EFFECTS OF GARLIC (*ALLIUM SATIVUM*) AND CHLORAMPHENICOL ON GROWTH PERFORMANCE, SURVIVAL AND BODY COMPOSITION OF *HETEROBRANCHUS BIDORSALIS* (GEOFFERY, 1809) FINGERLINGS

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA
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DEPARTMENT OF BIOLOGY,
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DECLARATION

I declare that the thesis entitled "EFFECTS OF GARLIC (*ALLIUM SATIVUM*) AND CHLORAMPHENICOL ON GROWTH PERFORMANCE, SURVIVAL AND BODY COMPOSITION OF *HETEROBRANCHUS BIDORSALIS* (GEOFFERY, 1809) FINGERLINGS" has been carried out by me in the Department of Biology, Faculty of Life Sciences. The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this thesis was previously presented for any other degree or diploma at this or any other Institution.

MOHAMMED MALUD MALUD ______________________________

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CERTIFICATION

This thesis entitled "EFFECTS OF GARLIC (*ALLIUM SATIVUM*) ANDCHLORAMPHENICOL ON GROWTH PERFORMANCE, SURVIVAL AND BODY COMPOSITION OF *HETEROBRANCHUS BIDORSALIS* (GEOFFERY, 1809) FINGERLINGS" by MOHAMMED Malud Malud meets the requirements governing the awards of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

Affectionately dedicated to my late dad late Mal. Mohammed Wakil Malut

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ABSTRACT

The effects of garlic *Allium sativum* and chloramphenicol on growth performance, survival and body composition of *Heterobranchus bidorsalis* was conducted in concrete tanks, Department of Biology, Ahmadu Bello University, Zaria. A total number of one hundred and eighty (180) fingerlings of *Heteroranchus bidorsalis* of 8.55±0.25 mean weight were assigned to nine treatments with two replicates each. Treatment groups had a different level of garlic (10, 20, 30 and 40g/kg) and chloramphenicol (10, 20, 30 and 40mg/kg) added to their diets, the control group diet was free from garlic and chloramphenicol. The diets also contained 40% crude protein (CP) and were administered at a rate of 5% body weight twice daily for sixteen (16) weeks. The results obtained revealed that the highest final body weight (173.82g/kg and 144.63mg/kg) and weight gain (165.22g/kg and 136.48mg/kg) at 30g/kg and 30mg/kg inclusion of garlic (*Allium sativum*) and chloramphenicol respectively in the diet were higher than that of the control (97.99g/kg and 89.44g/kg). The highest Survival Rate of (95.00% and 85.00%) was recorded in 30g/kg of *Allium sativum* and 30mg/kg of chloramphenicol which were higher than that of the control (75.00%). The highest Feed Intake 140.58g and 115.47g were recorded in 30g/kg and 30mg/kg of garlic and chloramphenicol supplemented diets respectively which were higher than the control (96.24g). The Feed Conversion Ratio values indicated improved performance to the levels of garlic and chloramphenicol in the diets where 1.06 and 1.13 was recorded in the 30g/kg and 30mg/kg of garlic and chloramphenicol supplemented diets as against the control which had FCR value of 1.92. Similarly, the highest Protein Efficiency Ratio was 2.87 and 2.81 for the 30g/kg garlic and 30mg/kg chloramphenicol supplemented diets. The control diets was the lowest with 2.17 which is

significantly lower ($p<0.05$) than the garlic and chloramphenicol supplemented diets. Crude protein and lipid content in whole fish were significantly higher than the initial carcass protein and lipid in the fish. The highest Apparent Protein Digestability APD of 87.68% and 82.02% were recorded in 30g/kg and 30mg/kg of garlic and chloramphenicol supplemented diets respectively which were higher than the control (79.90%). The water quality parameters obtained revealed that Dissolved Oxygen, Temperature and pH were within the range of (4.03 – 4.34) mg/l, (27.00 – 20.05) °C and (7.07 – 7.57) respectively. The cost-benefit analysis revealed that 10g/kg of garlic and 10mg/kg of chloramphenicol which gave best incidence of cost and profit index to invest at that level. It is however suggested that *Allium sativum* and chloramphenicol should be incorporated in the fish diets as they promote growth and provide high survival rate.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Feed is one of the major inputs in aquaculture production and fish feed technology is one of the least developed sectors of aquaculture particularly in Africa and other developing countries of the world (Gabriel *et al*., 2007). In Nigerian the bulk of feed used in fish production especially for catfish are imported and this has led to high production cost of farmed fish (Aniebo *et al*., 2009). Expensive feeds marginalize or even minify the profitability of fish farming thereby incapacitating the expansion of farms to increase production and consequently low yield in term of quality and quantity, resulting in the scarcity of the commodity (fish) and eventual high cost of the few available ones to the disadvantage of the populace (Adikwu, 1992). Gabor *et al*. (2010) concluded that the use of phytoadditives in fish feeding stimulate fish appetite as a nutritional additive, improving the voluntary intake of a diet as a sensory additive, improve the nutritional value of a diet as a zootechnical additive and control the health of fish through direct effects as a coccidiostats and histomonstats. However, phytoadditives have benefits for both fish welfare and environment.

Garlic (*Allium sativam*) is one of such ingredients showing potentials for use as growth promoter. Garlic is originating in Asia Minor and spontaneously grows in southern Europe, but in cultures, it could be found all over the world. It's a rich source of calcium, phosphorus and vitamin B1; it has a high content of carbohydrates and as a consequence a high nutritive value (Gabor *et al*., 2010). Garlic also contains iodine salts which have a positive effect on the circulatory system and rheumatism, silicates which have a positive effect on the skeletal and circulatory system and sulfur salts with positive effects on the skeletal system, cholesterolemia, and liver diseases. Garlic also contains vitamin B complex, vitamins A, and C (Drăgan *et al*., 2008). Garlic (*Allium sativam*) has been proven to control pathogens, particularly bacteria and fungi, thus improving the health of fish (Corzo-Martinez *et al*., 2007). Garlic has many beneficial effects on livestock and man. These include exhibiting antimicrobial, antioxidant, anti-hypertensive properties (Sivam, 2001). Garlic has found its usage as food by man as well as livestock for centuries. They are often used for the cure of a number of animal diseases (Shalaby *et al.,* 2006). Several herbs such as garlic, onion among others have been tested and evaluated for promoting growth promoting (Citarasu *et al.,* 2002; Sivaram *et al*., 2004). Garlic is an important vegetable extensively cultivated in many countries. It is used as food for humans as well as some animals and as remedy for several diseases, as reported in folk medicine.

Another important antibiotic used as growth promoter with lesser health implication as reported by Shalaby *et al*., (2006) is Chloramphenicol. It is a potent antibiotic effective against most bacteria such as rickettsia and the psittacosis-lymphogranuloma group. It suppresses anaerobic bacteria and most Gram-negative bacteria growth (Somjetlerdcharoen, 2002). Chloramphenicol antibiotic is generally used in fish feed to promote health and growth, but its use for long periods may cause blood dyscrasias such as aplastic anemia, and it has recently been implicated as carcinogenic agent (Shalaby *et al*., 2006). This negative effect of chloramphenicol has led to the use of other natural products such as garlic, which has the same effect as chloramphenicol. Chloramphenicol supplementation as a feed additive antibiotic has a greater effect than diets without antibiotics in improving live body weight and feed conversion efficiency in broiler chicks (Shalaby *et al*., 2006).

The most popular culturable fish species in Nigeria and other parts of Africa are members of the catfish family called Clariidae. *Clarias gariepenus* and *Heterobranchus bidorsalis* are the two commonly cultured clariid fish (Vanden and Bernacsek, 1990 ; Ojutiku, 2008). The Clariid exhibit many qualities which make them suitable for culture. These include fast growth rate, high resistance to disease, tolerance to adverse environmental conditions, ability to feed on wide range of feed and capacity to withstand low pH and oxygen (Fagbenro *et al*., 1992). It also has high feed efficiency and utilization (Adebayo and Olanrewaju, 2000).

1.2 STATEMENT OF RESEARCH PROBLEM

Stunted growth and mortality in ponds has been the major problem facing aquaculturist all over the world. This phenomenon has generated interest in the use of many chemicals and additives over the years as growth promoters most of which are synthetic materials posing residual implication on human health (Adekunle, 2012).

Studies on garlic as an alternative of growth promoter in livestock production were conducted and its beneficial effects on growth, digestibility and carcass traits have been reported (Bampidis *et al*., 2005; Tatara *et al*., 2008). However, study of the effect of dietary garlic extract on growth and survival of *Heterobrancus sp.*is scanty.

High cost of fish feeds due to scarcity of imported conventional feedstuffs such as fish meal has necessitated compounding livestock ratios with local ingredients such as garlic. Garlic has hypolipidemic (Sumiyoshi, 1997), antimicrobial (Kumar and Berwal, 1998), antihypertensive (Suetsuna, 1998), hepatoprotective (Wang *et al.,* 1998) and insecticidal (Wang *et al.,* 1998).

The use of antibiotic growth promoters (AGPs) as feed additives in the aquaculture industry has been criticized by government policies and consumers because of possible development of microbial resistance to these products and their potential harmful effects on human health (Baruah *et al*., 2008).

1.3 JUSITIFICATION

Olfactory feed ingredients enhance growth through their ability to act as feeding enhancers for fish to eat more feed than in normal (Adams, 2005). With the shift away from synthetic drugs, the use of medicinal herbs as an alternative for antibiotic growth- promoters in fish is becoming acceptable (Adedeji *et al*., 2008).

World Health Organization encourages using of medicinal herbs and plants to substitute or minimize the use of chemicals through the global trend to go back to the nature. Attempts to use the natural materials such as medicinal plants could be widely accepted as feed additives to enhance efficiency of feed utilization and animal productive performance (Levic *et al*., 2008).

Faster growth rate and high survival rate in fish, which reduce production time to reach table size which reduces cost of productions, have been the major concern for every fish producer.

The choice of *Heterobrancus bidorsalis* among other fish species was due to the fact that the fish species is found in nearly all fresh water bodies in Nigeria. They could be cultured in small water bodies and they also have attributes of being good converters of feed (FAO/IFAD, 1987). The fish are also cultured due to their tolerance to low dissolved oxygen, rapid growth rate, acceptability of a wide variety of food items, hardy and disease resistant, ability to spawn in captivity and respond to induced breeding (Madu, 1995; Adesulu, 2001; Omitoyin, 2007). The fish is in high demand, highly priced, and high economic returns either as fresh or smoked/dried (Banyigyi *et al*., 2001a).

Therefore, the use of dietary garlic as a growth promoter in *Heterobrancus bidorsalis* diet will reduce the use of synthetic growth enhancers whose safety has not being guaranteed for human health and the environment in general.

1.4 AIM OF THE STUDY

To compare the effects of garlic (*Allium sativum*) and chloramphenical on growth performance, nutrient utilization and digestability of *Heterobrancus bidorsalis*.

1.5 OBJECTIVES OF THE STUDY

To determine the:

i. growth performance and survival rate of *Heterobranchus bidorsalis* fed garlic and chloramphenicol supplemented diets.

ii. Apparent digestilibity of *Heterobranchus bidorsalis* fed garlic and chloramphenicol supplemented diets.

iii. carcass composition of *Heterobranchus bidorsalis* fed on garlic and chloramphenicol supplemented diets.

iv. Cost benefit of the inclusion of garlic and chloramphenicol supplemented in *Heterobranchus bidorsalis* diets.

1.6 RESEARCH HYPOTHESES

i. There is no significant difference between growth performance and survival rate of *Heterobrancus bidorsalis* fed garlic and chloramphenical supplemented diets compared to the control.

ii. Apparent digestability of *Heterobrancus bidorsalis* fed garlic and chloramphenical supplemented diets did not differ significantly with the control.

iii. Carcass composition *Heterobranchus bidorsalis* fed garlic and chloramphenicol supplemented diets is not significantly different with the control

iv. Cost benefit of garlic and chloramphenicol based diets do not differs significantly from the control.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fish feed development

Fish feed technology is one of the least developed sectors of aquaculture particularly in Africa and other developing countries of the world (FOA, 2003). Feed is one of the major inputs in aquaculture production. It is one of the fundamental challenges facing the development and the growth of aquaculture in the Africa continent. Fish feed development in Sub-Saharan Africa has not made a significant progress in aquaculture as expected. According to Hecht (2000), it is observed that the research on inexpensive feed ingredients has not contributed greatly to aquaculture development in Africa and suggested that more research on how best plant protein can be used as fish feed is required. Development and management of fish feed plays very important role in aquaculture growth and expansion. In fact, the major factors that determine the profitability of aquaculture venture.

Jamu and Ayinla (2003) reported that feed accounts for at least 60% of the total cost of fish production in Africa, which to a large extent determines the viability and profitability of fish farming enterprise. As aquaculture becomes intensive, most farmers in Africa depend largely on imported fish feed from European countries for the productivity and sustainability of the industry. For example, in Nigeria an estimated 4,000 tons of quality fish feed are imported into the country each year (AIFP, 2004). This has contributed in no small way in increasing the total cost of production which will ultimately translate to high cost of fish, thereby making it expensive for the teeming population of the poor people living in Sub-Saharan Africa.

In some countries like Nigeria, Kenya, Namibia, Malawi, Uganda, Madagascar, Ghana and Cote D'ivoire, where little quantity of fish feeds are produced locally, the quality is very poor and production rate is inconsistent. Jamu and Ayinla (2003) reported that the low quality of fish feed and its attendant high cost are the major factors limiting the development of aquaculture in Africa. Hence, research in fish nutrition that will utilize locally available ingredients and fabricated equipment without reducing the quality of the feed is urgent and crucial to the overall success of aquaculture development, growth and expansion in Africa. Aquaculture production in Africa involves both the intensive and semi-intensive system of production, which is daily gaining ground in the continent. For any aquaculture venture to be viable and profitable, it must have a regular and adequate supply of balance artificial diets for the cultured fishes. This is so because the dissolved nutrients that promote primarily and secondary production in the natural environment are seasonal and might be insufficient or may not occur in required proportions to meet the nutritional demand of cultured fish (Ugwumba and Ugwumba, 2007).

There is therefore the need to develop and encourage fish farmers to make use of ideal pond fertilization programs, non-conventional feed stuff processing, refinement and formulations that take cognizance of the requirements of the various species and their stages (Ibiyo and Olowosegun, 2004). In comparison to livestock feeds, fish feeds are unique in that they are pelleted and the size of the pellet depends to a large extent on size and age of the fish involed. Fish feed is very important in the efficiency and overall performance of fish in the pond and least cost feed production which will reduce the cost of production of fish. This is why any attention towards the production of effective and cheap feed will benefit fish farmers in Africa, since the feed ingredients are rich in desired nutrients (Hecht, 2000).

2.1.1 Utilization of plant ingredient in fish feeds

These are generally known as non conventional plant feed stuff (NCPF). These are many and abundant, almost in every locality in Africa, Nigeria inclusive (Gabriel *et al.*, 2007). Their potential and utilization in aquaculture feed have been reviewed (Ugwumba and Ugwumba, 2007; Bichi and Ahmed, 2010; Agbabiaka *et al.*, 2012). Their levels of inclusion in aqua feed varies and largely depends on their availability, nutrient level, processing technique, species of fish and cultural farming pattern prevalent in the locality. According to Nandeesha *et al.*, (1989) the recommended level of inclusion of NCPF so many factors limit higher level of incorporation and 30% of the diet. These are such as low protein content (Oresegun and Alegbeleye, 2001; Ibiyo and Olowosegun, 2004), amino acid imbalance (Eyo, 2001) and the present of antinutritional factors (Oresegun and Alegbeleye, 2001; Bawa *et al.*, 2007). The extend of plant protein utilization depends on availability, acceptability by fish, ease of processing and nutritive value. However it resulted in reduced growth and poor feed efficiency, probably the result of improper balance of essential nutrients.

The need to increase aquaculture production requires corresponding increases in nutrition related an input that is intensifying culture practices by feeding more and better feedstuffs (Machena and Moehl, 2001). Feeds are mostly based on agricultural by products available in an area and may be of modest quality but of a reliable quantity. Commercially produced feeds require cost effective inputs and the industrial means to manufacture feeds, preferably pelletized feeds.

Therefore, countries that have expanding agriculture sector and produced surpluses are often well placed for the economical production of commercial fish feeds (Machena and Moehl, 2001). In term of aqua feed manufacturing in Sub Saharan Africa, Nigeria being the largest aquaculture producer also manufactures the largest amount of aqua feed. Production was estimated at 10,760 metric tons in 2000 and 2001 (Shipton and Hecht, 2005). This feed was however, manufactured solely for the tilapia and catfish industries, accounting only for 30.3% of the country's aquatic feed production. The remainders, which represent the majority of the feeds used, were farm made feeds. Dependence on farm made products to satisfy feed requirements of aquaculture organisms is prevalent in all the Sub Saharan Africa countries (Moehl and Halwart, 2005). Feeds are still mostly produced at the farm level and in most cases only one or a mixture of two or more feed ingredients are used as supplementary feed in pond culture. Farmers who were desperate to increase production have tried poultry feed with little or no success (Amisah *et al*., 2009). The few commercial farms in Nigeria produce their own feed. The feed produced and used widely in Africa are categorized into conventional and non conventional feedstuff, the categorization is based on the availability and acceptability of the feedstuff involved (Jamu and Ayinla, 2003).

2.1.2 Conventional feed source

These are the feed stuff that are regularly used in the formulation of fish feed. Their usage is standardized and widely acceptable. Many of these are cheaper and readily available in very large quantity. They are usually agro-based industry's by-products. Examples include wheat bran, groundnut cake, and rice bran. Some are animal based (for example fish meal, blood meal, and shrimp meal), whereas others are plant based maize, soya bean meal, cotton seed meal (Okoye and Sule, 2001). Generally these materials are relatively cheap and available throughout the year (Gabriel *et al*., 2007). The effectiveness of a feed is preferred as a determinant rather the cheapness. Hence, balance is therefore needed, if aquaculture is to be profitable (Falaye, 1992). Animal protein sources that have been tested in partial or total replacement of fishmeal component of feed used in aquaculture include terrestrial and aquatic worms, fish silage, poultry by-product meal, tadpole meal and whey powder. However attempt to partially or wholly replace fish meal in fish feed formulations with these sources have resulted in either good, fair or poor results in terms of growth and food conversion as indicated respectively by Pfetter and Berkers (1977) and Ayinla (1991).

2.1.3 Non conventional feedstuff

The non conventional feedstuff of animal origin are high quality feed ingredients which could compare to certain extent with the conventional types. They are cheaper by virtue of the fact that there is no competition for human consumption. Non conventional feeds are potential feed ingredients which have hitherto not been used in fish feed production for the reasons that; they are not well-known or understood, no effective study of the method of production with a view to commercializing them, they are not readily available and they can be toxic or poisonous (Moehl and Harwart, 2005). Theses feeds are generally referred to as unconventional feed ingredients. They contain high quality feed ingredients that can compare favorably with conventional feed types. Unconventional fish feed can be of animal or plant source (Jamu and Ayinla, 2003). These are locally available feed stuffs that are not standardized. The usage is not widely spread and they are not consumed by man in most cases. Utilization in aqua feed is very common especially in the rural area of Sub

Sahara Africa, among low income group that are actively engage in fish farming. Gabriel *et al*., (2007) reported that these feeds normally come from three sources.

2.2 Feed Additives in Fish

Feed additives are substances which are added in trace amounts to a diet or feed ingredient either (a) to preserve its nutritional characteristics prior to feeding [i.e. antioxidants and mould inhibitors], (b) to facilitate ingredient dispersion or feed pelleting [i.e. emulsifiers, stabilisers and binders], (c) to facilitate growth [i.e. growth promotants, including antibiotics (garlic and chloramphenicol) and hormones], (d) to facilitate feed ingestion and consumer acceptance of the product [i.e. feeding stimulants and food colourants], or (e) to supply essential nutrients in purified form [i.e. vitamins, minerals, amino acids, cholesterol and phospholipids] NRC (1983) and Matty and Lone (1985).

2.2.1 Preservatives

A major problem faced by the animal feed compounder is the susceptibility of individual feed ingredients and formulated feeds to oxidative damage (oxidative rancidity) and microbial attack on storage. For example, in the absence of natural antioxidant protection (ie. absence of vitamin E, selenium, soy lecithin, active β-carotene) feedstuffs rations rich in polyunsaturated fatty acids (ie. fish oils, fish meals, rice bran, and some expeller oil seed cakes) are highly prone to oxidative decomposition which in turn may cause a reduction in the nutritive value of the constituent lipids, protein and vitamins (Rumsey, 1980; NRC, 1983; Bell and Cowey, 1985). Similarly, feedstuffs and rations posessing elevated moisture content (> 15%) are prone to microbial attack and decomposition with a consequent loss in nutritional value for non-ruminant animals and deleterious mycotoxin production (Chow, 1980; NRC, 1983; Jones, 1987).

2.2.2 Antibiotics

Antibiotics are drugs of natural or synthetic origin that have the capacity to kill or to inhibit the growth of micro-organisms. Antibiotics that are sufficiently non-toxic to the host are used as chemotherapeutic agents in the treatment of infectious diseases of humans, animals and plants. Such chemical agents have been present in the environment for a long time, and have played a role in the battle between man, animal (fish) and microbes (FOA, 2005). In the last century, the discovery of new antibiotics revolutionized the treatment of infectious diseases, leading to a dramatic reduction in morbidity and mortality, and contributing significantly to improvements in the health of fish. The feeding of antibiotics is associated with decreases in animal gut mass, increased intestinal absorption of nutrients and energy sparing (FOA, 2005). This results in a reduction in the nutrient cost for maintenance, so that a larger portion of consumed nutrients can be used for growth and production, thereby improving the efficiency of nutrient use. Antibiotics act by eliminating the subclinical population of pathogenic microorganisms (FOA, 2005). Eradicating this metabolic drain allows more efficient use of nutrients for food production. Antibiotics alter the non-pathogenic intestinal flora, producing beneficial effects on digestive processes and more efficient utilization of nutrients in feeds (FOA, 2005). Antibiotics are used in aquaculture to treat diseases caused by bacteria. Sometimes the antibiotics are used to treat diseases, but more commonly antibiotics are used to prevent diseases by treating the water or fish before disease occurs (FOA, 2005) While this prophylactic method of preventing disease is profitable because it prevents loss and allows fish to grow more quickly, there are several downsides. Some of these antibiotics are; Garlic and Chloramphenicol.

2.2.2.1 *Garlic*

Garlic is originating in Asia minor and spontaneously grows in southern Europe, but in cultures, it could be found all over the world. It is rich course of calcium, phosphorus and vitamins B1, it has a high content of the carbohydrates as a consequence a high nutritive value. Garlic also contains iodine salts, which have a positive effect on the circulatory system and rheumatism, silicates which have a positive effect on the skeletal and circulatory system and sulfur salts with positive effects on the skeletal system, cholesterolemia, and liver diseases. Garlic also contains vitamin B complex, vitamin A and C Dragan *et al*., (2008). Garlic has the following effects. Lower the cholesterol and the triglycerides, ameliorates, atherosclerosis, has a hypertensive coronary dilator, antioxidant and anti-cancer effect. Garlic contains sulfur containing compounds. Allium is converted to the anti-microbial active allicin, when the bulb is cut or bruised. Ajuvene, which is a secondary degradation product of allium, is presumably the most active compound responsible for the anti-thrombotic activity of garlic (Wichtl, 2004); the fish bulb contains allin, allicin and volatile oils. When the garlic close is crushed, the odourless compound allin is converted to allicin via the enzyme allinase. Allicin gives garlic its characteristic pungent smell. (Skidmore, 2003). Garlic has also been shown to have antioxidant properties which could have a protective nature against gastrointestinal neoplasias against blood clots (anti-platelet action) due in part to the compounds alliums and ajoene, which have fibrinolytic activity. Ajuvene inhibits thromboxane synthesis through the inhibition of the cyclo-oxygenase and lipo-oxygenase enzymes (Schulz *et al.,* 2004).

2.2.2.2 *Chloramphenicol Antibiotic*

Chloramphenicol is an antibiotic useful for the treatment of a number of bacterial infections (FAO, 2005). It became available in 1949. It is considered a prototypical broad-spectrum antibiotic, alongside the tetracyclines, and as it is both cheap and easy to manufacture, it is frequently an antibiotic of choice in the developing world (FAO, 2005). Chloramphenicol, also known as chlornitromycin, is effective against a wide variety of Gram-positive and Gram-negative bacteria, including most anaerobic organisms (Shalaby *et al*., 2006). Chloramphenicol is still widely used because it is inexpensive and readily available. Chloramphenicol antibiotic is generally used in fish feed to promote health and growth, but its use for long periods may cause blood dyscrasias such as aplastic anemia, and it has resently been implicated as carcinogenic agent (Shalaby *et al*., 2005). The most serious adverse effect associated with chloramphenicol treatment is bone marrow toxicity, which may occur in two distinct forms: bone marrow suppression, which is a direct toxic effect of the drug and is usually reversible, and aplastic anemia, which is idiosyncratic (rare, unpredictable, and unrelated to dose) and generally fatal.

Chloramphenicol supplementation as a feed additive antibiotic and diets has a greater effect in improving live body weight and feed conversion efficiency in broiler chicks. Antibiotics are largely used for prophylaxis and treatment to reduce bacterial contermination to a degree that enhances host defence mechanism (Smith and Reynard, 1992).

2.3 Biology and characteristics of *Heterobranchus bidorsalis*

The genus *Heterobranchus* is recognized and differentiated from *Clarias* by the presence of a dorsal adipose fin, in addition to the rayed dorsal fin. The following four species of this genus are known: *Heterobranchus bidorsalis* Geoffroy Saint-Hilaire 1809, *H. longifilis* Valenciennes, 1840, *H. isopterus* Bleeker, 1863 and *H. boulengeri* Pellegrin, 1922; the last is the smallest member of the genus (Reed *et al.,* 1967; Froese and Pauly, 2013). According to Teugels *et al*. (1990), *Heterobranchus* Geoffroy Saint-Hilaire, 1809 is generally considered the most primitive genus, mainly because of the presence of a large adipose fin (22-35% standard length) supported by 19 to 26 elongated neural spines. *Heterobranchus bidorsalis*, the African catfish or eel-like fattyfin catfish, is an airbreathing catfish found in Africa (Azeroual *et al*., 2010). The head of *Heterobranchus bidorsalis* is shaped like an oval and has a rectangular dorsum. The snout is round and the eyes are lateral. The frontal fontanelle is long and narrow while the occipital fontanelle is relatively long and is shaped like an oval. The postorbital bones are completely united. The suprabranchial organ is well developed. The pectoral spine is smooth. The body and fins may have spots. It can reach a length of 150 cm (59.0 inches) TL. The maximum recorded weight for this species is 30.0 kg. The species has 40-46 dorsal (in the back) soft rays, 49-58 anal soft rays, and 62-63 vertebrate (Froese and Pauly, 2011). This catfish is demersal and inhabits. It lives in waters of 22.0-28.0°C (71.6-82.4°F). It is found widely in the northern half of Africa between Senegal and Ethiopia, as well as the Nile (Azeroual *et al*., 2010). It can be found in the Niger River, Gambi River, Senegal River, Baro River, Benue River, Volta River and Lake Chad (Froese and Pauly, 2011).

2.4 Food and feeding habits of *Heterobrancus bidorsalis*

Heterobrancus bidorsalis is equipped to feed on a wide variety of food items, from minute crustaceans to fish. Predation is more efficient on invertebrate prey. Most feeding takes place at night on active benthic organisms, but they may also feed during the day and at the water surface. Individual bottom foraging is the normal mode of feeding, although catfish may also feed in groups at the water surface (Bruton, 2010). They are not specific in their food requirements. They are known to feed on insects, plankton, snails, crabs, shrimp, and other invertebrates. They are also capable of eating dead animals, birds, reptiles, amphibians, small mammals, other fishes, eggs, and plant matter such as fruit and seeds. Because they are mobile on land, they are able to prey on terrestrial organisms (Bruton, 2010). This species may also hunt in packs on occasion by herding and trapping smaller fish (Agbabiaka, 2010).The species is euryphagous and generally regarded as an opportunistic, omnivorous predator. It has the ability to efficiently utilize and/or switch between alternative food sources such as plants and detritus when prey animals become scarce (Dadebo, 2000). Normally catfish are bottom feeders, but their feeding habits are adaptable and they occasionally filter feed in groups at the water surface. There are four (4) recognized feeding modes, viz. individual foraging, individual shoveling, surface feeding and formation feeding. Adoption of any one of the feeding modes depends on food availability (Bruton, 2010). Catfish in ponds have been observed to snatch sinking pellets before they reach the substratum (Agbabiaka, 2010). The buccal cavity is capable of considerable vertical displacement that enables suction feeding. The teeth are numerous, small, cardiform and backwardly directed (Teugels, 1986a). The premaxillary, mandibular and pharyngeal teeth are conical and sharp, whereas the vomerine band has mainly granular molar-like teeth with variable numbers of conical teeth, usually on the distal margin. The vomerine teeth band has no ventral partner, so that crushing and gripping of prey take place against the hyoid apparatus, which bulges upwards to form a tongue. *Heterobrancus bidorsalis* has long gillrakers on the anterior borders of the five bronchial arches, and additional gillrakers on the posterior margins of the third and fourth arches that interdigitate with those from the anterior row of the next arch (Anoop *et al*., 2009).The number of gillrakers increases with length. The mean width between gillrakers varies between 0.1 and 0.6mm, but this increase with length. Despite this, larger fish are known to filter feed on phytoplankton, zooplankton and surface scum. The stomach is muscular, and the intestine is thin walled and relatively short, implying a dependence on high-protein foods. The stomach in North African catfish becomes functional 5–6 d (11 mm TL) after the start of exogenous feeding at 27.5°C (Verreth *et al.*, 1992). Predation is most efficient on relatively slow-moving benthic organisms, but fast prey such as fishes can also be caught individually or by using pack-hunting tactics (Merron, 1993). The percent composition of natural food is dependent on the availability and abundance of various food items within systems. Based on the proximate composition of diets of wild populations, Hecht, (2000) predicted that the species would have a relatively high protein demand (>45 percent), a lipid demand of around 18.5 percent and a dietary energy requirement of around 18 kJ/g. The predictions were very close to the empirically determined requirements. The species feeds mainly on insects, phytoplankton and zooplankton, invertebrates and fish, but also takes young birds, rotting flesh and plants (Yalcin *et al*, 2001). Frogs, snakes, fledgling birds, small mammals, seeds and fruits have also been recorded in the stomachs. The natural diet is determined largely by prey abundance in any particular habitat. During the larval and early juvenile phase, the natural diet is restricted mainly to zooplankton and chironomids. During this stage, the taste buds on the circumoral barbels play an important role in prey detection (Nyina-wanniza *et al*., 2010). The species is also able to detect electrical pulses and uses this ability to detect prey (Hanika and Kramer, 2000). With increasing size and development of the feeding apparatus, the diet becomes more diverse. Bruton (2010) recorded over 40 prey species in the stomachs of *C. gariepinus* in lakes Sibaya (South Africa) and Kinneret (Israel), with fish contributing 75 percent and 81 percent of the dry weight of the diet, respectively, followed by crustaceans. On the other hand, Hecht (2000) found that zooplankton becomes more important in the diet with increasing size. This simply illustrates the extraordinary ability of the species to switch diet. Agonistic behavior and cannibalism in larvae and early juveniles under culture conditions is affected by light intensity, photoperiod, feeding method, density, food availability and feed type (Verreth *et al*., 1992). Van de Van de Nieuwegiessen *et al*. (2009) suggested that welfare in fish up to 100 g is significantly improved with increasing density, while welfare of larger fish is not negatively affected by increasing density. The behavioral effect of increasing density is that the fish assume a behavior pattern that is reminiscent of a “rolling bait ball” in which there is no sign of aggression, and this leads to improved feed consumption and improved food conversion ratios (Hecht and Uys, 1997).

2.5 Water Quality in Aquaculture

The productivity of a given body of water is determined by its physical, chemical and biological properties. The environmental properties of water need to be conducive for fish to grow well; therefore an ideal water condition is a necessity for the survival of fish since the entire life processes of the fish is wholly dependent on the quality of its environment. These water quality parameters become more critical in intensive culture systems where fish are raised in artificial ponds with reduced self-purification capabilities as compared with natural systems. The physical properties of water which are of paramount importance in outdoor digestibility studies include temperature and total dissolved solids (TDS), this is because the outdoor tanks are directly exposed to sunlight, therefore wide temperature values may occur while TDS affect turbidity or water transparency. The chemical properties of water include pH, dissolved oxygen and electrical conductivity (Lind, 1979). A drastic change i.e either a rise or fall from the optimum will affect the existence of fish and so is usually properly monitored.

2.5.1 Dissolved Oxygen

In the absence of deliberate poisoning, dissolved oxygen is the single most important and critical water quality parameter for fish in pond culture systems (Boyd and Lichtkoppler, 1979). Nearly all aquatic organisms, with the exception of some bacteria, must have oxygen to survive (Wheaton, 1977). Most of these organisms must extract their oxygen from liquid water. Thus, the extraction of oxygen from water and the addition of this gas to water are operations of critical importance to fish. Oxygen is often a limiting factor in aquatic systems. Primary production sources (i.e., photosynthetic plants) produce oxygen in the presence of light but require it when it is dark. Thus oxygen can limit both primary and secondary production. The two major sources of oxygen for water are plants in which photosynthesis occurs and the atmosphere. The amount of oxygen in water is increased by primary productivity which takes place in outdoor ponds and by wind action which aerates the water surface. Wheaton (1977) states that the rate of oxygen transfer from air to water depends on; water temperature, degree of saturation of the water and turbulence of the air-water interface. Photosynthesis stops at night, but plants and animals continue to respire and consume oxygen. As a result, dissolved oxygen levels fall to a low point just before dawn.

Photosynthetic oxygen production lags slightly behind the daily radiant energy cycle. Because of this, oxygen content of natural and pond waters usually reaches its daily minimum just at or slightly after daybreak. From then on the dissolved oxygen levels rise from morning through the afternoon as a result of photosynthesis, reaching a peak in late 22 afternoons. Maximum oxygen concentrations are usually observed in the mid to late afternoon. Inadequate dissolved oxygen has many effects on fish; fish stop feeding, growth is impaired and fish become stressed thereby becoming more susceptible to diseases. Cold water fishes require large amounts of dissolved oxygen in water. This is only physically possible in cold water (5° – 15°C). Warm water fish, on the other hand, are able to survive in water with low oxygen content, which is the case in water between 20° – 40°C, where these fish are reared (Boyd and Lichtkoppler, 1979).

2.5.2 Temperature

Temperature is next to dissolved oxygen as the single most important factor affecting the welfare of cultured fish. Fish are poikilothermic and water temperature plays a tremendous role in their feeding. This parameter affects the metabolic activities, feeding potential, growth, survival, reproduction in all fishes (Dupree and Hunner, 1984) and efficiency of food conversion (Martinez-Palacios *et al*., 1993). It has been reported that a 5°C sudden change in temperature will stress or even kill fish and this has formed the basis of the acclimatization of fish (Adeniji and Ovie, 1990). Temperature has a pronounced effect on the rate of chemical and biological processes in water. For instance, fish require twice as much oxygen at 30°C than at 20°C (Adeniji and Ovie, 1990). Increment of the water level may therefore be necessary at higher temperatures. Temperature also affects the dominance and distribution of phytoplanktons in water. It is recommended that fish in the tropics be kept in water whose temperature range is between 25^o C and 30^o C (Auta, 1993).

2.5.3 Hydrogen ion concentration (pH)

The pH of water is a measure of how acidic or alkaline it is on a scale of 0 to 14 with 7 being neutral. In fish ponds, the time of day that a sample is taken often will influence the pH because of variations in the carbon dioxide concentration. As plants in the water remove carbon dioxide for photosynthesis, the pH will increase. At night, the pH will decrease as carbon dioxide accumulates. Increasing the total alkalinity concentration in water helps buffer against pH changes. Chronic pH levels may reduce fish reproduction and are associated with fish die offs (Stone and Thomforde, 2006). Adeniji and Ovie (1990) noted that acid and alkaline death points are approximately at pH 4 and 11 respectively and that waters with pH values ranging from 6.5 to 9 were observed to be the most suitable for fish production. Dupree and Hunner (1984) also observed that high pH increased the toxicity of sulphides. Also, Auta (1993) stated that the desirable pH range for fish is 6.7 to 9.0.

2.6 Nutrient Requirements of Fish

Lall (1991) and Helfrich and Craig (2002) indicated that proper nutrition is one of the major factors influencing ability of fish to attain genetic potential for growth, reproduction and longevity. Efficient production and growth of fish in the culture systems depends entirely on feeding complete feed appropriate rate with due considerations to the dietary requirements of the fish which should not be exceeded (Ayinla, 1991). Formulated or artificial diets may either be complete or supplemental. Complete diet supply all the nutrients (proteins, carbohydrates, fats, vitamins and minerals) necessary for the optimal growths and health of fish. Generally, the basic nutrient composition of fish feed include protein (18-50%), carbohydrate (basal diet) 15-20%, lipid (10-25%), ash (<8.5%), phosphorus (<1.5%), water (<10%), vitamin minerals. Among these nutrients energy forms the bulk or basal diet while protein constitutes the most expensive item in formulated diets. These key nutrients determine the scale of production of a fish diets while the rest of the nutrients promote the efficiency of utilization of these two nutrients (Annune and Oniye, 1993).

Fish are normally provided with complete diets when reared in high density indoor system or confined in cages and cannot forage freely on natural feeds (Helfrich and Craig 2002). However, supplemental (incomplete, partial) diets are fed only to help support the natural food (insects, algae, small fish) that are naturally available in fishponds or outdoor raceways. Supplemental diets do not contain full complement of vitamins and mineral, although they are used to help fortify the natural available diet with extra protein, carbohydrate and lipid (Helfrich and Craig 2002). The main objective of fish feed formulation is to put together raw materials (feed ingredients) that will provide nutritionally balanced feed for fish. This is actually aimed at providing nutrients for rapid fish growth so as to enhance optimal production at low feed cost (Ayinla 1991 and Annune and Oniye, 1993). The formulation of fish diets therefore needs an understanding of the nutrient requirement of different fish species in relation to age, feeding, habits, production objectives and physical state and nutrient composition of the feed stuffs and the level of associated anti-nutritional factors and feed contamination in such feed stuff. The science of aquaculture nutrition and feeding is concerned with the supply of these dietary nutrients to fish or shrimp either directly in the form of an exogenous ‘artificial’ diet or indirectly through the increased production of natural live food organisms within the water body in which the fish or shrimp are cultured (Luquet, 2002).

2.7 Protein and Amino acids Requirement of Fish

Protein is the most expensive part of fish feed, it is important to accurately determine the protein requirements for each species and size of cultured fish. Proteins are formed by linkages of individual amino acids. Although over 200 amino acids occur in nature, only about 20 amino acids are common. Of these, ten (10) are essential (indispensable) amino acids that cannot be synthesized by fish. The ten (10) essential amino acids that must be supplied by the diet are: methionine, arginine, threonine, tryptophan, histidine, isoleucine, lysine, leucine, valine and phenylalanine. Of these, lysine and methionine are often the first limiting amino acids. Fish feeds prepared with plant (soybean meal) protein typically are low in methionine; therefore, extra methionine must be added to soybean-meal based diets in order to promote optimal growth and health. It is important to know and match the protein requirements and the amino acid requirements of each fish species reared. Helfrich and Craig (2002) indicated that protein levels in aquaculture feeds generally average 18-20% for marine shrimp, 28-32% for catfish, 32-38% for tilapia, 38-42% for hybrid striped bass. Protein requirements usually are lower for herbivorous fish (plant eating) and omnivorous fish (plant-animal eaters) than they are for carnivorous (flesh-eating) fish, and are higher for fish reared in high density (recirculating aquaculture) than low density (pond aquaculture) systems. Protein requirements generally are higher for smaller fish. Protein requirements of fish vary for each fish species and with each life state (Lim and Dominy, 1989; Alcestes and Jory, 2000).

Helfrich and Craig (2002) stated as fish grow larger, their protein requirements usually decrease. Protein requirements also vary with rearing environment, water temperature and water quality, as well as the genetic composition and feeding rates of the fish. Protein is used for fish growth if adequate levels of fats and carbohydrates are present in the diet. If not, protein may be used for energy and life support rather than growth. Proteins are composed of carbon (50%), nitrogen (16%), oxygen (21.5%), and hydrogen (6.5%) Helfrich and Craig (2002). Fish are capable of using a high protein diet, but as much as 65% of the protein may be lost to the environment. Most nitrogen is excreted as ammonia (NH_3) by the gills of fish, and only 10% is lost as solid wastes. Accelerated eutrophication (nutrient enrichment) of surface waters due to excess nitrogen from fish farm effluents is a major water quality concern of fish farmers. Effective feeding and waste management practices are essential to protect downstream water quality. Fry and fingerling fish require a diets higher in protein (which may frequently exceed 50% crude protein), lipids, vitamins and minerals and lower in carbohydrates because they are developing muscles, internal organs and and bone with rapid growth (Alcestes and Jory, 2000).

Sub-adult fish require more calories of fats and carbohydrates for basal metabolism and a smaller percentage of protein for growth. Adult fish require lesser amount of protein however the amino acid which make up that protein need to be available in certain ratios. Maintainance diets may contain as little as 25 – 35% crude protein (Francis-Floyd, 2004) and food for grow-outs phase often approach or exceed 40% crude protein. Broodstock animals also require high protein and fat levels to increase the reproductive efficiency (Alcestes and Jory, 2000). However the reports of Ayinla and Bekibele (1992) and Alcestes and Jory, (2000) vary with the report of Ayinla (1988) which indicated that fingerling state of *Heterobranchus bidorsalis* required 31 – 34% crude protein; juvenile 31 – 34% crude protein; adults 40% crude protein and broodstock, 40% crude protein.

2.8 Carbohydrates Requirements of Fish

Carbohydrate (starches and sugar) are the most economical and inexpensive sources of energy for fish diets. Carbohyradrate are included in aquaculture diets to reduces feed costs and for their binding activity during feed manufacturing. They are also used due to their natural abundance. In fish, carbohydrate are stored as glycogen that are mobilized when necessary to satisfy energy demands (Annune and Oniye, 1993, Helfrich and Craig 2002).

Helfrich and Craig (2002) indicated that fish have lower dietary energy requirement because they exert relatively less energy to maintain position and move in water than do mammals and birds and because they excrete most ot their nitrogenous wastes as ammonia (through the gills) instead of urea or uric acid thus loosing less energy in protein catabolism and excretion of nitrogenous wastes (Goldstein and Forster, 1970).

Fish also have a lower dietary energy requirement because they do not have to maintain a constant body temperature. Therefore maintainance energy requirement and heat increament are lower for fish than for land animals, with the implication that carbohydrates are not efficiently used by fish (Lovell, 1981, Helfrich and Craig 2002).

Helfrich and Craig (2002) stated that mammals can extract about 4Kcal of energy from 1gram of carbohydrate whereas fish can only extract 1.6Kcal from the same amount of carbohydrate. Helfrich and Craig (2002) further indicate that upto 20% dietary carbohydrates can be used by fish as earlier indicated by Buhler and Halver (1961). Most research effort provision of adequate feed for fish has been centered on manipulation of dietary protein used in feed formulation. Generally, fish nutritionist have given priority to meet the requirement for protein, and major minerals and vitamins thereby allowing energy to take care of itself (Lovell, 1988). Lovell (1988) furthermore stressed that fish uses protein efficiently as a source of energy, it was also maintained that a high percentage of digested energy in protein is metabolisable in fish than land animals. However, a ration poor in carbohydrate entails the use of either lipid or protein to provide necessary calories (Cowey and Sargent, 1972).

The common attributes of carbohydrates are that they contain only the elements carbon, hydrogen and oxygen, and that their combustion will yield carbon dioxide plus one or more molecules of water. Carbohydrates make up three-fourths of the biomass of plants but are present only in small quantities in the animal body as glycogen, sugars and their derivatives. No dietary requirement for carbohydrates has been demonstrated in fish. However, Warm water fish can use much greater amounts of dietary carbohydrates than cold water and marine species (NRC, 1993).

2.9 Lipid and Fatty acids Requirement of Fish

Lipids are non-protein calorie source which are often neglected in fish feed preparation, they are generally more digestible than some carbohydrates (Hilton *et al*., 1983). Due to the high energy content of fats they can be utilized to partially spare or substitute for protein in aquaculture feed (Helfrich and Craig, 2002). The protein sparing effects of lipids varies between species bur appear to be optimal at about 15 – 18% of the diet (De-Silver and Anderson 1995). Lipids supply about twice the amount of energy as proteins and carbohydrates and typically lipids comprise about 15% of fish diets, lipids supply essential fatty acids (EFA) and serve as transporters of fat-soluble vitamins. Dietary lipids are important sources of energy and fatty acids that are essential for normal growth and survival of fish. Although fish have low energy demand, and thus susceptible to deposition of excessive lipid (Earle, 1995). Lipids are important in the structure of biological membranes at both the cellular and sub cellular levels. They are components of hormones and precursors for synthesis of various functional metabolites such as prostaglandins, and are also important in the flavor and textural properties of the feed consumed by fish (NRC, 1983). The use of lipids (fats and oils) in catfish feeds is desirable because lipids are highly digestible sources of concentrated energy containing about 2.25 times as much energy as does an equivalent amount of carbohydrate (Eyo, 2002).

Eyo (2003) indicated that lipids and fatty acids perform three different functions in the organism, as they serve as energy carriers, metabolism regulators and elements in the cells. Helfrich and Craig (2002) indicated that a recent trend in fish feed is to use higher levels of lipids in the diet. They further asserted that increasing lipids can help reduce the high cost of feeds by partially sparing protein in the feed, it was also noted that problems such as excessive fat deposition in the liver can decrease the health and market quality of fish.

Helfrich and Craig (2002) stated that simple lipids include fatty acids and triacylglycerols and that fish typically require fatty acids of the Omega 3 and 6 (n – 3 and n – 6) families for maximum growth and efficient utilization.

2.10 Vitamins Requirement of Fish

Vitamins are organic compounds necessary in the diet for normal fish growth and health. They often are not synthesized by fish, and must be supplied in the diet. The two groups of vitamins are water-soluble and fat-soluble. Water-soluble vitamins include: the B vitamins, choline, inositol, folic acid, pantothenic acid, biotin and ascorbic acid (vitamin C). Of these, vitamin C probably is the most important because it is a powerful antioxidant and helps the immune system in fish. The fat-soluble vitamins include A vitamins, retinols (responsible for vision); the D vitamins, cholecaciferols (bone integrity); E vitamins, the tocopherols (antioxidants); and K vitamins such as menadione (blood clotting, skin integrity). Of these, vitamin E receives the most attention for its important role as an antioxidant (Prather and Lovell, 1973).. Deficiency of each vitamin has certain specific symptoms, but reduced growth is the most common symptom of any vitamin deficiency. Scoliosis (bent backbone symptom) and dark coloration may result from deficiencies of ascorbic acid and folic acid vitamins, respectively. Other signs common to several vitamin deficiencies were identified as abnormal skin pigmentation, ataxia, hypersensitivity haemorrhage, fatty livers and increased susceptibility to bacterial infection Craig and Helfrich (2002).

Vitamins are distinct from the major food nutrient (protein, lipids, and carbohydrates) in that they are not chemically related to one another, are present in very small quantities within animal and plant feedstuffs, and are required by the animal body in trace amounts. Approximately 15 vitamins have been isolated from biological materials; their essentially depending on the animal species, the growth rate of the animal, feed composition, and the bacterial synthesizing capacity of the gastro-intestinal tract of the animal Helfrich and Craig (2002).

2.11 Minerals Requirement of Fish

Minerals are inorganic elements necessary in the diet for normal body functions. They can be divided into two groups (macro-minerals and micro-minerals) based on the quantity required in the diet and the amount present in fish Craig and Helfrich (2002). Common macro-minerals are sodium, chloride, potassium and phosphorous. Of all the minerals required by fish, phosphorus is one of the most important because it is essential in growth, bone mineralization and lipid and carbohydrate metabolism. It is needed in the diet due to low content in natural water. However, the pollution of water by excess phosphorus excreted appeared highly critical, as this may lead to eutrophication. These minerals regulate osmotic balance and aid in bone formation and integrity (NRC, 1993).

Micro-minerals (trace minerals) are required in small amounts as components in enzyme and hormone systems. Common trace minerals are copper, chromium, iodine, zinc and selenium (NRC, 1993). Fish can absorb many minerals directly from the water through their gills and skin, allowing them to compensate to some extent for mineral deficiencies in their diet. Minerals are also required by fish for tissue formation and various functions in metabolism and regulation (NRC, 1983).

2.12 Energy Requirement of Fish

Energy is defined as the capacity to do work, and it derived by animals through the catabolism of dietary carbohydrates, lipid and protein within the body. Although many forms of energy exist in nature (i.e. radiant, chemical, mechanical, heat, and electrical energy), all have the capacity to do chemical, electrical and mechanical work. Energy is therefore essential for the maintenance of life processes such as cellular metabolism, growth, reproduction and physical activity. In particular, life on earth is dependent on radiant solar energy and its subsequent fixation and conversion by green plants during photosynthesis into stored chemical energy (i.e. Carbohydrates) for use as an energy source by plants themselves or for animals that consume them through respiration. Major food nutrients (i.e. carbohydrates, proteins and lipids) are required by animals not only as essential materials for the construction of living tissues, but also as source of stored chemical energy to fuel these processes as work. The ability of a food to supply energy is therefore of great importance in determining its nutritional value to animals (Phillips, 1975).

2.13 Digestability

Digestibility of the feed is a function of feed composition and is directly related to the digestive capacity. A digestibility value is a relative measure of the extent to which ingested food and its nutrient components have been digested and metabolized by the fish. The ability of fish and vertebrates to use nutrients depends on many factors, such as the synthesis of appropriate enzymes, production of digestive enzymes in suitable amounts and their distribution along the gut lumen (Kuz'mina, 1990). In carnivorous fish or those with a meat-orientated omnivorous diet there is normally a definite stomach (foregut) whilst herbivorous or plant-orientated omnivores normally have no stomach but rely on a much extended mid gut area for the digestion of the food (Chou *et al.*, 2001).

The African catfish (*Heterobranchus bidorsalis*), together with the walking catfish and the hybrid catfish, are classified as omnivores, and can be expected to utilize dietary carbohydrates more efficiently than other fish (Jantrarotai *et al.*, 1994; Nematipour *et al.*, 1992a, Chow and Halver, 1980). Previous studies on omnivorous fish such as common carp, tilapia and African catfish, have shown that they are able to digest carbohydrates efficiently. Moreover, tilapia appears to digest animal protein better than carp, probably because most of the carp food originates from benthic source, while most of the tilapia food originates from plants (Anderson *et al.*, 1984; Degani and Revach, 1991). Studies on African catfish (*Clarias gariepinus*) have shown that they can perform equally well on isonitrogenous and isocaloric diets (40% protein, 20 kJ GE g^{-1}) with a dietary carbohydrate content ranging from 27 to 38% and with a carbohydrate to lipid ratio of 1.7 to 3.4 (Ali and Jauncey, 2004).

2.13.1 Protein digestibility

The total tract apparent digestibility values for protein in protein-rich feedstuffs in channel catfish are usually in the range of 75-95 % (NRC, 1993). According to Fagbenro (1996), the apparent digestibility of protein in feedstuffs of animal origin or of plant origin in catfish (*Clarias isiriensis)* is similar. It has been reported that the protein digestibility of cottonseed meal in catfish is about 84%, but the lysine availability is only about 66% (Fagbenro *et al*., 1998). A similar situation may exist for other feedstuffs. Therefore, if feeds are formulated on a protein basis, a lysine deficiency may result. A major problem in formulating catfish feeds on an available amino acid basis is the lack of sufficient data (Robinson *et al*., 2001)

2.13.2 Lipid digestibility

The total tract apparent digestibility values for lipids in channel catfish are high and vary between feedstuffs (NRC, 1993). Lipids are a highly digestible source of concentrated energy for catfish feed and contain more than twice as much energy as does an equivalent amount of carbohydrates (Robinson *et al*., 2001). Total tract apparent digestion values for lipids in channel catfish fed uncooked corn, meat and bone meal, cotton seed, soybean meal, poultry feather meal, wheat grain, fish oil and anchovy meal were 76, 77, 81, 81, 83, 96, 97 and 97%, respectively (Wilson and Poe, 1985).

2.13.3 Carbohydrate digestibility

Starch is an important dietary non-protein energy source for catfish, and which has to be included at suitable levels to maximize the use of dietary protein for growth (Ali and

Jauncey, 2004). The ability to digest starch depends on the secretion of α-amylase to the gastrointestinal tract. It is believed that all species of fish have the ability to secrete α-amylase. In carnivores such as the rainbow trout and sea perch, amylase is primarily of pancreatic origin, whereas in herbivores the enzyme is widespread throughout the entire digestive tract (Chow and Halver, 1980). Average total tract apparent digestibility values of starch in channel catfish fed wheat grain, uncooked corn (30 percent of diet), uncooked corn (60 percent of diet), cooked corn (30 percent of diet) and cooked corn (60 percent of diet) were 59, 66, 59, 78 and 62 %, respectively (Wilson and Poe, 1985).

2.14 Methods of digestibility determination

Determining digestibility of food and feeds in animals requires collection of faecal material. In assessing diet digestibilities, the two key methodological approaches used are the direct and indirect assessment methods. Both involve feeding test feed ingredients singly or, more commonly, as a component of a diet (NRC, 2011).

2.14.1 Direct method

In the direct assessment method, a complete account of both feed inputs and faecal outputs is required (NRC, 2011). The digestibility value of the feeds is then determined on a mass-balance basis (Glencross *et al.,* 2007). The main advantage with the direct method is that faecal excretion is qualitatively collected, making it possible to determine the digestibility with high accuracy. In addition, this method allows the carbon and nitrogen balance to be determined, as well as digestible energy and metabolisable energy (NRC, 2011). The main problems with this method are related to the difficulty and the possible errors involved with collection of accurate data on feed intake and faecal production (NRC, 1993).

Moreover, fish easily become stressed, which may affect digestive and metabolic processes and may result in digestibility values that are not credible (NRC, 2011).

2.14.2 Indirect method

The indirect method for digestibility determination is commonly used in most species of farmed fish and shrimp. This method relies on the collection of a representative sample of faeces that is free of uneaten feed particles and the use of an indigestible marker for calculation of digestibility (NRC, 2011). The marker can be added to the feed or it can be a component in the feed. The added marker should be non-toxic and inert and possible to include at low concentrations. Common indigestible markers added to the feed are chromic Oxide (Cr_2O_3), yttrium oxide (Y_2O_3) and titanium dioxide (NRC, 2011). Acid insoluble Ash (AIA) is a common and reliable feed-associated indigestible marker used to assess digestibility in pigs (McCarthy *et al.*, 1973) and fish (Montaño-Vargas *et al.*, 2002).

Digestibility of nutrients is estimated based on relative enrichment of marker in faeces compared with the level present in the feed (NRC, 2011). It is assumed that the amount of the marker in the feed and faeces remains constant throughout the experimental period and all ingested marker will appear in the faeces. The ratio of the marker in the feed and faeces determines the digestibility of dietary components and energy (Glencross *et al.*, 2007).

According to NRC (2011), the indirect method has several advantages over the direct method. These include minimum stress on fish or shrimp associated with a rearing/holding tank environment and the fact that fish or shrimp can be used in a single replicate tank rather than a single fish or shrimp.

2.16 Carcass and Nutritional Composition of Fish

The main component of fish flesh is moisture (water) or which usually accounts for about 80 percent of the weight of a fresh white fish fillet. Whereas the average water content of the flesh of fatty fish is about 70 percent, individual specimens of certain species may at times be found with water content anywhere between the extremes of 30 and 90 percent (FOA, 2016). Agbebi *et al*., 2013 reported that the moisture content of *Clarias gariepinus* fed dietary garli about 85%. Similar results was reported by Akbary *et al*., 2015 of *Mugil cephalus* larvae on garlic extract and Fagbenro *et al*., 1998 moisture content of rossele seed meal and kenaf seed meal in nile tilapia.

Proteins compose approximately 70% dry weight of the organic material in fish tissue; therefore, protein content is one of the most important nutritional compounds of fish feeds and tissues. Crude protein content is the general measure of fish feed quality, and is usually referenced when identifying specific fish feeds such as a "36% protein fingerling ration". It was reported that the initial crude protein of African catfish (*Clarias gariepinus*) increases after the feeding trial on soyabean waste. The chemical composition of the lipid content of fish flesh differs from that of most other naturally-occurring oils and fats in: having a greater variety of lipid compounds, possessing larger quantities of fatty acids with chain lengths exceeding 18 carbons, containing a much greater proportion of highly unsaturated fatty acids and having polyunsaturates, primarily at the W3 rather than W6 position. The lipid content of a species of fish varies with season, geographic origin, prevailing temperatures of the environment, physiological status of the animal (pre-or-post-spawning), and available food.

Ash in fish muscles contains nutritionally important minerals. Sodium and potassium play a significant role in cellular physiology. Values reported in literature range from 30 to 150 milligrams (mg) for sodium with an average of 60 mg/100g of fish musles, and 250 to 500 mg with an average of 400 mg for potassium. Freshwater fish are somewhat lower in sodium than salt water fish, 34 – 96 mg in salt water fish and 38-84 mg/100g in freshwater fish. The corresponding figures for potassium are 240 – 400 mg in flesh of marine species and 133 – 440 mg/100g of freshwater fish. Some species from different areas show differences in sodium content, for example, whiting from the Atlantic Ocean contain 82 mg/100g compared to 65 mg/100g for the Pacific Ocean whiting. These elements also vary with size and season.

2.16 Cost Benefit of fish feed

Cost benefit analysis (CBA), sometimes called benefit cost analysis (BCA), is a systematic approach to estimating the strengths and weaknesses of alternatives (for example in transactions, activities, functional business requirements or projects investments); it is used to determine options that provide the best approach to achieve benefits while preserving savings. The CBA is also defined as a systematic process for calculating and comparing benefits and costs of a decision, policy (with particular regard to government policy) or (in general) project. Diet supplementation is an important aspect in aquaculture management especially in intensive or in semi-intensive fish culture, and is promising for increasing fish production. In aquaculture, diet is often the single largest operating cost item and can represent over 50% of the operating costs in intensive aquaculture (EL-Haroun, 2007). This cost depends on many factors such as protein level, the source, and type of ingredients that could be derived from plant or animal resources, and manufacture practices. Apart from developing low-cost diets, different feeding management strategies such as on-demand feeding regimes (Noh *et al*., 1994) and/or good husbandry and pond management could improve fish growth. The optimum feeding regimes/schedules of cultured fish is an important aspect in achieving efficient production and also could lead to significant saving in diet cost.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The experiment was conducted in concrete ponds, Department of Biology, faculty of life Science, Ahmadu Bello University Zaria, Nigeria**.**

3.2 Source of Experimental Fish

A total number of 180 fingerlings of *Heterobrancus bidorsalis* of 8.55±0.15g mean weight were procured from fish hatchery unit National Institute of Freshwater Fisheries Research New Bussa Niger State. They were transported in 50 liter plastic container.

3.3 Experimental Design

Fish were acclimated for two weeks, during which they were fed commercial feed (40%cp) at a daily rate of 5% of biomass. Thereafter, batch weighing and length measurement of fish was done to ascertain their initial mean weight in grams and initial mean length in centimeters using weighing balance Sartorius Model (CP 8201) and fish measuring board respectively, before the commencement of the experiment. The fingerlings were randomly grouped into nine treatments of ten fish per concrete pond ($40 \times 100 \times 40cm^3$) with 400 litres of water in every pond. And that experimental diet were formulated to contain different levels of *Allium sativum* (10, 20, 30, 40 g/kg) and Chloramphenical antibodies (10, 20, 30, 40mg/kg) and the control group were free from garlic and antibiotic. Each treatment was replicated two times making a total of eighteen experimental units. Each treatment was assigned to a different level of inclusion; Treatment 0 (control), Treatment 1(10g/kg GM), Treatment 2 (20g/kg GM), Treatment 3 (30g/kg GM), Treatment 4 (40g/kg GM), Treatment 5 (10mg/kg CM), Treatment 6 (20mg/kg CM, Treatment

7 (30mg/kg CM) and Treatment 8 (40mg/kg CM). The experimental period lasted for sixteen (16) weeks.

3.4 Feed Formulation and Compounding

Garlic powder and Chloramphenicol antibiotic were obtained from Samaru Market Zaria and a licensed pharmacy respectively. Amounts of 10, 20, 30 and 40 g/kg of garlic and 10, 20, 30, 40mg/kg of Chloramphenicol antibiotic diets were taken and incorporated in to a basal feed (40% crude protein), comprising standard amounts of fish meal, yellow maize, soya bean meal, wheat bran, blood meal, palm oil, salt, vitamin premix and starch, formulated according to Fagbenro and Adebayo (2005). The proportion of ingredients used to formulate each diets i.e presented in table 3.1. The dry ingredients were then weighed out according to the formulation using Pearson Square Method. All dietary ingredients were separately milled to a less than 250um particle size. The ingredients were thoroughly mixed to obtain a homogeneous mass, and cassava starch be added as a binder. Water will be added (20%-30%) slowly to the mixture with continuous stirring until dough is formed. Fabricated hammer mill will be used to pellet the diets using a die size of 2mm. The pellets will be sun dried and packaged into layers of plastic bags and stored in a well ventilated room under ambient temperatures.

3.4.1 Feeding

The fish were fed to apparent satiation twice daily during the week fish were considered satiated when the feed began to float on the surface of the pond after approximately 7 minutes of gradual hand feeding. A fixed feeding regime of 3% of the body weight/day (dry food/whole fish) was employed with half of the daily ration fed in the morning 9 am and the other half in the evening 5pm. Feeding was performed for 13th consecutive days with no food being given on the 14th day when the fish were weighed and measured. The necessary adjustment in the quantity of feed intake was carried out at the end of every weighing period. Fish health and mortalities were also observed and recorded during the feeding period.

3.5 Proximate Compositon

Proximate analysis of dietary ingredients, Experimental diets, fish whole body and faecal samples were carried out according to AOAC (1990), procedures at the Department of Animal Science, Ahmadu Bello University, Zaria.

3.5.1 Crude Protein

The micro-kjeldahl method according to AOAC (1990) was used for the crude protein determination in triplicate as follows; 200g of sample was digested in concentrated sulphuric acid and ammonia from the digest is released which reacts with 40% sodium hydroxide and distilled water, trapped in 2% boric acid and quantified by titration against 0.2M hydrochloric acid. Crude protein was calculated by multiplying the Nitrogen by a factor 6.25.

3.5.2 Moisture

Moisture content was calculated using the formula below. Samples will be weighed before and after drying.

$$\text{Moisture} = \frac{\text{final mass} - \text{initial mass}}{\text{initial mass}} \times 100$$

(Sulivan, 2008)

3.5.3 Ash content

To determine the ash content, samples was weighed before and after being placed in a muffle furnace for approximately 6 h or until powdery white. Then cooled, and then place in a desiccator for further cooling to room temperature before the final mass is taken. The formula below was used to calculate the ash content.

$$\text{Ash} = \frac{\text{final mass} - \text{initial mass}}{\text{initial mass}} \times 100$$

(Sulivan, 2008)

3.5.4 Lipid

To determine the crude lipid content, the Soxhlet method (AOAC, 1990) was used to extract the lipid from the samples. Approximately 1g of sample was placed in the cellulose thimble and extracted using 150ml of acetone solvent. The system was heated in a water bath for approximately 10hours after which time the solvent is evaporated using a rotary evaporator. The flask was then placed in a drying oven for 1hour to remove water. After cooling, the flask was weighed and the lipid content calculated using the following formula.

$$\text{Lipid} = \frac{\text{final lfask mass} - \text{initial flask mass}}{\text{initial flask mass}} \times 100$$

(Sulivan, 2008)

3.6 Water Quality Parameters

Careful monitoring of the water quality parameters was necessary in order to know, manage and maintain conditions within acceptable limits as recommended by Boyd and Lickotcoper (1990). Temperature and pH was determined using Hanna instrument (Model HI 98129) and dissolve oxygen (DO) was determined by titration. Waste water will be completely drained and replaced weekly.

3.7 Growth Parameters

Parameters to be used in evaluating growth performance in this study are weight gain by fish and specific growth rate (SGR). SGR is the most commonly used expression of fish growth. All these parameters were measured for all the treatments and their replicates including the control diets.

3.7.1 Weight Gain (WG)

Weight Gain (WG) is the difference between the final body weight and the initial body weight of fish over a period of time.

$$WG = \frac{FBW - IBW}{IBW} \times 100$$

(Ricker, 1979)

Where, FBW is final mean body weight (g), IBW is initial mean body weight (g).

3.7.2 Specific Growth Rate

Is the instantaneous change in weight of fish expressed as the percentage increase in body weight per day over any given time interval. It is calculated by taking natural logarithms of body weight, and expresses growth as %.day-1 (Ricker, 1979).

$$SGR = \underline{\ln FBW - \ln IBW}$$

(Ricker, 1979)

Where D is the number of days between weighing

3.7.3 Survival Rates of Fish

$$R = \frac{\text{Initial number stocked}}{\text{number survived}} \times 100$$

(Ricker, 1979)

3.7.4 Condition Factor (K)

Is information relating to the physiological status of the fish. CF will be calculated as:

$$K = \frac{W \times 100}{L^3}$$

Where: W = Weight of fish. L = Standard length of fish

(Ricker, 1979)

3.8 Nutrient utilization parameter

The following indices were used to calculate the efficiency of the experimental diets in relation to nutrient utilizations.

3.8.1 Feed Conversion Ratio (FCR)

Conversion of feed stuffs into high quality protein by fish for human consumption at a profit for the farmer is the main objective of fish culture (Balogun *et al*., 2005) FCR is defined as the amount of dry feed fed per unit live weight gain (Nelson,2005). It often serves as a measure of efficiency of the diet. The more suitable the diet for growth, the less food is required to produce a unit weight gain, i.e. a lower FCR (De Silva and Anderson, 1995). It is calculated as;

$$\text{FCR} = \frac{\text{live weight gain}}{\text{feed fed}}$$

(De Silver and Aderson, 1995)

3.8.2 Protein Efficiency Ratio

Protein efficiency ratio (PER) is defined as the ratio between the weight gain of fish and the amount of protein fed (De Silva and Anderson, 1995):

$$\text{PER} = \frac{\text{weight gain (g)}}{\text{crude protein fed (g)}}$$

(De Silver and Aderson, 1995)

3.8.3 Productive Protein Value (PPV)

Productive Protein Value (PPV) sometimes also called efficiency of protein utilization' (Gerking, 1971), evaluates the protein in the diet by the ratio between the protein retained in fish tissues and the dietary protein fed. PPV is determined by carcass analyses of samples of fish taken before and after feeding with the evaluated protein, and generally expressed as a percentage of the protein fed.

$$\text{PPV} = \frac{\text{Retained protein in tissues}}{\text{Dietary protein consumed}} \times 100$$

(De Silver and Aderson, 1995)

PPV is a more refined criterion for the evaluation of dietary protein compared to PER since it takes into account the transformation of the dietary protein into body protein rather than the overall increase in body weight (Hepher, 1988). Due to practical constraints in experiments with fish, it is not possible to ensure that all food presented is ingested nor is it possible to collect uneaten food from the experimental tanks. Therefore for calculation of FCR, PER and PPV (ANPU – Apparent Net Protein Utilization) the amount of feed fed (instead of feed consumed/intake) will be used without correction being made for any wastage. This could actually lead to overestimation of feed and underestimation of the ratios (Smiter *et al.*, 2005).

3.9 Apparent Digestibility Coefficient

Digestibility of a diet or feed ingredient can be determined directly or indirectly. In the direct method, the quantity of food ingested and the quantity of faecal matter voided are determined. The ratio gives the percentage digestibility of the feed or the nutrient under consideration.

The apparent digestibility coefficients (ADC) for the nutrients of the diets will be calculated as follows (Bureau *et al*., 1999):

$$\text{Digestability} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times 100$$

(Bureau *et al.*, 1999)

Where D is the concentration of the nutrient or FA (or kJ/g gross energy) in the diet, F is the concentration of the nutrient or FA (or kJ/g gross energy) in the faeces, Di is the concentration of the inert marker in the diet and Fi is the concentration of the inert marker in the faeces.

3.10 Cost Analysis of Diets

A simple economic analysis was conducted to assess the cost effectiveness of the diets to be used for this experiment. Only the cost of feed was used in the calculations with the assumption that all other operating costs remained constant. A cost of the feeds was calculated using market prices of ingredients (Nelson, 2008). Vincke (1969) proposed what he called Incidence Cost (IC), which is governed by the unit cost of the feed and its apparent FCR;

$$IC = \frac{\text{weight of fish produced}}{\text{cost of feeding}}$$

(Vincke, 1969)

IC is actually the cost of feed to produce a kg of fish (relative cost per unit (weight gain), and the lower the value the more profitable using that particular feed. The value of fish will be calculated using the sale price of kg-1 fish. Miller (1976) also suggested another simple parameter called the Profit Index:

$$\text{Profit index} = \frac{\text{value of fish}}{\text{cost of feeding}}$$

3.11 Data Analyses

The data was subjected to analysis of variance (ANOVA) to test the significance among treatment means. Where there was significant difference, Duncan multiple range tests were applied to rank treatments means ($p < 0.05$). All statistical analyses were performed with SAS software system, Version 6 for Windows.

Table 3.1: Formulation and proximate composition of the basal diets

	Control	Garlic (*Allium sativum*) levels (g/kg diet)				Chloramphenicol level (mg/kg diet)			
Parameters	0	10	20	30	40	10	20	30	40
Fish Meal (72%)	171.7	171.7	171.7	171.7	17.17	171.7	171.7	171.7	171.7
Blood meal (77%)	171.7	171.7	171.7	171.7	171.7	171.7	171.7	171.7	171.7
Soya bean meal(44%)	171.7	171.7	171.7	171.7	171.7	171.7	171.7	171.7	171.7
Wheat bran (16.4%)	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4
Yellow maize(8.5%)	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4
Garlic powder	-	10.00	20.00	30.00	40.00	-	-	-	-
Chloramphenicol	-	-	-	-	-	10.00	20.00	30.00	40.00
Vitamin premix	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Methionine	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Lysine	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Palm oil	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Table 3.2: proximate compositions of the basal feed

		Garlic (*Allium sativum*) levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	Control (0)	10	20	30	40	10	20	30	40
DM	95.42 ±0.30^{ab}	94.49±0.47^{c}	96.29±0.23^{a}	95.35±0.23^{abc}	95.50±0.50^{ab}	95.44± 0.22^{ab}	95.62± 0.04^{ab}	95.28± 0.05^{bc}	95.50±0.36^{ab}
ASH	7.83±0.01^{ab}	5.55±0.01^{e}	6.09±0.01^{de}	6.35±0.01^{cde}	8.51±0.00^{a}	6.45±0.03^{cd}	7.19±0.77^{bc}	7.97±0.01^{ab}	7.91±0.0^{ab}
EE	4.90±0.32^{e}	11.70±0.10^{c}	9.21±0.02^{e}	18.12±0.52^{a}	17.83±0.83^{ab}	11.44±1.18^{c}	12.42±0.21^{c}	16.55±0.44^{ab}	15.96±0.54^{b}
CF	4.55±0.005^{b}	3.39±0.05^{c}	5.00±0.01^{b}	4.18±0.19^{bc}	4.81±1.00^{b}	6.39±0.05^{a}	7.44±0.01^{a}	6.33±0.03^{a}	6.55±0.01^{a}
NFE	6.78±0.01^{i}	7.39±0.01^{g}	8.06±0.01^{d}	7.87±0.01^{e}	7.77±0.01^{f}	8.08±0.01^{c}	8.28±0.01^{b}	8.65±0.01^{a}	7.40^{g} ±0.01^{g}
CP	42.32±0.01^{bc}	42.20±0.01^{cd}	42.31 ±0.01^{bc}	42.25 ±0.01^{cd}	42.45±0.01^{b}	42.33±0.11^{bc}	42.69±0.01^{a}	42.10±0.10^{d}	42.25±0.01^{cd}

Mean with the same superscripts across the columns were not significantly different ($p>0.05$)

Keys: DM – Dry Matter, ASH – Ash content, EE – Ether Extract, CF – Crude Fibre, NFE – Nitrogen Free Extract, CP – Crude Protein

CHAPTER FOUR

4.0 RESULTS

4.1 Growth performance and survival of *Heterobranchus bidorsalis* fed with experimental diets for sixteen (16) weeks

The Growth performance of *Heterobranchus bidorsalis* fed with experimental diets for sixteen (16) weeks are summarized in Table 4.1; *Heterobrachus bidorsalis* fed on 30g/kg of garlic diets gave the highest weight gain (165.22g/kg) and percentage weight gain (1921.16%) compare to that of the control and the other experimental diets. There was significant difference ($p<0.05$) in the weight gain (165.22g/kg) of fish fed on 30g/kg of garlic diet than that of the control (89.44g/kg). Similarly, 30mg/kg of chloramphenicol in the diets gave better weight gain (136.48mg/kg) compare to the control (89.44g/kg) diets. However, there was no significant difference ($p<0.05$) between 30mg/kg chloramphenicol with the control group. Generally, growth performance of the fish fed on garlic and chloramphenicol fortified diets gave better weight gain than the control group. The Survival Rate ranged from 75% - 95%. There was significant difference ($p>0.05$) between the control and the test diets. Generally there was increased survival rate in the experimental fish fed garlic supplemented diet compared to the control and those fed chloramphenicol based diet. Similarly, condition factor (K) was significantly higher ($p<0.05$) in fish fed 30g/kg garlic compared to the control which recorded the lowest value (2.40) and those fed chloramphenicol fortified diets. Similarly, the growth performance of fish fed garlic supplemented diets was superior to those fed on chloramphenicol based diets.

Table 4.1: Effects of garlic (*Allium sativum*) and chloramphenicol on growth performance and survival rate of *Heterobranchus bidorsalis* fed with experimental diets for sixteen (16) weeks

	Control	Garlic (*Allium sativum*)levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	0	10	20	30	40	10	20	30	40
IL	10.10±0.10^{a}	10.35±0.05^{a}	10.25±0.05^{a}	10.55±0.05^{a}	10.55±0.05^{a}	10.10±0.20^{a}	10.40±0.10^{a}	10.10±0.30^{a}	10.45±0.05^{a}
FL	15.13±0.02^{c}	17.45±0.45^{ab}	17.60±0.50^{ab}	18.95±1.05^{a}	17.35±0.05^{ab}	17.03±0.00^{abc}	17.03±0.00^{abc}	17.25±0.85^{ab}	16.60±0.50^{bc}
IBW	8.55±0.15^{a}	8.80±0.00^{a}	8.55±0.05^{a}	8.60±0.00^{a}	8.30±0.00^{a}	8.10±0.10^{a}	8.40±0.10^{a}	8.15±0.25^{a}	8.10±0.2^{a}
FBW	97.99±14.70^{c}	153.29±9.41^{ab}	164.34±16.20^{ab}	173.82±24.63^{a}	150.85±4.10^{ab}	134.33±8.10^{abc}	136.69±2.81^{abc}	144.63±2.97^{ab}	129.33±0.63^{bc}
WG	89.44±14.89^{c}	144.49±9.41^{ab}	155.79^{ab}±16.15	165.22±24.63^{a}	142.56±4.16^{ab}	126.23±8.20^{abc}	128.29±2.71^{abc}	136.48±2.72^{ab}	121.18±0.48^{bc}
PWG	104.94±92.57^{b}	164.18±106.87^{a}	182.11±78.24^{a}	192.11±86.40^{a}	171.75±50.06^{a}	155.98±20.49^{a}	152.70±14.08^{a}	167.51^{b}±18.01	149.78±47^{ab}
SGR	0.022±0.00^{a}	0.025±0.00^{a}	0.030±0.00^{a}	0.030±0.00^{a}	0.030±0.00^{a}	0.025±0.00^{a}	0.020±0.00^{a}	0.030±0.00^{a}	0.025±0.00^{a}
K	2.40±0.14^{b}	2.86±0.07^{ab}	2.94±0.06^{ab}	3.37±0.21^{a}	2.78±0.06^{ab}	2.52±0.04^{b}	2.61±0.14^{b}	2.69±0.46^{b}	2.51±0.06^{b}
SR	75.00^{c}±5.00^{c}	90.00±0.00^{ab}	90.00±5.00^{ab}	95.00±0.00^{ab}	85.00±5.00^{abc}	80.00±0.00^{ab}	80.00±0.00^{ab}	85.00±5.00^{abc}	80.00±0.00^{ab}

Means with the same superscripts across the columns were not significantly different ($p>0.05$)

Key: IL – Initial Length, FL – Final Length, IBW – Initial body weight, FBW – Final body weight, WG – Weight gain, , SGR – Specific growth rate,

PWG – Percentage weight gain, K – Condition factor, SR – Survival Rate.

4.2 Nutrient utilization of *Heterobrachus bidorsalis* fed with experimental diets for sixteen (16) weeks

The nutrient utilization of *Heterobranchus bidorsalis* fed with experimental diets for sixteen weeks are summarized in Table 4:2. The values of Feed Conversion Ratio FCR (1.06) and Protein Efficiency Ratio PER (2.87) of 30g/kg of garlic diets clearly shows that inclusion level gave the best nutrient utilization. The FCR in garlic supplemented diet increased with increase level of concentration upto 30g/kg but above 30g/kg the value decreased. Similarly, 30mg/kg of chloramphenicol diets gave better Feed Conversion Ratio FCR (1.13) and Protein Efficiency Ratio PER (2.81). There was no significant difference ($p>0.05$) in the FCR and PER. In addition, garlic diets gave the best nutrient utilization compared to chloramphenicol diets.

Table 4:2: Nutrient utilization of *Heterobranchus bidorsalis* fed with experimental diets for sixteen (16) weeks

	Control	Garlic (*Allium sativum*)levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	0	10	20	30	40	10	20	30	40
FI	96.24±4.76^{b}	128.64±2.18^{ab}	138.82±19.36^{a}	157.18±32.60^{a}	117.47±9.86^{ab}	107.01±5.38^{ab}	114.43±9.57^{ab}	115.47±0.05^{ab}	104.74±0.72^{ab}
FCR	1.92±0.11^{a}	1.12±0.07^{a}	1.16±0.28^{a}	1.06±0.20^{a}	1.22±0.07^{a}	1.18±0.02^{a}	1.19±0.03^{a}	1.13±0.07^{a}	1.16±0.07^{a}
PF	40.71±2.01^{d}	54.29±0.93^{abc}	58.72±8.19^{ab}	66.10±2.91^{a}	49.92±4.19^{bcd}	45.27±2.28^{bcd}	48.86±4.08^{bcd}	48.61±0.02^{bcd}	44.30±0.30^{cd}
PPV	5.24±0.26^{c}	0.37±0.01^{g}	5.33±0.75^{c}	3.13±0.14^{de}	4.17±0.35^{cd}	1.26±0.07^{fg}	8.51±0.71^{b}	2.33±0.01^{ef}	11.44±0.08^{a}
PER	2.17±0.26^{a}	2.64±0.15^{a}	2.75±0.66^{a}	2.87±0.16^{a}	2.52±0.48^{a}	2.79±0.04^{a}	2.64±0.17^{a}	2.81±0.06^{a}	2.74±0.00^{a}

Mean with the same superscripts across the columns were not significantly different ($p>0.05$)

Keys: FI – Feed intake, FCR - Feed conversion ratio, PF – Protein feed, PPV – Productive protein value, PER – Protein efficiency ratio

4.3 Apparent nutrient digestability of *Allium sativum* and chloramphenicol diets for *Heterobranchus bidorsalis* fed

The result in table 4.3 shows that the Apparent digestability of *Heterobranchus bidorsalis* fed on *Allium sativum* and chloramphenicol diets. The diets with 30g/kg of garlic gave the best ALD (87.68), APD (92.20), AGED (72.42) and ACD (40.31) respectively. It was significant difference ($p<0.05$) with that of the control and all other diets. The APD increased with increase of inclusion level from 10g/kg to 30g/kg after 30g/kg it decreased. Similarly, the diet with 30mg/kg of chloramphenicol also gave the better ALD (82.02), APD (86.93), AGED (65.47) and ACD (33.53) than the control (85.05). In addition, garlic supplemented diets gave the best nutrient digestability compared to chloramphenicol diets.

Table 4.3 Apparent nutrient digestability of *Allium sativum* and chloramphenicol diet for *Heterobranchus bidorsalis* fed

	Control	Garlic (*Allium sativum*)levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	0	10	20	30	40	10	20	30	40
ALD	79.90±0.53[cd]	84.12±0.82[b]	82.90±0.63[bc]	87.68±0.59[a]	86.10±0.06[a]	81.10±1.21[cd]	81.13±0.53[cd]	82.02±0.54[cd]	78.36±0.38[e]
APD	85.05±0.52[cd]	89.53±0.06[b]	89.90±0.63[b]	92.20±0.75[a]	90.89±0.31[b]	85.68±0.57[cd]	86.59±0.73[c]	86.93±0.63[b]	84.04±1.05[d]
AGED	62.64±0.60[de]	67.36±0.74[b]	66.26±0.83[b]	72.42±0.83[a]	71.12±0.15[a]	64.23±0.73[cd]	63.12±0.53[de]	65.47±0.50[bc]	61.56±0.68[e]
ACD	28.78±0.85[d]	33.95±0.54[b]	31.25±0.69[c]	40.31±0.66[a]	39.34±0.74[a]	33.69±0.68[bc]	28.27±0.64[d]	33.53±0.89[bc]	27.89±1.40[d]

Means with the same superscript across rows were not significantly difference ($p<0.05$)
ALD – Apparent Lipid Digestability
APD – Apparent Protein Digestability
AGED – Apparent Gross Energy Digestability
ACD – Apparent Carbohydrate Digestability

4.4 Carcass composition of whole body of *Heterobranchus bidorsalis* under different treatment for sixteen (16) weeks

Generally, there was an increased in crude protein (CP) with increasing level of garlic and chloramphenicol in the diets but, decreased at 40g/kg and 40mg/kg level of inclusion respectively as presented in table 4.4. The highest crude protein of 73.35% and 71.51% were recorded in 30g/kg and 30mg/kg garlic and chloramphenicol supplemented diets respectively. There was no significant difference ($p>0.05$) in the test diets and the control. Similarly, garlic based diets gave better crude protein value than chloramphenicol fortified diets.

Table 4.4: Carcass composition of whole body (% dry matter basis) of *Heterobranchus bidorsalis* under different treatments for sixteen (16) weeks

			Garlic (*Allium sativum*) levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	Control(0)	Initial	10	20	30	40	10	20	30	40
Lipid content	10.16±0.04^{b}	7.25±0.05^{e}	10.36±0.35^{b}	12.25±0.05^{a}	12.56±0.42^{a}	9.16±0.05^{c}	8.42±0.28^{d}	9.22±0.18^{c}	10.25±0.25^{b}	8.25±0.05^{d}
Ash content	14.39±0.23^{a}	14.56±0.33^{a}	12.16±0.22^{cd}	12.08±0.50^{cd}	11.32±0.26^{d}	13.30±0.17^{b}	13.39±0.26^{b}	13.38±0.30^{b}	12.51±0.07^{bc}	13.40±0.30^{b}
Dry matter	97.25±0.05^{a}	97.50±0.06^{ab}	95.21±0.23^{d}	96.01±0.05^{c}	96.65±0.01^{bc}	97.21±0.10^{ab}	96.11±0.13^{c}	96.27±0.05^{c}	96.34±0.46^{c}	96.51±0.39^{c}
Crude fibre	0.91±0.00^{a}	0.29±0.05^{a}	0.33±0.27^{a}	0.33±0.21^{a}	0.62±0.02^{a}	0.75±0.03^{a}	0.72±0.01^{a}	0.48±0.07^{a}	0.66±0.01^{a}	0.70±0.02^{a}
Crude protein	69.01±0.01^{a}	68.52±0.11^{a}	.^{a}71.51±0.01^{a}	72.06±0.50^{a}	73.35±0.15^{a}	68.62±0.19^{a}	69.34±0.22^{a}	70.51±0.01^{a}	71.51±0.01^{a}	70.28±0.28^{a}

Means with the same superscripts across the columns were not significantly different (p>0.05)

4.5 Cost-benefit analysis of the inclusion of Allium sativum and Chloramphenicol supplemented diets fed *Heterobranchus bidorsalis* under different treatment

The result of analysis of cost-benefit (table 4.5) revealed in the group fed garlic diets at 10g/kg gave the best result with regard to profit index (3.41). Similarly, the incidence of cost (0.38) was highest at 30g/kg with correspondingly lower profit index (2.72). In the group fed chloramphenicol based diet the same trend was observed where 10mg/kg chloramphenicol diet recorded the highest profit index (3.98) and lowest incidence of cost (0.26), but 30mg/kg level of inclusion recorded the highest incidence of cost (0.27) and corresponding lower profit index (3.80).

Table 4.5: Cost - benefit analysis of the inclusion of garlic and chloramphenicol supplemented diets fed to *Heterobranchus bidorsalis* under different treatments for sixteen (16) weeks

		Garlic (*Allium sativum*) levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	Control (0)	10	20	30	40	10	20	30	40
Cost of feeding	28.56±1.41^{d}	42.06±0.71^{bc}	50.78±7.09^{b}	61.19±2.33^{a}	47.76±4.01^{b}	31.77±1.59^{cd}	33.94±2.84^{cd}	34.26±0.01^{cd}	31.07±0.21^{d}
Profit Index	3.12±0.37^{ab}	3.41±0.19^{ab}	3.18±0.77^{ab}	2.72±0.51^{b}	2.99±0.17^{ab}	3.98±0.06^{a}	3.97±0.08^{ab}	3.80±0.24^{a}	3.90±0.00^{ab}
Incidence Cost	0.33±0.04^{a}	0.30±0.02^{a}	0.33±0.11^{a}	0.38±0.10^{a}	0.33±0.02^{a}	0.26±0.01^{a}	0.26±0.01^{a}	0.27±0.02^{a}	0.26±0.00^{a}

Means with the same superscripts across the columns were not significantly different (p>0.05)

4.6 Water quality parameters

The water quality characteristics of the experimental ponds monitored during the feeding trial are presented in Table 4.6.The result indicates an insignificant variations ($p>0.05$) among the experimental Tanks. Water temperature ranged from 27.00°C - 28.305°C. Hydrogen ion concentration (pH) values ranged from 7.07 - 7.57. Dissolved Oxygen (DO) ranged from 4.02 –4.335mg/l.

Table 4.6 Mean water quality parameter observed during the experimental period

		Garlic (*Allium sativum*) levels (g/kg diet)				Chloramphenicol levels (mg/kg diet)			
Parameters	Control (0)	10	20	30	40	10	20	30	40
Temp	27.60±0.20[a]	27.80±0.10[a]	27.60±0.40[a]	27.75±0.15[a]	28.05±0.45[a]	27.90 ±0.10[a]	27.40 ±0.40[a]	27.90±0.10[a]	27.00±0.10[a]
pH	7.25±1.01[a]	7.07±0.03[a]	7.42±0.93[a]	7.29±0.96[a]	7.34±0.98[a]	7.29±0.97[a]	7.57±0.67[a]	7.30±1.03[a]	7.21±1.00[a]
DO	4.11±0.10[a]	4.11±0.90[a]	4.11±0.22[a]	4.17±0.39[a]	4.10±0.01[a]	4.10±0.10[a]	4.34±0.26[a]	4.09 ±0.02[a]	4.03±0.03[a]

Means with the same superscripts across the columns were not significantly different ($p>0.05$)

Keys: Temp. – Temperature, pH – Hydrogen ion concentraction, DO – Dissolved Oxygen

CHAPTER FIVE

5.0 DISCUSSION

5.1 Growth performance and Nutrient utilization of *Heterobranchus bidorsalis* fed experimental diets

The growth performance and nutrient utilization of *Heterobranchus bidorsalis* fed experimental diets indicates that the final body weight, weight gain, percentage weight gain and specific growth rates increased significantly with all treatments of both garlic and chloramphenicol diets. The growth performance of *Heterobranchus bidorsalis* fed on garlic and chloramphenicol fortified diets increased with increased level of concentration from 10g/kg to 30g/kg garlic and 10mg/kg to 30mg/kg chloramphenicol. Above 30g/kg and 30mg/kg of garlic and chloramphenicol, inclusion level retarded greatly. The highest growth performance was obtained in *Heterobranchus bidorsalis* fed on 30g/kg of garlic and 30mg/kg of chloramphenicol diets. Similar result was reported by Shalaby *et al*., (2006), who obtained 15.05g at 30g/kg of garlic and 13.66g at 30mg/kg of chloramphenicol. however, Diab *et al*., (2002) reported the feeding diet with 2.5% garlic per kg diet resulted highest growth performance in the Nile tilapia (*Oreochromis niloticus*). Furthermore, Metwally (2009) reported that the best growth performance in terms of growth was observed when *Oreochromis niloticus* was fed with diet containing 32g/kg of garlic powder. Feed intake and specific growth rate increased with increasing level of garlic and chloramphenicol. However, at 40% garlic and chloramphenicol, these parameters showed decreasing trend. The improved performance may be due to the effects of the allicin property of the garlic which has been reported by Khalil *et al*., (2001) to be responsible for improved performance of the intestinal flora thus improving digestion. The reduced performance recorded at 40% levels of inclusion may be due to the offensive odour of garlic which reduces the palatability and acceptability of the diets. This consequently enhances the utilization of energy, bringing about improved growth. The feed conversion ratio decreased with increasing *Allium sativum* level and increased with increasing level of chloramphenicol. This is in line with Shalaby *et al*., (2006); Agbebi *et al*., (2013) and Megbowon *et al*., (2013). Protein efficiency ratio and productive protein value showed increasing trend to level of garlic and chloranphenicol in the diets, protein efficiency ratio and productive protein value are used as quality indicators for fish diets and amino acid balance. These parameters were to assess protein utilization and turnover. This is in lines with Khalil *et al*. (2001); Shalaby *et al*. (2003); El-Dakar *et al*. (2004) and Khattab *et al*. (2004).

The survival rate of garlic ranged from 85% to 95% and chloramphenicol ranged from 80% to 85% with garlic having the highest survival rate of 95%. This may be due to the immunological attributes of garlic have been reported to control pathogens, combat stress, increase the welfare of fish and enhance the immune response (Ress *et al*., 1993) and (Corzo-martinez *et al*., 2007). The improved survival rate may be due to the enhance immune response resulting from improved defense mechanism which occurs in both garlic and chloramphenicol. Mortality recorded in this experiment may be due to accidental jumping of fish and unavoidable stress during weighing and length measurements which agree with report of many scholars involving feeding trial with fish (Ashref *et al*., 2010; Bichi and Ahmed, 2010 and Jonny *et al*., 2011). The condition factor (K) of garlic ranged from 2.78 to 3.37 and chloramphenicol ranged from 2.51 to 2.69 which were found to be significantly different ($p<0.05$), indicating that dietary inclusion of garlic and chloramphenicol have influenced the welfare of the experimental fish. The condition factor is information relating to the physiological status of the fish relating to its welfare and health fitness or well being of fish (Nath *et al*., 2006). It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Ndemele *et al*., 2010). Condition factor is also a useful index for monitoring of feeding intensity, age and growth rates of fish (Ndemele *et al*., 2010).

5.2 Carcass composition

Generally, the carcass crude protein of garlic (g/kg) levels at 10 (71.51%), 20 (72.06%), 30 (73.35%) and 40 (68.68%) after feeding trial experiment indicated that all the treatments were significantly ($p<0.05$) higher than the initial crude protein value (68.52%). Nwanna and Bolarinwa (2001) indicated that the crude protein and lipid contents of the African catfish increased after feeding trial. This also agrees with the findings of Arunlertaree and Moolthongnoi (2008) who reported that final protein in the experimental fish carcass was related to the percentage of lipid content in carcass. The fish carcass protein of all the dietary treatments were higher than the initial carcass protein, indicating that there was synthesis and increased tissue protein production, thus the growth of the fish was not due to increase in weight only as reported by Fuller (1969); Ipinjolu (1999) and Banyigyi *et al*., (2001). Contrary to the result of chloramphenicol diets, the fish carcass protein as well as lipid in fish fed chloramphenicol diets followed the same trend as the fish fed garlic diets.

5.3 Apparent nutrient digestability for garlic and chloramphenicol diets fed *Heterobranchus bidorsalis*

The Apparent protein digestability increases with an increase in garlic and chloramphenicol level from 10 – 30g/kg and 10 – 30mg/kg respectively. There is significant difference ($p<0.05$) between all the fish fed diets. This shows that there is an effective level of production of protein level during the digestion process of the fish fed diets by the fish. Generally, the protein quality of dietary ingredient is the leading factor affecting fish performance and protein digestability is the first measure of its availability by fish. This result is in agreement with the findings of (Halver and Hardy, 2002), similar results were obtained by Gomes *et al*., (1993) in rainbow trout. Similarly apparent lipid digestability was found to be highest in garlic level at 30g/kg and 30mg/kg at chloramphenicol, this indicates that *Heterobranchus bidorsalis* is capable of digesting lipid very efficiently at the level of (30g/kg and 30mg/kg). The finding is in line with Falaye *et al*., (2014). However lowest level of apparent lipid digestability was obtained in 20g/kg and 20mg garlic and chloramphenicol, this may be due to fatty acid composition and the melting point of the fat having a strong influence on digestability. This agree with the findings of Kirchgessner *et al*., (1986) who worked on carp (*Cyprinus carpio*). The apparent gross energy digestability was found to be within the range of 61.56±0.06 to 72.42±0.83, this revealed that there is high digestability of energy. This could be as a result of the removal of large percentage of carbohydrate during heat cooking and the increase in the digestability of the remaining carbohydrate may be responsible for the high digestability of energy. This is in line with the findings of Falaye *et al*., (2014). The present result also agrees with those obtained by Goddad and Mclean (2000) in *Oreochromis aureaus* which shows an increase. Moreover, the apparent carbohydrate digestability ranges from 27.89±1.40 to 40.31±0.74 in both garlic and chloramphenicol, this also indicates high levels of carbohydrate digestability as suggested by Falaye *et al*., (2014).

5.4 Cost-benefit analysis of the inclusion of garlic and chloramphenicol diets

The cost and benefit analysis of the experimental diets as presented in table 4.5 indicates that 30g/kg of garlic diet and 30mg/kg of chloramphenicol diet recorded the highest profit index (3.41) and (3.98) rsspectively while 10g/kg of garlic and 10mg/kg of chloramphenicol diets recorded the lowest profit index of (2.72) and (3.80) respectively. The optimum aim of every agricultural investor is to make profit at the end of the cultural season. This same phenomenon is as well applicable to fisheries. Since cost of feed has been one of the major constraint to the development of aquaculture sector as reported by Sogbesan *et al*., (2004). The improved profit margins recorded in this experiment may be due to enhanced utilization of the experimental diets as influenced by the inclusion of garlic (*Allium sativum*) and chloramphenicol respectively.

5.5 Water quality parameters of *Heterobranchus bidorsalis* fed experimental diets

The water quality parameters (Temperature, pH and Disolved oxygen) monitored during the experimental period were not significant different ($p>0.05$) among the experimental tanks. The dissolved oxygen ranged from 4.03±0.03 to 4.34±0.26, this indicates that the dissolved oxygen range of values were suitable for fish culture. Similar findings were observed by Ayoola and Fedrick (2012) who stated that the dissolved oxygen values of 3 – 8mg/l is recommended for fresh water fish culture. The pH values ranged from 7.07±0.03 to 7.57±0.07 while temperature ranged from 27.00±0.10 to 28.05±0.03, this range of values for pH and temperature recorded in this experiment is an indication that optimal water quality was maintained by partial replacement of water to the pond.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Both garlic and chloramphenicol diets gave better growth than the control, that is 30g/kg of garlic supplemented diets had the highest weight gain (165.22), specific growth rate (0.03), condition factor (3.37), survival rate (95.00%), protein efficiency ratio (2.87) with lowest feed conversion ratio (1.06). Similarly, chloramphenicol supplemented diets; 30mg/kg had the highest weight gain (136.69), specific growth rate (0.03), condition factor (2.69), survival rate (85.00%), protein efficiency ratio (2.81) with lowest feed conversion ratio (1.13).

The highest carcass crude protein of (73.35%) and (71.51%) were recorded in 30g/kg and 30mg/kg of garlic and chloramphenicol diets. Therefore, supplemented diets enhanced the carcass composition of *Heterobranchus bidorsali* at the inclusion levels, while the water quality parameters indicated dissolved oxygen (4.03 to 4.34) mg/l, temperature (27.00 to 28.05) °C and Ph (7.07 to 7.57) were within the range suitable for fish culture and is an indication that optimal water quality was maintained.

The apparent protein digestability shows that there was an effective level of production of protein during the digestion process at 30g/kg and 30mg/kg of garlic and chloramphenicol based diets.

Diet containing 30g/kg garlic was the most profitable recording profit index value of (3.37). Similarly, chloramphenicol based diet at 30mg/kg also recorded the profit index of (3.80) and was more profitable.

6.2 Recommendations

This study established the efficacy of garlic (*Allium sativum*) and chloramphenicol feed additives as a growth promoter in *Heterobranchus bidorsalis* fingerlings and fish farmers should be encouraged to supplement these feed additives in fish diet.

Similarly, study is recommended in other culturable fish species with complementary feeding habit to that of *Heterobranchus bidorsalis*

Future research should be focus on the improvement of rearing technology for different species of fish reared using garlic *Allium sativum* as well as cloramphenicol as a growth promoter.

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