# EFFECTS OF GRADED LEVELS OF RAW AND COOKED TURMERIC RHIZOME ON PERFORMANCE OF BROILER CHICKENS

**BY**

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**REG. NO: 20134869038**

**A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI, NIGERIA**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF (MASTER OF SCIENCE), M.SC IN ANIMAL NUTRITION.**

**JUNE, 2016**

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## CERTIFICATION

We certify that this work "Effects of Graded Levels of Raw and Cooked Turmeric Rhizome on Performance of Broiler chickens" was carried out by Obionwu, Dandy Chukwunwendu (Reg. No. 20134869038) in partial fulfillment for the award of the degree of Master of Science (M.Sc.) Animal Nutrition in the Department of Animal Science and Technology of the Federal University of Technology, Owerri.

| | |
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## DEDICATION

This work is dedicated to the lord God Almighty for His love to me.

**ACKNOWLEDGMENTS**

I thank my Father in heaven who faithfully instructed me to move on with my studies and stood by me in strength, peace of heart, joy and enthusiasm and for the help and favour he caused me to receive from all the people he brought before me. With a shout am saying I love you above all.

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## TABLE OF CONTENTS


| | | |
|---|---|---|
| Title page | | i |
| Certification | | ii |
| Dedication | | iii |
| Acknowledgment | | v |
| Abstract | | vi |
| Table of Content | | vii |
| List of Tables | | x |
| List of Plates | | xii |
| List of Figures | | xii |
| **CHAPTER ONE** | | |
| 1.0 | Introduction | 1 |
| 1.1 | Background information | 1 |
| 1.2 | Problem statement | 3 |
| 1.3 | Research objectives | 3 |
| 1.4 | Justification | 4 |
| 1.5 | Scope | 4 |
| **CHAPTER TWO** | | |
| 2.0 | Literature review | 5 |
| 2.1 | History and etymology | 5 |
| 2.1.1 | Origin of turmeric | 5 |
| 2.1.2 | Botanical description | 5 |
| 2.1.3 | Appearance | 5 |
| 2.1.4 | Inflorescence, flower, and fruits | 6 |
| 2.2 | Taxonomy of turmeric plant | 6 |
| 2.3 | Propagation and post-harvest | 7 |
| 2.4 | Products from turmeric | 8 |
| 2.4.1 | Primary products | 8 |
| 2.4.2 | Dried rhizomes | 8 |
| 2.4.3 | Turmeric powder | 8 |
| 2.4.4 | Secondary derived products | 9 |
| 2.5 | Phytochemistry of turmeric | 9 |
| 2.6.1 | Responses on growth performance of broiler | 10 |
| 2.6.2 | Responses on egg production and quality | 16 |
| 2.6.3 | Responses on health status of broilers | 16 |
| 2.6.4 | Responses on immunomodulatory system | 18 |
| 2.6.5 | Responses on carcass traits of broilers | 19 |
| 2.6.6 | Toxicological effects of turmeric | 19 |

**CHAPTER THREE**


| | | |
|---|---|---|
| 3.0 | Materials and methods | 21 |
| 3.1 | Experimental site | 21 |
| 3.2 | Processing of turmeric rhizome | 21 |
| 3.3 | Proximate analysis | 25 |
| 3.4 | Experiment 1 (Starter phase) | 26 |
| 3.4.1 | Experimental diets | 26 |
| 3.4.2 | Experimental birds | 26 |
| 3.4.3 | Data collection for starter phase | 26 |
| 3.4.4 | Data analysis | 27 |
| 3.5 | Experiment 2 (Finisher phase) | 27 |
| 3.5.1 | Experimental diets | 27 |
| 3.5.2 | Experimental birds | 27 |
| 3.5.3 | Data collection for finisher phase | 27 |
| 3.5.4 | Carcass and organ weight evaluation | 27 |
| 3.5.5 | Nutrient Digestibility | 30 |
| 3.5.6 | Haematology and Biochemical Analysis | 30 |
| 3.5.7 | Serum biochemistry | 33 |
| 3.5.8 | Data analysis | 37 |


**CHAPTER FOUR**


| | | |
|---|---|---|
| 4.0 | Results and discussion | 38 |
| 4.1 | Proximate composition of turmeric | 38 |
| 4.2 | Experiment 1 broiler starter trial | 38 |
| 4.2.1 | Body weight changes | 38 |
| 4.2.2 | Average daily feed intake | 38 |
| 4.2.3 | Feed conversion ratio | 38 |
| 4.2.4 | Mortality | 39 |
| 4.3 | Experiment 2 broiler finisher trial | 39 |
| 4.3.1 | Body weight changes | 39 |
| 4.3.2 | Average daily feed intake | 39 |
| 4.3.3 | Feed conversion ratio | 39 |
| 4.3.4 | Mortality | 42 |
| 4.4 | Nutrient digestibility | 42 |
| 4.4.1 | Dry matter digestibility | 42 |
| 4.4.2 | Crude protein digestibility | 42 |
| 4.4.3 | Ether extract digestibility | 42 |
| 4.4.4 | Crude fibre digestibility | 44 |
| 4.4.5 | Nitrogen free extract digestibility | 44 |

4.5 Carcass and internal organ weight 44
4.5.1 Dressing Percentage 44
4.5.2 Gizzard 44
4.5.3 Liver 46
4.5.4 Kidney 46
4.5.5 Heart 46
4.6 Heamatological indices of the experimental finisher broiler birds 46
4.6.1 Red blood cell count (RBC) 46
4.6.2 Packed cell volume (PCV) 48
4.6.3 Haemoglobin count (Hb) 48
4.6.4 White blood cell count (WBC) 48
4.6.5 Lymphocytes 48
4.6.6 Heterophils 48
4.6.7 Eosinophil basophil monocyte 49
4.7 Serum biochemical indices of the finisher broiler birds 49
4.7.1 Total protein (TP) 49
4.7.2 Albumin 49
4.7.3 Globulin 49
4.7.4 Creatinine and urea 51
4.7.5 Glucose 51
4.7.6 Cholesterol 51
4.7.7 Triglyceride concentration 51
4.7.8 High density lipoprotein concentration HDL-C 52
4.7.9 Low density lipoprotein-concentration 52
4.8 General discussion 52

**CHAPTER FIVE**

5.0 Conclusion and recommendations 58
5.1 Conclusion 58
5.2 Recommendation 58

**REFERENCES** 59

## LIST OF TABLES


| | | |
|---|---|---|
| Table 2.1 | Composition of turmeric | 11 |
| Table 2.2 | Phytochemical analysis of rhizomes of *Curcuma Longa* Linn | 13 |
| Table 2.6 | Percentage yield of various solvents | 14 |
| Table 3.1 | Ingredient and nutrient composition of the experimental starter broiler diets | 28 |
| Table 3.3 | Ingredient and nutrient composition of the experimental finisher broiler diets | 29 |
| Table 4.1 | Proximate Composition of Raw and Cook Turmeric Meal | 40 |
| Table 4.2: | Performance of broiler starter fed diets containing graded levels of raw and cooked turmeric meal | 41 |
| Table 4.3: | Performance of broiler finisher fed diets containing graded levels of raw and cooked turmeric meal | 43 |
| Table 4.4: | Effect of the experimental diets on nutrient digestibility and utilization | 45 |
| Table 4.5: | Carcass and internal organ weights of the experimental finisher broilers | 47 |
| Table 4.6 | Effect of the experimental diets on the haematological indices of finisher broiler | 50 |
| Table 4.7 | Effect of the experimental diets on serum biochemical indices of finisher broiler birds | 53 |

## LIST OF PLATES


| | | |
|---|---|---|
| Plate 1 | Fresh turmeric rhizomes | 22 |
| Plate 2 | Sun-dried raw turmeric rhizomes | 23 |
| Plate 3 | Cooked turmeric rhizomes | 24 |

## LIST OF FIGURE

Fig. 1: Medicinal properties of turmeric 12

## ABSTRACT

Feeding trials were conducted to evaluate the effect of graded levels of raw and cooked turmeric rhizome meal on the performance of broiler birds. Turmeric rhizome was washed with water and divided into two batches of 40kg each. The first batch was crushed, sundried for 3 days, ground to produce raw turmeric rhizome meal and bagged. The second batch was cooked for an hour, crushed with a roller and sun-dried for 3 days. Both the raw and cooked sundried turmeric rhizomes were then ground using a hammer mill to produce raw and cooked turmeric rhizome meal respectively. Seven (7) broiler starter diets were formulated to contain raw or cooked turmeric rhizome meal at 0% (common control diet), 0.5%, 1.0% and 1.5% levels, respectively. In the finisher phase, seven (7) finisher diets were formulated to contain raw or cooked turmeric rhizome meal at 0% (common control diet), 1.0%, 1.5% and 2.0% levels, respectively. Both diets were offered *ad libitum* during their respective phases to 189 Cobb broilers divided into 7 dietary treatment groups, each containing 3 replicates of 9 birds per replicate. At the end of the finisher phase, 5 birds from each dietary treatment group were selected, sacrificed and analysed for dressing percentage, organ weights, haematological profile and serum biochemical composition. The results showed that diet-related differences in final liveweigth, liveweight gain, feed intake and feed conversion ratio were not significant ($P>0.05$) both at the starter and finisher phases. Similarly, dietary effects were not significant ($P>0.05$) for nutrient digestibility, dressing percentage, carcass and organ weights, most blood parameters and serum biochemical constituents. Significant differences ($P<0.05$) were observed in red blood cell counts and packed cell volume, although no consistent trends were established. It was evident that the different processing methods had no effect on broiler performance based on the results obtained in this study and within the circumstances of the experiments. It can be concluded that sun-dried raw and cooked turmeric rhizome meal did not significantly affect broiler performance except packed cell volume and red blood cell count.



***Keyword:*** Turmeric, broiler, processing method, performance, blood parameters and biochemical constituents.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background Information

Agriculture in Nigeria has remained the largest sector for decades and employs nearly 60% of its workforce (Olagunju, 2010).Over 80% of the country's population living in the rural areas are directly or indirectly dependent on agriculture for their livelihood. (NBS, 2005).The growth rate of the agricultural sector in Nigeria is still below the potentials of the country's natural and human resources due to cost of agricultural inputs, poor funding of agriculture, inadequate functional infrastructural facilities, inconsistencies in government agricultural policies, inadequate private sector participation, poor mechanized farming and little or no adoption of simple agricultural technologies developed by scientists (Nworgu, 2006).

The increasing human population in the tropics including Nigeria has given rise to increased demand of poultry and livestock products to satisfy protein need of the people. Poultry meat and eggs play very useful roles in bridging the animal protein intake gap in Nigeria. Moreover, poultry products are palatable and acceptable. This acceptability cuts across nearly all cultural and religious boundaries in Nigeria.

In spite of Nigeria's numerous human and natural resources, Nigeria still remains among the least consumers of animal protein in Africa (Esonu, 2009). CBN (1993) reported that North America and Western and Eastern European countries consume 66.39 and 33g of animal protein per head per day respectively, while an average Nigerian consumes 7.5g,which is below the recommended level of 27g/head/day (Esonu, 2009). However, high cost of feed is making it almost impossible for farmers to continue production (Oluyemi and Robert, 2000). In order to reduce feed cost and increase poultry production, series of research and production strategies have been adopted using feed materials ranging from conventional feedstuffs to unconventional feedstuffs and their bye products and growth promoters which have been used in poultry feed formulations to enhance growth rate and improve feed efficiency and utilization (Abbas and Ahmed, 2010; Raeesi *et al*., 2010).

The economic and nutritional demand of our modern society for food from poultry necessitates the raising of poultry under intensive production system. Under such condition, feed additives/growth promoters are often used to suppress or eliminate harmful microorganisms in the intestine and to improve growth and performance. Growth promoters or feed additives are molecules that are added to animal feeds without changing considerably

their composition (Biovet, 2005). They speedily increase the body weight and size of the animals (Biovet, 2005).Among growth promoters, the most commonly used are antibiotics. However, the use of antibiotics as growth promoters in the animal feed has been banned in the European Union since January, 2006. As a result of this ban in EU and growing pressure on livestock productions in other parts of the World, alternative substances and strategies for animal growth promotion and disease prevention are being investigated among which phytogenic and herbal products have received increased attention since they have acquired more acceptability among consumers as a natural additives (Toghyani *et al.*, 2011).

Pronutrients are sometimes referred to as phytogenic feed additives (Biovet, 2005).Herbs and plant extracts used in animal feed are referred to as phytogenic feed additives (PFA), and are defined as compounds of plant origin incorporated into animal feed to enhance livestock productivity through the improvement of digestibility, nutrient absorption and elimination of pathogens resident in the animal gut (Kamel, 2001; Balunas and Kinghorn, 2005, Athanasiadou, *et al.*, 2007). Herbs and spices are currently in use in livestock production because of their positive properties including anti-inflammatory, antiseptic, sedative, and anti-fungal activities, the stimulation of appetite and feed intake, the improvement of endogenous digestive enzyme secretion, activation of immune responses and antibacterial, antiviral, and antioxidant actions (Toghyani *et al.*, 2010, 2011). A variety of these herbs and spices including turmeric have been widely used as alternatives to synthetic antimicrobial growth promoter in livestock and poultry production.

Turmeric (*Curcuma longa*) is a tropical plant native to southern Asia which is known as golden spice of India and has existed for more than 500 years (Plant Cultures, 2005). India being the largest producer of turmeric supplies 94% of the World's demand (Plant Cultures, 2005). In Nigeria it is cultivated mostly in the homestead gardens in about 19 states where they bear different names and serve different purposes. In Ebonyi and Enugu states, it is used for treatment of malaria and for circumcision, in Benue state it is used fresh for making yams meals while in Katsina State inhabitant use it for decoration (Olojede *et al.*, 2000).

Turmeric has been shown to have several biological effects, exhibiting anti-inflammatory (Holt *et al.*, 1999), anti-oxidant (Igbal *et al.*, 2003) and hypolipidaemic (Ramirez Tortosa *et al.*, 1999) activities. It has also been suggested that turmeric possess hepato-protective, antitumor, antiviral and anticancer activities (Polasa *et al.*, 1999). Reports exit indicating that it has been used in gastrointestinal and respiratory disorders (Anwarul *et al.*, 2006).

## 1.2 Problem State

There is stiff competition between human beings, industries and livestock feed for available feed/feedstuffs. Oluyemi and Robert (2000) reported that feed account for 65-75% of total cost of intensive poultry production. The stiff competition has reduced the rate of expansion of the poultry industry, increased cost of production and consequently increased cost of poultry products. This in turn resulted to low demand and low level of protein intake of the people.

The use of antibiotics such as virginmycin, salinomycin, neomycin, doxycycline and avilamycin in poultry feeds as growth promoters has been found to be beneficial in enhancing performance and disease prevetion (Peterolli *et al.*, 2012). Continuous use of dietary antibiotics has given rise to development of drug resistant pathogens which pose biosecurity threat to human and animal health. Other problems include antibiotic residue accumulation in animal products and alteration (imbalance) of natural gut micro flora of the animal (Al-Bahry *et al.*, 2006). Series of research has been done using plant materials to reduce cost of production and increase productivity in order to bridge the protein gap in Nigeria. However, method of processing of some of these feed materials, and their availability to farmers make most of them difficult to be utilized by farmers. However, there is still the need for a material that will enhance utilization of feed by the animals. Herbs and spices including turmeric have been used as an alternative due to their properties that encourage reduction in feed intake and enhances efficient performance.

## 1.3 Research Objectives

The current study was designed:

- To evaluate the effect of dietary levels of raw and cooked turmeric rhizome on growth and carcass characteristics of broilers
- To determine the effect of feeding the experimental diets on haematological profile of the birds
- To determine the effect of feeding the experimental diets on serum biochemical indices of the birds
- To determine the effect of feeding the experimental diets on digestibility of nutrients.

## 1.4 Justification

Although a number of studies have been conducted to evaluate the effect of feeding turmeric rhizome on the performance of broiler chickens, laying hens and rabbits, the results have been inconsistent. However there is need for the determination of optimum level of turmeric rhizome meal in the diet of poultry and livestock. Improvements in feed efficiency and poultry productivity through dietary incorporation of this natural feed additive would be of tremendous benefit to the animal production industry and the economic wellbeing of the nation.

## 1.5 Scope of Study

The study was essentially a feeding trial and was carried out in the University Farm. The turmeric was sourced locally while the stock were exotic broilers. The slaughtering and laboratory analysis were also carried out locally and the entire study lasted about 6 months.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 History and Etymology

### 2.1.1 Origin of Turmeric

Turmeric has been used in Asia for thousands of years and is a major part of Siddha Medicine (Chaltopadhyay *et al.,* 2004). It was first used as a dye and then later for its medicinal properties (NCCAM, 2012). The name appears to be derived from the Middle English/early Modern English as Turmeryte or Tarmaret having uncertain origin. It may be of Latin origin *terra merita* (merited earth), (dictionary.com 2013). The name of the genus *Curcuma* is from an Arabic name of both Saffron and Turmeric.

*Curcuma* is genus of about 100 accepted species in the family of *Zingiberaceae* that contains such species as turmeric and siam tulip. They are native to South-east Asia, Southern China, the Indian Sub-continent, New Guinea and Northern Australia. Some species are reportedly naturalized in other warm parts of the World such as Tropical Africa, Central America, Florida, and Various Islands of the Pacific, Indian and Atlantic Ocean (Skomickova *et al.*, 2010).

### 2.1.2 Botanical Description

Turmeric (*Curcuma longa*) is a rhizomatous herbaceous perennial plant of the ginger family *Zingiberaceae* (Chan *et al.,* 2009).It is a native of Southeast India and needs temperatures between $20^0$C and $30^0$C ($68^0$F and $86^0$ F) and a considerable amount of annual rainfall to thrive. Prasad *et al.* (2011) reported that the plant is gathered annually for it's rhizome and propagated from some of these rhizomes in the following season. When not used fresh, the rhizomes are boiled for about 30 – 45 minutes and then dried in hot oven (Indian Spices, 2013) after which they are ground into a deep-orange-yellow powder commonly used as a spice in India cuisine and curries, dyeing, and to impart colour to mustard condiments. India is a significant producer of turmeric (Tahira *et al.*, 2010).

### 2.1.3 Appearance

Turmeric is a herbaceous plant which reaches up to 1m tall. Highly branched, yellow to orange, cylindrical and aromatic rhizomes are found. The leaves are alternate and arranged in two rows. They are divided into leaf sheath, petiole, and leaf blade (Grieve, 2013). From the leaf sheaths, a false stem is formed. The petiole is 50 to 115cm long. The simple leaf blades are usually 76 to 115cm long, but rarely up to 230cm. They have a width of 38 to 45cm and are oblong to elliptic narrowing at the top.

### 2.1.4 Inflorescence, Flower, and Fruits

In China, the flowering time is usually in August. Terminally on the false stem is a 12 – 20cm long inflorescence stem containing many flowers. The bracts are light green and ovate to oblong with a blunt upper end with a length of 3 to 5cm. At the top of the inflorescence, stem bracts are present on which no flowers occur. These are white to green and sometimes tinged reddish-purple and the upper ends are tapered (China Bot. Garden, 2013) The hermaphrodite flowers are zygomorphic and threefold. The three 0.8 to 1.2cm long sepals are fused, white, have fluffy hairs and the three calyx teeth are unequal. The three bright-yellow petals are fused into a corolla tube up to 3cm long. The three corolla lobes have a length of 1.0 to 1.5cm and are triangular with soft spiny upper ends. All stamens (except the median) are converted staminoides. The outer staminoides are shorter than the labellum. The labellum is yellowish with a yellow ribbon in its centre and it is obovate with a length from 1.2 to 2.0cm. Three carpels are under a trilobed ovary which is sparsely hairy. The fruit capsule opens with three compartments.

## 2.2 Taxonomy of Turmeric Plant

Turmeric (*Curcuma longa, Linn.*) is a rhizomatous herbaceous perennial herb of ginger family that is widely used and cultivated in the tropical and sub-tropical regions of the World, such as in Pakistan, China, Indonesia, India, Malaysia, Jamaica, and Peru (Govindarajan and Stahl, 1980). It is also produced in Nigeria where it is mostly cultivated in the homestead gardens in about 19 States (Olojede *et al.,* 2000). According to Chattopadhyay *et al*.(2011), Linnaeus described turmeric as *Curcuma longa* and its taxonomic position is as follows:

Scientific Classification of Turmeric

| | |
|---|---|
| Kingdom: | Plantae |
| Order: | Zingiberales |
| Phylum: | Angiosperm |
| Class: | Monocots (Liliopsida) |
| Sub-class: | Commelinids |
| Family: | Zingiberaceae |
| Genus: | Curcuma |
| Species: | C. longa |
| Binomial Name: | *Curcuma longa* |

*Curcuma Longa* is the domesticated species of turmeric, while the wild one is called C. aromatic. It belongs to the family of *Zingiberaceae* that consists of hundreds of species of

plants, along with other noteworthy members like curcuma ginger, white turmeric, black-turmeric, mango-ginger, cardamom, Siam-tulip (hidden ginger), zedoary, and galangal.This medicinal plant possesses rhizomes and underground root-like stems (Araujo and Leon, 2001) that had been originally used as food additives in curries to improve the storage condition, appearance, flavour, palatability and preservation of food ( Jaya Prakash *et al.,* 2005).

## 2.3 Propagation and Post-Harvest Handling

Turmeric is propagated through the rhizome. Turmeric can be grown under diverse tropical conditions with altitudes ranging from sea level to 1500m above sea level (Rema and Madan, 2001). It requires well drained clay loan or sandy soil and temperature ranging between 20 – $30^0$c with annual rainfall of 1500mm – 1800mm (Olojede *et al.,* 2005).Considering the prevailing climatic and favorable soil condition in Nigeria, the country can play a leading role in turmeric production. Albeit, this potential has not been fully harnessed as the production techniques required are poorly understood, hence, production have been restricted to homestead gardens (Olejede *et al.,* 2005).Turmeric is ready for harvesting, it is indicated by the drying of the plant and stem, approximately 7 to 10 months after planting, depending on cultivar, soil and growing conditions. The rhizome bunches are carefully dug out manually with a spade. The rhizomes are soaked in water to clean them and remove adhering soil. The long roots are removed as well as leaf scales. Rhizomes are then further cured, processed or stored for the next year's planting (Anamdaraj *et al.,* 2001; Dahal and Idris, 1999; Weiss, 2002).Turmeric rhizomes are cured before drying. Curing involves boiling the rhizomes until soft. This is performed to gelatinize the starch for a more uniform drying, and to remove the fresh earth odour (Weiss, 2002). Boiling in alkaline water by adding 0.05% to 1% sodium carbonate or lime may improve the colour (Weiss, 2002). It is important to boil batches of equal size rhizomes since different size material would require different cooking times. However, the same water may be used for cooking several batches, (Anandaraji *et al.,* 2001; Weiss, 2002).

Curing should be done two to 3days after harvesting to avoid spoilage of the rhizome (Anandaraji *et al.,* 2001). It was reported that the quality of cured rhizomes is negatively affected for material with higher initial moisture content (Pruthi, 1992).Benefits of curing turmeric include reduction of the drying time and a more attractive product (not wrinkled) that lends itself to easier polishing. It was reported that while the total volatile oil and colour remained unchanged, curcuminoid extractability might be reduced (Buescher and Yang,

2000). Slicing rhizomes reduces time and yield turmeric with lower moisture content as well as better curcuminoid extractability (Buescher and Yang, 2000).

Sun drying of the sliced rhizomes is carried out to reduce the moisture content to a level of 5% to 10%. Sun drying may take 5 to 15 days depending whether it is cooked or raw and the rhizomes should be spread in 5 – 7cm thick layers to minimize direct sunlight that result in surface discolouration (Anandaraji *et al.*, 2001). It was reported that turmeric is one of the species for which it is more advantageous to use mechanical driers because of its sensitivity to light (Weiss, 2002). After drying, the rhizome is ground. Grinding is a simple process involving cutting and crushing the rhizomes into small particles, then sifting through a series of several screens (Tanter and Grenis, 2001). The resulting rhizome meal may be stored for a prolonged period of time without significant deterioration in quality.

## 2.4 Products from Turmeric

### 2.4.1 Primary Products

There are two main types of turmeric found in the World market: Madras and Alleppey, both named after the regions of production in India. Alleppey turmeric is predominantly imported by the United States, where users prefer it as a spice and a food colorant (ASTA, 2002). Alleppey turmeric contains about 3.5% to 5.5% volatile oils, and 4.0% to 7.0% curcumin (ASTA, 2002; Buescher and Yang, 2000; Weiss, 2002). In contrast, the Madras type contains only 2% of volatile oils and 2% of curcumin (ASTA, 2002).

### 2.4.2 Dried Rhizomes

Turmeric is mostly imported as whole rhizomes which are later processed into powder or oleoresin by flavour houses and the industrial sector (ASTA, 2002).

### 2.4.3 Turmeric Powder

Ground turmeric is mostly used in retail trade and by food processors. Rhizomes are ground to approximately 60 – 80unit $mm^3$ mesh particle size (Buescher and Yang, 2000). Since curcuminoids, the colour constituents of turmeric, deteriorate with light and to a lesser extent under heat and oxidative conditions, it is important that ground turmeric be packed in UV protective packaging and appropriately stored (Buescher and Yang, 2000). Turmeric powder is the major ingredient in curry powder and pastes.

### 2.4.4 Secondary Derived products

- **Curry Powder**: Turmeric is an important ingredient in curry powder that it merits special mention in the export statistics of spices in Indian. Turmeric content in curry powder blends range from 10 – 15% to 30% (Gopalan *et al.,* 2000). Typical Indian curry powder for meat and fish dishes contains 20 – 30% turmeric, 22 – 26% coriander, 12% and 10% cardamom and cumin, (Gopalan *et al.*,2000).
- **Oleoresins:** Oleoresins are obtained by solvent extraction of the powdered or comminutated rhizome. This process yields about 12% of an orange/red viscous liquid, which depending on the solvent used for extraction and on the turmeric type and cultivars, contains various proportions of curcuminoid. The compounds of interest in turmeric oleoresin includes: Curcuminoids, 40 to 55%; volatile oils,15 to 20% (Buescher and Yang, 2000; Gopalan *et al.,* 2000).The curcuminoids consist mostly of curcumin (1, 7 –bis, 4 –hydroey- 3-methoxyphenyl)-1,6 – heptadiene –3,5 – dione) and also demethoxycurcumin and bisdemetoxycurcumin. It was reported that oleoresin export from India in 1998 was ranked third after peper and paprika oleoresins (Peter and Raghuram, 2000).
- **Essential Oil:** In Western food industry, turmeric essential oil attracts little interest and has no commercial value as opposed to olereosin (Gopalan *et al., 2000;* Weiss, 2001). However, there is an increasing literature showing medicinal activities of turmeric of which some are attributed to compounds present in the volatile fraction. Turmeric essential oil is obtained by distillation (Weiss, 2000) or by superficial fluid extraction of the powdered rhizome (Gopalan *et al*, 2000).

## 2.5 Phytochemistry of Turmeric

Turmeric contains a wide variety of phytochemicals including curcumin, demethoxycurcumin, bisdemethoxycurmin zingiberene, curcumenol, curcumol, eugenol, tetrahydrocurcumin, turmerin, turmerones, and turmeronols (Chattopadhyay et al., 2004). The main yellow bioactive substances isolated from the rhizomes of Turmeric are curcumin, demethoxycurcumin and bisdemethoxycurcumin which are present to the extent of 2-5% of the total spice in turmeric powder (Nunes, 1989). The rhizome is rich in curcumnoid pigments (6%) and essential oils (5%). It also contains 69.43% carbohydrate, 6.30% protein, 3.50% mineral, 5.0% starch, 3.0% crude fibre, moisture 6.0%, 4.5% volatile oil, 3.5% fixed oil and 3.1% curcumin (Manjunath, 1991;Nunes ,1989; Olojede *et al.,* 2005). Curcumin is the

most active component of turmeric which makes up 2 to 6% of the spice. It is the phytochemical that gives a yellow colour to turmeric and is recognized to be responsible for most of the therapeutic effects Bizuneh Adinew, (2012). Curcumin is hydrophobic in nature and freely soluble in dimethylsultoxide, acetone, alkalis ethanol, chloroform, and oils and insoluble in water. It melts at 176 – 177$^{o}$C and forms red-brown salts with alkalis. In the molecule of curcumin, the main chain is aliphatic, unsaturated and acyl group may be substituted or not Sawant and Godghate (2013). Composition of the Turmeric is shown in the table 2.1 Sawant and Godghate extracted the rhizomes of *Curcuma longa* in acetone, methanol, ethanol and chloroform solvents giving 16, 10, 15.42, 25.75, and 15.50% yields, respectively. From the results, Saxena Jyoti *et al*. (2012) isolated ten phytochemicals (carbohydrate, proteins, starch, amino acids, steroids, glycoside, flavonoid, alkaloid, tannin, and saponin) from methanolic extracts of rhizomes. Rajesh *et al*. (2013) also reported ten phytochemicals from methanolic extract of *curcuma longa*. Swadhini, *et al* (2011) obtained six phytochemicals (alkaloids, flavonoids, tannin, saponins, cardiac glycosides and phenol) from aqueous extract of turmeric. Sawant and Godghate (2013) has reported that ethanolic extract gives more percentage yield (25%) than methanolic extract. Acetone extract revealed the presence of 15 phytochemicals; methanolic extracts 16; ethanolic extract 13 while chloroform extract contains 12 secondary metabolites (Sawant and Godghate, 2013). This is shown in table 2.2, and the medicinal properties are illustrated in figure 2.1. **2.6.1 Responses on Growth Performance of Broilers**

Numerous reports have been published, indicating the beneficial effects of turmeric meal supplementation on growth performance of broiler chickens. Kumari *et al.* (2007) reported that turmeric meal supplementation at the rate of 1.0g/kg improved growth performance of 42-d old Vencob broiler chickens. Al-sultan (2003) observed that addition of turmeric meal at the rate of 5.0g/kg increased body weight and feed conversion ratio of broiler chickens. In another study, Durrani (2006) found that supplementation of 5.0g/kg turmeric meal in the diets of broilers resulted in a significant improvement of body weight gain and feed efficiency without any adverse effects such as mortality. Allen *et al*. (1998), Abbas *et al.* (2010) and Lee *et al.*(2010a) noted that turmeric meal supplementation alleviated growth-depression effect of Eimeria infection. Similarly, Yarru *et al.* (2009) reported positive effects of 5.0g/kg turmeric meal supplementation in birds exposed to aflatoxin. Gowda *et al.* (2009) reported that feeding broiler chickens with diets containing 74ppm curcuminoids from turmeric meal ameliorated the growth-depressing effect of aflatoxin B1.

Table 2.1: Composition of Turmeric

| Sr. No. | Constituents | Quantity |
|---|---|---|
| 1. | Curcumin ( curcuminoids) | 2 – 6% |
| 2. | Volatile (essential) oil | 3 – 7% |
| 3. | Fibre | 2 – 7% |
| 4. | Mineral Matter | 3 – 7% |
| 5. | Protein | 6 – 8% |
| 6. | Fat | 5 – 10% |
| 8. | Moisture | 6 – 13% |
| 9. | Carbohydrate | 60 – 70% |

Source: (Kotwal, 2005)

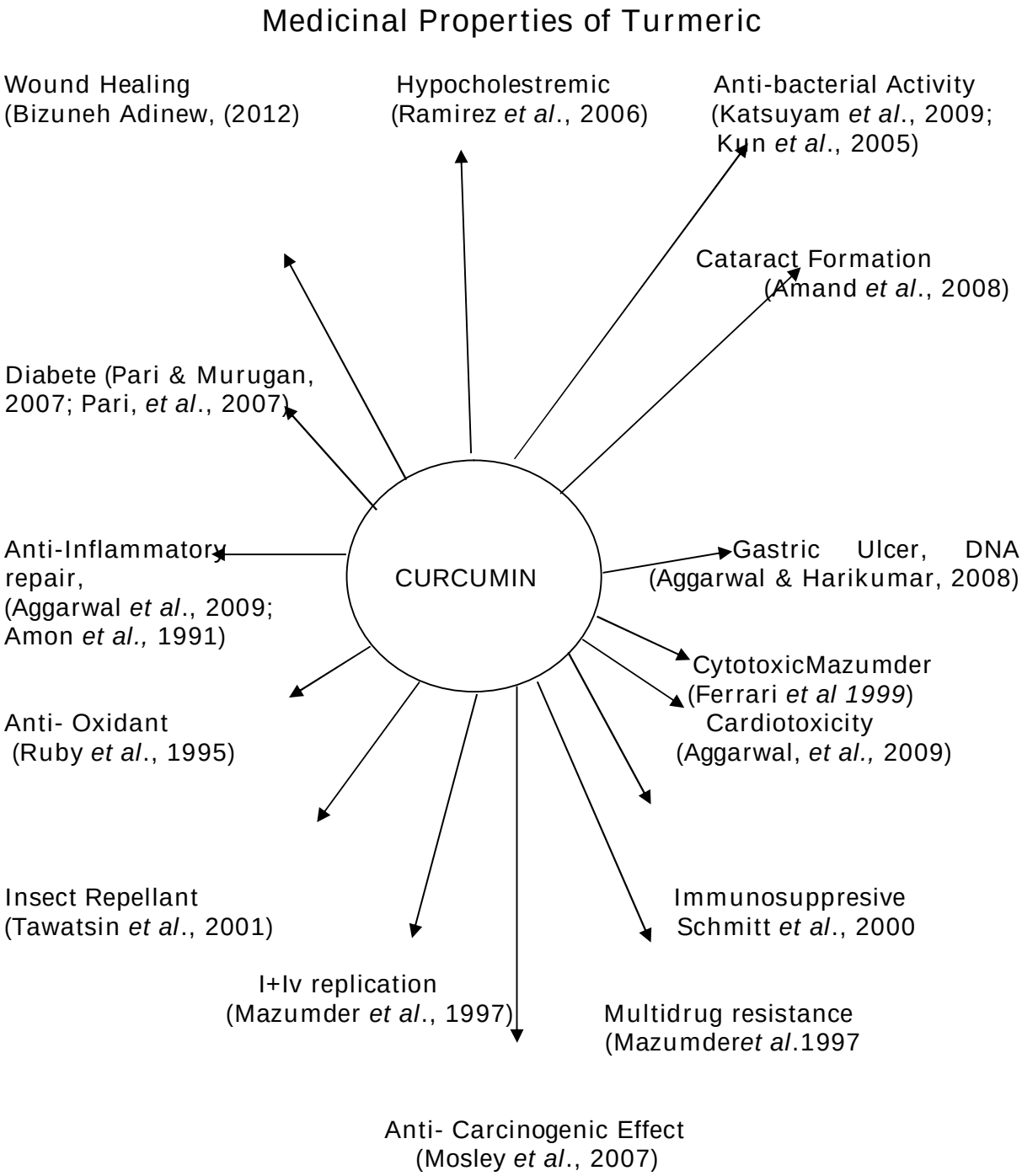


Fig 2.1 Source: Gupta Sandeep et al. (2010)

Table 2.5: Phytochemical Analysis of Rhizomes of *Curcuma Longa Linn*

| Phytochemical | Acetone | Methanol | Ethanol | Chloroform |
|---|---|---|---|---|
| Alkaloids | | | | |
| Wagner's | + | + | + | _ |
| Dragen droff's | + | + | + | + |
| Hager's | + | + | + | + |
| Saponin | + | + | + | + |
| Steroid | _ | + | _ | + |
| Tannin | + | + | + | _ |
| Anthocyanin | + | + | + | + |
| Coumarin | _ | _ | _ | _ |
| Emodin | + | + | + | + |
| Protein | _ | _ | _ | _ |
| Amino acid | _ | _ | _ | _ |
| Flavonoids | | | | |
| 10% NaOH | + | _ | _ | _ |
| 10% $NH_4OH$ | + | + | _ | _ |
| Mg test | + | + | + | + |
| Zn test | _ | _ | _ | _ |
| Diterpenes | + | + | + | _ |
| Phytosterol | + | + | _ | _ |
| Phenol | + | + | _ | _ |
| Phlobatannin | + | + | + | + |
| Leucoanthocyanin | + | + | + | + |
| Anthroquinone | + | + | + | + |
| Chalcones | + | + | + | + |
| Cardiac Glycosides | | | | |
| Legal's test | + | + | + | + |
| Kellar-Killiani tests | + | + | + | + |
| Carbohydrate | + | + | + | + |
| Molisch's Barfoed | + | + | + | + |
| Iodine | + | _ | + | + |
| Fehling | + | + | + | + |
| Benedict | _ | _ | _ | _ |

Note: + = Present; - =Absent

Source: Sawant and Godghate, (2013)

Table 2.6: Percentage Yield of Various Solvents

| Solvent | % yield |
|---|---|
| Acetone | 16.10 |
| Methanol | 15.42 |
| Ethanol | 25.75 |
| Chloroform | 15.50 |

Source: Sawant and Godghate, ( 2013)

Zainali *et al*. (2008) reported that dietary supplementation of 10.0g/kg turmeric meal increased the body weight gain of (Ross× Ross) broiler chickens reared under the heat stress condition. In a recent study using Arbor Acre broiler chickens, Rajput *et al.* (2012) showed that supplementation with 0.2g/kg pure curcumin-phytochemicals derived from turmeric increased the body weight gain and reduced the FCR of broiler chickens.

Some studies have shown that combinations of turmeric meal and other phytobiotics have beneficial effects live enhance the growth performance of broiler chickens. Al-Kassie *et al*. (2011) reported that supplementation of turmeric and cumin mixture in the diets at the rate of 0.5g/kg resulted in a greater body weight gain and lower feed conversation ratio in 42-d old Arbor Acres broiler chickens. Sawale *et al*. (2009) have reported that dietary supplementatiom of layer diets with herbal-mineral mixture containing turmeric reduced the harmful effect of ochratoxin A infection on body weight gain and feed efficiency. Improvement of the growth performance due to supplementation of turmeric meal in those studies might be attributed to the beneficial properties of phytochemicals in turmeric that possess antimicrobial, antifungal, and antioxidant activities in broiler chickens that may improve the bird utilization of dietary nutrients (Osawa *et al.*,1995; Al-Sultan, 2003; Radwan *et al*.,2008). In addition, there are reports that show that turmeric have the ability to the digestive system, such as stimulate the intensive lipase, sucrase and maltase activities (Platel and Srinivasan,1996) as well as the secretion of pancreatic lipase, amylase, trypsin, and chymotrypsin enzymes (Platel and Srinivasan 2000). Recently, Rajput *et al*. (2012) showed that dietary supplementation of pure curcumin at the rate of 0.2k/kg in a corn-soybean based diets increased villus length and width in the duodenum, jejunum, and caeca of 42 days old broiler chickens. Therefore, there is the liklihood that improvement of the growth performance due to dietary turmeric meal inclusion in broiler chickens is attributable to improvement in the digestive system of the body. However, some authors did not find beneficial effects on supplementing diets with turmeric meal at the rate of 0.5g/kg (Akbarain, 2012), 1.0g/kg (Rahmatnejad, 2009), 2.0g/kg (Mehala and Moorthy, 2008; Elhakim *et al.*,2009),10.0g/kg (Al-Sultan 2003; Durrani *et al.*, 2006; Abass *et al*.2010), or 30.00g/kg (Abass, 2010). In addition, supplementing drinking water with turmeric at the rate of 5.0g per litre also did not influence body weight gain or daily feed intake 0f broiler chickens (Sadeghi *et al*., 2012).The differences in responses of broiler chickens reported in these studies may be due to differences in the basal diets, rearing periods of the broiler or other experimental

details used in those studies, such as statistical design, dose supplementation, and breed of the birds.

### 2.6.2 Responses on Egg Production and Quality

There were evidences to show that dietary supplementation with turmeric meal stimulated egg production of laying hens. Supplementation of 5.0g/kg turmeric meal in laying diets increased egg production, egg weight and mass, while supplementation of 10.0g/kg increased the yolk weight and yolk index (Radwan *et al.*, 2008). The authors suggested that supplementing layer diets with turmeric meal improved the environment in the uterus (specifically the site of calcium deposition) and consequently increased shell weight and thickness. In a study using a commercial product, supplementation of a herbo-mineral toxin binder product containing turmeric alleviated the adverse effect of Ochratoxin A infection on egg production (Sawale, 2009).

However, some studies found no effect of dietary supplementation with turmeric meal on egg production and quality. In a study using single Comb White Leghorn layers, Moorthy(2009) found that dietary supplementation of 1.0g/kg turmeric meal did not influence hen housed egg production as well as percent hen day egg production. Results from other studies showed that supplementation of turmeric meal in the diets at 2.0g/kg (Riasi, 2012) or 5.0g/kg (Radwan, 2008) did not affect egg shell thickness or egg shell weight. In recent study, Malekizadeh (2012) reported that supplementation of turmeric meal in the diet at the rate of 10.0 or 30.0g/kg did not influence egg production, egg weight, and egg mass of Single Comb White Leghorn (W-36) laying hens. The dissimilarity in results found in the egg traits may be caused by some differences in the experimental methods in those studies (Nanung, 2013).

### 2.6.3 Responses on Health Status of Broilers

Turmeric also has beneficial effects on blood parameters in broiler chickens. Fat metabolism studies using male Wanjiang Yellow (Zhongze, 2007) and Arbor Acres (Zhongze, 2009) broiler chickens showed that dietary supplementation of turmeric meal at the rate of 0.35g/kg consistently stimulated the activity of hormone sensitive lipase (HSL) and increased the content of high-density lipoprotein (HDL) in the serum. Dietary supplementation of turmeric meal also reduced the total cholesterol concentration, total triglycerides as well as the very low-density lipoprotein (VLDL) contents in the blood serum. A study by Kermanshahi and Riasi (2012) showed that 0.5-1.5g/kg turmeric meal supplementation decreased level of

triglyceride, total cholesterol, and (HDL)-cholesterol, and increased level of low-density lipoprotein cholesterol (LDL) cholesterol in the blood of Hy-line W-36 laying hens. Raisi (2012) reported that turmeric has a strong property to change the serum lipid profile in laying hens. Dietary supplementation of 0.5g/kg turmeric meal in the study reduced the serum triglyceride, total and LDL-cholesterol and increased the serum HDL-cholesterol of Hy-line W-38 laying hens. Emadi (2007) reported that 2.5g/kg turmeric meal supplementation in the diet increased the total cholesterol and HDL-cholesterol, while 5.0g/kg supplementation increased haemoglobin and reduced LDL-cholesterol, very low-density lipoprotein-cholesterol (VLDL-cholesterol), and red blood cells of male Ross broiler chickens at 42 days of age. Malekizadeh (2012) reported that 10.0-30.0g/kg turmeric meal supplementation reduced total cholesterol in the blood serum of Single Comb White Leghorn (w-36) laying hens. Al-Sultan (2003) reported a significant improvement in both erythrocyte and leukocyte counts when the diets of broiler chicken were supplemented with 10.0g/kg turmeric meal, while Sugiharto (2011) reported a significant increase in erythrocyte count following 600mg turmeric meal supplementation per kg live body weight in the drinking water of broiler chickens. Antony *et al*. (1999) suggested that these improvements were due to the presence of curcumin in turmeric rhizome.

A study using (Ross × Ross) male broiler chickens (Gowda, 2009) showed that dietary inclusion of 222mg/kg curcuminiods from turmeric ameliorated the adverse effects of aflotoxin B1 on serum chemistry in terms of total protein, albumin and μ-glutamyl transferase activity. In that study, the depression in antioxidant functions caused by aflatoxin B1 was also mitigated by 222mg/kg curcuminiods inclsion in the diet. In a study using cumin and turmeric mixture, Al-kassie. (2011) reported that supplementation of 2.5g/kg herbal mixture reduced blood cholesterol and mortality of Arbor Acres broiler chickens. The improvement in the serum lipid profile supported previous studies by chattopadhyay (2004) and Srinivasan (2005) indicating that turmeric has hypolipidemic and hypochoesterolemic properties.

Turmeric contains active compounds that beneficially stimulate bile secretion and bile flow which can support health of the liver. According to Emadi and Kermanshahi (2007b), supplementation of turmeric meal in the diets at the rate of 2.5-7.5g/kg reduced the concentrations of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and lactate dehydrogenase (LDH) in the blood of broiler chickens.

Reductions of these enzymes are important as the accumulations of these enzymes in the liver are related toxicity.

Curcumin has also been reported to be able to enhance the concentration of catalase (Pulla Reddy and Lokesh, 1994), as well as the expression of hepatic superoxide dismutase (Cheng *et al.*, 2005) and glutathione peroxidase (Yarru *et al.*, 2009). Other studies showed the beneficial properties of phytochemicals in turmeric as antioxidant and hepato-protective agents in poultry (Osawa *et al.*, 1995; Araujo and Leon, 2001; Maheswari *et al.*, 2006; Shukla and Singh, 2007). These efficacies of phytochemicals in turmeric might be the reason why this additive supports the health status of poultry.

### 2.6.4 Responses on Immunomodulatory System

Response of broiler chickens due to dietary turmeric supplementation on the immunomodulatory system has been evaluated in some studies. Kurkure *et al.* (2000) reported that dietary supplementation of 0.5 g/kg turmeric ameliorated the harmful effect of aflatoxin B1 on the body immune system, showing the humoral response against aflatoxicosis in cockerels. The number of lymphocytes in lymphoid organs was partially repaired following turmeric administration. Results in a mycotoxicosis study (Sawale *et al.* 2009) showed that turmeric ameriolated the deleterious effects of ochratoxin A on haemetobiochemical and body immune system of laying hens. Haemagglutination titre of the birds were increased when the diets were supplemented with 1.25 g/kg herbomineral toxin binder containing turmeric. In another study using (Ross × Ross) broiler chickens, Lee *et al.* (2010) demonstrated immunomodulatory properties of turmeric against parasitic infection. Serum antibody level against a microneme protein 2 from *Eimeria tenella* (EtMIC2) was significantly higher in birds fed diets supplemented with turmeric. EtMIC2 is an apical complex protein which plays an important role in host cell invasion by Eimeria parasites. It has a putative function in parasite adhesion to the host cell and plays an important role in inhibiting sporozoite invastion of host cell (Sasai *et al.*, 2008).

Turmeric has also been proven to have ability to stimulate the expression of genes which are involved in antioxidant and immune system of broiler chickens. Using a quantitative real-time PCR technique, Yarru *et al.* (2009) showed that 5.0 g/kg turmeric meal stimulated genes expression that involved antioxidant function [cytochrome P450 1A1 and 2H1 (CYP1A1 and CYP2H1)] and gene expression that involved the immune system [interleukins 6 and 2 (IL-6

and IL-2)] in broiler chickens. Lee *et al.* (2010b) reported that when compared to the control group, birds with turmeric administration had significantly higher level of transcripts encoding pro-inflammatory cytokine IL-1β in the duodenum. The levels of transcripts encoding IL-6, IL-15 and IFN-y were also higher in turmeric treated birds. In a study with mice, Chuchill *et al.* (2000) showed that curcumin treatment increased the number of mucosal CD4 (+) T and B cells, suggesting that curcumin modulates lymphocyte-mediated immune functions. These improvements could be attributed to activity of curcumin as immunostimulant agent (Avtony *et al.*, 1999; Yadav *et al.*, 2005; Gautam *et al.*, 2007).

### 2.6.5 Responses on Carcass Traits of Broilers

Dietary supplementation with turmeric may have beneficial effects on the carcass traits of broiler chickens as it contains beneficial phytochemicals, like curcumin, Ar-turmeron, methycurcumin, and othe active compounds. Dietary supplementation of curcumin meal at the rate of 0.35 g/kg reduced the abdominal fat content, subcutaneous fat thickness, intermuscular fat width, and liver fatness of male Wanjiang Yellow broiler chicken (Zhongze *et al.*, 2008). In a later study, Zhongze (2009) reported that percentage abdominal and liver fat weight as well as subcutaneous fat thickness of Arbor Acres and Wangjiang Yellow broiler chickens were reduced following 0.25-0.35 g/kg curcumin supplementation. Samarasingle *et al.* (2003) noted that 3.0 g/kg turmeric meal supplementation reduced the fat content and improved carcass quantity of broiler chickens. Using a higher level of supplementation (5.0 g/kg), Durrani *et al.* (2006) showed beneficial effects of dietary turmeric meal supplementation in reducing fat content, increase carcass quality and dressing percentage, as well as to increase the breast, thigh, and giblet weight of broiler chickens.

However, some studies did not find any significant effect of turmeric supplementation at the rate of 1.0 g/kg (Rahmatnejad *et al* 2009) or 2.0 g/kg (El-Hakim *et al.*, 2009) on carcass characteristics. Al-Sultan (2003) reported no difference found in the crude protein content in breast and thigh muscles following turmeric meal supplementation in the broiler diets.

### 2.6.6 Toxicological Effects of Turmeric

Turmeric is known to be a safe, natural, and residue free phytobiotic (Wang *et al.*,1998). The World Health Organization declared turmeric and its yellow coloring agent (curcumin) as safe to be used in human food and animal feed (WHO 1987). In human and animal studies so far turmeric is considered to have low toxicity (Alia *et al.*, 2009) and is secure and ideal for

poultry. There is no publication as yet that have reported harmful effects of turmeric meal in poultry diets when used at low to moderate concentrations.

Consumption of excessive dosage of turmeric is not recommended because it may induce hepatotoxic effect as noted in studies using mice (Kandarkar *et al*.,1998) and rats (Deshpande *et al.,* 1998). In particular, Al-Sultan and Gameel (2004) recommended that supplementation of broiler diets with more than 50.0.g/kg turmeric meal should be avoided as it may contribute to induction of parenchymal and portal infiltration of mononuclear cells and hyperaemia of portal vessels.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Experimental Site

The experiment was carried out in the Poultry Unit of Teaching and Research Farm and the Animal Science Laboratory in the School of Agriculture and Agricultural Technology (SAAT) of the Federal University of Technology, Owerri, Imo State, Nigeria. Owerri is in the South-Eastern agro-ecological zone of Nigeria. The climatic data of Owerri as summarized in the Ministry of Lands and Survey Atlas of Imo State (1984) showed that Owerri is located at an altitude of 90m. The mean annual rainfall, temperature and humidity are 2500mm, 26.5-27.5$^0$C and 70-80%, respectively. The duration of the dry season is 3 months with rainfall of 65mm and the mean annual evaporation is 1450mm. the soil is sandy loam with an average pH of 5.5.

## 3.2 Processing of Test Materials

Turmeric rhizomes were procured fresh from National Root Crops Research Institute, Department of Minor Root Crops, Umudike, Umuahia, Abia State, Nigeria. The turmeric rhizomes (plate 1) were washed with tap water and divided into two batches of 40kg each. One batch was processed raw and the other batch was cooked. The first batch (processed raw) was crushed and sun-dried for 5 days. The second batch was cooked (poured into boiling water and was allowed to boil) for 1hr, the water drained off, crushed and sun-dried for 5 days. The raw and cooked sun-dried turmeric were then ground using a hammer mill to produce raw and cooked sun-dried turmeric rhizome meals. (Plates 2 and 3) The processed turmeric rhizome meal were subjected to proximate analysis (AOAC, 2005).

## 3.3 Proximate Analysis

**Moisture Content**:

The crucible was washed, oven-dried and transferred into a desiccator for cooling before weighing. Two grams (2g) of the sample was weighed and put into the container and dried in the oven at a temperature of 1050C overnight and then removed and re-weighed. Drying was continued until a weight was obtained. The decrease in weight was expressed as a percentage of the original weight and referred to as percentage moisture content.

Plate 3.2.1: Fresh turmeric rhizome

Plate 3.2.2: Processed raw turmeric rhizome

Plate 3.2.3: Cooked, dried and milled turmeric

**Ash Content**

Two grams (2gm) of the feedstuff was accurately weighed and introduced into a silica dish that had been previously heated and cooled. The dish was placed in a Muffle furnace and the temperature of the furnace was increased to $450^0$C and maintained at this temperature until a whitish-grey ash remained. The dish was then placed in the desicator and allowed to cool, after which it was weighed. Percentage ash content was calculated by expressing the weight of the ash as a percentage of the original weight.

**Crude Fibre**

Two (2g) of the sample was weighed and placed in a hot 200ml of 1.25% $H_2SO_4$ and boiled for 30 minute. It was filtered through a Buckner funnel covered with mushin cloth and held firm with elastic band.

The hot acid sample solution was filtered and the residue was washed with boiling water to remove acid from it. The residue was returned into 200 ml boiling 1.25% NaOH and boiled for 30 minutes.

It was filtered and residue washed with boiling water, 1% HCL and boiling water to remove acid from it. The residue was washed twice with alcohol and three times with petroleum ether using small quantities. The residue was then transferred completely into a porcelain crucible and dried in the oven to a constant weight, cooled and receipt. It was incinerated at $600^0$C for 2 hrs in a Muffle furnace. The crucible and content was cooled in a desiccator and weighed. The loss weight on incineration is the mass of the crude fibre, and its value was calculated by dividing it with the original weight and multiplying by 100.

**Crude Fat (Ether Extract)**

A flask was washed and dried in an oven at $100^0$C for about 5 minutes. It was allowed to cool in a desiccator and weighed.

Three 3gm of the sample was weighed into a thimble or filter paper and carefully wrapped and tied with a thread. The filter paper and content was placed in the soxhlet extractor column, the flask was connected and the lipid extracted for about 6 hours. When the solvent was clear in the column, the defatted sample swas carefully removed and solvent recovered. The flask and oil was oven dried until the solvent vaporized. The flask with content was reweighed, and the weight of the extract determined. The ether extract value was calculated as a percentage of the original weight.

**Crude Protein**

Crude protein was determined using the micro-Kjeldahl procedure. This involved oxidizing a sub-sample (1-2gm) to $(NH_4)SO_4$ by digestion with concentrated $H_2SO_4$. The digest was made alkaline with NaOH and the $NH_3$ was distilled into a 4% solution of boric acid. The ammonium borate produced was titrated with standard HCL. The nitrogen obtained was multiplied by a factor 6.25 to get the crude protein content of the sample

## 3.4 Experiment One (Starter phase)

### 3.4.1 Experimental Diets

Seven experimental broiler starter diets were formulated incorporating the turmeric meal at seven dietary levels of 0%, 0.5%, 1.0%, and 1.5% raw turmeric and cooked turmeric meals, respectively (table 3.1).

### 3.4.2 Experimental Birds

A total of 189 (one hundred and eighty nine) day old unsexed broiler chicks of Cobb-strain were purchased from a reputable distributor in Owerri. The birds were divided into 7 groups of 27 birds each. Each group was further subdivided (replicated) into 3 groups of 9 birds each and randomly assigned to one of the 7 experimental diets in a completely randomized design (CRD). The birds were housed in a 1.4 x 1.4m pen with wood shavings of 2cm hieght as litter material. Stoves and lanterns were used as sources of heat and light respectively. Feed and water were provided ad-libitum for all treatment groups throughout the experimental period. Also adequate prophylactic medications and vaccinations were administered.

### 3.4.3 Data Collection for Starter Phase

The birds were brooded for 14 days on the control diet for stabilization before commencement of the experiment.The birds were weighed at the beginning of the experiment and weekly thereafter. Daily feed intake was recorded as the difference between weight of feed offered and the left over the next morning. At the end of starter phase, data collected included initial body weight, final body weight, weekly body weight, daily feed intake, weight gain, feed conversion ratio (g feed/g gain). The trial lasted 21 days.

### 3.4.4 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) as outlined by Snedecor and Cochran, (1978). Where significant differences were observed, treatment means were compared using Duncan’s New Multiple Range Test as outlined by Obi (1990).

### 3.5 Experiment Two (Finisher phase)

#### 3.5.1 Experimental Diets

Seven experimental broiler finisher diets were formulated incorporating processed turmeric rhizome meals at seven dietary levels of 0%, 1.0%, 1.5%, and 2.0% for raw and cooked turmeric rhizome meals respectively. Other ingredients were adjusted in such a way that the diets were iso-nitrogenous and iso-caloric and met the nutrient requirements of the birds. Ingredient composition and calculated chemical composition of the diets are presented on (table 3.2).

#### 3.5.2 Experimental Birds

A total of 189 (one hundred and eighty nine) unsexed 35day old broiler chicks of Cobb-strain were used. The birds were divided into 7 groups of 27 birds each. Each group was further subdivided into 3 groups of 9 birds each and randomly assigned to one of the 7 experimental diet in a completely randomized design (CRD). The birds were housed in a 1.4 x 1.4m pen with wood shavings of 2cm height as litter material. Stoves and lanterns were used as sources of heat and light respectively. Feed and water were provided ad-libitum for all treatment groups throughout the experimental period. Also adequate prophylactic medications and vaccinations were administered. This trial lasted 21days.

#### 3.5.3 Data Collection for Finisher Phase

The birds were weighed at the beginning of the experiment and weekly thereafter. Daily feed intake was taken by the difference between weight of feed offered and the left over the next morning. Data collected included feed intake, body weight gain, feed conversion ratio, carcass and organ weights and blood samples.

#### 3.5.4 Carcass and Organ Weight Evaluation

At the end of the feeding trial, five birds were randomly selected from each treatment, starved overnight of feed but not water, weighed and slaughtered by severing their neck and eviscerated for carcass and organ analysis. The weight of heart, liver, kidney and gizzard were measured and expressed as percentage of liveweight.

Table 3.1 Ingredient and nutrient composition of the experimental broiler starter diets.

| Ingredients (%) | Dietary levels of Turmeric (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Raw | | | Cooked | | |
| | 0.00 | 0.50 | 1.00 | 1.50 | 0.50 | 1.00 | 1.50 |
| Maize | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 |
| SBM | 28.0 | 28.0 | 28.0 | 28.0 | 28.0 | 28.0 | 28.0 |
| P K C | 5.00 | 4.50 | 4.00 | 3.50 | 4.50 | 4.00 | 3.50 |
| Turmeric | 0.00 | 0.50 | 1.00 | 1.50 | 0.50 | 1.00 | 1.50 |
| BDG | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| Fish meal | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Wheat offal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Vit/minpremix* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Nutrient | composition | (%) | | | | | |
| CP | 22.0 | 22.0 | 21.95 | 21.90 | 21.98 | 21.90 | 21.87 |
| CF | 4.06 | 4.82 | 5.20 | 4.95 | 5.28 | 5.50 | 5.65 |
| EE | 4.40 | 5.10 | 5.50 | 5.57 | 5.10 | 4.95 | 5.25 |
| Calcium | 1.31 | 1.37 | 1.4 | 1.4 | 1.37 | 1.4 | 1.4 |
| Phosphorous | 1.03 | 1.1 | 1.13 | 1.15 | 1.1 | 1.13 | 1.15 |
| NFE | 65.28 | 62.18 | 60.46 | 63.36 | 58.09 | 66.3 | 61.06 |
| *ME (kcal/kg) | 2872.20 | 2852.40 | 2850.70 | 2845.35 | 2850.10 | 2850.30 | 2846.06 |

Soyabean meal (SBM), Palm kernel cake (PKC), Brewers dry grain (BDG), Crude protein (CP), Crude fibre (CF), Ether extract (EE), Ntrogen free extract (NFE), Metabolizable energy (ME) *Provided the following per kg of feed: Vitamin A 12000000I.U, Vitamin $D_3$ 3000000I.U, Vitamin E 30000mg, Vitamin K, 2500mg, folic acid 1000mg, Niacin 40000mg, Calpan 10000mg, Vitamin $B_2$ 5000mg, Vitamin $B_{12}$ 20mg, Vitamin $B_1$ 2000mg, Vitamin $B_6$ 3500mg, Biotin 80mg, Antioxidant 125000mg, Cobalt 250mg, Selenium 250mg, iodine 1200mg, Iron 40000mg, Manganese 70000mg, Copper 8000mg, Zinc 60000mg, Chlorine Chloride 200000mg.

Table 3.2 Ingredient and nutrient composition of the experimental broiler finisher diets

| | | Dietary levels of Turmeric (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Raw | | | Cooked | | |
| Ingredients % | 0.00 | 1.00 | 1.50 | 2.00 | 1.00 | 1.50 | 2.00 |
| Maize | 55.00 | 55.00 | 55.00 | 55.00 | 55.00 | 55.00 | 55.00 |
| SBM | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| PKC | 5.00 | 4.00 | 3.50 | 3.00 | 4.00 | 3.50 | 3.00 |
| Turmeric | 0.00 | 1.00 | 1.50 | 2.00 | 1.00 | 1.50 | 2.00 |
| BDG | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Fish meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Wheat Offal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.25 | 0.25 | 0.25. | 0.25 | 0.25 | 0.25 | 0.25 |
| Vit/minpremix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Nutrient | Composition | (%) | | | | | |
| CP | 20.06 | 20.09 | 20.04 | 20.06 | 20.43 | 20.11 | 20.24 |
| CF | 5.30 | 5.34 | 5.50 | 5.80 | 5.40 | 5.80 | 5.60 |
| EE | 4.37 | 6.75 | 6.77 | 7.05 | 6.76 | 6.79 | 7.1 |
| Ca | 1.31 | 1.4 | 1.41 | 1.43 | 1.4 | 1.41 | 1.43 |
| P | 1.03 | 1.1 | 1.11 | 1.13 | 1.1 | 1.11 | 1.13 |
| NFE | 67.54 | 63.91 | 64.56 | 62.60 | 63.17 | 63.09 | 62.36 |
| *ME (Kcal/kg) | 2957.85 | 2959.70 | 2961.00 | 2965.20 | 2945.80 | 2940.91 | 2941.35 |

Soyabean meal (SBM), Palm kernel cake (PKC), Brewers dry grain (BDG), Crude protein (CP), Crude Fibre (CF), Ether extract (EE), Calcium (Ca), phosphorous (P), Nitrogen free extract (NFE), Metabolizable energy (ME) *Provided the following per kg of feed: Vitamin A 12000000I.U, Vitamin $D_3$ 3000000I.U, Vitamin E 30000mg, Vitamin K, 2500mg, folic acid 1000mg, Niacin 40000mg, Calpan 10000mg, Vitamin $B_2$ 5000mg, Vitamin $B_{12}$ 20mg, Vitamin $B_1$ 2000mg, Vitamin $B_6$ 3500mg, Biotin 80mg, Antioxidant 125000mg, Cobalt 250mg, Selenium 250mg, iodine 1200mg, Iron 40000mg, Manganese 70000mg, Copper 8000mg, Zinc 60000mg, Chlorine Chloride 200000mg.

### 3.5.5 Nutrient Digestibility

Another set of five birds per treatment group were used for nutrient digestibility and utilization study. Daily fecal samples and daily feed intake were collected and analyzed for nutrient digestibility. The trial lasted for 10 days.

Before the actual collection of faeces, the broiler birds were brought to a constant daily feed intake and daily faecal output for a period of 7 days. Faeces are then collected for the next 3 days and daily averages obtained. The faecal sample were analysed for proximate composition.

**Calculations**

1. Amount of a nutrient in daily feed minus amount of that nutrient in daily feaces = Amount of that nutrient digested daily.

Note:

a. Amount of nutrient in daily feed = (amount of feed eaten daily × % of nutrient in feed)/100.
b. Amount of a nutrient in daily feaces = (Average amount of feaces excreted daily × % of nutrient in feaces)/100.

2. Coefficient of digestibility of any nutrient = (Amount of that nutrient digested daily/ amount of the nutrient eaten daily) × 100.
3. % of digestible nutrient in a feed = (Amount of that nutrient in the feed × coefficient of digestibility of that nutrient)/100.

### 3.5.6 Haematology and Biochemical Analysis

#### 3.5.6.1 Blood collection

Blood samples were collected from each treatment group at the end of the feeding trail. Five birds per treatment were bled and blood collected from the basilica vein in the wing and analysed. The basilica veins in the wings were punctured with a 5ml scalp vein needle set and 12ml of blood was collected from each bird, 2ml of the blood collected was put into well labelled and sterilized bijon bottles containing ethylene diamine tetra acetic acid (EDTA) as anticoagulant. These were used for the determination of the haematological indices. The remaining 10ml of each blood sample was allowed to coagulate to produce sera for determination of serum biochemical indices. Blood samples were analysed within three (3) hours of their collection for total erythrocyte (RBC) and leukocyte (WBC) counts, haematocrit (PCV), haemoglobin concentration (Hb) and erythrocyte sedimentation rate (ESR). ESR was determined within six hours of sample collection.

### 3.5.6.2 Haemoglobin Concentration

The concentration of blood haemoglobin in the test samples were estimated according to the cyanomethaemoglobin method of Alexander and Griffiths (1993).The haemoglobin in the test samples were converted to cyanomethaemoglobin through methaemoglobin by the Drabkins reagents. Three test tubes were cleaned, dried and labeled B (blank), T (test) and S (standard). Into the tubes were pipette 0.02ml of distilled water, haemoglobin standard and heparinised blood (test) samples, respectively. Thereafter, 5ml of Drabkin's reagent was pipette into each of the tubes (B, S and T). The solutions obtained were mixed and incubated for 5 minutes at room temperature for the colour to be well developed, after which the absorbance of test samples and standard were read against blank at 540nm.

**Calculation**

$$\text{Hbc (g/dl)} = \frac{\text{A sample}}{\text{A std}} \times \text{C std}$$

Where:

A sample = Absorbence of sample

A std = Absorbence of standard

C std = Concentration of standard

### 3.5.6.3 Red Blood Cell (Erythrocyte) Count

The blood samples were diluted 1:200 in a solution of 10ml of 40% formalin in a litre of 32g/l trisodium citrate. The diluents and samples were mixed and carefully loaded into the counting chamber (Petri dish with a small piece of damp blotting paper). This was left for 2-3 minutes for the cells to settle before they were counted using improved Neubauer haemocytometer at magnification of x 40. Sufficient number of cells were counted to minimize errors due to variable cell distribution. To obtain a variance of 20% it is necessary to count about 2500 cells. All the cells in the entire central square ($1mmm^2$) were counted.

**Calculation**

$$\text{Cell count (1)} = N \times (D/A) \times 10 \times 10^9$$

Where

N = Total number of cells counted

D = Dilution factor of blood

A = Total area counted (in $mm^2$)

10 = Factor to convert area to volume (in µ1)

$10^9$ = Factor to convert count per µ1 to count per litre

### 3.5.6.4 White Blood Cell (Leucocyte) Count

Before counting the number of white blood cells, a 1-in-20 dilution of the blood samples was made by adding 0.02ml of whole blood to 0.38ml of diluting fluid (2% acetic acid lightly coloured with 1% crystal violet) and mixed for 2-3 minutes. By this dilution, the red cells were lysed but the leucocytes remain intact. Before filling the counting chamber, the fluid was inspected to ensure that it was clear. The chamber was then filled and left for 2-3 minutes for the cells to settle. Thereafter, the chamber was laced on the microscope stage and, using the x25 objective, the number of cells seen in the four large ($1mm^2$) corner squares were counted while observing the criteria for inclusion and exclusion of cells touching the border.

**Calculation**

Cell count (/1) = N × (D/A) x 10 x $10^9$

N = Total Number of cells counted

D = Dilution factor

A = Total area counted (in $mm^2$)

10 = Factor to convert area to volume (in µI)

$10^9$ = factor to convert count per µI to count per litre

### 3.5.6.5 Erythrocyte Sedimentation Rate(Westergren Technique)

0.4ml of sodium citrate anticoagulant was pipette into a small container, 1.6ml of venous blood or EDTA anticoagulated blood was added thereto and well mixed. The cap of the container was then removed and the sample placed in the ESR stand with a Westergren pipette inserted and properly positioned vertically. Using a safe suction method, the blood was drawn to the 0 mark of the Westergren pipette, avoiding air bubbles. It was ascertained that the ESR stand was level by ensuring that the bubbles in the spirit level was central.

The timer was then set for 1 hour; it was ensured that the ESR stand and pipette were not exposed to direct sunlight during the period. After exactly 1 hour, the level at which the plasma met the red cells was read in mm.

### 3.5.6.6 Packed Cell Volume (PCV- Haematocrit)

This was estimated from heparinized blood samples using the haematocrit method of Alexander and Griffiths (1993). Haematocrit (capillary) tubes were filled by capillary action to mark with whole blood. The bottom end of the capillary tubes were sealed with plastacine and the tubes centrifuged in a haematocrit centrifuge for 4 minutes. The PCV was subsequently determined by measuring the height of the red cell column and expressing it simultaneously as a ratio of the height of the total boold column using a PCV reader.

**Calculation**

**%** PCV = Height of red cell column/Height of total blood column × 100.

### 3.5.7 Serum Biochemistry

### 3.5.7.1 Recovery of Blood Sera

The bottles of coagulated blood were centrifuged at 3000 rpm for ten minutes for serum separation. Thereafter, the harvested sera were used for evaluation of total serum protein (TSP), serum albumen (SA) and globulin. Cholesterol (determined from fresh blood) and other biochemical constituent such as creatinine and urea concentration were also assayed.

### 3.5.7.2 Estimation of Total Serum Protein By Biuret Method

**Method**

This assay was based on Tietz (1999)

**Reagents**

**Reagent 1**:

| | |
|---|---|
| Soduim hydroxide | 80mmol/L |
| Potassium sodium tartate | 12.5mmol/L |

**Reagent 2**

| | |
|---|---|
| Sodium hydroxide | 100mmol/L |
| Potassium sodium tartrate | 16mmol/L |
| Potassium iodide | 15mmol/L |
| Copper sulphate | 6mmol/L |

Working reagent (sample start procedure): To 4 parts reagent 1, one part of reagent 2 was mixed to constitute the working reagent.

**Test procedure**

Three test tubes were labelled blank, standard and sample respectively. Thereafter, the serum, distilled water and working reagent were dispensed into them in the scheme shown below.

| | Blank | Standard | Sample |
|---|---|---|---|
| Sample (serum) | - | 20µL | 20µL |
| Distilled water | 20µL | 10µL | - |
| Working reagent | 1000µL | 1000µL | 1000µL |

These tubes were mixed, incubated for 5 minutes at $25^0$C-$37^0$C absorbance read against blank at 540nM.

**Calculation**

Total protein (g/dL) = $\frac{\text{Absorbance (Sample)}}{\text{Absorbance (standard)}} \times$ Conc. (standard)

### 3.5.7.3 Serum Albumin/Globulin Assay (BCG Method)

Albumin bonds with bromocresol green (BCG) to produce a blue green colour whose intensity is directly proportional to the concentration on albumin in the sample.

**Materials and Reagents**

Sample: Serum

Reagent: Single, ready-to-use working reagents, composed of

Bromocresol Green (BCG) 0.26mmol/L

Citrate Buffer, pH 4.2 30mmol/L

**Test procedure**

With reagent and sample brought to room temperature, three test tubes labelled blank, standard and sample respectively were set, into which the working reagent, serum sample and standard were dispensed as shown in the scheme below.

| | Blank | Standard | Sample |
|---|---|---|---|
| Working Reagent | 1000µL | 1000µL | 1000µL |
| Sample (Serum) | - | - | 10µL |
| Standard | - | 10µL | - |

The tubes were mixed, incubated for 10 minutes at $25^0$C/$35^0$C and absorbance read at 540nm against reagent blank.

**Calculation**

Albumin (g/dL) = $\frac{\text{Absorbance (sample)}}{\text{Absorbance (standard)}} \times$ Conc. (Standard)

Serum globulin = Total protein – Albumin (g/dL)

### 3.5.7.4 Creatinine Essay

The method adopted for this analysis was based on WHO's guidelines on Standard Operating Procedures in clinical chemistry (SOP, 2005).

**Stage 1**

To a centrifuge tube was added 1.5ml of distilled water, 0.5ml of serum, 0.5ml 5% sodium tungstate and 0.5ml of $2/3NH_2SO_4$. These were mixed and spun at 1000 rpm for 5 minutes. This constituted the working reagent.

**Stage 2**

Three test tube were labeled: Test, standard and blank respectively.

To the test (tube) was added 2ml of clear supernatant from the working reagent, 1ml of 0.15N NaOH, 1ml of picric acid and 2ml of distilled water.

To the standard (tube) was added 2ml of creatinine standard, 1ml of 0.75N NaOH, 1ml of picric acid and 2ml of distilled water.

To the blank (tube) was added 2ml of distilled water, 1ml of 0.75N NaOH, 1ml of picric acid and 2ml of distilled water (for the second time). The contents of the various tubes were properly mixed and allowed to stand for 20 minutes at room temperature, after which absorbance were read at 490nm.

**Calculations**

$$\text{Creatinine content (mg/dl)} = \frac{\text{Abs. of test}}{\text{Abs. of Std.}} \times \text{Conc. Of Std. (4mg/dl)}$$

### 3.5.7.5 Estimation of Serum Total Cholesterol (Kits Based)

**Materials and Reagents**

**Sample:** Fresh serum

**Reagent:**

A single ready to use reagent comprising:

| | | |
|---|---|---|
| Good's Buffer, pH 6.7 | - | 50mmol/L |
| Phenol | - | 5mmol/L |
| 4-Aminoantipyrine | - | 0.3mmol/L |
| Cholesterol esterase | - | ≥200μ/L |
| Cholesterol Oxidase | - | ≥50μ/L |
| Peroxide | - | ≥3μ/L |

**Test procedure**

Both reagent and samples were brought to room temperature and into three test tubes (blank, standard and sample). The following were pipetted as shown in the scheme below:

| | Blank | Standard | Sample |
|---|---|---|---|
| Reagent | 1000µL | 1000µL | 1000µL |
| Sample/Standard (Std.) | - | 10µL | 10µL |
| Distilled water | 10µL | - | - |

The content of the tubes were mixed, incubated for 20 minutes at $25^0$C, after which absorbance of sample and standard were read at 500nm against reagent blank within 60 minutes.

**Calculation**

$$\text{Cholesterol (mg/do)} = \frac{\text{Absorbance Sample)}}{\text{Absorbance (Std.)}} \times \text{Conc. (Std.)}$$

**3.5.7.6 Determination of Urea (Based On WHO, 2005)**

**Materials and Reagents**

Sample: Serum

Reagents: Ready-to-use colour reagent, urea standard.

**Analytical procedure**

Three test tubes were labeled (test, standard and blank) respectively.

To the test tube was added 2.5m1 of acid reagent, 2.5m1 of colour reagent and 25µL (0.025L) of serum.

To the standard tube was added 2.5m1 of acid reagent, 2.5m1 of colour reagent and 25µL of urea standard.

To the Blank tube was added 2.5ml acid reagent, 2.5ml of colour reagent and 25µL of distilled water.

All tubes were well mixed, capped with cotton wool and placed in boiling water for 10 minutes. Thereafter they were cooled and read at 540nm.

**Calculations**

$$\text{Urea (mg/ml)} = \frac{\text{Abs. of Test}}{\text{Abs. of Std.}} \times \text{Conc. Of Std. (50mg/ml)}$$

### 3.5.7.7 Determination of Glucose (Glucose Oxidase Reagent Kit)

**Materials and Reagents**

**Samples:** Fresh Serum

**Reagents:**

**Glucose Reagent:** A single ready-to-use reagent consisting of glucose oxidase 15µL/ml, peroxidase 1.2µl/ml, mutarotase 4.0µl/ml, 4-aminoantipyrine 0.38mM, p-hydroxybenzenesulfonate 10mM, and non-reactive ingredients.

**Glucose Standard:** (100mg/dl 3-D glucose).

**Analytical procedure:**

1. Test tubes were labelled: blank, standard, sample.
2. 1.5ml of working reagent was pipetted into all tubes and placed in $37^0$C heating bath for at least five (5) minutes.
3. 0.01ml of sample was added to sample tubes, mixed and incubated at $37^0$C for exactly ten (10) minutes.
4. After incubation, spectrophotometer was brought to zero with the reagent blank and absorbance of all tubes were read and recorded at 500nm.

**Calculation**

4(A= Absorbance)

$$\text{Glucose (mg/dl)} = \frac{\text{A (Sample)}}{\text{A (Standard}} \times \text{Conc. of Standard}$$

### 3.5.8 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) as outlined by Snedecor and Cochran (1978). Where significant differences were observed, treatment means were compared using Duncan's Multiple Range Test as outlined by Obi (1990).

# CHAPTER FOUR

# 4.0 RESULTS AND DISCUSSION

## 4.1 Proximate Composition of Turmeric

The proximate composition of raw and cooked turmeric is presented in table 4.1. the sun-dried raw and cooked sample contained: moisture 12% and 7%; crude protein, 14.54% and 13.72%; crude fibre, 12.0% and 10.0%; and NFE, 52.46% and 60.28%, respectively.

## 4.2 Experiment One (Broiler Starter Trial)

Results on the effect of dietary inclusion of raw and cooked turmeric meal on broiler performance are shown in table 4.2.

### 4.2.1 Body Weight Changes

The initial body weight of the starter broilers were 277.0g, 277.0g, 277.0g, 277.0g, 280.0g, and 277.0g for 0.0%, 0.5%, 1.0%, 1.5% raw and 0.5%, 1.0%, 1.5% cooked turmeric diet respectively. The final body weight were, 1143.33, 1140.0, 1147.0, 1167.0, 1133.33, 1200.0, and 1180.0g respectively for 0%, 0.5%, 1.0%, 1.5% raw turmeric meal and 0.5%, 1.0%, 1.5% cooked turmeric meal groups respectively. There were no significant differences ($P>0.05$) among the groups in daily body weight gain. The group on 1.0% cooked turmeric meal recorded the highest daily body weight gain (44.0g) while the group on 0.5% raw turmeric diet recorded the least daily body weight gain (41.09g).

### 4.2.2 Average Daily Feed Intake

The average daily feed intakes of the starter broiler were 99.00, 97.00, 89.00, 97.00, 94.50, 98.50, and 88.00gm for 0.0%, 0.5%, 1.0%, 1.5% raw turmeric meal and 0.0%, 0.5%,1.0%,1.5% cooked turmeric meal groups respectively. There were no significant differences ($P>0.05$) among the groups in average daily feed intake. The group on 0.0% turmeric diet recorded the highest average daily feed intake (99.0g) while the group on 1.5% cooked turmeric diet recorded the least average daily feed intake (88.0g).

### 4.2.3 Feed Conversion Ratio

The values for feed conversion ratio were 2.39, 2.36, 2.15, 2.28, 2.30, 2.24, and 2.05 for 0.0%, 0.5%, 1.0%, 1.5% raw turmeric meal and 0.5%, 1.0%, 1.5% cooked turmeric meal groups, respectively. There were no significant differences ($P>0.05$) among the groups in feed conversion ratio. The group on 0.0% turmeric diet recorded the highest feed conversion

Table 4.1: Proximate composition of raw and cooked turmeric meal

| Composition | Raw turmeric | Cooked turmeric |
|---|---|---|
| Moisture content | 12.0 | 7.0 |
| Ether extract | 5.0 | 4.82 |
| Ash | 6.0 | 5.53 |
| Crude fibre | 12.0 | 10.0 |
| Crude protein | 14.54 | 13.72 |
| Nitrogen free extract | 52.46 | 60.28 |

ratio (2.39) while the group on 1.5% cooked turmeric diet recorded the least feed conversion ratio (2.05).

### 4.2.4 Mortality

No mortality was not recorded among the treatment groups.

## 4.3 Experiment Two (Broiler Finisher Trial)

Results on the effects of raw and cooked turmeric meal on the performance of broiler finishers are presented in table 4.3

### 4.3.1 Body Weight Changes

The initial body weight of the finisher broilers were 1100.0g, 1167.0g, 1213.33g, 1210.0g, 1167.0g, 1080.0, and 1100.0g for 0.0%, 1.0%, 1.5%, 2.0% for raw turmeric diets and 1.0%, 1.5%, 2.0% for cooked turmeric diets respectively. The final body weight were 2120.14g, 2212.04g, 2119.44g, 2196.29g, 2203.70g, 2144.44g, and 2146.29g for 0.0%, 1.0%, 1.5%, 2.0% for raw turmeric meal and 1.0%, 1.5%, 2.0% cooked turmeric meal groups, respectively. There were no significant differences ($P>0.05$) among the groups in daily body weight gain. The group on 1.5% cooked turmeric meal recorded the highest daily body weight gain (51.0g) while the group on 2.0% raw turmeric diet recorded the least daily body weight gain (47.0g).

### 4.3.2 Average Daily Feed Intake

The average daily feed intakes of the finisher broiler were 164.7g, 155.4g, 156.1g, 154.07g, 150.5g,146.0g, and 159.0g for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and1.0%,1.5%, 2.0% cooked turmeric meal groups respectively. There were no significant differences ($P>0.05$) among the groups in average daily feed intake. The group on 0.0% turmeric diet recorded the highest average daily feed intake (164.7g) while the group on 1.5% cooked turmeric diet recorded the least average daily feed intake (146.0g).

### 4.3.3 Feed Conversion Ratio

The values for feed conversion ratio were 3.42, 3.12, 3.32, 3.32, 3.09, 2.87, and 3.21 for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and 1.0%, 1.5%, 2.0% cooked turmeric meal respectively. There were no significant differences ($P>0.05$) among the groups in feed conversion ratio. The group on 0.0% turmeric diet recorded the highest feed conversion ratio (3.42) while the group on 1.5% cooked turmeric diet recorded the least feed conversion ratio (2.87).

Table 4.2. Performance of broiler starter fed diets containing graded levels of raw and cooked turmeric meals

| | Dietary levels of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| Parameters (g/bird) | 0.0 | 0.5 | 1.0 | 1.5 | 0.5 | 1.0 | 1.5 | SEM |
| Initial body weight | 277.00 | 277.00 | 277.00 | 277.00 | 277.00 | 280.00 | 277.00 | 5.35 |
| Final body weight | 1143.33 | 1140.00 | 1147.00 | 1167.00 | 1133.33 | 1200.00 | 1180.00 | 17.93 |
| Body weight gain | 866.33 | 863.00 | 890.00 | 890.00 | 856.33 | 920.00 | 903.00 | 19.57 |
| Daily weight gain | 41.30 | 41.09 | 41.43 | 42.40 | 41.00 | 44.00 | 43.00 | 4.67 |
| Daily feed intake | 99.00 | 97.00 | 89.00 | 97.00 | 94.50 | 98.50 | 88.00 | 7.92 |
| Feed conversion ratio | 2.39 | 2.36 | 2.15 | 2.28 | 2.30 | 2.34 | 2.05 | 0.78 |
| Mortality % | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 4.3.4 Mortality

There were no significant (P>0.05) differences among the groups. However, the result from finisher phase showed that the control recorded highest mortality (7.41%) while fed 2.0% raw turmeric and all broilers fed cooked turmeric meals recorded 0.0% mortality.

## 4.4 Nutrient Digestibility

Results on the effects of raw and cooked turmeric meal on nutrient digestibility by the experimental finisher broiler birds are presented in table 4.4

### 4.4.1 Dry Matter Digestibility

The values for dry matter digestibility were 90.60%, 90.23%, 81.74%, 93.33%, 91.8% 91.9% and 91.9% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P> 0.05) among the groups. The group on 2.0% raw turmeric meal recorded the highest DM digestibility (93.33%) while the group on 1.0% raw turmeric meal recorded the least DM digestibility (81.74%).

### 4.4.2 Crude Protein Digestibility

The values for crude protein digestibility were 96.88%, 99.9%, 99.46%, 98.19%, 96.04%, 96.94% and 96.35% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric diet and 1.0%, 1.5% and 2.0% cooked turmeric diet groups, respectively. There were no significant differences (P> 0.05) among the groups. The group on 1.0% raw turmeric diet recorded the highest CP digestibility (99.9%) while the group on 1.0% cooked turmeric diet group recorded the least CP digestibility (96.04%).

### 4.4.3 Ether Extract Digestibility

The values for ether extract digestibility were 97.61%, 98.12%, 97.81%, 99.37%, 98.68%, 98.76% and 98.34% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric diet and 1.0%, 1.5% and 2.0% cooked turmeric diet groups, respectively. There were no significant differences (P> 0.05) among the groups. The group on 2.0% cooked turmeric meal recorded the highest EE digestibility (99.37%) while the group on 0.0% turmeric diet group recorded the least EE digestibility (97.61%).

Table 4.3: Performance of broiler finisher fed diets containing graded level of raw and cooked turmeric meals

| | Dietary levels of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| Parameters (g/bird) | 0.0 | 1.0 | 1.5 | 2.0 | 1.0 | 1.5 | 2.0 | SEM |
| Initial body weight | 1100.00 | 1167.00 | 1213.33 | 1210.00 | 1167.00 | 1080.00 | 1100.00 | 91.57 |
| Final body weight | 2120.14 | 2212.04 | 2119.49 | 2196.29 | 2203.70 | 2144.44 | 2146.29 | 13.47 |
| Body weight gain | 1020.14 | 1045.40 | 999.00 | 986.30 | 1037.04 | 1064.44 | 1046.30 | 120.75 |
| Daily body weight gain | 48.60 | 49.80 | 48.00 | 47.00 | 49.40 | 51.00 | 49.82 | 5.75 |
| Daily feed intake | 164.70 | 155.40 | 156.10 | 154.07 | 150.50 | 146.00 | 159.00 | 8.94 |
| Feed conversion ratio | 3.42 | 3.12 | 3.32 | 3.32 | 3.09 | 2.87 | 3.21 | 0.39 |
| Mortality % | 7.41 | 3.90 | 3.90 | 0.00 | 0.00 | 0.00 | 0.00 | 2.91 |

### 4.4.4 Crude Fibre Digestibility

The values for crude fibre digestibility were 96.66%, 91.76%, 97.39%, 98.37%, 92.64%, 89.0% and 97.0% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric diet and 1.0%, 1.5% and 2.0% cooked turmeric diet groups, respectively. There were no significant differences (P> 0.05) among the groups. The group on 2.0% raw turmeric meal recorded the highest CF digestibility (98.37%) while the group on 1.5% cooked turmeric diet group recorded the least CF digestibility (87.00%).

### 4.4.5 Nitrogen Free Extract (NFE) Digestibility

The values for crude protein (NFE) digestibility were 98.4%, 96.91%, 96.86%, 98.05%, 95.22% 97.45% and 94.82% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P> 0.05) among the groups. The group on 0.0% control turmeric diet group recorded the highest NFE digestibility (98.4%) while the group on 2.0% cooked turmeric meal recorded the least NFE digestibility (94.82%).

## 4.5. Carcass and Internal Organ Weights

Results on the effects of raw and cooked turmeric meal on carcass and the internal organs weight characteristics of the experimental finisher broiler birds are presented in table 4.5

### 4.5.1 Dressing Percentage.

Values for live weights were 2075.0g, 2400.0g, 2200.0g, 2350.0g, 2125.0g, 22225.0g and 2000.0 while the dressing percentages were 76.51%, 77.60%, 77.84%, 72.34%, 72.94%, 75.28% and 75.0% for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups in dressing percentage. The group on 1.5% raw turmeric meal recorded the highest dressing percentage (77.84%) while the group on 2.0% cooked turmeric diet recorded the least dressing percentage (75.0%).

### 4.5.2 Gizzard

Values for percentage gizzard contents were 3.48%, 2.59%, 3.18%, 3.78%, 3.02%, 3.59%, and 3.34% for 0.0%, 1.0% , 1.5% and 2.0% for raw turmeric meal group and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences (P>0.05) among the groups. The group on 2.0% raw turmeric meal recorded the highest gizzard percentage (3.78%) while the group on 1.0% raw turmeric meal recorded the least gizzard percentage (2.59%).

TABLE 4.4: Effect of the experimental diets on nutrient digestibility

| | Dietary level of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| Parameters(%) | 0.0 % | 1.0 % | 1.5 % | 2.0 % | 1.0 % | 1.5 % | 2.0 % | SEM |
| Dry matter | 91.00 | 90.23 | 81.74 | 93.33 | 91.80 | 91.90 | 91.90 | 2.90 |
| Crude protein | 96.88 | 99.9 | 99.46 | 98.19 | 96.04 | 96.94 | 96.35 | 3.20 |
| Ether extract | 97.61 | 98.12 | 97.81 | 99.37 | 98.68 | 98.76 | 98.34 | 3.30 |
| Crude fibre | 96.66 | 91.76 | 97.39 | 98.37 | 92.64 | 89.00 | 97.00 | 3.90 |
| Nitrogen free extract | 98.40 | 96.91 | 96.86 | 98.05 | 95.22 | 97.45 | 94.82 | 3.90 |

### 4.5.3 Liver

Values for percentage liver contents were 1.99%, 2.12%, 2.36%, 1.92%, 2.28%, 2.17% and 2.06% for 0.0%, 1.0% , 1.5% and 2.0% raw turmeric meal group and 1.0% , 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences (P>0.05) among the groups. The group on 1.5% raw turmeric meal recorded the highest percentage liver content (2.36%) while the group on 0.0% recorded the least percentage liver content (1.99%).

### 4.5.4 Kidney

Values for percentage kidney contents were 0.17%, 0.10%, 0.10%, 0.10%, 0.10%, 0.10% and 0.12% for 0.0%,1.0% , 1.5% and 2.0% raw turmeric meal group and 1.0% ,1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 0.0% recorded the highest percentage kidney content (0.17%) while the group on 1.0% , 1.5% , 2.0% raw turmeric meal and 1.0% , 1.5% cooked turmeric meal recorded the least percentage kidney content (0.10%), respectively.

### 4.5.5 Heart

Values for percentage heart contents were 0.42%, 0.44%, 0.55%, 0.45%,0.58%, 0.53% and 0.46% for 0.0%, 1.0% , 1.5% and 2.0% raw turmeric meal group and 1.0% , 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences (P>0.05) among the groups. The group on 1.0% cooked turmeric meal recorded the highest percentage heart content (0.58%) while the group on 0.0% recorded the least percentage heart content (0.42%).

## 4.6 Haematological Indices of the Experimental Finisher Broiler.

Result on the haematological indices of the experimental finisher broiler birds are presented in table 4.6

### 4.6.1 Red Blood Cell Count (RBC)

The values for red blood cell count (RBC) were 3.2, 1.04, 2.79, 1.87, 3.26, 3.74, and 2.66 x $10^6$/ul for 0.0%, 1.0%, 1.5%, 2.0% raw turmeric meal and 1.0%, 1.5%, 2.0% cooked turmeric meal groups, respectively. There were significant differences (P<0.05) among the groups. The group on 1.5% cooked turmeric meal recorded the highest RBC count ($3.74x10^6$/ul) while the group on 1.0% raw turmeric meal recorded the least RBC count ($1.04x10^6$/ul).

Table 4.5: Carcass and internal organ weights of the experimental finisher broilers fed graded levels of raw and cooked turmeric meals.

| | Dietary levels of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| Parameters | 0.0 | 1.0 | 1.5 | 2.0 | 1.0 | 1.5 | 2.0 | SEM |
| Live weight (g) | 2075.00 | 2400.00 | 2200.00 | 2350.00 | 2125.00 | 2225.00 | 2000.00 | 106.07 |
| Dressed weight (g) | 1587.50 | 1862.50 | 1712.50 | 1700.00 | 1550.00 | 1675.00 | 1500.00 | 96.13 |
| Dressing percentage (%)[a] | 76.51 | 77.60 | 77.84 | 72.34 | 72.94 | 75.28 | 75.00 | 31.34 |
| Gizzard (%)[a] | 3.48 | 2.59 | 3.18 | 3.78 | 3.02 | 3.59 | 3.34 | 11.05 |
| Liver (%)[a] | 1.99 | 2.12 | 2.36 | 1.92 | 2.28 | 2.17 | 2.06 | 4.72 |
| Kidney (%)[a] | 0.17 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.12 | 0.83 |
| Heart (%)[a] | 0.42 | 0.44 | 0.55 | 0.45 | 0.58 | 0.53 | 0.46 | 2.37 |

[a] percentage of liveweight

### 4.6.2 Packed Cell Volume (PCV)

The values for PCV were 35.5%, 31.0%, 21.0%, 36.5%, 41.5% and 29.5% for 0.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0 cooked turmeric meal groups respectively. There were significant differences (P<0.05) among the groups. The group on 1.5% cooked turmeric meal recorded the highest PCV (41.5%) while the group on 2.0% raw turmeric meal recorded the least PCV (21.0%).

### 4.6.3 Haemoglobin Content (Hb)

Haemoglobin concentration were 5.7, 5.9, 6.2, 4.9, 7.1, 5.3 and 6.0g/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 1.0% cooked turmeric meal recorded the highest Hb content (7.1g/dl) while the group on 2.0% raw turmeric meal recorded the least Hb content (4.9g/dl).

### 4.6.4 White Blood Cell Count (WBC)

The white blood cell counts (WBC) were 18.84, 24.3, 13.88, 18.72, 26.22, 17.06 and 17.08 x $10^5$/ul for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 1.0% cooked turmeric meal recorded the highest WBC count ($26.22x10^5$/ul) while the group on 1.5% raw turmeric meal recorded the least WBC count ($13.88x10^5$/ul).

### 4.6.5 Lymphocytes

Lymphocytes values were 81.5%, 64.0%, 76.5%, 76.5%, 78.0%, 79.5% and 56.0% for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 0.0% recorded the highest lymphocytes (81.5%) while the group on 2.0% cooked turmeric meal recorded the least lymphocytes (56.0%).

### 4.6.6 Heterophils

The values for heterophils were 17.0%, 36.0%, 22.5%, 21.0%, 30.0%, 18.5% and 42.0% for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5%, and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 2.0% cooked turmeric meal recorded the highest heterophil value (42.0%) while the group on 0.0% recorded the least heterophil value (17.0%).

### 4.6.7 Eosinophil Basophil Monocyte

Eosinophil values were 1.5%, 0.0%, 1.0%, 2.5%, 2.0%, 2.0% and 2.0% for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5%, and 2.0% cooked turmeric meal groups, respectively. There were no significant differences (P>0.05) among the groups. The group on 2.0% raw turmeric meal recorded the highest eosinophil value (2.5%) while the group on 1.0% raw turmeric meal recorded (0.0%) eosinophils value. No trace of monocytes and basophils were observed.

## 4.7 Serum Biochemical Indices of the Finisher Broiler Birds

Results on the serum biochemical indices of the finisher broiler birds are presented in table.

### 4.7.1 Total Protein (TP)

The values for total protein content were 3.42, 3.65, 3.48, 4.11, 3.29, 3.39, and 3.52 g/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric groups, respectively. There were no significant difference (P> 0.05) among the groups. The group on 2.0% raw turmeric meal recorded the highest total protein content (4.11g/dl) while the group on 1.5% cooked turmeric meal recorded the least total protein content (3.39g/dl).

### 4.7.2 Albumin

The values for albumin content were 1.54, 1.80, 1.86, 1.64, 1.95, 1.78, and 1.75g/dl for 0.0%, 1.0%, 1.5% and 2.0%, raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant (P> 0.05) differences among the treatments. The group on 1.0% cooked turmeric meal recorded the highest albumin level (1.95g/dl) while the group on 0.0% recorded the least albumin level (1.54g/dl).

### 4.7.3 Globulin

There were no significant differences (P>0.05) between the globulin values recorded at the different inclusion levels of raw and cooked turmeric rhizome meal. However, values obtained from birds fed the cooked rhizome meal tended to be higher at each level of inclusion. The values were within the normal range (1.6-1.9) for broiler finisher birds.

Table 4.6: Effect of the experimental diets on the haematological indices of finisher broiler

| | Dietary levels of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| Parameters | 0.0 | 1.0 | 1.5 | 2.0 | 1.0 | 1.5 | 2.0 | SEM |
| RBC(*$10^6$/ui | $3.20^{a}$ | $1.04^{c}$ | $2.79^{a}$ | $1.87^{bc}$ | $3.26^{a}$ | $3.74^{a}$ | $2.66^{ab}$ | 0.50 |
| PCV (%) | $35.50^{b}$ | $17.70^{d}$ | $31.00^{c}$ | $21.00^{d}$ | $36.50^{b}$ | $41.50^{ac}$ | $29.50^{cd}$ | 1.32 |
| Hb (g/dl) | 11.83 | 5.90 | 10.33 | 7.00 | 12.17 | 13.83 | 9.83 | 1.32 |
| WBC *$10^5$/ul | 18.84 | 24.30 | 13.88 | 18.72 | 26.22 | 17.06 | 17.08 | 5.18 |
| Heterophils (%) | 17.00 | 36.00 | 22.50 | 21.00 | 30.00 | 18.50 | 42.00 | 6.61 |
| Lymphocyte (%) | 81.50 | 64.00 | 76.50 | 76.50 | 78.00 | 79.50 | 56.00 | 14.86 |
| Eosinophils (%) | 1.50 | 0.00 | 1.00 | 2.50 | 2.00 | 2.00 | 2.00 | 0.99 |
| Monocyte (%) | - | - | - | - | - | - | - | - |
| Basophil (%) | - | - | - | - | - | - | - | - |

A,b,c means being different superscripts in the same row are significantly different (P<0,05).

RBC=Red blood cell; PCV= Pack cell volume; Hb= haemoglobin; WBC= White blood cells

### 4.7.4 Creatinine and Urea

The values for creatinine were 1.41, 1.52, 1.09, 1.50, 1.16, 1.39, and 1.14mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. The values for urea were 21.26, 29.52, 24.41, 37.0, 40.36, 33.77 and 52.11mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups, respectively. There were no significant ($p > 0.05$) differences among the groups. The group on 1.0% raw turmeric meal recorded the highest creatinine level (1.52mg/dl) while the group on 1.5% raw turmeric meal recorded the least creatinine level (1.09mg/dl). The group on 2.0% cooked turmeric meal recorded the highest urea level (52.11mg/dl) while the group on 0.0% recorded the least urea level (21.26mg/dl).

### 4.7.5 Glucose

The values for glucose concentration were 124.0, 108.5, 163.0, 106.0, 121.0, 83.0, 82.0 mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant ($P > 0.05$) differences among the groups. The group on 1.5% raw turmeric meal recorded the highest blood glucose level (163.0mg/dl) while the group on 2.0% cooked turmeric meal recorded the least blood glucose level (82.0mg/dl).

### 4.7.6 Cholesterol

The cholesterol values were 67.65, 65.46, 80.48, 70.52, 63.50, 78.22 and 69.05mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences among the groups ($P > 0.05$). The group on 1.5% raw turmeric meal recorded the highest cholesterol level (80.48mg/dl) while the group on 1.0% cooked turmeric meal recorded the least cholesterol level (63.50mg/dl).

### 4.7.7 Triglyceride Concentration

The triglyceride concentration were 59.42, 48.39, 49.4, 49.74, 50.06, 55.08 and 47.27mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences ($P > 0.05$) among the groups. The group on 0.0% recorded the highest triglyceride concentration (59.42mg/dl) while the group on 2.0% cooked turmeric meal recorded the least triglyceride concentration (47.27mg/dl).

### 4.7.8 High Density Lipoprotein Cholesterol (HDL-C)

The HDL-C values were 51.0, 47.94, 47.24, 44.97, 47.74, 49.82 and 47.51mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences (P>0.05) among the groups. The group on 0.0% recorded the highest HDL-C (51.0mg/dl) while the group on 1.5% raw turmeric meal recorded the least HDL-C (47.24mg/dl).

### 4.7.9 Low Density Lipoprotein-Cholesterol (LDL-C)

The LDL-C values were 43.66, 39.62, 55.69, 48.16, 36.43, 52.05 and 43.26mg/dl for 0.0%, 1.0%, 1.5% and 2.0% raw turmeric meal and 1.0%, 1.5% and 2.0% cooked turmeric meal groups respectively. There were no significant differences (P>0.05) among the groups. The group on 1.5% raw turmeric meal recorded the highest LDL-C (55.69mg/dl) while the group on 1.0% cooked turmeric meal recorded the least LDL-C (36.43mg/dl).

## 4.8 General Discussion

**Proximate Composition of Turmeric**

Cooked turmeric was lower in moisture content (7%) than raw turmeric (12%). Most likely, cooking caused shrinkage of turmeric and this facilitated moisture loss during the subsequent sun-drying. Prithi (1992) observed that quality of cooked rhizomes is negatively affected for materials with higher moisture content. In concurrence, the ether extract, ash, crude fibre and crude protein values for cooked turmeric were lower than corresponding values for the raw turmeric counterpart. The higher nitrogen free extract value for cooked turmeric may have resulted from the effect of heat on fibre or the relatively lower moisture content of cooked turmeric compared to raw turmeric.

Table 4.7: Effect of the experimental diets on serum biochemical indices of finisher broiler birds

| Parameters | Dietary levels of Turmeric (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Raw | | | | Cooked | | | |
| (mg/dl) | 0.0 | 1.0 | 1.5 | 2.0 | 1.0 | 1.5 | 2.0 | SEM |
| Protein | 3.42 | 3.65 | 3.48 | 4.11 | 3.29 | 3.39 | 3.52 | 0.25 |
| Albumin | 1.54 | 1.80 | 1.86 | 1.64 | 1.95 | 1.78 | 1.75 | 0.24 |
| Globulin | 1.88 | 1.85 | 1.62 | 2.47 | 1.34 | 1.61 | 1.77 | 0.25 |
| Creatinine | 1.41 | 1.52 | 1.09 | 1.50 | 1.16 | 1.39 | 1.14 | 0.25 |
| Urea | 21.26 | 29.52 | 33.16 | 37.0 | 40.36 | 33.77 | 52.11 | 21.59 |
| Glucose | 124.00 | 108.50 | 103.00 | 106.00 | 121.00 | 83.00 | 82.00 | 42.61 |
| Cholesterol | 67.65 | 65.46 | 80.48 | 70.52 | 63.50 | 78.22 | 69.05 | 9.92 |
| TGL | 59.42 | 48.39 | 49.40 | 49.74 | 50.06 | 55.08 | 47.27 | 7.50 |
| HDL-c | 51.00 | 47.94 | 47.24 | 44.97 | 47.74 | 49.82 | 47.51 | 2.00 |
| LDL-C | 43.66 | 39.62 | 55.69 | 48.16 | 36.43 | 52.05 | 43.26 | 3.40 |

TGL= Triglyceride, HDL-C= High density lipoprotein cholesterol, LDL-C= Low density lipoprotein cholesterol

**Broiler Starter Trial**

The performance of the broiler starter showed no significant (P>0.05) differences among the treatment groups in terms of final body weight, total body weight gain, daily body weight gain, daily feed intake, feed conversion ratio and mortality. Although the treatment containing 1.5% cooked turmeric rhizome meal performed better than all other treatment groups with respect to feed conversion ratio of 2.05, daily feed intake of 88.00g and daily body weight gain of 43.00g. Nouzarian, *et al* (2011) reported that number of studies have been conducted to evaluate the effect of turmeric on the performance of broiler chickens, laying hens and rabbits and noted that the results have been inconsistent. However, our result are in accordance with Nouzarin *et al.* (2011) who reported that supplementation with turmeric rhizome meal showed no significant differences between the groups on body weight changes, daily feed intake and feed conversion ratio. Nonetheless, there are reports sugesting that increasing turmeric inclusion rate in broiler diets results in significant reduction in feed intake, feed conversion ratio and increase in body weight gain Nanung, (2013).

Emadi and Kermanshahi (2006) and Durrani *et al.* (2006) reported that at 5g/kg level of inclusion, turmeric significantly decreased feed consumption of chickens, whereas feed intakes of birds supplemented with 2.5 and 10g/kg levels turmeric were similar to that of control group. The results obtained on body weight are also in concurrence with Emadi and Kermanshashi (2006) who reported that an inclusion rate of 2.5, 5 and 7.5g/kg of diet, turmeric had no effects on weight gain of broiler chickens. Similarly, Durrani *et al.* (2006) found that though at 2.5g/kg and 10g/kg levels, turmeric had no effect on body weight but at an inclusion of 5g/kg body weight was significantly higher. It was concluded that the significant increase in body weight might be due to optimum antioxidant activity of turmeric at the levels of 5g/kg that stimulated protein synthesis by enzymatic systems. Durrani *et al.* (2006) reported that chickens receiving diets supplemented with 5g/kg turmeric powder had better feed conversion ratio than 2.5 and 10g/kg supplementation level.

Interestingly, some authors did not find beneficial effects on supplementing diets with turmeric meal at the rate of 0.5g/kg (Akbaria *et al.,* 2012) or 2.0g/kg (Mehala and Moorthy, 2008). These reports, including the present study suggested that a lot is yet to be understood on the exact effect and mechanism of turmeric on poultry performance.

**Broiler Finisher Trial**

The performance of the broiler finisher showed no significant ($p>0.05$) differences among the treatment groups in body weight gain, daily body weight gain, daily feed intake, feed conversion ratio and mortality.

Although treatment containing 1.5% cooked turmeric rhizome meals performed better than all other treatment groups with respect to daily body weight gain (51.00g) daily feed intake (146.0g) and feed conversion ratio (2.87). The above results agreed with Namagirilakshmi (2005) who stated that broilers fed with turmeric (0.25, 0.50, 0.75 and 1%) levels did not significantly differ in body weight gain.

**Nutrient Digestibility and Retention**

Previous reports indicated that dietary supplementation of turmeric rhizome meal promotes nutrient digestibility due to its photochemical properties which included the stimulation of appetite and feed intake, the improvement of endogenous digestive enzyme secretion, activation of immune response and antibacterial, antiviral antifungal and antioxidant actions (Toghyani *et al* 2010, 2011). However, in the present study, significant effects due to dietary inclusion of turmeric were not observed. Results obtained may not necessarily be a contradiction of the earlier reports because the digestibility of the control diets were very high and further improvement on this may not result in statistical significance.

**Carcass and Organs Weight Characteristics**

The dressing percentage and percentage of the liver, heart, gizzard, and kidney were not affected by the treatments. Similarly, Mehala and Moorthy (2008) failed to observe any significant impact of turmeric powder (up to 10g/kg of diet) on carcass percentage of broiler chicken reared to six weeks of age. On the contrary, Durrani *et al* (2006) reported higher dressing percentage, and higher breast, thigh and giblet weight in broilers fed diet containing 5g/kg turmeric powder.

Soni *et al* (1997) reported that curcuminiods also protect the heart from cancer and mutagenicity. Durrani (2006) observed no effect on heart, liver and gizzard while Lal and Kapoor (1991) observed no improvement in liver and gizzard by dietary application of turmeric. Liver is a strategic organ involved in nutrient metabolism (Udedibie and Omekam 2001). Since there were no increases in weight of the liver among the treatment groups, it

would appear that dietary inclusion of turmeric at the levels used in this study has no adverse effects on metabolism.

**Mortality**

There were no significant (P>0.05) differences in mortality among the groups both for starter phase and finisher phase, respectively. Mortality were not recorded among the treatment groups from starter phase. However, the result from finisher phase showed a reduced group on the control due to higher mortality (7.41%). However, 2.0% raw and 1.0, 1.5 and 2.0 cooked turmeric rhizome meal groups recorded zero mortality. This may be attributed to health protective effect of compounds in turmeric such as (antioxidants, antimicrobial, ant mutagenic etc.) that kept birds in good health condition.

**Haematological Indices**

The results of haematological indices showed significant effects were observed in RBC, PCV and WBC.

The group on 1.5% cooked turmeric rhizome meal exhibited a significant highest in RBC count which is not in agreement with Noori *et al.* (2011) who reported no significant difference on RBC count between similar treatments. The increased RBC count and PCV may be due to turmeric inclusion. The group on 1.5% cooked turmeric rhizome meal exhibited a significant increase in PCV (41.5) which agreed with Noori *et al.* (2011) who reported significant increase in PCV at 0.5% inclusion level.

Dietary inclusion of turmeric had no significant effect on WBC count which is not in agreement with Noori *et al.* (2011) who reported a significant effect in inclusion of 1.0% turmeric powder. Similarly, the result showed no significant differences in haemoglobin, heterophils, lymphocyte, eosinophil, monocyte, and basophil levels, which are not in agreement with Emadi and kermanshahi (2007) who reported that supplementation of turmeric at 0.5 percent level in broiler diets showed a significant increase in Hb Reghdad (2012) reported significant ($p<0.05$) reduction in heterophil in blood of broiler fed diet containing turmeric powder compared to control. This was not the case in the present study. Heterophils constitute the first line of defense with efficient chemotactic response. It was suggested that birds of treated group were better equipped for the non-specific cellular response when invaded by foreign agents viable or innate (Raghdad, 2012).

**Serum Biochemical Indices**

The values of total protein, albumin, glucose, creatinine, urea, cholesterol, HDL-C and LDL-C in blood sera of broiler birds showed no significant ($p>0.05$) differences among treatment groups. This result agreed with Namagirilakshmi (2005) who stated that supplementation of turmeric in broiler diet at 0.25, 0.5, 0.75 and 1.0% levels had no significant effect on total cholesterol. Noori *et al.* (2011) reported the different dietary levels of turmeric at 42 days of age had no significant effect on total cholesterol and albumin of the chickens.

Mehala and Moorthy (2008) similarly stated that supplementation of turmeric in broiler diet at 0.1 and 0.2% levels had no significant effect on total cholesterol. These results contradicts Emadi and Kermanshahi (2007) who reported that supplementation with turmeric at 0.25, 0.5 and 0.75% levels in broiler diets significantly decreased blood albumin but had no significant effect on total protein.

Results from this present study are in agreement with the result reported by Emadi *et al.* (2007) who observed that turmeric supplementation into the basal diet of broiler chickens significantly increased total cholesterol and HDL-C and decreased LDC-Cholesterol, but did not affect total triglyceride. Ordinarily one would expect that supplementation of poultry diets with turmeric at the levels used in this study would significantly reduce the serum levels of these lipids. However, this was not the case. A possible explanation is the manner of processing or the length of storage after processing. Another possible cause of discrepancy in results from various authors may be due to difference in cultivars, time of planting, nature of the soil and time of harvesting and processing. Hopefully future research will throw more light and help to explain the underlying cause of these variations.

# CHAPTER FIVE

## 5.0 Conclusion and Recommendations

## 5.1 Conclusion

From the findings, it was concluded that neither level of inclusion nor processing methods (raw and cooked) had any significant effect on feed intake, growth rate and feed conversion ratio. Similarly, dietary treatments and methods of processing had no significant effect on dressing percentage, carcass characteristics/ organ weighs and serum lipid levels. Although significant differences were observed in red blood cell count and packed cell volume, though no consistent trend were established. The higher mortality recorded by broiler finisher fed the control diet may imply that turmeric possessed health protective principles.

## 5.2 Recommendations

It can be concluded that sun-dried raw and cooked turmeric rhizome meal did not significantly affect broiler performance except packed cell volume and red blood cell count. Therefore, turmeric cannot be recommended as an effective feed additive in poultry diets.

## 5.3 Contribution to Knowledge

This study has shown that inclusion of turmeric in broiler starter diets up to 1.5 % or broiler finisher diet up to 2.0% has no effect on feed intake, liveweight gain and organ weights of the broilers. Also no diet related consistent variation in haematological profile was discernible.

## REFERENCES


Abbas, R.Z., Igbal, Z., Khan, MN., Zabir, MA. And Zia, MA.(2010). Anticoccidial activity of *Curcuma longa* L. in broilers. *Braz Arch Biological Technology.*, 53:63-67.

Abbas, T.E.E. and Ahmed, M.E. (2010). Effects of supplementation of Nigella sativa seeds to broiler chicks diet on the performance and carcass quality. *International Journal of Science*, 2(2):09-13.

Aggarwal, BB., Sundarma, C., Malini, N. and Ichikawa, H. (2007). *Adv. Exp. Biology.*, 595:1-75.

Ahmed-Raus, R.R., Abdul-latif, E.A. and Mohammed, J.I. (2001). Lowering of lipid composition in aorta of guinea, pig by *Curcuma domestica*, BMC Compt A j. *International Med.*, 1:6.

Akbarian, A., Golian, A., Kermanshahi, H., Gilani, A. and Moradi, S. (2012). Influence of Turmeric and black peper on blood constituent and broiler performance. *African Journal of Biotechnology.*,11:8606-8611.

Al-Bahry, S.N., Al-Mashani, B.M., Elshafie, A.E., Pathare, N. and Al-Harthy, A.H. (2006). Plasmid profile of antibiotics resistant Escherichia coli isolated from chicken intestines. *Journal of Alabama Academy. Of Science*, Vol. 77,No.3-4:152-159Z.

Alia, BH., Marrif, H., Noureldayemc, SA., Bakheitd, AO. and Blunden, G. (2006). Biological properties of curcumin: a review. NPC., 1:509-521.

Al-kassie, GAM., Mohseen, AM. And Abd-Al-jabeel RA. (2011). Modification of productive performance and physiological aspect of broiler on the addition of mixture of cumin and turmeric to the diet. *Res Opin Anim Vet Sci.*, 1: 31-34.

Allen, P.C., Danforth, H.D. and Augustine, P.C. (1998). Dietary modulation of avian coccidiosis. *International Journal of Parasitol.*, 28:1131-1140.

Al-Sultan, S.I. and Gameel, A.A (2004). Histopathological changes in the livers of broiler chicken supplemented with turmeric (*Curcuma longa*). *International Journal of Poultry Science*, 3: 333-336.

Al-Sultan, SI. (2003).The effect of *Curcuma longa* (turmeric) on overall performance of broiler chickens. International Journal of Poultry Science, 2:351-353.

Anandraj, M., Devasahayam, S., Zachariah, T J., Eapen, S.J., Sasikumar, B., and Thankamani, C.K. (2001). Turmeric (Extension Pamphet). J. Rema and M.S. Madan, Editors. Indian Institute of Spices Research, Calicut, Kerala. API-Ayurvedic Pharmacopoeia of India 1989. New Delhi: Government of Inidia-Ministry of Health and Family Welfare-Department of Health. 45-46.

Antony, S., Kuttan, R. and Kuttan, G. (1999). Immunomodulatory activity of curcumin. *Immunol Investig.,* 28:291-303.

Anuwarul, H.G., Abdul, J., Muhammed, N. and Kashifu. (2006). Pharmacological basis for the use of turmeric in gastrointestinal and respiratory disorders. *Life Science,* 76, 3089-3105.

AOAC (Association of Official Analytical Chemist), 2005 Official method of Analysis Edn. Virginia USA.

Araujo, CAC. and Leon, LL. (2001). Biological activities of *Curcuma longa L. Memorias do instituto Oswaldo Cruz.,* 96:723-728.

ASTA (2001). A concise guide to Spices, Herbs, Seeds and Extractives. American Spice Trade Association. pp. 48-50.

Athanasiadou, S., J. Githiori and I. Kyriazakis. (2007). Medicinal plant for helminthes parasites control: Facts and Fiction. *Animal*. 1 (9):1392 -1400.

Bahman Abdi-Hachesoo, Alieza Talebi and Siamak Asri-Rezaei (2011) Department Of Clinical Sci. Poultry Diseases Division, School Of Vet Med. Shiraz University P.O. Box 1731, Postal Code 71345, Iran Comparative Study on Blood Profile of Indigenous and Ross-308 Broiler Breeders.

Balunas, M.S. and A.D. Kenghora. (2005). Drug discovery from medical plants. *Life Science,* 78 (5): 431-441.

Bhowmik, S. Chowdhury, S.D., Kabir, M.H. Ali, M.A. (2008). Chemical composition of some medicinal plant producs of indigenous origin. Dept. of Poultry Science, Faculty Of Animal Husbandry, Bangladesh Agricultural University, Mymensingh-2202, *Bangladesh verterinarian*, 25(1): 32-39.

Biovet, S. A. Laboratories (2005). The intensive Production and spreading of high Productivity Genetic Holks have conditioned the common use of chemical substances known as growth Promoters. www.thepigsite.com/articles.

Bizuneh adinew (2012). Phytochemical of turmeric: an overview Mizan-Tepi University, ETHIOPIA Chemistry: *Bulgarian Journal of Science Education,* Volume 21 Number 6.

Bolu, SAO., Sola-Ojofe, Olorunsuya, O.A. and Idris, K. (2009) Effect of graded levels of dried pawpaw (Carica papaya) seed on the performance hematology, serum biochemistry, carcass evaluation of chicken broilers. *International Journal of Poultry Science,* 8(9): 905-909.

Buasinska, B. and Kulrysek, G. (2004). Garlic and its impact on animal and human health. *Medycyna Weterymaryjna,* 60:1151-1155.

Buescher, R., and Yang, L. (2001). Turmeric in natural food colorants. Science and Technology. G.L. Lauro and Francis (Eds). *Marcel Dekker, New York., pp*. 205-226.

CBN (1993). Central Bank of Nigeria Annual Report and Statement of Account for the year ended, December, 1993:5-15.

Chattopadhyay, I., Biswas, K., Bandyopadhyay, U. and Banjerjee, RK. (2004). Turmeric and curcumin: Biological actions and medicinal applications. *Curr Science,* 87:44-53.

Chen, HW. and Huang, HC.( 2009). Effect of curcumin on cell cycle progression apoptosis in vascular smooth muscle cells. *Br Journal of Pharmacol.,* 124:1029-1040.

Cheng, H., Liu, W. and Ai, X. (2005). Protective effect of curcumin on myocardial ischemia reperfusion injury in rats. *Zhong Yao Cai J Chin Med Mater*., 28:920-922.

China Botanical Garden (2013). Curcuma longa linn Description from flora of China Botanical Garden Accessed November, 2013.

Churchill, M., Chadburn, A., Bilinski, RT. and Bertagnolli, MM. (2000). Inhibition of intestinal tumours by curcumin is associated with changes in the intestinal immune cell profile. *Journal of Surg. Res.,* 89:169-175.

College and research institute Namakkal Tamil Nadu, India. *International Journal of Poult. Science,* 7 (9): 857-869.

Cosmas, C. Ogbu and Perpetual, C. Maefule (2015). Performance and hematological indices of broiler chicken supplements of Gongronema latifolium, Olimum gratissiaum and Telferia occidentalis. Dept. of Animal health and production College of Vet. Med. Michael Okpara University of Agriculture Umudike, Abia State, *Nigeria Global J. of Poultry Farming,* ISSN: 2449-1772 Vol. 3(2), pp. 140-145.

Dahal, K.R., and Idris, S. (1999). *Curcuma longa.* In: de Guzman, C.C. and Siemonsma, J.S (Editors): Plant Resources of South-East Asia No 13. Spices. Backhuys Publishers, Leiden, the Netherlands, Pp:111-116.

Das, SK., and Vasudevan, DM. (2006). Tulsi the Indian holy power plant. Natural Product Radiance, 5:279-283.

Deshpande, SS., Lalitha, VS., Ingle, AD., Raste, AS., Gadre, SG. and Maru, GB.(1998). Subchromic oral toxicity of turmeric and ethanolic turmeric extract in female mice and rats. Toxicity Lett. 95:183-193.

Dictionary.com (2013) Current events, history in the News blog.dictionary.com/2013/11/

Duncan, D.B. (1955). Multiple Ranges and Multiple F Test Biometries 11: 1-24.

Durrani, FR., Ismail, M., Sultan, A., Suhail, SM., Chand, N. and Durrani *(*2006). Effect of different levels oil seed added turmeric *(Curcuma!nnga)* on the performance of broiler chicks. *Journal of Agric and Biol Set.,* 1:9-11.

El-Itakim, ASA., Cherian, G. and Ali, MM. (2009). Use of organic acid, herbs and their combination to improve the utilization of commercial low protein broiler diets. *International Journal of Poultry Science,* 8:14-20.

Emadi, M. & Kermanshahi, H. (2007). Effect of turmeric rhizome powder on the activity of some Blood Enzymes in broiler chickens. *International journal of Poultry Science*, 6 (1): 48-51.

Emadi, M. and Kermanshahi H. (2007a). Effect of turmeric rhizome powder on immunity responses of broiler chickens. JAnim Vet Adv. 6:833-836.

Esonu, B.O. (2009). Unconventional feed resources for livestock development and food security. Paradigim for Nigerian Livestock Industry 14th Inaugural Lecture, Federal University of Technology Owerri, pp: 51.

Esonu, B.O., Azubuike, J.C., Emenalom, O.O., Etuk, E.B., Okoli I.C., Ukwu, H.O. and Nneji, C.J. (2004) Effect of enzyme supplementation on performance of broiler finisher fed (Microdesmis puberula leaf meal. *Int. J. poultry Sci.,* 3:112-114.

Gautam , SC., Gao, X. and Dulchavsky, S. (2007). Immunotnodulation by curcumin. The Molecular Targets and Therapeutic Uses of Curcumin in health and Disease. 595:321-341.

Ghani, A. (2000). Medicinal Plants of Bangladesh: Chemical Constituents and Uses. Asiatic Society of Bangladesh, Dhaka.

Gopalan, B., Goto M., Kodama, A. and Hirose, T. (2009). Supercritical carbon dioxide extraction of turmeric (*Curcuma longa*). *Journal of Agric. Food Chem.,* 48:21892192.

Govindarajan, VS. and Stahl, WI. (1980). Turmeric-Chemistn. Technology, and quality. *Crit Rev Food Sci Nut.,* 12:199-301.

Gowda, N.K.S., l.edoux, D.R., Rottinghaus,G.E., Bermudez, A.I. and Chen Y.C. (2009). Antioxidant efficacy of curcuminoids from turmeric ((*Curcuma longa*) powder in broiler chickens fed diets containing aflatoxinB-l. *BrJNulr.,* 102:1629-1634.

Gowda, N.K.S., Ledoux, D.R., Roltinghaus, G.E., Bermudez, AJ. And Chen, Y.C. (2008). Efficacy of turmeric *(Curcuma longa).* Containing a known level of curcumin. And a hydrated sodium calcium aluminosilicate to ameliorate the adverse effects of aflalnxin in broiler chicks. *Poult. Sci.,* 87:1125-1130.

Gupta Sandeep, K., Latter Amit, Jaiswal Vinay, Garg Siddhartha Iyoti, Kumar Amy (2010). Phytochemical of curcuma longa an overview school of pharmaceutical Sci. Shobbit University Meerut, India Dept of Pharm. Sci. MID, University, Rahtak India. *Journal of pharmaceutical. BMS.,* 2010, 4(01) ISSN NO. 2230-7885

Holt, P.R., Kats, S. and Kirshoff, R. (2005). Curcumin Therapy in inflammatory bowel disease: *a pilot study, Digest. Dis. Sci.,* 50, 2191-2103.

Ibrahim Albokhadam (2012). Dept. of physiology, biochemistry and pharmacology, college of Vet Med. And Ani. Resourses, King Fanisal Uni. Al-Ahaa, *Saudi Arabia Asian J. of Poult Sci.* Volume:6/ Issue:4/Page No:. 138-145

Iheukwumere, F.C., Ndubuisi, E.C., Mazi, E.A. and Onyekwere, M.U. (2008). Performance, nutrient utilization and organ characteristics of broilers fed cassava leaf meal (*Manihot esculenta*, Crantz). *Pak. J. Nutr.,* 7: 13-16.

Iqbal., Sharma, S.D., Okazaki, Y., Fujisawa, M. and Okada, S., (2003). Dietary influence of turmeric rhizome and black pepper on blood constituents and performance of broiler chickens. *Afr J Biotechnol*., 11:8606-8611.

Jayaprakasha, G.K., Jagan Mohan Rao, L. and Sakariah, K.K. (2005). Chemistry and biological activities of *C* I trends. *Food Sci and Teehnol.,* 16:533-548.

Jayaprakasha, G.K., Negi, P.S., Anandharamakrishnan, C., and Sakariah, K.K. (2001). Chemical composition of turmeric oil- a byproduct from turmeric oleoresin industry and its inhibitory activity against different fungi . *Z. Naturforschung.*, 56c:40-44.

Kamel, C. (2011). Natural plant extracts classical remedies brings modern animal production solutions. Feed manufacturing in the mediteraneanB region. Improving safety: from feed to food. In *Brufau J. (Ed) Zaragoza*: CIHEAM-IAM2, 31-38.

Kandarkar, S.V., Sawant, S.S., Ingle, A.D., Deshpande, S.S. and Maru, O.R. (1998). Subchronic oral hepatotoxicity of turmeric in mice—histopathological and ultraslrncliiral studies. *Indian J. Exp Biol.,* 36:675-679.

Kekocha C.C. (1984) Pfizer Corporation Nairobi in association with Macmillan pub. London.

Kermanshahi, I.I. and Riasi, A. (2006). Effect of turmeric rhizome powder *(Curcuma lunga)* and soluble NSP degrading enzyme on some blood parameters of laying liens. *International Journal of Poultry Science,* 5:494-498.

Khan, R.U., Naz, S. Javdani, M., Nikousefat, Y., Selvaggi, M., Tufarelli, V. and Eaudadio, V. (2012). The use of turmeric *(Curcuma longa)* in poultry feed. *World's Poultry Science journal* 68:97-103.

Kotwal G.J. (2005). Natural products and molecular Therapy. First International Conference. New York: *Annal New York Academy Science*, 2005 1056.

Kumar, M., Choudhary, R.S. and Vaishnav, J.K. (2005). Effect of supplemental prebiotic, probiotic and turmeric in diet on the performance of broiler chicks during summer .*Ind. J. Poult. Sci.,* 40:137-141.

Kumara, P., Gupta, M.K., Ranjan, R.K., Singh, K.K. and Yadava, .R. (2007). Curcuma longa as feed additive in broiler birds and its pathophysiological effects. *Indian J. of Experimental Biology*, 45:272-277.

Kumari, P., Gupta, M.K., Ranjan, R., Singh, K.K. and Yadava, R. (2007). *Curcuma longa* as feed additive in broiler birds and its patho-physiological effects. *Indian J Exp Biol*., 45:272-277.

Kurkure, N.V., Pawar, S.P., Kognole, S.M., Bhandarkar, A.G., Ganorkar, A.G. and Kalorey, D.R. (2000). Ameliorative effect of turmeric *(Cwcwna hnga)* in induced aflatoxicosis in cockerels. *Indian J Vet Pathot*., 24:26-28.

Lee, K., Eillehoj, U.S. and Siragusa, O.R. (2010a). Direct-fed microbials and their impact on the intestinal microflora and immune system of chickens. *Journal of Poult Science,* 47:106-114.

Lee, S.H., Lillehoj, H.S., Jang, S.I., Kim, D.K., lonescu, C. and Bravo, D. (2010b). Effect of dietary *curcuma, capsicum,* and *Ientinis* on enhancing local immunity against *Eimeria acervulina* infection. *Journal of Poultry Science,* 47:89-95.

M. Grieve Accessed November 2013 Curcuma longa A modern Herbal .

M.A. Al-Noori, A.B., Hossain, A.H., Al-Maahidy and S. Th.J.Al. Rawi, (2011). The effect of dietary Curcuma longa powder (Turmeric) supplementation on some blood parameters and carcass traits of broiler chicken. Co*llege of Veterinary Medicine/ University of Anbar J. Vet. Sci*., Vol.: 4, Supplement, 2011

Maheshvari, R.K., Singh, A.K., Gaddipati, J. and Srimal, R.C. (2006). Multiple biological activities of curcumin: a short review. *Life Science,* 78:2081-2087.

Malekiadeh, M., Moeini, M.M. and Ghazi S. (2012). The effects of diiTerent levels of ginger *(Zingiber officinaie* Rose) and turmeric *(Curcuma longa* Linn) rhizomes powder on some blood metabolites and production performance characteristics of laying hens. *Journal of Agric Science Teehnol*., 14.127-134.

Manjunath, M.N., Sattigieri, V.V. and Nigara, K.V. (1991). Curcumin in turmeric Spice India, 4(3), PP. 7-9.

Mehala, c. & Moorthy, M. (2008). Production Performance of Broilers Fed with Aloe Vera and curcuma longa (Turmeric). *Int.J. Poult. Sci*., 7 (9): 852-856.Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet.

Mehala, C. and Moorthy, M. 2008, Effect of Aloe Vera and Turmeric on Carcass characteristics and Serum Biochemical parameter of broiler. Dept. of poult. Sci, vet.

Ministry of works (1984): planning studies in Imo State. Atlas of Imo State of Nigeria dept. of land and survey Owerri, Imo State.

Moorthy, M., Saravanan, S., Mehala, C., Ravi, S., Ravikumar, M., Viswanathan, K., Edwin, S.C. (2009). Performance of single comb white leghorn layers fed with *Aloe vera. Curcuma loiign* (turmeric) and probiotic. *International Journal of Poultry Science*, 8:775-778.

Nagpal, M Soods (2013). Role of curcumin in systemic and oral health: An overview' *Nat. Sci. Biology Med.*, 4 (1): 3-7 d0:10.4103/0976-9668. 107253 pmc 3633300 PMID 23633828.

Namagirilakshmi, S. (2005). Turmeric *curcuma longa* as nutraceutical to improve broiler performance. Msc thesis submitted to Tamil Nadu Vertinary and Animal Sciences University, Chennai, India.

National Bureau of Statistics (NBS) (2005). Social Statistics in Nigeria. Federal Republic of Nigeria.

NCCAM (2012). 5 most searched for herbs of 2012: NCCAM website nccih.nih.gov/health/provider/difest.

Nouzarian, R., Tabeidian, S.A. and Toghyan, M. (2011). Effect of turmeric powder on performance, carcass traits, humoral immune responses and serum metabolism in broiler chicken. *Journal of Animal. And Feed Science,* 20:389-400

Nunes, F.V. (1989). Cultivo da curcuma e facil e luciative, manchete rural, 29:60.

Nwogu, C.M. (2013). Physiological responses of pullets fed commercial diet supplemented with varying levels of plantain stalk and root base ashes. M.Sc. Thesis, Federal University of Technology, Owerri, Nigeria.

Nworgu, F.C. (2006). Prospect and Pitfalls of Agricultural Production in Nigeria. Ist Edition. Blessed Pub., Ibadan, Nigeria, 79 -96.

Obi I.U. (1990). Statistical method of detecting diff between treatments means 2nd Snaap press Enugu, Nigeria.

Ohanaka, A.U.C. (2015). Evaluation of the physiological benefits of palm kernel shell ash supplementation of broiler rations MSc. Project Seminar, Dept of Animal Science and Technology, Federal University of Technology Owerri, Nigeria.

Olagunju, F. I. (2010). Impact of Credit on Poultry Productivity in South western Nigeria. Dept. of Agricultural Economics and Extension, LadokeAkintola University of Technology, P.M.B. 4000 Ogbomoso, Oyo State, Nigeria.

Olojede, A. O., P. Iluebbry and A.G.O. Dixon, (2005). IITA/NRCRI collaborative IITA/NRCRI Collaborative Germplasm and data collection on root and tuber crops in Nigeria NRCRI annual Report 2005, pp 77 – 81.

Olojede, A.O. (2000). IITA/NRCRI collaborative Germplasm and Data Collection on root and tuber crops in Nigeria NRCRI Animal report. 2000.

Oluyemi, J.A. and Robert, F.A. (2000). Poultry production in warm wet climate. Review Edition spectrum book. Spectrum house ring road Ibadan, nigeria pp 40-45

Osawa, T., Sugiyama, Y., Inayoslii, M. and Kawakishi, S. (1995). Antioxidative activity of tetrahydtocurcuminoids. *BiosciBiotechnolBiochem*, 59:1609-1612.

Pari , L. & Murugan, P. (2007). Antit=hyperlipidemic effect of curcumin and tetrahydro curcumin in experimental type 2 diabetic rats. *Renal Failure, 29,* 881-889.

Peter, K.V. and Zachariah, T.J. (2000). Spice oils and Oleoresins: Challenges and opprtunities, *Journal of Medicinal and Aromatic Plant Science,* 22 (IB): 247-252.

Petrolli, T.C., Postagno, H.S., Gomed, P.C., Tavernari, F.C. and Balbino, E.M. (2012). Herbal extracts in diets for broilers. *Rivista Brasileira de Zootecnia, Vicosa, MG,* Vol. 41. N.i.p. 1683-1690. 2012.

PlantCultures (2005). Turmeric production and Trade. www.plantcultures.org.uk/accsssed. 21/06/2005.

Platel, K. and Srinivasan, K. (2000). Influence of dietary spices and their active principles on pancreatic digestive enzymes in albino rats. *Food/Nahtung*, 44:42-46.

Polasa, K., Raghuram, T.C. and Krishna, T.P. (1991). Turmeric (Curcuma Longa L.) induced reduction in urinary mutagens. *Food chem. Toxicol.*, 29, 699-706.

Pruthi, J.S. (1992). Postharvest technology of spices: pre-treatments, cutting, cleaning, grding and packing. *Journal of Spices and Aromatic Crops*, 1 (1):1-29.

Pulla Reddy Ach. Lokesh BR. (1994). Effect of dietary turmeric *(Curcuma longa)* on iron-induced lipid pet-oxidation in the rat liver. *Food Chem Toxieol.*, 32:279-283.

Radwan, N., Hassan, R.A., Qota, E.M. Eayek, M.M. (2008). Effect of natural antioxidant on oxidative stability of eggs and productive and reproductive performance of laying hens. *International Journal of Poultry Science*, 7:134-150.

Raeesi, M., S.A. Hoseini-Aliabad, A, Riofchaee, A.Z.VShahneh and S. Pirali (2010). Effects of periodical use of garlic (Allium Sativum) powder on performance and carcass characteristics in broiler chickens. *World Acad. Sci. Eng. Technol.*, 68:1213-1219.

Rajesh, H., Rao, S.N., Megha, Rani N., Prathima, K., Shetty, Rajesh E.P and Chandrashekhar, R. (2013). Phytochemical Analysis of Methanolic extract of *Curcuma longa* Linn. *International Journal of Universal Pharmacy and Bio Sciences*, 2(2):39-45.

Rajput, N., MuViammah, N., Yan, R., hong, X. and Wang, T. (2012). Effect of dietary supplementation of curcumin on growth performance, intestinal morphology and nutrients utilisation of broiler chicks. *.1nternational Poultry Science*, 50:44-52.

Ralimatnejad, E., Roshanfekr, 1.1., Ashayerizadeh, O., Mamooee, M. and Ashayerizadeh, A. (2009). Evaluation the effect of several non-antibiotic additives on growth performance of broiler chickens. *Journal Animal Vet Adv.*, 8:1670-1673.

Ramirez-Tortosa, M.C., Mesa, M.D., Aguilera, M.C., Quiles, J.L. and Baro L. (1999). Oral Administration of a turmeric extract inhibits LDL oxidation and has hypocholesterolenic effects in rabbits with experimental atherosclerosis. Altherosclerosis 147, 371-378.

Rema, J. and M.S Madaa, (2001). Turmeric. An extension pamphlet. Agricultural Technology information centre. Indian institute of spice research, PP:8. *Res Opin Anim Vet Sci.* 1:31-34 . Resources, Vol. 1.

Riasi, A., Kermanshahi, 1.1. Mahdavi, A.H. (2012). Production performance, egg quality and some serum metabolites of older commercial laying hens fed different levels of turmeric rhizome *(Curcuma longa)* powder. *Med Plants Res.*, 6:2141-2145.

RIM (1992): Resource Inventory Management Limited. Nigerian Livestock Roughley PJ, Whiting DA. 1979. Experiments in the biosynthesis of curcumin. *J Chem Soc Perkin Trans* 1., 20:2379-2388.

Sadeghi, l.l., Karirm ,A., Padidar Jahromi, S.l.l., Azi, I.T and Daneshmand A. (2012). Effects of cinnamon, thyme and turmeric infusions on the performance and immune responsein of 1-to 21-day-old male broilers. *Rev Bras Tien Avic.*, 14:15-20.

Saeed, S. and Tariq, P. (2006). Pharmacological activities of ginger (*Zingiber officinale). International Journal of Biology and Biotechnology*., 3:519-526.

Sai Prasad , Aggarwal,B.B., Benzie F.F. and Wachtil-Galov S. (2011). Analytical evaluation of aqueous extract of Haridra. Between 2010 and 2011 Description of botanicals features of turmeric.

Sakarkar, D.M., Gonsalvis, L., Fatima, F., Khandelwal, L.K., Jaiswal, B. and Pardeshi, M.D. (2006). Tumeric: an excellent traditional herb. *Plant Archives,* 6:451-458.

Samarasinghe, K., Wenk, C., Silva, KSP'I. and Gunasekera, JMPM (2003). Turmeric *(Curcuma hnga)* root powder and mannanoligosaccharides as alternatives to antibiotics in broiler chicken diets. *Asian-Australasian .Journal Anim Science*, 16:1495-1500.

Sasai, K., Fetterer, R.H., Lillehoj, H., Matsuura, S., Constantinoiu, C.C., Maisubayashi, M., Tani, H. and Baba, E. (2008). Characterization of monoclonal antibodies that recognize the *Eimeria fenella* microneme protein *MlcY Parasitol*., 94:1432-1434.

Sawale, G.K., Gosh, R.C., Ravikanth, K., Maini, S. and Rekhe, D.S. (2009). Experimental mycotoxicosis in layer induced by ochratoxin A and its amelioration with

lieibomineral toxin hinder 'Toxiroak'. *International Journal of Poultry Science,* 8:798-803.

Sawant R.S. and A.G. Godghate*(2013). Qualitative phytochemical screening of rhizomes of *Curcuma longa linn.* Dr. Ghali College , Gadhinglaj, 416502, Dist. Kolhapur, (M.S.) *India International Journal Of Science, Environment And Technology*, Vol. 2, No. 4, 2013, 634-641.

Saxena Jyoti and Sahu Rajeshwari. (2012). Evaluation of phytochemical constituents in Conventional and Non- conventional species of Curcuma. *International Research Journal of Pharmacy*, 3(8):203-204.

Shukla, Y. and Singh, M. (2007). Cancer preventive properties of ginger: A brief review. *Food Chem Toxicol.,* 45:683-690.

Skorniekova, Sabu M. Prasanth Kumar M.G. (2004). Curcuma Mutabilis (Zingiberaceae) a new species from South India Gardens bull Singapore 2004 56: 43-54.

Snedecor, G.W and Cochran, W.G. (1978). Statistical method 6th edition Lowa State University press, Amen Lowa.

Srinivasan, K. (2005). Spices as influencers of body metaholism: An overview of three decades of research. *Food Res Int.*, 38:77-86.

Sugiharto, Isroli. Widiastuti E, Prahowo NS. 2011, Effect of turmeric extract on blood parameters, feed efficiency and abdominal fat content in broilers. *.1 Indonesian Trop Anim Agric.,* 36:21-26.

Swadhini, SP., Santosh, R., Uma, C., mythili, S. and Sathiavelu, A. (2011). Phytochemical Screening and Antimicrobial activity of five medicinal plants against *Myrothecium SP. International Journal of Pharm and Biosciences,* 2(1):B272-B279.

Tahira J.J. (2010). Weed flora of curcuma longa. *Pakistan J weed Science Res.*, 16 (2): 241-6

Tainter, D.R. and Grenis, A.T. (2001). Spices and seasonings. A food technology handbook. 2nd ed. Wiley-Vch.New York.

Talebi, A., Asri-Rezaei, S., Rozeh-chai, R. and Sahraei, R. (2005). Comparative studies of hematological values of broiler strains (Ross, Arbor-acres and Avian). *Inter. J. of Poultry Science,* 4(8): 573-579.

Toghyani, M., Gheisari, A.A., Ghalamkari, G. and Eghbalsaeid S., 2011. Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. *Livest. Sci*., 13:167-173.

Toghyani, M., Gheisari, A.A., Ghalamkari, G. and Mohammedrezaei, M. (2010). Growth performance, serum biochemistry and blood hematology of broiler chicks fed different levels of black seed (*Nigella sativa)* and peppermint *(Mentha piperita). Livest. Sci*., 129:173-178.

Udedibie A.B.I and V.N. Omekam (2001) nutritional and health implications of dietary inclusions of dried poultry waste (DPW) for broilers. *Agro-science,* z:24-29

Wang R, U D. Bourne S. (1998). Can 2000 years of herbal medicine history help us solve problems in the year 2000. In Lyons TP, Jacques KA. eds. Biotechnology in the Feed Industry. Proceedings of Alltech's 14* Annual Symposium. Nottingham (1'K): Nottingham University Press, p. 273-291.

Weiss, E.A. (2002). Spice crops CAB Intl. Poultry, Oxon, UK.Zhongze M. Like W. Aiyou W. 2008. F fleet of curcumin on fat metabolism in Wanjiang Yellow chickens. Cereal Feed Ind. 4:012 Aiello, S.E. and Mays, A.(Eds) (1998). The Merck veterinary manual, 8$^{th}$Edition. Merck and Co., Incig Whitehouse station, New Jersey, USA.

WHO. (1987). Principles for the safely assessment of food additives and contaminants in food. World Health Organization (WHO). International Programme on Chemical Safety (IPCS), in cooperation with the Joint WHO/FAO Expert Committee on Food Additives (JF.CFA). Geneva, Switzerland. World Health Organization No. 70.

Wuthi-udomler, M., W. Grisanapan, O. Luanratana and W. Caichompoo. (2000). Anti-fungal activities of plant extracts. *South Asian J. Trop. Med. Public Health.31, Suppl.,* 1:17182.

Yadav, V.S., Mishra, K.P., Singh, D.P., Mehrotra, S. and Singh, V.K. (2005) Inimnnomodulalory effects of curcumin. Iniinunopbannacol Itmnunotoxicol., 27:485-497.

Yang, Y., Iji, P.A. and Choct, M. (2000). Dietary modulation of gut micro flora in Broiler chickens: as review of the role of six kinds of alternatives to in-feed antibiotics. *World's Poultry Science Journals,* 65:97-1.

Yang, Y., Iji, PA. and Choct, M. (2009). Dietary modulation of gut microflora in broiler chickens: a review of the role of six kinds of alternatives to in-feed antibiotics. *Worlds Poultry Science Journal.* 65:97-114.

Yarru, L.P., Settivari, R.S., Dowda, NKS., Antoniou, E., Ledoux, I.R. and Rottinghaus, G.E. (2009). Effects of turmeric *(Curcuma Ivnga)* on the expression of hepatic gene? associated with biotransformation. antioxidant, and immune systems in broiler chicks fed aflatoxin. *Poult Sci*., 88:26'20-2627.

Zainali, A., Riasi, A., Kermanshahi, H. and Ziaei, H. (2008). Effect of selenium and (or) turmeric rhizome powder on growth performance of broiler chickens reared under heat stress condition. 1" Mediterranean Summit of WPS A, Advances and Challenges in *Poult Sci Greece,* p. 790-792.

Zhongze, H. (2009). Effect of curcumin on fat deposition and its mechanism in different breeds chickens. *Anhui Agric. Sci. Bull.,* 15:10.

Zhongze, H., Yuanqing, I.I., Like, W. and Aiyon, W. (2007). Effect of curcumin on metabolism of fat for broilers. *J Animi Sci. Technol. Univ*., 6:001.