). Composition and utilisation of poultry by-product and hydrolysed feather meal in broiler diets. Poultry Science. 54: 1511 – 1518.

Bjornstad, J.,Opstvedt, J. and Lunde, G. (1974). Unidentified growth factors in fish meal. Experiments with organic compounds in broiler diets. British Journal of Nutrition 15: 481-487.

Blair, R. (2008). A text book, Nurition and feeding of Organic Poultry. Cromwell Press, Trowbridge. United Kingdom.

Bolubasi, S.C., Celebi S. and Utlu, N. (2005). The effects of calcium and vitamin $D_3$ on plasma calcium and phosphorus, eggshell calcium and phosphorus levels of laying hens in late laying period. International Journal of Poultry Science 4(8): 600

Business Day (2004). Shell/USAID N266bn shrimp project on shaky start. *Business Day Newspaper*, December 13, 2004, vol. 3 (374): 1 – 2.

Caires, C.M.I., Fernandes, E.A., Fagundes, N.S., Carvalho, A.P., Maciel, M.P. and Oliveira, B.R. (2010). The use of animal byproducts in broiler feeds. Use of animal co-products in broilers diets. Revista Brasileira de Ciência Avícola **V**ol.12**(**1**)**

Caraway, W.T. (1963). Standard Methods of Clinical Chemistry .4: pg. 239 – 245.

Chaney, S.G. (2006a). Principles of Nutrition I: Macronutrients. In: Devlin, TM (ed.), Textbook of Biochemistry, with Clinical Correlation, 6th ed. John Wiley and sons, New York, pp: 1071-1090.

Chen, L.H and Marlett, A.L. (1975). Effect of vitamin B6 levels and exercise on glutamic pyruvic transaminase activity in rat tissues Journal of Nutrition 105 pg 401 – 407.

Cohen, J. T., Duggar, K., Gray, G. M and Kreindel, S. (2001). Evaluation of the potential for bovine spongiform encephalopathy in the United States. Harvard Center for Risk Analysis, Harvard School of Public Health, Boston, MA.

Daghir, N.J. (1975): Studies on poultry by-product meal in broiler and layer rations. World Poultry Science Journal 31: 200 – 216.

Daghir, N.J. (2008). Poultry production in hot climates. 2nd Edition, Cromwell Press, Trowbridge, United Kingdom.

Daniel, O.C., Lee and John, F.W. (1992). Crustacean Farming. Wiley Blackwell Scientific Publication, Osney Mead, Oxford, 400pgs

Denton , J.H., Coon, C.N., Pettigrew, J.E., Parsons, C.M. (2005). Historical and scientific perspectives of same species feeding of animal by-products. Journal of Applied Poultry Research, 14:352-361.

Doumas, B.T. and Briggs, H.G. (1972). Standard Methods of Clinical Chemistry 7 pg 175

Dozier, W.A., Gehring, C.K., Corzo, A. and Olanrewaju, H.A. (2011). Apparent metabolizable energy needs of male and female broilers from 36 to 47 days of ag**e.** Poultry Science 90:804-814

Dubowski, K.M. (1962). An o-Toluidine method for body-fluid glucose determination. Clinical Chemistry, Vol 8, 215-235

Durnna, C.S., Udedibie, A.B.I. and Etuk, E.B. (2006). Performance and organ characteristics of broiler finisher fed graded levels of *Anthromata macrophyla* seed meal as replacement of *Arachis hypogaea* meal. Proceedings of 11th Annual conference of Animal Science Association of Nigeria.

Edwards, D., Machin, D.H. and Hector, D.A. (1979): The production and utilisation of poultry offal hydrolysate in the Bahamas: a development programme financed by the European development fund. European Development Fund Report, 1979.

Elizabeth, C., Denis, R., Jose, A and Pedro, E (1993). Aquaculture, 115 pg 53 – 63.

Eggum, B.O. (1970). Blood urea measurement as a technique for assessing protein quality, British Journal of Nutrition. 24 : 983-988.

Eggum, B.O. (1976). Indirect measures of protein adequacy In: Cole, D.J.A., Booman, K.M., Buttery, P.J., Lewis, D., Nesile R.J., Swan, H. (Eds). Protein metabolism and Nutrition. European Association for Animal Production Publication. Vol. 16: 249-258.

Escalona, R.R and G.M. Pesti (1987): Nutritive value of poultry by-product meal 3 Incorporation into practical diet. Poultry Science 66: 1067 – 1070.

Fanimo, A .O. (1991): Substitution of soyabean and animal by-product for fish meal in pig rations. Ph.D. Thesis, University of Ibadan, Ibadan.

Fanimo, A.O., Mudama, E., Umukorol, T.B., Oduguwa, O.O. (1996). Substitution of shrimp waste meal for fish meal in broiler chick rations. Tropical Agric. (Trinidad). 73(2): 201 – 205

FAO (1998). FAO Production Year Book, Rome, Italy.

FAO (2004). Food and Agricultural Organization. Poultry feed and availability in developing countries – Poultry Development Review, Monogastric Research Centre, Massey University, Palmerston North, New Zealand.

FAO/WHO, (1973): Energy and protein requirement. Reports of a joint FAO/WHO ad Hoc expert committee on energy and protein requirement. WHO Technical Report Serial No. 522, Geneva. FAO, Nutrition. Reports Serial No. 52, Rome.

FDA-ANPR. (1996). Statistics. Document 96N-0135. Food and Drug Administration, Washington, DC.

FDF (2003). Federal Department of Fisheries. Report of the presidential forum on aquaculture development in Nigeria.

Feed International (1996). Apparent digestibility of feedstuffs by marine shrimp. No. 10(1) pg 19 – 22.

Fernández-Fígares, I., Prieto, C., Nieto, R. and Aguilera, JF (1997). Free amino acid concentrations in plasma, muscle and liver as indirect measures of protein adequacy in growing chickens. Animal Science, 64: 529—539.

Fetuga, B.L.A (1984). Techniques in feed formulation. Paper presented at the feed mill management training workshop. Department of Agricultural Economics, University of Ibadan.

Frank, B.M. (1984). Feed and feeding 9th edition. The Morrison Publishing Company. Pg 606.

Frank, G.R.. Taylor, M. and Hillyer, H.(2010). Diagnostic Techniques in Equine Medicine. 2nd Edition, Elsevier Ltd., U.K.

Fuller,H.L. (1956). The value of poultry by-products as sources of protein and unidentified growth factors in broiler rations. Poultry Science 35:1144 (Abstract).

Gous, R.M. (2010). Nutritional limitations on growth and development in poultry. Livestock Science ,Vol. 130(1-3): 25-32

Guoyao Wu. (2009). Amino acids: metabolism, functions, and nutrition. Amino Acids 37(1): 1-17.

Gruhu K. and Wunderlich, S. (1981): Estimation of the feeding value of poultry offal meal: a field experiment on fattening pigs. Tierernah Futter: VEB Deut. Landwirtsch. 12: 93 – 98.

Haq Nawaz, T.M. and Yaqoob, M.M.. (2006). Effect of varying levels of energy and protein on live performance and carcass characteristics of broiler chicks. Journal of Poultry Science, Vol. 43: 388-393.

Hoffan, W.E. and Solter, P.F. (2008). Diagnostic enzymology of domestic animals. In: Kaneko, J.J., Harvey, J.W. and Bruss, M.L. Clinical biochemistry of domestic animals

Ibe, S.N (1999). Livestock Production in the South-East one: Prospects and strategies in the New Millennium. In: Proceeding of the 14th Annual Farming Systems research and Evaluation workshop (Ed..Enyinnia, T) National Root Crops Research Institute Umudike, 9 – 12 Nov. 1999.

Ikegwuonu, F.I. and Bassir, O. (1976). Toxicol. Application Pharmacy 37: 211-216.

Islam, M.A., Hossian, M.D., Balbul, S.M. and Howlider, M.A.R. (1994). Indian Veterinary Journal. 71 :775-780.

Jackson, N and Fulton, R.B. (1971): Composition of feather and offal meals and its value as protein supplement in the diet of caged laying hens. Journal Science Federal Agriculture 22: 41 – 46.

Kerr, B.J. and Kidd, M.T. (1999). Amino acid supplementation of low-protein broiler diets: 2. formulation on an ideal amino acid basis. Journal of Applied Poultry Research. 8:310-320

Keyser, E.G., Waldroup, P.W and G.C. Harries (1968). Effect of dietary protein levels on serum protein. Poultry Science 47: 1678-1680.

Knabe, D.A., LaRue, D.C., Gregg, E.J., Martine, G.M., and Tanksley, T.D. Jr (1989): Apparent digestibility of nitrogen and amino acids in protein feedstuff by growing pigs. Journal of Animal Science 67 (2): 441 – 458.

Lay Jr., D.C.,Fulton, R.M., Hester, P.Y., Karcher, D.M., Kjaer, J.B., Mench, J.A., Mullens, B.A., Newberry, R..C., Nicol, C.J., O'Sullivan, N.P. and Porter, R.E. (2011). Hen welfare in different housing systems. Poultry Science. 90(1): 278 - 294.

Leeson, S. (2007). Vitamin requirements: Is there basis for re-evaluating dietary specifications? World's Poultry Science Journal. 63: 256-266

Leeson, S. and Summers J.D. (2005). Commercial poultry nutrition 3rd Edition, Nottingham University Press, England.

Leeson, S., Castor, L.J., Summers, J.D. (1988). Response of male and female broilers to diet protein. Canadian Journal Animal Science 68 3, 881-889.

Leeson, S. Summers, J.D.and Castor,L.J (2001).Response of layers to low nutrient density diets. Journal of Applied Poultry Research.10:46-52.

Leeson, S. (2002). Impact of Removing Rendered Products from Poultry and Animal Feed. Proc. Natl. Poult. Extension Workshop, Newark, DE.

Lehninger Albert L. (2008). Principles of Biochemistry, Third Edition, C.B.S. Publishers and Distributors India.

Lima, G (1988): Composition of chicken offal meal. Poultry Science (Abstract) 14(10).

Livestock Farmer, Vol. 1, 1994. Pfizer.

Martin, D.W., Mayer, D. and Rodwell, V.W.(1981). Harper's review of biochemistry. Drawer L. Altos, California, 18th edition, pg. 453

McDonald P.R.A. Edwards and J.F.D. Greenhalgh (2010). Animal Nutrition 7th Edition. The English Language Book Society and Longman.

Meeker, D.L. (2009). North American Rendering - processing high quality protein and fats for feed. R. Bras. Zootec. vol.38 no.spe Viçosa

Meyers, S.P. (1986). Utilisation of shrimp processing wastes. INFOFISH Marketing Digest. 486 : 18-21.

Mitruka, B.M. and Rawnsky, H.M. (1977). Clinical, biochemical and haematologyical reference values in normal experimental animals. Masson Publishing, Inc. U.SA.

Mohammed, G., Igwebuike, J.U., Adamu, S.B. Dibal, E. and Ayewe, F. (2009). Haematological indices and carcass characteristics of broiler chicken fed graded levels of yam peel as partial replacement for maize. Proceedings of 14th Annual conference of Animal Science Association of Nigeria. Pp 475-477.

Naber, E.C. and Morgan, C.L. (1956): Feather meal and poultry meat scrap in chick starter rations. Poultry Science 35: 888 – 895.

Nahashon, S.N., Adefope, N. and Wright, D. (2011). Effect of floor density on growth performance of Pearl Grey guinea fowl replacement pullets. Poultry Science. 90:1371-1378.

Namroud, N.F., Shivazad, M. and Zaghari, M. (2008). Effects of fortifying low crude protein diet with crystalline amino acids on performance, blood ammonia level, and excreta characteristics of broiler chicks. Poultry Science, 87: 2250-2258

Narahari, D., Ranga, P.R., Venka Tarama Ranjuga and Kathan Daraman P., (1981): Chicken offal as substitute for fish meal in broiler finisher diets India Poultry Review. 37: 127 – 136.

Ndifon, P.A. (1987): Studies on the nutritive value of chicken offal meal with emphasis on its production, shelf life stability and its biological evaluation. Ph.D. Thesis, University of Ibadan, Ibadan.

Ndifon, P.A. (1988): Preparation and uses of unconventional protein concentrates from animal slaughter wastes and fish processing industries, their nutritive values and prospects for large scale inclusion in livestock feeds in Nigeria. In: proceeding of National workshop on alternative formulation of livestock feeds in Nigeria, November, 21 – 25, 1988. Pg. 316 – 360. ARMTI, Ilorin,

Ngoan, I.D., An, L.V., Ogle, B. and Lindberj, J.B. (2000a). Ensiling techniques for shrimp by-products and their nutritive value. Asian-Australasian Journal of Animal Sciences. 13 :1278-1284.

Nigeria Agro Vet News Jan/Feb' 94. Vol. 1 No. 1 pg 6.

NRC, 1994: National Research Council. Nutrient Requirement of Poultry, 9th rev. ed. National Academic Press, Washington.

Nwokolo, S.O. (1993). Effects of blood meal, chicken offal meal and fish meal as sources of methionine and lysine in starter cockerels' diets. Nigerian Journal of Animal Production. 20 (1&2): 86-95.

Oduguwa, O.O. and Ogunmodede, B.K. (1995). Growth and protein utilisation by broiler chicks fed three commercial micro nutrient mixture. International Journal Animal. Science, 10: 171 – 175

Oduguwa, O.O., Ogunmodede, B.K. and Fanimo, A.O. (1996). Comparative efficiency of three commercial vitamins and trace mineral premixes for rearing broiler chicks at the starter and finisher phase. Pertanika Journal Tropical Agriculture 19(1) pg 81 – 87.

Oduguwa, O.O; Fanimo, A.O.; Jegede, A.V.; Kolajo, S.O and Efuntoye, A.S (2002). Effect of enzyme supplement on the utilisation of shrimp waste meal based diets by broilers chickens. Proc. 7th Annual Conference, Animal Science Association of Nigeria (ASAN) pg 71 - 74

Ogunmodede, B.K. (1980). Performance of broiler chicks fed maize guinea corn or combination of the grains with palm oil. Nigeria Journal of Nutrition Science 37: 41

Oguntunji, A.O. and Alabi, O.M. (2010). Influence of high environmental temperature on egg production and shell quality: a review. World's Poultry

Ojewola, G.S., Okoye, F.C. and Ukoha, O.A. (2005). Comparative utilisation of three animal protein sources by broiler chickens. International Journal of Poultry Science. 4(7): 462-467.

Olorode, B.R., Onifade, A.A., Okpara, A.O. and Babatunde, G.M. (1996). Growth, nutrient retention, haematology and serum chemistry of broilers fed Shea butter cake or palm kernel cake in the humid tropics. Journal of Applied Animal Research. 10: 173-180.

Olomu, J.M. (1995): Monogastric Nutrition: Principle and practice. 1st edition. Pp 75 – 82.

Oloyo, R.A. and Ogunmodede, B.K. (1991): Biotin requirement of broiler fed maize-palm kernel meal based ration. Poultry Abstract, 18 (11) 321.

Olutunde, (1997): Comparative nutritive value of shrimp waste meal and maggot meat to rats. Performance characteristics and organ weight measurement. Unpublished B. Agric, Project, Dept. of Animal Nutrition, University of Agricultural, Abeokuta.

Oluyemi, J.A. and F.A. Roberts (2001). Poultry production in warm wet climates. Macmillan Press Ltd.(4th Edition), London and Basingstoke.

Oyeleke, O. (1997): Trip to profitable egg production. Livestock farmer 13 (1)

Parsons, C. M. (1998). Bioavailability of the digestible lysine and total sulfur amino acids in meat and bone meals varying in protein quality. Poult. Sci. 77:1003-1009.

Pellett, P. and S. Ghosh, S. (1997). Global nutritional problems with special attention to the role of animal foods in human nutrition. Proceedings of a Consultation on Setting Livestock Research Priorities in West Asia and North Africa (WANA) Region, 12–16 November 1997, International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.

Pond, W.G, Church, D.C and Pond, K.R (1995): Basic Animal Nutrition and Feeding. 4th Edition John Wiley & Sons. New York.

Poppi, D.P. and McLennan, S.R. (2010). Nutritional research to meet future challenges. Animal Production Science 50(6) 329–338.

Potter D. K. and Fuller H. L. (1967). The nutritional value of poultry offal meal in chicks' diet. Poultry Science 46: 225 – 227.

Ranjhan, S.K. (2000): Animal Nutrition in Tropics. Vikas Publishing House. PVT Ltd. New Dehli. Pg 214 – 215.

Ravindran, V. and Bryden, W.L. (1999). Amino acid availability in poultry – In vitro and In vivo measurements. Australian Journal of Agricultural Research. 50:889-908.

Reinhold, J.G. (1953): Standard methods of clinical chemistry, vol.1 pg 88. Academic Press, New York

Roche, (1990): Roche Product Ltd – Vitamin E allowances for broiler chicken. VITEC Newsletter. No. 3, Vol 14c3/1 – 3/6

Roschlan, I.E., Bernt and Grubber, W. (1974). Enzymatiache Bestimung des Gesamtcholestrins in serus. Clinical Chem. Biochem. 12: 403-407.

Rosenfeld, D.J., Gernat, A.G., Marcano, J.D., Murillo, J.G., Lopes, G.H., and Flores, J.A. (1997): The effect of using different levels of shrimp meal in broiler diets. Poultry Science 76: 581-587.

Ross, J.G., Christie, G., Haliday, W.C. and Jones, R.M. (1978). In Poultry Vet. Record. 102: 29-31.

Sainsbury, D. (1992): Poultry Health and Management: Chicken Ducks, Turkeys, Geese, Quail. 3rd Ed. Blackwell Scientific Publication, London.

Salami, R.I. and Oyewole, S.O.O. (1997). Evaluation of poultry viscera offal meal as a substitute for fish meal in grower pullets' diets. Nigerian Journal of Animal Production 24 (1) : 20-25.

Saroka, J.M and Combs, G.F (jnr). (1986): The lack of effect of a pyridoxine, 2nd edition. Granada Publishing Limited, New York, U.S.A

SAS (2003). SAS Institute Inc., Cary, NC, USA.

Skurray, G.R. and Carroll, P.N. (1978). The effect of meat meal quality on egg production. World Poultry Science Journal. 34 (1): 22-27.

Singh, R.A. (1990). Poultry Production 3rd Kalyani Publishers, New Delhi.

Smith, A.J. (1990): Poultry, In: The Tropical Agriculturalist. Publisher Macmillan.

Smith, M.O. and Teeter, R.G. (1987). Influence of feed intake and ambient temperature on the relative yield of broiler parts. Nutr. Rep. Int. 35: 299-306

Springer, N., Morrsey, J. and Stokol, T. (2010). Evaluation of the utility of plasma glutamate dehydrogenase for the diagnosis of hepatic diseases in birds: a retrospective study (2004-2009). Veterinary Clinical Pathology 38(4):552-569.

Steffof, R. (2009). The Arachnid Class. Marshall Cavendish Benchmark, Tarrytown, New York

Swennen, Q., Everaert, N., Debonne, M., Verbaeys, I., Careghi, C., Tona, K., Janssens, G.P.J., Decuypere, E., Bruggeman, V. and Buyse, J. (2010). Effect of macronutrient ratio of the pre-starter diet on broiler performance and intermediary metabolism. Journal of Animal Physiology and Animal Nutrition. Volume 94(3): 375–384

Tewe, O.O. (1997). Sustainability and development paradigms from Nigeria's livestock industry. Inaugural lecture, University of Ibadan.

The Guardian (2008). Instate, private firm partner on shrimp farming training. The Guardian Newspaper, Nigeria. Sunday June 22, 2008.

This Day (2008). Nigeria needs $200m to boost shrimp farming. This Day Newspaper, Vol. 13 No. 4707, March 11, 2008.

Tibbetts, G.W., Seerley R.W and McCambell H.C. (1987): Poultry offal ensiled with lactobacillus acidophilus for growing and finishing swine diets. Journal Animal Science 64(1): 182 – 190

Tornheim, K. and Ruderman, N.B. (2011). Intermediary metabolism of carbohydrate, protein and fat. Metabolic basis for Obesity. Pages 25-31

Traylor, S., (2005). Update on current issues of importance for feed manufacturers. Proceedings of the Midwest Swine Nutrition Conference, Indianapolis, Indiana, USA.

Ubdaonu, C.N. and Nwawuchi, P.C.(1996). Production and evaluation of the acceptability of protein-fortified weaning food formulated with malted maize, Soya beans and Groundnut. In: Proceedings of the 10th Annual Farming Systems Research and Extension Workshop in Eastern Nigeria.

Udedibie, A.B.I., Esonu, B.O. and Ngoka, D.A (1987): Poultry offal meal as a protein supplement for grower pigs. Nigerian Journal of Animal Production. 14: 105 – 111.

Udedibie, A.B.I., Anyanwu, G., Ukpai, U.I. and Oyet, A.J. (1988). Poultry offal meal as a protein supplement for laying hens and finisher broilers. Nigerian Journal of Animal Production. 15: 103-109

United Kingdom Ministry of Agriculture, Fisheries and Food Leaflet (1986): Feeding by-product to pigs. U.K. Min. Agric. Fish. Food leaflet No. P 3057

Urlings, H.A.P., Mul, A.J., vanKlooster, A.T., Bijker, P.G.H., vanLogtestijn, J.G and vanGils L.G.M (1993): Microbial and nutritional aspects of feeding fermented feed (poultry by-product) to pigs. Veterinary Quarterly 15(4): 146 – 150

Vanluen, T.A., Anderson, D.M., St. Laurent A.M., Barclay, J and Nicholson, J.W.G (1991): The utilisation of acid-preserved poultry offal by growing finishing pigs. Canadian Journal Animal Science 71(3): 935 – 938.

Waldroup, P. W. and Adams, M.H. (1994). Evaluation of the phosphorus provided by animal proteins in the diet of broiler chickens. J. Appl. Poult. Res. 3:209-218.

Wilesmith, J.W., Wells, G.A.H., Cranwell, M.P., Ryan, J.B.M., 1988. Bovine spongiform encephalopathy: epidemiological studies. Veterinary Research 123:472.

Yalçin, S., Ozsoy, B., Erol, H. and Yalçin, S. (2008). Yeast Culture Supplementation to Laying Hen Diets Containing Soybean Meal or Sunflower Seed Meal and Its Effect on Performance, Egg Quality Traits, and Blood Chemistry. Journal of Applied Poultry Research 17:229-236.

Yamane, T., Nakazato, T., Nakajima, T., Ohmori, S. and Kosaka, S. (1982). The feeding value of fish meal in broiler feed. Japan Poultry Sci. 19: 276-285.