UTILIZATION OF SHEA NUT (*Vitellaria paradoxa*) FRACTIONS (SHEA NUT MEAL AND SHEA NUT RESIDUE) IN PRACTICAL DIETS OF *Clarias gariepinus*

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MTech/SAAT/ 2017/6938

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ABSTRACT

Feeding trial was carried out to evaluate the utilization of shea nut (*Vitellaria paradoxa*) fractions (shea nut meal and shea nut residue) in the practical diets of *Clarias gariepinus* fingerlings through their mineral composition, proximate composition and nutrient utilization for a period of 56 days. It is an attempt towards reducing the high cost of feed in aquaculture through the use of energy rich diets for feeding trial. 600 Fingerlings of *Clarias gariepinus* with an average weight of (3.02 ± 0.54 g) fed 9 formulated diets and commercial reference diet (CRD) Multifeed for both experiment, Diet 2 (10 % Lipid and 30 % Protein), Diet 3 (15 % Lipid and 30 % Protein), Diet 4 (20 % Lipid and 30 % Protein), Diet 5 (10 % Lipid and 35 % CP), Diet 6 (15 % Lipid and 35 % Protein), Diet 7 (20 % Lipid and 35% Protein), Diet 8 (10 % Lipid and 40 % Protein), Diet 9 (15 % Lipid and 40 % Protein) and Diet 10 (20 % Lipid and 40 % Protein), all in ratio. Results obtained showed significant difference ($p<0.05$) in the mean weight gain, feed conversion ratio, and specific growth rate. However, diet 9 with Shea nut meal inclusion exhibited highest mean weight gain 9 (13.70 ± 0.21 g) and survival rate (80 %) than other diets in experiment one (1), and experiment Two (2) commercial reference diet D1 (CRD) had the highest mean weight gain (12.29 ± 0.06 g), specific growth rate (2.59 % day^{-1}) and survival rate (76.76 %) compared to other diets. Similarly, in experiment two (2) which has shea nut residue inclusion, diets10 has the highest lipid and correspondingly low body crude protein than other diets. Experiment two (2) with shea nut residue inclusion, commercial reference diet (D1) and diet 9 demonstrated good growth performance and body compositions than other diet in experiment two (2). It was observed that all water quality parameters were within the acceptable range for culturing *Clarias gariepinus* fingerling throughout the experimental period. Inferences from this study recommends inclusion of varying levels of Shea nut meal and Shea nut residue in the diets of *Clarias gariepinus* fingerlings for efficient growth at (15 Protein: 40 Lipid), which has a positive effect on the growth performance and survival rate of *Clarias gariepinus* fingerlings.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Aquaculture has sustained a global growth at present and is expected to increasingly fill the shortfall in aquatic food products. Aquaculture activity is considered as the only alternative for the development and improvement of fisheries resources and revitalization of ecosystems (Okechi, 2004). Gabriel *et al*. (2007) reported that Fish feeds constitute 40 - 60 % of the total cost of aquaculture production which is expensive and led to extensive studies on replacing a costly fish meal in the diets. Growth performances and survival of aquatic organisms can be influenced by the development of nutritionally balanced commercial diets (FAO, 2016). The improvement of nutritional interventions supports the aquaculture industry sustainable, economical and nutritious finfish and shellfish production (Robinson *et al*., 1998; FAO, 2014).

The science of nutrition draws heavily on findings of chemistry, biochemistry, physics, microbiology, physiology, medicines, genetics, mathematics, endocrinology, cellular biology and animal behavior. To the individuals involved in aquaculture, nutrition

represents more than just feeding. Nutrition becomes the science of the interaction of a nutrient with some part of a living organism, including feed composition, ingestion, energy liberation, wastes elimination and synthesis for maintenance, growth and reproduction. Feeds and feed stuffs contain the energy and nutrients essential for the growth, reproduction and health of aquatic animals (FAO, 2016).

Deficiencies or excesses can reduce growth or lead to disease. Dietary requirements set the necessary levels for energy, protein, amino acids, lipids (fat), minerals and vitamins. The NRC publishes the nutritional recommendations for fishes. Dietary nutrients are essential for the building and maintenance of living tissues. They are also a source of stored energy for fish digestion, growth, reproduction and the other life processes. The nutritional value of dietary ingredients is in part dependent on its ability to supply energy. Physiological fuel values are used to calculate and balance available energy values in prepared diets. They typically average 4 and 9 kcal/g for protein, carbohydrate and lipid respectively (Helfrich & Smith, 2001).

Prepared or artificial diets may be either complete or supplemental. Complete diets supply all the ingredients (protein, carbohydrates, fats, vitamins and minerals) necessary for the optimal growth and health of the fish (Orire *et al*., 2013; FAO, 2005). Most of the commercial diets containing the essential nutrients including protein, lipid, carbohydrate, ash, phosphorous, water, minerals and vitamins in the range of 18 - 50 %, 10 - 25 %, 15 - 20, 8.5 %, 1.5 %, 10 % and 0.5 respectively (Craig & Helfrich, 2009). Natural foods may not be available for the aquatic organisms which are cultured in the indoor systems or confined cages; hence the nutritional need of this cultured organisms can be fulfilled only by the addition of nutritionally enriched supplementary feeds (Craig & Helfrich, 2009).

The expensive nature of most conventional feed stuffs is the major challenge faced by local fish farmers (Abowei & Ekubo, 2011). Orire and Sadiku (2013) reported that high demand for the conventional feed ingredients by other sectors and also for human consumption contributed to expensive and competitive nature of these conventional feed ingredients. Gabriel *et al*. (2007) also reported that fish feed account for 50 - 60 % of aquaculture production, hence has necessitated the search for cheap and locally available feed stuffs that can serve as alternative energy feed for fish. The paradigm shift is aimed at reducing production cost without compromising feed quality.

Conventional oilseed resources such as ground nut cake, soybean cake, cotton seed cake and palm kernel meals which have made remarkable contribution to the livestock feeds industries in Nigeria. It becomes imperative to explore other alternatives for the feed industry in order not to worsen the current food supply situation. Exploring the nutritional content of shea kernel and its cake in Nigeria, the world's leading producers of shea nuts (Nikiema & Umali, 2007) is viewed as a step in the right direction. Similarly, Ugese *et al*. (2010) took more elaborate understanding of the nutritional make-up of the seed among others; to offers a better assessment of the possible uses to which it can be put by determine the proximate qualities of shea seed and seed cake across Nigeria, Savanna region. Shea nut trees are common in the Sahara and sub-Sahara economic tree commonly whose seeds are gathered for shea- butter production. After extraction of the oil the remains can be utilized as feed ingredients are usually discarded.

Dei *et al*. (2008) described shea nut residue as the by product (that is the residue) after the oil or butter or fat extraction from shea nut (*Vitellaria paradoxa*). Shea nut meal has similarities in its nutrient composition to wheat feed (NRC, 1993). These by products

are often exported; this exportation can lead to its scarcity and high price. The proximate composition of shea nut reported by Umali and Nikiema (2007), had crude protein (16 %), crude fat (1.69 %), and crude fibre (17 %). The ability of a fish to digest and absorb feed ingredients depends primarily on the chemical composition of the ingredients and how digestible the nutrients are (McGoogan & Reigh 1996), therefore the first step in assessing their suitability in fish feed is to determine their nutritional composition and digestibility. The present study was therefore designed to evaluate the nutritional composition of shea nut meal (SNM) and shea nut residue (SNR) in cat fish *Clarias gariepinues* diets.

1.2 Statement of the Research Problem

Intensification in aquacultural practices and increase production in Nigeria has resulted in high demand for manufactured fish feed in the country, and also rise in price of conventional lipid or energy sources as one of the major ingredients in fish feed, which makes the product unaffordable and unsustainable to aqua feed producers and fish farmers, hence the need to research for an alternative that would be utilized by fish, at cheaper rate, readily available, affordable and sustainable.

1.3 Justification of the Study

The major constraint to commercial aquaculture is majorly increasing cost of feed which posses threat to recurrent cost. Conventional lipid or energy source which is one of the major ingredient in fish feed, constitute about three quarter (3/4) of this cost (Sogbesan, 2006). Using of available shea products or fractions to produce feed with high nutritive value as an alternative plant energy source that can be effectively utilized by cultured fish species in the growing aquacultural sector.

1.4 Aim and Objectives of the Study

The aim of this study was to evaluate the suitability of shea nut (*Vitellaria paradoxa*) fractions (shea-nut meal and shea-nut residue) in the practical diets of *Clarias gariepinus* fingerlings.

The specific objectives of the study ware to:

i determine mineral composition of shea-nut meal and shea-nut residue.

ii determine chemical composition of shea fraction diet (shea nut meal and shea nut residue).

iii evaluate the growth performance and nutrient utilization of *Clarias garipienus* fed with inclusion of Shea nut fractions (shea nut meal and shea nut residue).

1.5 Hypotheses

$H0_i$: There was no significant difference ($p>0.05$) in the mineral composition of shea nut fraction (shea-nut meal and shea-nut residue).

$H0_{ii}$: There was no significant difference ($p>0.05$) in the chemical composition of fish fed with shea nut fractions (shea-nut meal and shea-nut residue).

$H0_{iii}$: There was no significant difference ($p>0.05$) in growth performance and nutrient utilization of the fishes fed with shea nut fraction (shea-nut meal and shea-nut residue) inclusion.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Shea Tree Distribution

Shea tree is indigenous to the Guinea and Sudan savanna zone from Senegal to Sudan, and to western Ethiopia and Uganda, in a belt 500 - 700 km wide (Enaberue *et al*., 2011). It is found in the interior, separated from the Gulf of Guinea by forest; only in Ghana and Nigeria does it occur within 50 km from the coast (Umali & Nikiema, 2002). Shea tree grows naturally throughout Guinea Savannah region. It is perennial and deciduous. Mature tree height vary considerably with some trees attaining heights of over 14 m and girth of over 1.75 m. The tree has profuse branches with a round orhemisphere crown (Yidana, 1994).

The bark of the stem is conspicuously thick, waxy, and corky and deeply fissured that make it fire resistant. Many vernacular names are used for *Vittelaria*, which is a reflection of its extensive range of occurring nearly 5,000 km from (West) to (East) across the African continent. The nomenclature history and synonymy of the shea tree follow a very tortuous evolution since the oldest recorded specimen collected by a European explorer. It eventually arrived at the name *Vittellaria* with sub species *paradoxa* and *nilotica.* The abundance of the shea tree in Nigeria exists and thrives almost exclusively in the North. They mostly grow naturally in the wild, the long period taken to reach maturity has discourage its planting in an organized plantation (Anon, 2011).

The shea or Karite, formally *Butyrospermum* produces its first fruits (which resembles large plums) when it is about 20 years old and reaches its full production when the tree

is at about 45 years old and continue to produce nuts for up to two hundred (200) years, after reaching maturity (Anon, 2011). Shea tree is important as an economic crop because of the heavy demand for its butter, both locally and internationally mainly as cocoa butter substitute for the production of chocolate, following increasing international interest in Shea butter as a cocoa butter equivalent in confectioneries and pharmaceutical and cosmetic industries. Shea nut products are used domestically and exported (Matanmi, *et al*., 2011).

Nigeria is the largest producer of shea nut in West Africa, producing about 58 % shea nut in 2008. The long-term prospect of shea products measure in any Nation includes research and development, the improvement of shea productivity and product quality, the transfer of technology diversification and processing improvement of the sectorial infrastructure (Ademola *et al.*, 2012). The shea tree also comprises a unique resource for rebuilding the lives and livelihoods of rural farmers, this resource were already in use by mostly women and children to generate substantial income to support their domestic needs which in the medium- term, alleviates poverty amongst the rural women and in the long-term provides continuous employment opportunities for both rural women and young people, and not only that, the economic environmental and other benefits of shea tree to the nation is undoubtedly clear in providing revenues for increased income from both export and local consumption (Abu *et al.*, 2011).

This will also open new frontiers for the country in the world export market for Shea products as a substitute to palms of economic value. Local farmers on the other hand, who have become serious about production and protection of Shea resources, will generate income to sustain their families and improve the quality of their lives (Anon, 2011).

2.2 Shea Tree as One of NIFOR's Mandate Crop

In recent years the shea tree has gained importance as an economic crop because of the heavy demand for its butter, both locally and internationally, and the need to find substitutes for cocoa butter (Anon, 2011). Shea butter is a useful cocoa butter substitute because it has a similar melting point (32 - 45 °C) and high amounts of di-stearin (30 %) and some stearo-palmitine (6.5 %) which makes it blend with cocoa butter without altering flow properties (Anon, 2011). The high proportion of unsaponifiable matter, consisting of 60 - 70 % triterpene alcohols, gives shea butter creams good penetrative properties that are particularly useful in cosmetics (Umali & Nikiema, 2002). Therefore, in recognition of the need to find substitutes for the rather expensive cocoa products, and to maximize economic exploitation of the vast Shea resource in Nigeria, the Federal Government of Nigeria included Shea tree as one of the mandate crop of economic importance to the Nigerian Institute for Oil palm Research (NIFOR). This led to the establishment of NIFOR Shea nut tree research sub- station. The sole responsibility of this substation is to research into the economy, ecology and biology of the shea tree and with the aim of improving its yield (Umali & Nikiema, 2002).

The research sub-station, apart from providing job opportunities for researchers and others, it will also provide avenues for increased production of shea nut yields if extended to the end users (Odebiyi *et al*., 2000). Shea nut output, for both export and local consumption, will increase tremendously in the next few years. Shea tree mostly occurs in 19 countries across the African continent, namely Benin, Ghana, Chad, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Guinea Bissau, Cote D'Ivoire, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Uganda, Zaire, and Guinea (Wang *et al*., 2016).

2.3 Shea-Nut Production and International Trade

Vitellaria paradoxa is one of the most important sources of vegetable oil in rural areas of the savanna zone of West Africa. The bulk of the shea nuts produced are for home consumption and local trading. Nigeria is the leading producer of shea nut: 355,000 MT produced in 1999, 58 % of the African production, but 10,000 MT lower than in 1996 and 414,000 MT in 2005 (FAO, 2005). Mali and Burkina Faso are other leading producers; at the end of 2005 they produced 85,000 MT and 70,000 MT respectively, followed by Ghana (65,000 MT), Côte d'Ivoire (36,000 MT), Benin (15,000 MT) and Togo (8,000 MT). Up-to-date statistics on shea nut production are not available for most countries (Wallace-Bruce, 1995).

Reports on Burkina Faso show remarkable increase in production to 222,000 MT in 2005. Similar trends probably take place in other West African countries. In 1998, Africa exported 56,000 MT Shea nut, valued at US$ 10.5 million, of which 60 % came from Ghana. Benin's exports decreased from 15,266 MT in 1994 to 5,600 MT in1998, Togo had only a slight decrease from 6,562 MT in 1994 to 5,100 MT in 1998, whereas exports from Burkina Faso increased from 5000 MT in 1994 to 7,632 MT in 1997 and then to 26, 600 MT in 2003. African total export for five years (1993-1997) amounted to over 48,000 MT, valued at over US$ 10,000. No export data have been reported for Nigeria since 1995. Processed shea butter exports in 1998 for the whole of Africa amounted to 1200 MT, worth US$ 571,000. African exports of shea butter have increased to 3200 MT in year 2000 (Umali & Nikiema, 2002). Major shea nut importers in recent years were Belgium, Denmark, Japan, the Netherlands, Sweden and the United Kingdom (FAO, 2014).

2.4 The Nutritional Importance of Shea Nuts

The fruit of the shea tree ripens during the annual hunger season when food supplies are at their lowest ebb and agricultural labour requirements are at their peak (Enaberue *et al*., 2011). When the shea fruits ripen, they fall under their own weight to the floor and are gathered by hand mostly by Nigerian women and children (Matanmi *et al*., 2011). The fruit, which is green in colour, has a fleshy edible pulp; it is rich in vitamins and minerals and not lacking in protein too. It contains 0.7 - 1.3 g of protein and 41.2 g of carbohydrate and is very sweet. The fruit pulp is particularly rich source of ascorbic acid: 196.1 mg/100g compared with 50 mg/100g in oranges (Matanmi, *et al*., 2011). The iron and calcium content compares favorably with raspberries: 1.93 mg/100g as against 0.92 mg/100g for iron, and 36.4 mg/100g as against 26 mg/100g for calcium. (FAO, 2014), reports that vitamin B is also present. The sugar content varies from 3 - 6 %, equally distributed between glucose, fructose and sucrose. Shea butter has several industrial applications, but the majority of kernels (approximately 95 %) provide an important raw material for Cocoa Butter Replacers (CBRs), and is used for manufacturing chocolate and other confectionery. Shea butter could be used as a pan releasing agent in bread baking. The fruit pulp, being a valuable food source, is also taken for its slightly laxative properties (Peter, 2004).

Although not widespread, minor uses include cosmetics and pharmaceuticals. The fruit is also an important source of food for many organisms, including birds and bats. Inside the fruit is a seed rich in the mixture of edible oils and fats known as shea butter (Tiamiyu *et al*., 2002). The mature kernel contains 61 % fat which when extracted is edible. The oil extracted from the kernel (45 - 60 %) is important in the United Kingdom as cocoa butter substitute in chocolate manufacture. Greater quality assurance of the shea butter throughout the supply chain is a pre-requisite if the shea tree is to

reach its full nutritional resource for rural and urban households across the nation and for future generations (Somda *et al*., 2003).

2.5 Medicinal Properties of Shea Tree

Shea butter is one of the main edible oil for the rural people of northern Nigeria being the most important source of fatty acids and glycerol in their diet. It is an unguent for the skin. Alander and Aderson (2002) and Alander (2004) identified other specific compounds such as triterpene, alcohols, known to reduce inflammation; cinnamic acid esters, which have limited capacity to absorb ultraviolet (UV) radiation; and lupeol, which prevent the effect of skin aging by inhibiting enzymes that degrade skin proteins. Shea butter also protects the skin by stimulating production of structural proteins by specialized skin cells. It also has anti-microbial properties, which gives it a place in herbal medicine. It is also used in the pharmaceutical and cosmetic industries as an important raw material and or a precursor for the manufacture of soaps, candles, and cosmetics. Shea butter is used as a sedative or anodyne for the treatment of sprains, dislocations and the relief of minor aches and pains (Alander & Aderson, 2002).

Other important uses include its use as an anti-microbial agent for promotion of rapid healing of wounds, and as a lubricant for donkey carts. In Roger Caillie's own words as reported in (Hall *et al*., 1996), "the indigenous people trade with it, they eat it and rub their bodies with it; they also burn it to make light; they assure that it is a very beneficial remedy against aches and pains and sores and wounds for which it is applied as an unguent". Today the shea tree produces the second most important oil crop in Africa after oil palm (Poulsen, 1981), but as it grows in areas unsuitable for palm, it takes on primary importance in West Africa, and in regions where annual precipitation is less than 1000 mm of rainfall. However, it loses popularity in urban areas within these

regions due to the pungent odor it emits, should it become rancid (Ayeh, 1981). As a cosmetic, it is used as a moisturizer, for dressing hair Ezema and Ogujiofor, (1992) and for protection against the weather and sun. It is used as a rub to relieve rheumatic and joint pains and is applied to activate healing in wounds and incases of dislocation, swelling and bruising. It is widely used to treat skin problems such as dryness, sunburn, burns, ulcers and dermatitis (Bonkoungou, 2001) and to massage pregnant women and small children.

Having a high melting point of between (32 - 45 °C) and being close to body temperature are attributes that make it particularly suitable as a base for ointments and medicines (Umali & Nikiema, 2002). The healing properties of shea butter are believed to be partly attributable to the presence of allantoin, a substance known to stimulate the growth of healthy tissue in ulcerous wounds (Wallace-Bruce, 1995). A leaf decoction is also used as an eye bath (Abbiw, 1990). The leaves area source of spooning, which lathers in water and can be used for washing (Abbiw, 1990). Mixed with tobacco, the roots are used as a poison by the Jukun of northern Nigeria. Infusions of the bark have shown to have selective anti-microbial properties, as being effective against *Sarcina lutha* and *Staphylococcus mureas* but not *Mycobacterium phle*i as well as for diarrhea or dysentery (Soladoye *et al*., 2000).

Refuse water from production of shea butter is used as a termite repellent (Soladoye *et al*., 2000). In Burkina Faso, shea butter is used to protect against insect (*Callosobruchus maculatus*) damage to cowpeas (*Vigna sp*.). Research has shown that after treatment with shea butter a reduction occurs in the life span and fertility of the insects and hence the infestation rate. Shea butter, however, is not as effective as cottonseed or groundnut oil (Soladoye *et al*., 2000).

2.6 Other Uses of Shea Tree

The shea tree also has a great, untapped capacity for producing copious amounts of sap that can constitute an important source of raw material for the gum and rubber industry. Research into the properties and potential industrial uses of shea butter began in the first few decades of the last century. Previously, it was used in edible fats and margarine, e.g., Oleine, and was only beginning to attract the soap and perfume industry when interest ceased because of the second World War. Revival of the Shea industry after the war suffered serious setbacks from an insufficient pricing mechanism, logistical problems of transport (low availability and unpredictable) unable to cope with the supply of the nuts, thus making the ventures economically non-viable Alander and Aderson (2002).

During the mid-1960s, shea trader emerged when Japanese traders joined their European counterparts, which saw a considerable expansion of the industry, particularly in the cosmetics and confectionery industry barely a decade. The residual meal, as in the case with shea butter, is also used as a waterproofing agent to repair and mend cracks in the exterior walls of mud huts, windows, doors and traditional beehives. The sticky black residue, which remains after the clarification of the butter, is used for filling cracks in hut walls and as a substitute for kerosene when lighting firewood. The husks reportedly make a good mulch and fertilizer (FAO, 2012), and are also used as fuel on three stone fires. Latex is heated and mixed with palm oil to make glue (Hall *et al.*, 1996). It is chewed as a gum and made into balls for children to play with (FAO, 2005). Shea tree seed husks have capacity to remove considerable amounts of heavy metal ions from aqueous solutions, for example, from wastewater.

These were found to be more effective than the melon seed husks for absorption f Pb (II) ions (Eromosele & Otitolaye, 1994). The brown solid that is left after extracting the oil and the hard protective shell, are used as a waterproofing material on the walls of mud-buildings to protect them from the eroding forces of the wind and rain. Poor quality butter is not only applied to earthen walls but also to doors, windows, and even bee hives as a waterproofing agent. In a traditional setting, shea butter of poor quality is used as an illuminant (or fuel, in lamps or as candles), (Enaberue *et al*., 2011).

Unfortunately, in Nigeria very little research has been done aimed at expanding the benefits and adding value to the supply chain of the shea industry. This material has been shown to vary in composition depending on whether extraction of fat was by an industrial (expeller and sometimes solvent) or traditional cottage industry method, with the industrial methods tending to be more efficient at fat extraction (Dei *et al.*, 2008). The following range of nutrient compositions (gkg^{-1}DM): crude protein (80 - 250), ether extract (17 - 362), crude fibre (53 - 138), ash (33 - 76) and nitrogen-free extract (318 - 675) have been reported (Dei *et al*., 2007). They also reported that the major part of this variability could be traced to the amount of fat extracted, handling of the nuts prior to processing and seasonal effects on nut production. Dei *et al.* (2007) also reported an estimated true metabolis able energy corrected for nitrogen balance to be 12.6 MJ kg^{-1} to 15.1 MJ kg^{-1} for different shea nut cake (SNC) samples.

Fermentation as a means of reduction in level of ant- nutrients can improve shea-nut nutritional value and provide alternative and available feed resources indirect or to reduce fishmeal in the diets of the fish. From the proximate analysis of Nigeria savanna zone, Shea nut or kernel, Ugease *et al*. (2010) noted that the kernel is more of a carbohydrate supplement having content up to 46.70 % carbohydrate, 31 % fat and 7.8

protein. They also analyzed the Shea kernel proximate according to accession, where kernel seed, from Minna, Niger state are of higher protein than those from other places, such as Kano is higher in carbohydrate while Lokoja and Makurdi were higher in fat (Dei *et al.,* 2007).

The cake produced from seed of Niger state had the highest protein of 10.1 % and Makurdi is higher for carbohydrate with 69.1 %. In their analysis, Ugese *et al*. (2010) evaluate shea as protein (6.8/100) g, lipid (49/100) g, glucidis (35.6/100) g, calcium (mg/100g), thiamin, vitamin B1 (0.52 mg / 100 g), Fe (3 mg / 100 g) and 579 kcal/ 100 g. Ugese *et al*. (2010) concluded that proximate qualities including the high energy content has qualified shea seed cake at least as potential sources of feed for livestock.

Shea trees blossom during February to March, and the fruit become matured in June to July (Alander, 2004). The fruit are harvested during June to September once they fall to the ground from the trees (Alander, 2004). Shea fruit is light green colored with a diameter of 2 - 3 inches or 5 - 8 cm. Shea fruit consist of a green epicarp (the outer part), a fleshy mesocarp (pulp), and a relatively hard endocarp (shell) containing embryo (shea kernel) (Olaniyan & Oje, 2007). Mostly, shea fruit contain one or two kernels but occasionally have two to three from which shea butter is extracted (Alander, 2004).

2.7 Extraction of Shea Butter

Traditionally, the extraction of shea butter has been done at the village level, where Shea butter is sold in local markets. In recent years, the dried kernels have been exported to processing countries in Europe, Japan, and India where shea butter is extracted in large-scale industrial plants (Lovett, 2004). Traditional extraction has been usually done by boiling water and skimming off the released oil while commercial one

is conducted by pressing or solvent extraction with further refining and deodorizing of Shea butter (Alander, 2004). However, with the increased interest in naturally derived products, organic shea butter production is preferred and thus efforts have been made to industrially produce shea butter by following the traditional extraction methods. The shea butter obtained from the traditional extraction procedure not including a refining stage is called unrefined shea butter (Chalfin, 2004; Moharram *et al.,* 2006).

However, boiling can also cause high peroxide values since the high temperature and water can accelerate oxidation (Lovett, 2004; Bail *et al.,* 2009). After the boiling, the nuts are dried in the sun, though sun-drying of shea nuts during rainy season can lead to mold contamination and thus affect the quality of the final products (Moharram *et al.,* 2006). After then, the nuts are cracked to remove shells from the dried nuts and then kernels are further dried by roasting or sun-drying.

In the West African oven method, the nuts are roasted or smoked on ovens and the dried nuts that still have husks are stored. This procedure has the disadvantage that roasting or smoking in the oven can cause high amounts of polycyclic aromatic hydrocarbons (PAHs) known to be carcinogenic (Lovett, 2004).

While the West African methods include a heating stage, either boiling or roasting before or while drying, the East African method involves no heating step. Instead, the nuts are directly sun-dried, de-husked, and sun-dried again. The dried kernels are stored with occasional re-drying. Since the nuts are not subjected to high temperatures, in this method, there is less chance of deactivating lipases, which is usually linked with high levels of free fatty acids (FFAs) (Lovett, 2004). In this case, sun-drying should be avoided during rains to prevent microbial deterioration of the nuts and kernels.

The dried kernels are then subjected to pounding or wet milling to make a paste which is then emulsified by kneading and hand beating. The paste is then boiled to separate the fat from the shea nut cake and the resultant butter is scooped up, filtered through a filter cloth and placed in a cool place to solidify.

2.8 Utilization of Shea Nut Fraction (Shea Nut Meal and Shea Nut Residue) in Diets of Livestock

Shea nut products (SNPs) have shown that it contains substantial amount of nutrients (Agbo & Prah, 2014; Oddoye *et al*., 2012; Dei *et al*., 2008; Atuahene *et al*., 1998) although lower compared to other conventional oilseed meals used in fish feeds in terms of protein content in particular. They have been used in some animal feed trials including; poultry (Zanu *et al*., 2012; Dei *et al*., 2008; Atuahene *et al*., 1998), pig (Rhule, 1999; Okai & Bonsi, 1989), sheep (Konlan *et al*., 2012) and rabbit (Ansah *et al*., 2011) with authors reporting poor growth performances attributing this to the presence of anti-nutritional factors such as tannins and saponins, as well as poor palatability (Annongu *et al*., 1996).

There is very little information on the use of shea nut product in fish feed. Uzoma (2010) fed catfish fingerlings with shea nut meal-based diets and recommended 5 % inclusion and at 40 % crude protein. The ability of a fish to digest and absorb feed ingredients depends primarily on the chemical composition of the ingredients and how digestible the nutrients are (McGoogan & Reigh 1996).

The nutritional composition of the shea nut by products (SNPs) used in this study differed slightly from 862.05 to 883.3 g.kg. $^{-1}$. Their ash content varied slightly from (53.31 to 63.40 g.kg^{-1}), with shea nut recording the highest (Agbo *et al*., 2009). Shea nut residue recorded the highest crude protein level (159.90 g.kg^{-1}) and shea nut cake was the least (125.60 g.kg^{-1}). The crude lipid levels followed the opposite trend compared to

crude protein where shea nut residue had the lowest level (70.03 $g.kg^{-1}$) and shea nut meal had the highest 304.02 $g.kg^{-1}$ (Agbo *et al*., 2009).

The crude fibre content of the SNPs ranged between 48.81 g kg^{-1} and 86.62 g kg^{-1} with shea nut meal recording close to twice the levels for shea nut residue. The gross energy of the test ingredients ranged from 17.38 $g.kg^{-1}$ to 22.85 $g.kg^{-1}$ (Agbo & Prah, 2009). The dry matter ADC of the shea nut products ranged from 72.98 % to 83.81 % with shea nut meal being significantly higher ($p< 0.05$) than shea nut residue (Agbo & Prah, 2014).

2.9 Anti-Nutrients

Growth suppressors or anti-nutritional factors do occur in all available ingredients of plant origin. Anti-nutritional factors alter the nutritional value of feedstuffs thereby causing poor nutrient utilization and impaired growth as well as poor health in fish (Eyo, 2003). This dreadful phenomenon or trend in plant proteins utilization has initiated a lot of research work on the utilization of plant food sources. Considering that the cost of artificial feeds (commercial formulated feeds) are high due to the competition between man and his livestock for feedstuff (cereals and legumes) the need therefore arises to exploit the potentials of plant protein sources as animal feed by subjecting them to processing in order to get qualitative growth and Maximum production (Agbo & Prah, 2014).

The inhibitory effect of anti-nutritional factors can be reduced by subjecting the seeds to controlled heat treatments which include toasting, parboiling, extrusion methods, soaking and sun drying (Balogun & Ologhobo 1989, Banyigi*et al.,* 2001; Adeparusi, 2001; Eyo 2001; Francis, 2002; Vijayakumari, *et al.*, 2007; Vadivel & Pugalenthi, 2007; Olaniyi, 2009a; Tamburawa, 2010). Atuahene (1998) reported the presence of some anti

- nutritional factors such as theobromine and saponin in addition to tannin in the shea nut cake.

2.9.1 Saponin

Chemically, saponin consists of an aglycone of either steroidal or triterpenoid in nature and one or more glycosides (sugar chains) and occurs in plants that are consumed by humans and animals (Tamburawa, 2010). It has been reported to reduce feed intake, inhibit growth rate of swine and poultry and show toxicological effects at higher levels in the diet (Vadivel & Pugalenthi, 2007).

Saponins occur as steroid or triterpenoid glycosides in many plants such as legumes, with concentrations of about 50 mg/kg in various legume seeds (Francis, 2002). Dietary saponins above a level of 1.5 g/kg can retard growth and damage intestinal mucosa in fish. Extraction with water or gamma ray irradiation aid in the removal or neutralization of saponins (Francis, 2002). The presence of high saponins levels in water are highly toxic to fish due to the damage caused to the respiratory epithelium of the gills by the detergent action of the saponins (Francis, 2002).

2.9.2 Tannin

Generally, tannin induces negative responses such as astringency, bitterness or unpleasant taste when consumed (Brown, 2008). In poultry small quantities of tannin causes adverse effects. Levels from 0.5 to 2.0 % can cause depression in growth rate and egg production which levels from 3 to 7 % can cause death. Similar effects have been found in swine. Hydrolysable tannins are toxic to ruminants when fed at higher levels above 20 % (Brown, 2008). Tannin is resistant to fish enzymes and they reduce the availability of dietary phosphorus Tannin is reported to reduce absorption of minerals such as irons (Brown, 2008).

2.9.3 Theobromine

This is colourless and odourless 3, 7- dimethyl xanthine with slightly bitter taste, it occurs naturally in *Theobroma cacao* and other related *Theobroma* species (SOPCFC, 2008). It is an alkaloid and lethal to chickens, monogastrics and young ruminants (McDonald *et al.*, 1995). Brown (2008) indicated that, theobromine level of 150 g/kg is toxic for laying hens.

2.10 Processing Methods of Reducing and Detoxifying Anti-Nutrients in Feed Ingredients

Fermentation has been shown to reduce the saponin and phytate content of seeds because of the action of saponin produced by yeast or lactic acid bacteria (Abu, 2005). Abu (2005) reported the reduction in sponin contents of fermeted locust bean seed (*Parkia filicoidea*) by 17.7 %. Brown, (2008) reported that cooking decreased both water and acid extractable phytate phosphorus in legumes.

Vidavel and Pungalenthi (2007) indicated that cooking and autoclaving substantially reduced the level of phytate, saponin and tannin in Muncuna seed meal. Similarly, Tamburawa (2010) indicated that soaking locust seed meal for 3 days considerably reduced the levels of anti-nutrients particularly tannins and phytates 1.08 % in the raw to 0.17 %; 0.71 % to 0.27 % respectively (Owusu-Manu, 1991). Due to the concentration of theobromine in the outer endosperm of seeds particularly cereals, milling has been employed to remove the outer layers of seeds in order to reduce the theobromine content to considerable levels (Olaniyi, 2009a).

Heat treatment (autoclaving) was also found to reduce anti nutritive factors in linseed and sesame meals by up to 72 % and 74 % respectively (Olaniyi, 2009a). Abu (2005) identified toasting and de-fatting as processing methods that could be used for removal of anti-nutrients of some leguminous and cereal ingredients for fish feeds.

2.11 Geographical Distribution of *Clarais gariepenus*

The African catfish *Clarias gariepinus* is one of the unique groups of fish belonging to the subclass *Actionpterygii*, Division *Teleostei*, Order *Siluriformes* and family of *Clariidae. Clarias gariepinus*is widely distributed across the world and it has is ubiquitous habitat demands. It is tropical fresh water specie and has a pan-African distribution but is absent from the Maghreb, Cape Province, and the upper and lower Guniea. It is also found in countries such as Jordan, Israel, Lebanon, Southern Turkey and Syria (FAO, 2010). They are widely consumed in Eastern Africa and the species is found in most water bodies including streams, rivers, floodplains, and swampy vegetated areas of lakes which can easily dry up during periods of droughts (Ayanda, 2008).

Clarias gariepinus and Clarias angullaris are the major culturable species farmed in Africa, even though there are more than 100 species in the African water bodies. *Clarias gariepinus*is commonly known as Mudfish, common catfish, North African catfish etc. The indigenous species is native to the following countries such as: Nigeria, Rwanda, Senegal, South Africa, Cameroon, Democratic republic of Congo, Egypt, Turkey, Zambia, Zimbabwe Tanzania, Israel, Jordan, and Syrian Arab Republic etc. While the *Clarias angullaris* is not in abundant distribution and can be found in few countries and water bodies such as Mauritania, in the Nile and basins of most West African countries (Ayanda, 2008).

The culture systems have as it recently advanced in technology like recirculation systems, fibre reservoirs or concrete and development of extruded feed with an extrusion machine led to the commercial economic growth. It has boosted Gross Domestic Product of Nigeria and it is one of the fastest growing agricultural sectors.

Nigeria is reaping the benefits and currently leading the catfish production in Africa. This species can be cultured in a suitable culturable environment (FAO, 2012).

Other countries this species has been introduced and are currently farming *Clarias gariepinus* are: Bangladesh, Brazil, Cambodia, Greece, India, Netherlands, Thailand, and Czech Republic etc. It also discovered in countries like France, Hungary, Cyprus, Poland, Russian Federation etc.

The African catfish species does not qualify for Near Threatened (NT) or a threat category because of its wide distribution and ubiquitous habitat demands (Ayanda, 2008).

2.12 Habitat and Biology of *Clarias gariepinus*

Clarias gariepinus is portrayed as a scale less fish, stretched body and additionally long dorsal and butt-centric balance. It has air-breathing organs with head moulded like a protective cap and shading shifts from dim to light dark coloured with olive and greyish shades while the underside shading takes after pale cream to white. The class of *Clarias gariepinus* has been generally spread over African main lands with a few animal categories, for example, *Clarias mossambicus* and *Clarias lazera* (Ayanda, 2008).

Clarias gariepinus can survive for some period of time outside the water using specialized supra branchial organ because of the mechanism of its structure. Catfish can tolerate adverse and extreme conditions because it has the capacity to stay alive in moist sand or burrows within the air water interface (Van der Waal, 1998).

Compared with other species of catfish like the Thai spp. found in Thailand (*Clarias macrocephalus*), *Clarias gariepinus* is known for rapid growth rate. Fast growth level in

length and weight with ambient state and surroundings and also density dependent (FAO, 1988).

The *Clarias gariepinus* migrate from larger water bodies to temporarily flooded marginal areas or flood plains in order to breed. Rainy season is its breeding period (Gabriel *et al*., 2015). Its reproduction is seasonal with gonadal development associated to the period of flooding. The maturation period of the gonads is characterized by changes in water temperature and photoperiod, but increase in water level is determinant for their reproduction (Yalcin *et al.*, 2001).

Characteristics of catfish that makes it ideal for farming are that;

i It feeds on a large variety of agriculture by products.
ii. It is hardy and tolerates adverse water quality conditions.
iii. It can be raised in high stocking density, resulting in high net yields.
iv. In most markets, it is better priced than tilapia, as it can be sold live at market.
v. It grows quickly relative to other aquaculture candidates.

2.13 Nutritional Requirements of *Clarias gariepinus*

Clarias gariepinus is an omnivorous fish and it can also be predatory in nature (Lowe- and Connell, 1975), (Gabriel *et al*., 2015). *Clarias gariepinus* has a very high dietary protein requirement of about 40 - 50 % crude Protein (Gabriel *et al.*, 2014). The Larvae feed exclusively on zooplankton and phytoplankton in the first week, at juvenile stage it grows to feeding on aquatic insects, insect larvae and *ostracods* (Udo & Umoren, 2011). At fingerlings stage, they feed on micro-crustacean and also insect larvae. Higher percentage of about 70 % the fish consume occurs at nigh time (Udo & Umoren, 2011). Grow-out stage or adult fish feed on small fish, aquatic plants, aquatic insects etc (Mwebaza-Ndawula, 1984). During the early stage of growth, they require high protein

requirement. The fry, fingerlings, juveniles have a high protein requirement of about 55 %, lipid demand of about 9 % and carbohydrate of about 21 % (Steven & Louis, 2002). The basic nutritional requirements during the adult stage or grow-out stage range from 40 - 43 % for protein, 10 - 12 % lipids and carbohydrate of about 15 - 32 %. The optimum digestible energy is between 14 - 16 kj/g (Church & Pond, 1988).

2.13.1 Protein requirements

Proteins are long chains of amino acids linked by bonds called peptide bonds. All amino acids contain nitrogen, so all proteins contain nitrogen. In fact, measuring nitrogen content is a method of calculating protein content. Metabolism of protein for energy produces nitrogen end products (Hardy, 1989). Fish eliminate these through gills, feces and urine. These nitrogen end products can cause problems in fish ponds. Protein is the major concern during formulation of fish feed. It is the most expensive for fish feed and the most important factors that contributing to the growth performance of cultured species (Deng *et al*., 2011).

Protein serves three purposes in the nutrition of fish:

1. Provide energy
2. Supply amino acids
3. Meet requirements for functional proteins- enzymes and hormones and structural proteins

The requirement for protein in fish diets is essentially a requirement for the amino acids in the dietary proteins. Some amino acids the fish cannot synthesis are called indispensable or essential amino acids.

1. Arginine

2. Valine
3. Histidine
4. Isoleusine
5. Leucine
6. Lysine
7. Methionine
8. Threonine
9. Tryptophan
10. Phenylalanine

Research evidence suggests that large differences exist among fish species in their requirements for amino acids (Jantarotai *el al*., 1998). Some of these differences are probably caused by differences in growth rate, feed intake and the source of amino acids in the diet (Machiels & Henken, 1985). When proteins in most feedstuffs are properly processed, they are highly digestible (Cockreal *et al*., 1987; Abowei & Ekubo, 2011). For a variety of protein rich-feed stuffs, the digestibility ranges from 75 to 95 percent. As dietary carbohydrate increases, the digestibility of protein tends to decline. Also, overheating during drying or processing reduces proteins nutritive value (Abowei & Ekubo, 2011).

Protein requirements for catfish are considerably higher than those for warm blooded land animals. Protein requirements of catfish decline with age. Animal protein sources are generally considered to be of higher quality than plant sources, but animal protein costs more. In diets, a combination of protein sources yields better conversion rates than any single source (Pandey, 2013).

2.13.2 Lipid requirements

Each gram of fat contains 2.5 times the energy in a gram of carbohydrates or proteins. The digestibility of fat varies, depending on

i. Amount in the diet
ii. Type of fat
iii. Water temperature
iv. Degree of unsaturation
v. Length of carbon chain

Animal fats and fats that are highly saturated have a lower digestibility. On the other hand, in highly unsaturated fats, fats that fish can rapidly digest. There is danger of oxidation of the fats, resulting in feed spoilage. Antioxidants are routinely added to most fish diets to prevent fats from becoming rancid in storage (Krontveit *et al*., 2014). Besides being an important source of energy for fish, dietary fats provide essential fatty acids (EFA) needed for normal growth and development. Fish cannot synthesize these fatty acids. Also, dietary fats assist in the absorption of fat-soluble vitamins. Freshwater fish require a dietary source of linoleic acid and linolenic acid. Channel catfish, salmon and rainbow trout require linolenic acid (Jauncey, 1998).

In the body essential fatty acids function as a part of cell membranes and precursors of biochemical that perform a variety of metabolic functions. Fish diets are formulated to meet the optimum ratio of energy to protein for each species (Regost *et al*., 2001). Fats serve as important source of energy, but no definite percentage of dietary fat can be given without considering the type of fat, as well as the protein and energy content of the diet. Too much dietary fat can result in an imbalance of the digestible energy to

crude protein ratio and excessive deposition of fat in the body cavity and tissues (Endinkeau & Kiew, 1993).

2.13.3 Carbohydrates

Carbohydrates are the most economical and inexpensive sources of energy for catfish diets. Although not essential, carbohydrates are included in aquaculture diets to reduce feed costs and for their binding activity during feed manufacturing. Dietary starches like cassava starch are used in the extrusion production of floating feeds. Floating feeds for the various finfishes are prepared with varying ranges of carbohydrates (Robert, 1979; Bake *et al.*, 2009).

Catfish have the capability of digesting simple sugars efficiently. Digestibility will get decrease rapidly when the sugar becomes larger and more complex. Warm water fish can digest dietary carbohydrates efficiently when compared with cold water or marine fish. Utilization of carbohydrates as an energy source varies with different species. There are no recommended levels or ranges by national research council for formulating and preparing finfish and shellfish feeds. A general recommendation is a diet of no more than 12 percent digestible carbohydrates. Fats and proteins supply most of the energy in fish diets (Parker, 2011).

2.13.4 Vitamins

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 (Parker, 2011). The two groups of vitamins are water-soluble and fat-soluble (Adewole & Olaleye, 2014). 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 (Adewole & Olaleye, 2014).

The fat-soluble vitamins include A vitamins, retinols (responsible for vision); the D vitamins, chole caciferols (bone integrity); E vitamins, the tocopherols (antioxidants); and K vitamins such as menadione (blood clotting, skin integrity). Vitamin E receives the most attention for its important role as an antioxidant (Steven *et al*., 2017). 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 (Steven *et al*., 2017).

2.13.5 Minerals

Minerals are inorganic elements necessary in the diet for normal body functions (Davis and Gatlin, 1996). 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 (Webster *et al*., 2002). Common macro-minerals are sodium, chloride, potassium and phosphorous. These minerals regulate osmotic balance and aid in bone formation and integrity (Webster *et al*., 2002). 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 (Halver & hardy, 2002). 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 (Athithan *et al*., 2013).

CHAPTER THREE

3.0 MATERIALS AND METHODS

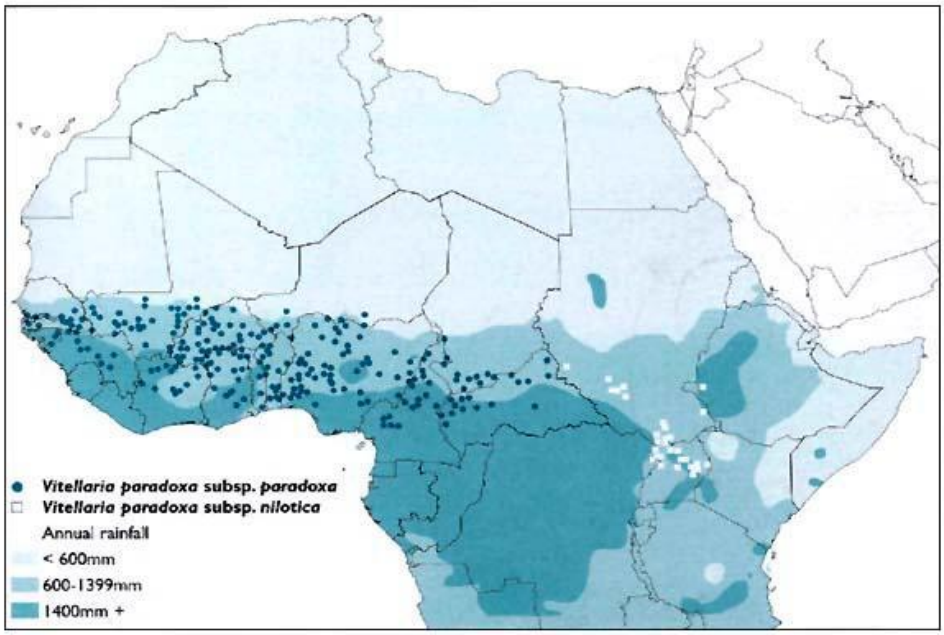

Figure 3.1: Distribution of Shea Tree in West Africa
Source: Hall *et al*. 1996

Figure 3.2: Distribution of Shea Tree in Nigeria

Source: Hall *et al*. 1996

Plate I: a, b and c Shows the mature fresh shea nut fruit harvestedfrom shea nut trea (*Vitellaria paradoxa*). The fruits were harvested in the month of June to September once they fall to the ground from the trees (Alander, 2004). Shea fruit is light green colored with a diameter of 2 - 3 inches or 5 - 8 cm. Shea fruit consist of a green epicarp (the outer part), a fleshy mesocarp (pulp), and a relatively hard endocarp (shell) containing embryo (shea kernel) (Olaniyan & Oje, 2007). Mostly, shea fruit contain one or two kernels but occasionally have two to three from which shea butter is extracted (Alander, 2004).

Plate I: d. This shows a dried shea-nut embryo (shea kernel), exposed to sun light to reduce its moisture content.

Plate I : e. This shows the process of removing the green epicarp (the outer part), and the fleshy mesocarp (pulp), from the shea nut fruit.

plate I : f. This shows the process of collecting, sorting, drying, di-husking and grinding of shea nut before the solvent extraction.

Plate I : g. This showes shea nut residue after solvent extraction. Shea nut residue is the by product after

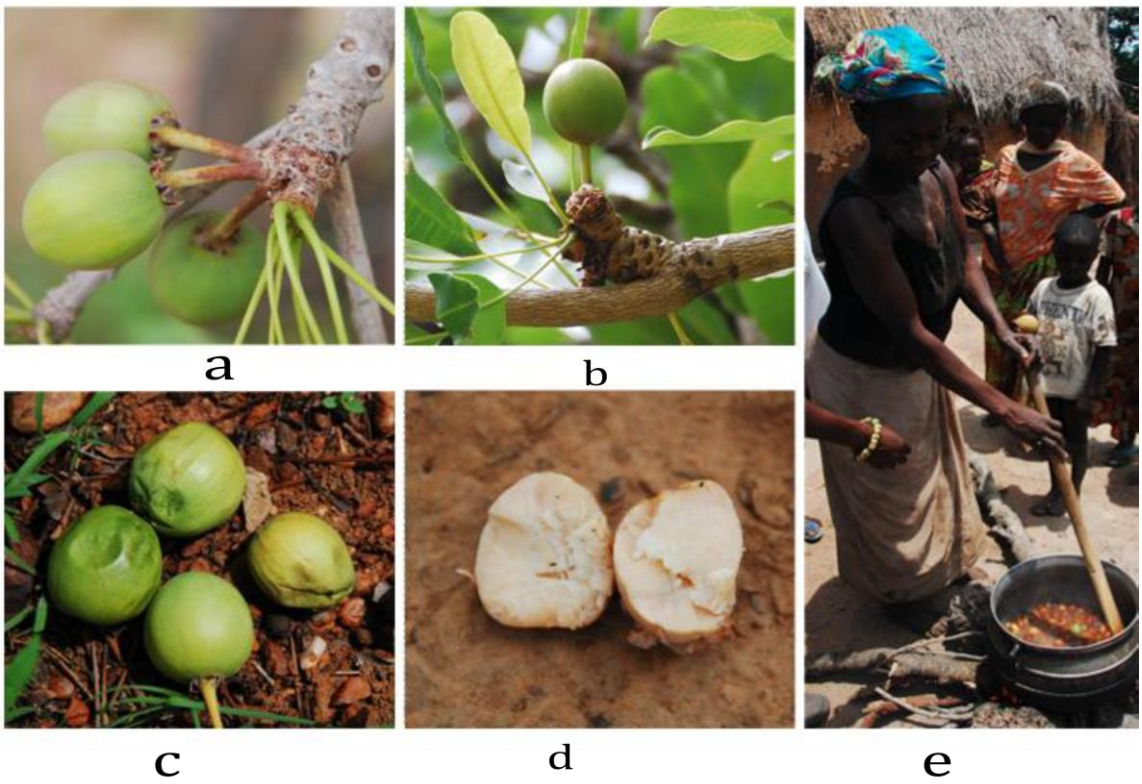

Plate I: Collection and Processing of Shea Nut

Source: Hall *et al*. 1996

Plate II: Collection and Processing Shea Nut and Its Residue

Source: Hall *et al*. 1996

3.1 Experimental Location of the Study

The shea nut meal and shea nut residue for this research work were collected at Kakakpangi Village market, in Gbako Local Government Area of Niger state. Located between Latitude 9^0 24 N and Longitude 6^o 27' 7.29'' E.

The study was carried out at the research (laboratory) of Prof. Sadiku Federal University of Technology Gidan kwano campus Minna, Niger State Nigeria. Located between Latitude 9^0 31'58.998'' N and Longitude 6^o 27' 7.29'' E.

3.2 Experimental Design of the Study

A complete randomized design was used in all the experiment, where treatments were of one variable; ingredient being incorporated, the variable. The fishes and treatments were randomly assigned to tanks in triplicate.

3.3 Experimental Fish

Six hundred and fifty (600) of African catfish *Clarias gariepinus* fingerlings of mean weight 3.02 ± 0.54 g, were collected from Ikhlas Agro Farm Ltd, Oke-Oyi of Ilorin-East Kwara State. The fishes were acclimatized in a 500 litres rubber tank for one week before the commencement of the feeding trial, during which period fishes were placed on commercial catfish diets (Multifeed).

3.4 Experimental Diets

Feedstuffs used for the research work include shea-nut meal, shea-nut residue and yellow maize. Shea nut and shea residue were collected in Kakakpangi Village, in Gbako Local Government Area of Niger state. The other feedstuffs were purchased from Minna market while Vitamin premix, Multifeed and fish meal were obtained from Minna Ultra-Modern Market. Nine (9) diets formulated to contain 40 % Crude protein. The lipids inclusion levels were at 10 %, 15 % and 20 % of the total lipid required by *Clarias gariepinus.*

Shea-nut meal and shea nut residue respectively for both experiments, Diets formulated were presented in Table 3.2 and 3.4, and commercial reference diets (Multifeed) was used as reference diet Orire, (2010). Equation method of three (3) unknown was used to formulate the diets according to Machiels and Henken (1985) and Orire *et al.* (2013).

X+y+z=95; x+y+z=A

Where x=Protein source (Fishmeal), y=Energy source (shea-nut meal and shea nut residue), Z= carbohydrate source (maize) A=% Crude protein and 95=Bulk.

Nine (9) diets containing varying inclusion levels of lipid protein ratios are diet 2 10 % lipid and 30 % protein (10 L:30 P), diet 3 15 % lipid 30 % protein (15 L : 30 P), and diet 4 which consist of 20 % lipid 30 % protein (20 L : 30 P), diet 5 10 % lipid and 35 % protein (10 L : 35 P), diet 6 15 % lipid 35 % protein (15 L : 35 P), and diet 7 which consist of 20 % lipid 35 % protein (20 L : 35 P), diet 8 10 % lipid and 40 % protein (10 L : 40 P), diet 9 15 % lipid 40 % protein (15 L : 40 P), and diet 10 which consist of 20 % lipid 40 % crude (20 L : 40 P) while diet 1 (reference diet) was commercial catfish feed Multifeed).

3.5 Processing of Shea Nut and Other Feed Stuffs

Ten (10 kg) of dried shea nut was soaked in 120 liters of water for 96 hours; thereafter, the water was decanted, and the seed was air-dried for 72 hours and toasted. Maize (yellow), shea products (shea nut and shea nut residue) and sorted fish (Clupeids) were ground using milling machine. Vitamin and mineral premix were then added to the ground feed stuffs then packed in clean polythene bags and sealed prior to use in feed preparation.

3.6 Feed Preparation

The feed preparation was carried out using the method described by Adepaurusi and Eleyimi (2004), Eyo (2003) and Banyigyi *et al*. (2001a). The ground ingredients were

sieved using a 0.2 mm diameter sieve to obtain the powdery form. The ingredients were weighed in the correct proportions as formulated in the diet (Table 3.2 and 3.4) and then mixed thoroughly before using gelatinized cassava starch as a binder. The obtained homogenous mass of dough was passed through a locally improvised pelletizer to produce 2 mm diets. The pelletized feed was then oven dried for 24 hours at 40 ^{o}C, packaged in air-tight cellophane bags and stored in a cool place.

3.7 Experimental Procedure

The experimental work was carried out in the Water Resources, Aquaculture and Fisheries Technology Laboratory of Federal University of Technology Minna, Gidan-Kwano Campus using the recirculatory system. Fishes were randomly stocked in triplicate, in 10 litres capacity round plastic bowls at a stocking density of 10 fishes per bowl in Professor Sadiku laboratory in the Department of Water Resources, Aquaculture and Fisheries Technology. The bowls were arranged in a randomized block and were covered with Mosquito nets to prevent fishes from jumping out.

3.8 Fish Feeding and Culture

The fish were starved for 24 hours prior to the onset of the feeding trial experiment. On commencement of the feeding trial the fish were fed 3 % of their biweekly body weight. The fish was fed equal rations trice daily (8 am - 9.00 am, 1 pm - 2 pm and 5 pm - 6 pm). The uneaten diets were siphoned 30 minutes post feeding for adjustment for feed fed at the end of the feeding trial. The feeding trial lasted for 8 weeks while the water exchange was carried out mechanically by the recirculatory system. The water quality parameters were monitored on weekly bases for temperature using clinical thermometer; dissolved oxygen according to the method of Lind, (1979) and APHA (1980). Hydrogen iron concentrations (pH) were measured using an EIL 7045/46 pH meter in the

laboratory at room temperature while conductivity was monitored using conductivity meter and Dissolved oxygen (DO) was measured using dissolved oxygen test kit (HANNA instruments model: HI - 3810).

3.9 Determination of Mineral Elements

Mineral element analyses were determined using Atomic Absorption Spectrophotometer (Model-ShimatzuAA-6300). The Shea-nut meal (SNM) and Shea-nut residue (SNR) was analyzed for calcium, potassium, sodium, magnesium and iron elements. The dried Shea-nut meal (SNM) and Shea-nut residue (SNR), (2.0 g) were mixed with 5.0 ml of distilled water, 25 ml of concentrated nitric acid and digested under reflux over a water bath at 90 ^{o}C for 4 hours. The refluxed solution was cooled and 10 ml of concentrated perchloric acid added. The samples were further digested for 1 hour and cooled. Concentrated hydrochloric acid (2 ml) was then added to the sample and made to 100 ml with distilled water. The analyses of minerals were then carried out in triplicate and all values expressed as mg/100g AOAC (2005).

3.10 Analysis of Proximate Composition

3.10.1 Determination of moisture

A clean petri-dish is weighed and 5gram of the sample is added to it and weighed. The moisture content was determined by adopting an air oven technique. After which the sample were recovered from the oven, and after 15 minutes it was allowed to cool before weighing. The loss in weight is regarded as moisture content present in the sample AOAC (2005).

$$\text{Percentage moisture} = \frac{\text{weight loss}}{\text{weight of sample}} \times \frac{100}{1} \quad (3.1)$$

3.10.2 Determination of crude protein

0.25 gram of the sample was measured by weighing the sample into 500 ml kjeldahl conicalflask and a pinch of copper sulphate was added to the sample, 15 ml of concentrated sulphuric acid was added to the flask. The macro kjeldahl method was described by AOAC (2005) was used. The sample was added into the digestion chamber for 8hours. After digestion, the digested sample was allowed to cool and 100 ml of distilled water was made and added into the digested sample. 10 ml of 4 % boric acid was laid into 250 ml compendium container and positioned below the compendium cork of the extraction tool. 10 ml of 40 % sodium hydroxide solution was added into the condenser with 10 - 15 ml of the digested sample. The solution was allowed to distill for about 10 minutes or when the volume of ammonia collected in boric acid in the receiver flask was up to 50 ml. the distillate was titrated against 0.1 ml of hydrogen chloride pending the time a pink color is obtained AOAC (2005).

$$\%\text{Protein is calculated thus} = \frac{TV \times 0.1 \times 0.0142 \times 5 \times 100 \times 6.25}{0.25\ (\text{weight of the sample})} \qquad (3.2)$$

Where;

TV: Titre value

100: Percentage conversion factor

6.25: Protein conversion factor

5: Dilution factor

0.0142: Nitrogen conversion factor

0.1: molarities of acid used

3.10.3 Determination of ash

The initial weight of a clean crucible was recorded. 2 g of the tests were poured into each crucible, after which it was weighed. The crucible and it content were placed into a furnace rack with a temperature of 500 °C for 3 hours until the sample was completely ashed. The crucible with the ashed sample was left to cool and re-weighed AOAC (2005).

$$\text{Percentage Ash} = \frac{W3-W1}{W2-W1} \times \frac{100}{1} \quad (3.3)$$

Where;

W1: Initial Weight of Crucible

W2: Weight of Crucible + Sample

W3: final weight of crucible and sample after ash

3.10.4 Determination of lipids

Weight of filter paper was taken and one gram of the sample was weighed. The weighed sample was added into the filter paper and it was folded neatly in such a way there would be no loss in sample. The thimble was partially held to the extractor and the evaluated on a weighing balance sample was cautiously moved into the thimble. Removal was carried out using petroleum ether (boiling point of 40 - 60 °C) the thimble was plugged, with cotton wool and removal was done for 6 hours completely AOAC (2005).

After the conclusion of removal, the sieve paper thimble was detached and conveyed to an air oven at 105 °C for duration of 30 minutes; it was then detached and allowed to

cool. The soxhlej solvent extraction method was used in determining fats contents of tests AOAC (2005).

$$\text{Percentage Fat} = \frac{\text{Weight of Extracted Fat}}{\text{Weight of Sample}} \times \frac{100}{1} \quad (3.4)$$

3.10.5 Crude fibre

Crude fiber includes materials that are indigestible in human and animal organisms. Two (2 gram) of the sample was weighed, put in side 250 ml conical flask containing 20 ml of diluted H_2SO_4 and heated for 30 minutes, washed again and put inside Gooch crucible to oven dry at 100 ^oC for 15 minutes, then the weight was taken and put inside the muffle furnace and heated at 400 ^oC for 15 minutes and allow to cool in a desiccator before reweighed. Crude fiber was calculated according to method of AOAC (2005).

$$\% \text{ CF} = \frac{W2 - W3}{W1} \text{ X } 100 \quad (3.5)$$

Where:

W1 = weight of the sample

W2 = weight of the sample and Gooch crucible

W3 = weight of the sample and Gooch crucible after heating

3.11 Proximate Composition of Some Feed Ingredients Used for this Study

Proximate composition of feed ingredients is presented in Table 3.1. Fish meal had the highest values for crude protein (70.99 %), fat (10.98 %) and ash (12.21 %) followed by shea-nut residue (SNR) (10.73 %, 31.87 % and 5.37 %) and maize meal (10.17 %, 5.82 % and 1.44 %) respectively. Shea nut meal (SNM) had lowest values for crude protein (9.8 %), and had the highest value for fat and crude fibre (50.02 % and 11.00 %) respectively.

Proximate composition of experimental diets of experiment one is presented in table 3.2. Moisture content was highest in reference diet 1 (8.73 %), while diet 4 had the lowest moisture content (6.67 %). Diet 8 had the highest ash percentage (12.91 %), followed by diet 9 (11.89 %), while the lowest value for ash was seen in diet 1(9.45 %). Diet 1 had the highest value for crude protein (45.95 %), followed by diet 8 (38.32 %), while diet 2 had the lowest crude protein percentage (31.41 %). Crude lipid was highest in diet 10 (19.42 %), followed by diet 4 (18.98 %), while diet 1 had the lowest lipid content (12.02 %). Crude fibre was highest in diet 10 (7.13 %), and lowest in reference diet 1 (3.70 %).

Proximate composition of experimental diets with shea nut residue inclusion is presented in Table 3.3. Moisture content was highest in commercial reference diet D1 (8.73 %), while diet 4 had the lowest moisture content (6.46 %). Diet 1 had the highest ash percentage (8.73 %) followed by diet 8 (7.89 %), while the lowest value for ash was seen in diet 1 (9.37 %). Diet 1 had the highest value for crude protein (45.95 %) followed by diet 10 (39.64 %) while diet 3 had the lowest crude protein percentage (31.50 %). Crude lipid was highest in diet 10 (19.89 %), while diet 1 had the lowest lipid content (12.02 %). Crude fibre was highest in diet 5 (7.09 %) and lowest in reference diet 1 (3.70 %).

Table 3.1: Proximate Composition of Some Feed Ingredients Used for this study

Composition	Fishmeal	Maize Meal	Shea Nut Meal (SNM)	Shea Nut Residue (SNR)
Crude Protein	70.99	10.17	9.80	10.73
Lipid	10.98	5.82	50.02	31.87
Ash	11.21	1.44	5.00	5.37
Moisture Content	6.06	6.07	9.81	5.57
Crude Fibre	0.69	1.34	11.00	5.75
NFE	0.07	75.16	14.37	40.71
Total	100.00	100.00	100.00	100.00

Key: NFE: Nitrogen Free Extract

Table 3.2: Formulated Diets Based on Various Lipids-Protein Ratios Using Shea Nut Meal (SNM) Inclusion

Composition of Diet	CRD (D1)	D2	D3	D4	D5	D6	D7	D8	D9	D10
Fishmeal	-	33.63	33.66	33.70	41.82	41.86	41.89	50.01	50.05	50.09
Maize Meal	-	55.25	43.89	32.53	48.01	36.65	25.29	40.77	29.41	18.05
SNM	-	6.13	17.45	28.77	5.17	16.50	27.82	4.22	15.54	26.87
Premix	-	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	500
Total	-	100	100	100	100	100	100	100	100	100

Keys:

D: - Diets
D1: - Commercial Reference Diets
D3: - 15 L: 30 CP Inclusion
D5: - 10 L: 35 CP Inclusion
D7: - 20 L: 35 CP Inclusion
D9: - 15 L: 40 CP Inclusion
SNM: - Shea Nut Residue

CRD: - Commercial Reference Diet
D2: - 10 L: 30 CP Inclusion
D4: - 20 L: 30 CP Inclusion
D6: - 15 L: 35 CP Inclusion
D8: - 10 L: 40 CP Inclusion
D10: -20 L: 40 CP Inclusion

Table 3.3: Proximate Composition of the Experimental Diets

Diet (%)	CRD (D1)	D2	D3	D4	D5	D6	D7	D8	D9	D10
CP	45.95	31.41	29.48	31.86	33.21	35.96	36.79	38.32	38.41	39.98
CL	12.02	13.17	15.31	18.98	13.87	17.14	18.21	12.98	13.98	19.42
CF	3.70	6.73	6.83	6.84	7.08	6.89	6.44	6.32	6.87	7.13
Ash	9.37	11.59	11.72	11.49	11.21	11.38	11.27	12.91	11.89	11.50
MC	8.73	7.36	8.49	6.67	6.83	6.91	7.97	7.89	7.46	6.68
NFE	20.23	29.74	28.17	24.16	27.80	21.72	19.32	21.52	21.39	15.29
Total	100	100	100	100	100	100	100	100	100	100

Keys:

D: - Diet **NFE: -** Nitrogen Free Extracts
CP: - Crude Protein
LP: - Lipid
CRD**: -** Commercial Reference Diet
D1: - Commercial Reference Diets
D2: - 10 L: 30 CP Inclusion
D3: - 15 L: 30 CP Inclusion
D4: - 20 L: 30 CP Inclusion
D5: - 10 L: 35 CP Inclusion
D6: - 15 L: 35 CP Inclusion
D7: - 20 L: 35 CP Inclusion
D8: - 10 L: 40 CP Inclusion
D9: - 15 L: 40 CP Inclusion
D10: - 20 L: 40 CP Inclusion
CF: - Crude Fiber
MC: Moisture Content

Table 3.4: Formulated Diets Based on Various Lipids-Protein Ratios, Using Shea Nut Residue (SNR) Inclusion

Composition of Diet (%)	CRD (D1)	D2	D3	D4	D5	D6	D7	D8	D9	D10
Fishmeal	-	33.44	33.12	32.81	41.66	41.34	41.03	49.88	49.57	49.25
Maize Meal	-	51.18	32.31	13.43	44.57	25.70	6.82	37.97	19.12	0.22
SNR	-	10.38	29.57	48.76	8.77	27.96	47.15	7.15	26.31	45.53
Premix	-	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	500
Total	-	100	100	100	100	100	100	100	100	100

Keys:

D: Diets **SNR**: - Shea Nut Residue
CRD: - Commercial Reference Diet
D1: - Commercial Reference Diets
D2: - 10 L: 30 CP Inclusion
D3: - 15 L: 30 CP Inclusion
D4: - 20 L: 30 CP Inclusion
D5: - 10 L: 35 CP Inclusion
D6: - 15 L: 35 CP Inclusion
D7: - 20 L: 35 CP Inclusion
D8: - 10 L: 40 CP Inclusion
D9: - 15 L: 40 CP Inclusion
D10: - 20 L: 40 CP Inclusion

Table 3.5: Proximate Composition of the Experimental Diets

Diet (%)	CRD (D1)	D2	D3	D4	D5	D6	D7	D8	D9	D10
CP	45.95	33.47	31.50	32.38	35.05	35.88	36.31	39.63	39.19	39.64
CL	12.02	12.41	14.32	18.18	12.21	14.38	19.87	13.46	15.81	19.89
CF	3.70	6.43	6.83	6.14	7.08	6.89	7.44	7.12	7.23	7.13
Ash	9.37	11.91	11.74	11.49	11.21	11.38	10.26	10.91	10.89	11.50
MC	8.73	7.56	7.49	6.67	6.83	6.91	6.94	6.87	6.46	6.68
NFE	20.23	28.44	28.14	24.84	27.62	24.56	19.18	22.01	20.42	15.18
Total	100	100	100	100	100	100	100	100	100	100

Keys:

D: -Diet
NFE: - Nitrogen Free Extract
CP: - Crude Protein
CF: - Crude Fiber
LP: - Lipid

CP: - Crude Protein
D3: - 15 L: 30 CP Inclusion
D5: - 10 L: 35 CP Inclusion
D7: - 20 L: 35 CP Inclusion
D9: - 15 L: 40 CP Inclusion

D1:- Commercial Reference Diets
D4: - 20 L: 30 CP Inclusion
D6: - 15 L: 35 CP Inclusion
D8: - 10 L: 40 CP Inclusion
D10: - 20 L: 40 CP Inclusion

3.12 Water Quality

Water quality is the totality of physical biological and chemical parameters that affect the growth and welfare of cultured fish. Quality of water is therefore, an essential factor to be considered when planning for high aquaculture production as it determines the health and growth conditions of cultured fishes. Fish perform all their bodily functions in water, because fish are totally dependent upon water to breath, feed, grow, excrete waste, maintain a salt balance and reproduce. Water quality parameters were taken during the experiment in every two weeks. Temperature was determined using a thermometer, Dissolved oxygen; pH and conductivity were also measured according to the method of (APHA, 1980).

3.12.1 Conductivity

The Jenway 4010 conductivity meter was used to determine the level of acidity and alkalinity the water holds at the departmental Laboratory. The conductivity meter was standardized with distilled water and the terminal was dunked into the water test and the readings were noted for stable values (APHA.1980).

3.12.2 pH

The parity of positive hydrogen particles (H+) and negative hydroxide particles (OH-) in water decides how acidic or alkaline the water is, pH model PHS-25 operated electronic meter was used to determine the pH of the water sample. Buffer solution was used to standardize the pH meter; the electrode was rinsed with distilled water and dipped into the water sample until the screen showed a fixed reading which is noted and recorded according to the methods of (APHA. 1980).

3.12.3 Temperature

This was determined using mercury-in glass thermometer by dipping it into the water body and allowed to stabilize for 5 seconds, the thermometer is removed and reading immediately recorded according to the method of (APHA.1980).

3.12.4 Dissolved oxygen

Dissolved Oxygen is the air that is disintegrated in water. It was resolved utilizing Winkler's strategy. It is clarified as thus, Oxygen tests was taken utilizing 100mlbroken dissolved oxygen bottle, the container was plunged into the water body and allowed to top off without letting air bubbles to go in, jug was dipped inside the experimental water. Then the sample was taken from the water and 1 mL of (Manganous Sulfate Solution) which is reagent A and 1ml of (Potassium Iodide) which is reagent B was incorporated. The jugs were stopped back and shacked for some seconds. At the point when the precipitates settled, a reasonable supernatant arrangement was watched in the solution. It was then transported to the Laboratory where 1 mL of concentrated Sulphuric acid was included; at that point the jug was recorded and blended tenderly. 10 ml of the solution was filled in a funnel shaped carafe and titrated with 5 ml of Na_2SO_3 utilizing 3 falls of starch solution as pointer, the end point was achieved when the blue-black shading changed to dull and the readings were taken. The dissolved oxygen was ascertained utilizing this formula according to the methods of (APHA.1980).

$$DO = \frac{TV \times 0.025 \times 8 \times 1000}{10} \qquad (3.6)$$

3.13 Evaluation of Growth Parameters

Nutrient utilization and growth performance were analysed in terms of final weight gain (FWG), percentage survival rate (% SR), specific growth rate (SGR), feed conversion ratio (FCR) and feed conversion efficiency (FCE) they were calculated using the formulae below as described by Maynard *et al*. (1979), Bondi (1987) and Halver (1989) and (Gabriel *et al*., 2014). The weight of individual fish was determined with a weighing balance. The experimental tanks were examined on daily basis to remove dead fish. The initial and final mean weights per treatment were computed as follows.

3.13.1 Mean weight gain (MWG)

The main weight gain is estimated as

Where

MFW: - mean final weight

MIW: - mean initial weight of fish

MWG = MFW – MIW

3.13.2 Mean length gain (MLG)

MWG = MFL – MIL

Where

MFL is mean final length

MIL is mean initial length

3.13.3 Protein efficiency ratio (PER) (Osborne *et al*., 1919), as cited by Sadiku *et al.* (2012).

$$\text{PER} = \frac{\text{Wet body gain}}{\text{protein intake}} \quad (3.7)$$

3.13.4 Body weight gain $= \frac{\text{Final weight (g)} - \text{initial weight (g)}}{\text{initial weight (g)}}$ (3.8)

3.13.5 Feed efficiency (%) $= \frac{\text{Weight gained (g)}}{\text{feed fed (g)}} \times 100$ (3.9)

3.13.6 Feed conversion ratio (%) $= \frac{\text{Feed fed (g)}}{\text{weight gained (g)}} \times 100$ (3.10)

3.13.7 Specific growth rate (%) Brown (1957)

$$\text{SGR} = \frac{\text{Ln final weight (g)} - \text{Ln initial weight (g)}}{\text{Time (days)}} \times 100 \quad (3.11)$$

3.13.8 Survival rate (%) $= \frac{\text{No.of fish left at end of experiment}}{\text{stocking rate}} \times 100$ (3.12)

3.13.9 Apparent net protein utilization ANPU (%) Bender and Miller, (1953)

$$\text{ANPU} = \frac{(\text{P2} - \text{P1})}{\text{total protein consumed(g)}} \text{x } 100 \quad (3.13)$$

Where,

P1 is the protein in fish carcass (g) at the beginning of the study

P2 is the protein in fish carcass (g) at the end of the study.

3.14 Statistical Analysis

Growth responses and feeds utilization parameters obtained from the different treatments and their replicates were subjected to statistical analysis using Minitab release 14 package. Data were subjected to analysis of variance (ANOVA) using Turkey's test at 5 % probability level. Multiple parameters mean comparison of treatments was according to Duncan multiple ranges tests Steel and Tories (1981), Duncan (1995) and cited by (Orire *et al*., 2013). Graphical analyses were plotted with Microsoft Excel window 2010.

CHAPTER FOUR

4.0 RESULTS

4.1 Mineral Compositions of Shea Nut Fractions (Shea-Nut Meal and Shea Nut Residue)

Table 4.1, shows the mineral composition in the shea fraction (shea nut meal and shea nut residue) used as one of the ingredients used in formulating the experimental diets. The following mineral composition was found in the shea nut and shea residue which is of economic importance to fish when incorporated in the diet. This includes potassium, calcium, magnesium, iron and sodium.

The most predominant mineral found in the Shea nut used for these experiments was potassium with values up to 36.4 mg/100g. Calcium and Sodium were also high with values of 10.72 mg/100g and 5.88 mg/100g respectively. Magnesium and iron minerals were generally low in the Shea nut with values of 3.35 mg/100g and 1.25 mg/100g, respectively.

More so, in Shea nut residue, the most predominant mineral found was potassium with values up to 41.75 mg/100g. Calcium and Sodium recorded 13.25 mg/100g and 6.30 mg/100g respectively. Magnesium and iron minerals were generally low in the Shea nut residue with values of 5.84 mg/100g and 2.18 mg/100g, respectively. However, it appeared that values of minerals obtained from shea nut residues in general were higher than from shea nut meal.

Table 4.1: Mineral Composition (Mg/100) of Shea Nut Meal and Shea Nut Residue

PARAMETERS		SHEA NUT	SHEA NUT RESIDUE
Sodium	Na	5.88	6.3
Potassium	K	36.4	41.75
Calcium	Ca	10.72	13.25
Magnesium	Mg	3.35	5.84
Iron	Fe	1.25	2.18

4.2 Growth Performance and Nutrients Utilization of *Clarias gariepinus* Fed Shea Nut Meal Based (SNM) Experimental Diets

There was no significant difference ($p>0.05$) in the mean initial weight (MIW) of the fish used for the experiment. However, there was significant difference ($P<0.05$) in the mean final weight of the experimental fish fed the shea nut meal based experimental diets.

The mean final weights varied between (14.68 g - 17.28 g). Fish fed diet 3 had the least mean final weight (14.68 g), while that fed diet 8 and 9 had the highest mean final weight (17.28 g). Diet 8 and diet 9 recorded high mean final weight gain (MFWG) of (17.28 g and 17.28 g) respectively. Similarly, there was significant difference ($P<0.05$), in mean body weight gain. Fish fed diet 9 recorded highest mean weight gain (MWG) (13.70 g), which was higher than the reference diet 1 (12.77 g), and other experimental diets. The least mean weight gain (MWG) was diet 3 (11.09 g) as shown in Table 4.2.

There was no significant difference ($P>0.05$) in the mean initial length (MIL) of the fish used for the experiment. However, there was significant difference ($P<0.05$) in the mean final length (MFL) of the experimental fish. The mean final length varied between (11.43 cm - 12.03 cm). Fish fed diet 7 had the least mean final length (11.43 cm), while diet 10, had the highest mean final length (12.03 cm). Similarly, there was significant difference ($P<0.05$) of mean body length gain. Fish fed diet 10, recorded highest mean length gain (6.9 cm) and the least was diet 7 (6.2 cm).

The specific growth rate (SGR) differed significantly among the Diets ($p<0.05$). Diet 9 had the highest SGR value (2.81 $\%day^{-1}$), followed by diet 8 (2.78 $\%\ day^{-1}$) as shown in Table 4.2.

The feed conversion ratio (FCR) of the diets differed significantly ($p<0.05$) from each other. However, diet 9 apparently recorded the lowest FCR of (0.85) and diet 2, 3 and 4 recorded the highest FCR as shown in Table 4.2.

The protein efficiency ratio (PER) differs significantly ($p<0.05$) from each other. Diet 4 had highest PER value of (3.18), followed by diet 7 and diet 3 with PER value of (3.16 and 3.11), while diet 10 had the lowest PER value of (2.33) as shown in Table 4.2.

The Apparent net protein utilization (ANPU) differed significantly ($P<0.05$) from each other. Diet 1 reference diet had the highest ANPU value of (5.52), followed by diets 6 and diet 3 with ANPU of (5.44 and 5.40) respectively.

Finally, from the result in Table 4.5, there was significant difference ($P<0.05$) in the percentage survival rate (SVR) of the experimental fish. Fish fed diet 1 reference diet had the highest survival rate (93.33 %), diet 10 had the least survival rate (60.00 %).

Table 4.2: Mean Growth Parameters of *Clarias gariepinus* Fed Various Lipid-Protein Ratios of Shea Nut Based Diets for 8 Weeks

Parameter	D1 (CRD)	D2	D3	D4	D5	D6	D7	D8	D9	D10
MIW (g)	3.55±0.44^{a}	3.70±0.13^{a}	3.59±0.56^{a}	3.49±0.06^{a}	3.49±0.82^{a}	3.59±0.10^{a}	3.71±0.06^{a}	3.66±0.03^{a}	3.58±0.10^{a}	3.44±0.09^{a}
MFW (g)	16.32±0.15^{b}	15.78±0.46^{b}	14.68±0.13^{c}	14.81±0.55^{c}	16.05±0.18^{b}	15.72±0.22^{b}	16.73±0.19^{ab}	17.28±0.12^{a}	17.28±0.13^{a}	15.76±0.35^{b}
MWG (g)	12.77±0.15^{a}	12.08±0.50^{b}	11.09±0.18^{c}	11.33±0.60^{c}	12.56±0.21^{ab}	12.13±0.13^{b}	13.08±0.15^{a}	13.62±0.11^{a}	13.70±0.21^{a}	12.21±0.41^{b}
MIL (cm)	5.2±0.06^{a}	5.2 ±0.10^{a}	5.2±0.10^{a}	5.2±0.06^{a}	5.4 ±0.06^{a}	5.5±0.06^{a}	5.2±0.10 ^{a}	5.3±0.15^{a}	5.2 ±0.15^{a}	5.2±0.31^{a}
MFL (cm)	11.9 ±0.81^{a}	11.8 ±0.45^{a}	11.9±0.35^{a}	11.6±0.31^{a}	11.9±0.25^{a}	11.7±0.42^{a}	11.4±0.21^{b}	11.7±0.27^{a}	11.9±0.31^{a}	12.0±0.40^{a}
MLG (cm)	6.7±0.85^{a}	6.6 ±0.55^{a}	6.7±0.44^{a}	6.4±0.30^{b}	6.6 ±0.31^{a}	6.3±0.40^{b}	6.2±0.29^{b}	6.4±0.31^{a}	6.7±0.46^{a}	6.9±0.67^{a}
SGR%day^{-1}	2.73±0.03^{a}	2.59±0.09^{a}	2.51±0.04^{a}	2.58±0.09^{a}	2.73±0.05^{a}	2.64±0.02^{a}	2.72±0.03^{a}	2.78±0.00^{a}	2.81±0.06^{a}	2.66±0.08^{a}
FCR	0.86±0.05^{a}	1.08±0.07^{a}	1.08±0.05^{a}	1.05±0.03^{a}	1.00±0.06^{a}	0.94±0.06^{a}	0.90±0.04^{a}	0.90±0.05^{a}	0.85±0.04^{a}	1.08±0.07^{a}
PER	2.59±0.14^{ab}	3.08±0.20^{a}	3.11±0.15^{a}	3.18±0.11^{a}	2.85±0.15^{ab}	3.06±0.21^{a}	3.16±0.13^{a}	2.79±0.6^{ab}	2.96±0.14^{ab}	2.33±0.14^{b}
ANPU	5.52±0.45^{a}	4.77±0.43^{b}	5.40±0.29^{a}	5.01±0.35^{b}	4.89±0.22^{b}	5.44±0.45^{a}	5.20±0.14^{a}	5.12±0.32^{b}	5.31±0.30^{a}	5.07±0.35^{b}
SVR (%)	93.33±5.77^{a}	70.00±10.00^{c}	73.33±5.77^{c}	70.00±10.00^{c}	66.67±5.77^{d}	73.33±5.77^{c}	73.33±11.55^{c}	83.33±5.77^{b}	80.00±10.00^{b}	60.00±0.00^{d}

Means with the same superscript along the row do not differ significantly (P>0.05)

MIW: - Mean Initial Weight

MFW: -Mean Final Weight

MWG: - Mean Weight Gain

MIL: -Mean Initial Length

MFL: - Mean Final Length

MLG: - Mean Length Gain

SGR: - Specific Growth Rate

FCR: - Feed Efficiency Rate

ANPU: - Apparent Net Protein Utilization

SVR: - Survival Rate

PER: - Protein Efficiency Ratio

CRD: Commercial Reference Diet

4.3 Effects of Shea Nut Meal Based (SNM) Diets on Body Composition

From the result in Table 4.3, the values of the body composition of crude protein, crude lipid, ash moisture and NFE shows significant difference ($P<0.05$) observed among the shea-nut based diets.

There was no significant difference in crude protein ($P>0.05$), between fish fed diets 1, 6 and 7 in percentage body composition (58.26 %), (58.88 %) and (58.99 %) respectively. The body crude protein of fish fed diet 10 containing 40 % protein and 20 % lipid of (Shea nut meal) was higher than initial carcass crude protein (50.15 %). The body crude protein for diet 4 containing 30 % protein and 20 % lipid (Shea nut meal) recorded the lowest crude protein (57.17 %) among the experimental diets and also was higher than initial carcass crude protein (50.15 %) as shown in Table 4.3.

However, there was corresponding increase in the body lipid contents for diets 10, 7, 1 and 4. There was significant difference ($P < 0.05$) in lipids with fish fed diet 4 (21.72 %), had the highest lipid and least diet 8 (16.41 %).

There was significant difference ($P<0.05$) in the crude ash content. However, fish fed diet 5 (8.52 %) had the highest ash content and diet 2 (6.80 %) was the least.

There was significant difference ($P<0.05$) in the moisture content with fish fed with shea nut based diets. Diet D8 (11.18 %) recorded the highest body moisture content and least was diet 10 (9.50 %).

There was no significant difference ($P<0.05$) in the crude fibre content with fish fed with shea nut based diets. Diet 2 (1.17 %) recorded the highest fibre content and least was diet 8 and 9 (1.18 %) as shown in Table 4.3.

There was no significant difference ($P<0.05$) in the NFE content of fish fed with shea nut based diets. Diet 8 (4.40 %) recorded the highest NFE content and least was diet 4 (1.33 %) as shown in Table 4.3.

4.4 Mean Weight (g) of *Clarias gariepinus* Fed with Shea Nut Meal (SNM) Based Diets

There was no significant difference in the initial weight of *Clarias gariepinus*. The weight of fish increased significantly from week 2 to week 8. However, in week 4 diet 9 (5.84 g) gave the highest weight which differed significantly ($P<0.05$) with diets 6, 4, 3 and 5. Comparatively at 4 weeks diets 1, 9 and 10 enhanced weight gain better than diet 4 and 6. At 6 and 8 weeks diet 6 significantly gave the least weight while diet 9 significantly gave the highest mean weight of 10.87 g and 13.70 g. Generally, diet 1 and 9 showed consistent increase in all the weeks compared to diet 3 and 4. This result shows that diet 9 (13.70 g) in the 8 weeks period gave the best weight gain (Figure 4.1).

Table 4.3: Body Compositions of *Clarias gariepinus* Fingerlings Fed Shea-Nut Meal Based Diets For 56 Days

PARAMETERS (%)	INITIAL CARCAS	D1 (CRD)	D2	D3	D4	D5	D6	D7	D8	D9	D10
CP	50.15±0.81^{e}	58.26±1.18^{c}	59.32±0.78^{bc}	60.75±0.41^{b}	57.17±0.7^{d}	59.20±0.99^{bc}	58.88^{c}±0.37	58.99^{c}±0.55	59.75^{bc}±0.65	59.03^{bc}±0.62	62.51^{a}±1.24
LP	16.08±0.54^{d}	19.17±1.35^{b}	18.14±0.04^{c}	16.88±0.48^{d}	21.72±0.39^{a}	17.36±0.21^{d}	17.53±1.04^{d}	19.24±0.47^{b}	16.41±1.21^{d}	18.84±0.58^{c}	19.58±0.90^{b}
Mc	16.15±1.65^{a}	11.07±0.31^{b}	10.96±0.22^{b}	10.01±0.18^{c}	9.91 ±0.80^{c}	10.56±0.34^{c}	9.72±0.23^{d}	10.63±0.12^{c}	11.18±0.56^{b}	10.74±0.39^{e}	9.50±0.30^{d}
ASH	5.51±0.43^{d}	7.73±0.56^{b}	6.80±0.53^{c}	7.74±0.59^{b}	8.40±0.09^{a}	8.52±0.13^{a}	8.29±0.10^{a}	7.45±0.29^{b}	7.09±0.28^{b}	7.66±0.17^{b}	7.71±0.21^{b}
CF	0.47±0.10^{d}	1.39±0.16^{b}	1.77±0.10^{a}	1.23±0.08^{c}	1.47±0.09^{b}	1.22±0.04^{c}	1.29±0.12^{c}	1.40±0.27^{b}	1.18±0.06^{c}	1.18±0.06^{c}	1.75±0.09^{a}
NFE	11.64±1.29^{a}	2.38±0.44^{d}	3.00±1.13^{c}	3.73±0.76^{b}	1.33±0.73^{e}	2.89±1.76^{c}	4.30±0.85^{b}	2.29±0.61^{d}	4.40±1.12^{b}	2.55±0.44^{d}	1.03±1.01^{e}

Mean data on the same row carrying different superscripts differ significantly from each other (p<0.05).

D: -Diet
NFE: - Nitrogen Free Extract
CP: - Crude Protein
CF: - Crude Fiber
LP: - Lipid

D1: - Commercial Reference Diets
D3: - 15 L: 30 CP Inclusion
D5: - 10 L: 35 CP Inclusion
D7: - 20 L: 35 CP Inclusion
D9: - 15 L: 40 CP Inclusion

D2: - 10 L: 30 CP Inclusion
D4: - 20 L: 30 CP Inclusion
D6: - 15 L: 35 CP Inclusion
D8: - 10 L: 40 CP Inclusion
D10: - 20 L: 40 CP Inclusion

CRD: - Commercial Reference Diet

MC: -Moisture Content

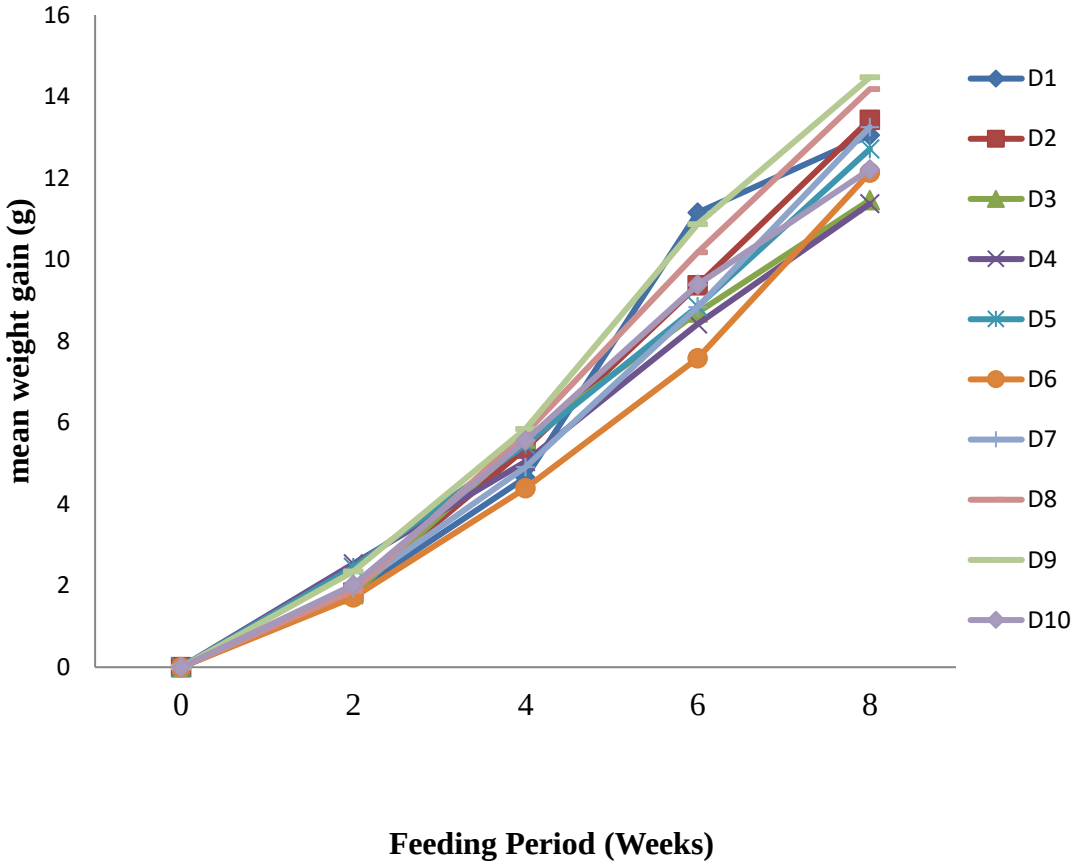

Figure 4.1: Growth Response of *Clarias Gariepinus* Fingerlings Fed Shea Nut Meal (SNM) Based Diets as Lipid Source For 8 Weeks

4.5 Growth Performance and Nutrients Utilization of *Clarias gariepinus* Fed Shea Nut Residue Based Experimental Diets

There was no significant difference (P>0.05) in the mean initial weight of the fish used for the experiment. However, there was significant difference (P<0.05) in the mean final weight of the experimental fish. The mean final weights varied between (7.98 g -16.05 g). Fish fed diet 4 had the least mean final weight (11.77 g), while that fed diet 1had the highest mean final weight (16.05 g). Similarly, there was significant difference (P<0.05), in mean body weight gain. Fish fed diet 1 had the highest mean weight gain (12.29 g) and the least was diet4 (7.98 g) as shown in Table 4.4.

There was no significant difference (P>0.05) in the mean initial length of the fish used for shea nut residue based experiment diets. However, there was significant difference (P<0.05) in the mean final length of the experimental fish. The mean final length varied between (10.70 cm - 11.70 cm). Fish fed diet 4 had the least mean final length (10.70 cm), while that fed diet 9 had the highest mean final length (11.70 cm). Similarly, there was significant difference (P<0.05) of mean body length gain. Fish fed diet 9 recorded highest mean length gain (6.60 cm) and the least was D1 commercial reference diet (5.80 cm) as shown in Table 4.4.

The specific growth rate (SGR) differed significantly among the Diets (P<0.05). Diet 1, the commercial reference diet had the highest SGR value (2.59 $\%day^{-1}$), while diet 4 has the least SGR (2.02 $\%day^{-1}$) as shows in Table 4.4.

The feed conversion ratio (FCR) of the diets differed significantly (P<0.05) from each other. However, diet 10 apparently recorded the lowest FCR of (0.97) while diet 4 recorded the highest FCR (1.19) as shown in Table 4.4.

The protein efficiency ratio (PER) differed significantly ($P<0.05$) from each other. Diet 2 recorded the highest PER value of (3.28) while diet D1 has the least PER (2.21). The Apparent net protein utilization (ANPU) differed significantly ($P<0.05$) from each other. Diet 7 had the highest ANPU value of (7.45) and least was diet 1 the reference diet (4.99).

From the result in Table 4.4 below there was significant difference ($P<0.05$) in the survival rate. Diet 1 (CRD), diet 6 and diet 9 recorded highest survival rate (SVR) of (76.67 %), while diet 4 recorded the least survival rate (53.33 %) as shown in Table 4.4.

Table 4.4: Mean Growth Parameters of *Clarias gariepinus* Fed Various Lipids: Protein Ratios of Shea Nut Residue Based Diets For 8 Weeks

Parameters	D1 (CRD)	D2	D3	D4	D5	D6	D7	D8	D9	D10
MIW (g)	3.77±0.06^{a}	3.80±0.02^{a}	3.80±0.01^{a}	3.79±0.02^{a}	3.78±0.05^{a}	3.77±0.06^{a}	3.78±0.07^{a}	3.80±0.03^{a}	3.80±0.02^{a}	3.85±0.12^{a}
MFW (g)	16.05±0.08^{a}	13.53±0.4^{e}	12.76±0.51^{f}	11.77±0.5^{g}	13.22±1.50^{e}	15.10±0.36^{c}	11.78±0.26^{g}	14.29±1.3^{d}	15.77±0.88^{d}	15.44±0.72^{c}
MWG(g)	12.29±0.06^{a}	9.73±0.43^{d}	8.96±0.50^{e}	7.98±0.56^{f}	9.44±1.46^{d}	11.33±0.39^{b}	8.00± 0.27^{f}	10.49±1.2^{c}	11.97±0.88^{ab}	11.58±0.69^{ab}
MIL (cm)	5.2±0.06^{a}	5.3±0.21^{a}	5.0±0.21^{a}	4.8±0.10 ^{a}	4.8±0.15 ^{a}	5.0±0.06 ^{a}	5.0±0.06 ^{a}	5.0±0.10 ^{a}	5.1±0.06 ^{a}	5.1±0.35 ^{a}
MFL (cm)	11.0±0.21^{b}	11.2±0.25^{b}	11.0±0.51^{b}	10.7±0.32^{bc}	10.9±0.20^{b}	11.3± 0.36^{b}	11.2±0.06^{b}	11.4±0.12^{b}	11.7±0.32^{a}	11.2±0.06^{b}
MLG (cm)	5.8±0.17^{b}	5.9±0.20^{b}	6.0±0.40^{b}	5.9±0.25^{b}	6.1±0.15^{b}	6.3±0.40^{ab}	6.2±0.30^{b}	6.4±0.21^{ab}	6.6± 0.26^{a}	6.1±0.31^{b}
SGR(%day^{1})	2.59±0.02^{a}	2.26±0.06^{c}	2.16±0.07^{c}	2.02±0.08^{d}	2.23±0.18^{c}	2.48±0.06^{a}	2.23±0.40^{c}	2.36±0.15^{bc}	2.54±0.10^{a}	2.48±0.08^{a}
FCR	1.01±0.01^{b}	1.02±0.07^{b}	1.12±0.06^{ab}	1.19±0.12^{a}	1.11±0.14^{ab}	1.01±0.06^{b}	1.17±0.13^{a}	0.99±0.01^{b}	1.03± 0.06^{b}	0.97±0.04^{b}
PER	2.21±0.02^{d}	3.28±0.20^{a}	2.98±0.15^{b}	2.66±0.26^{bc}	2.59±0.35^{bc}	2.78±0.18^{bc}	2.47±0.26^{bc}	2.44±0.14^{bc}	2.43±0.14^{bc}	2.59±0.11^{bc}
ANPU	4.99±0.13^{f}	6.47±0.51^{b}	6.66±0.17^{b}	6.50±0.14^{b}	6.71±0.30^{b}	6.00±0.07^{bc}	7.45±0.59^{a}	5.80±0.41^{c}	5.13±0.08^{e}	6.14±0.12^{bc}
SVR (%)	76.76±5.77^{a}	63.33±5.77^{b}	73.33±5.77^{a}	53.33±5.77^{c}	60.00±10.00^{b}	76.76±5.77^{a}	73.3±11.55^{a}	73.33±5.77^{a}	76.76±5.77^{a}	70.0±10.00^{a}

Mean data on the same row carrying different superscripts differ significantly from each other (p<0.05).

MIW: - Mean Initial Weight
MFW: - Mean Final Weight
MWG: - Mean Weight Gain
FER: - Feed Efficiency Rate
MFL: - Mean Final Length
MLG: - Mean Length Gain
SGR: - Specific Growth Rate
FCR: - Feed Conversion Rate
ANPU: - Apparent Net Protein Utilization
SVR: - Survival Rate
D: - Diets
MIL: - Mean Initial Length
CRD: - Commercial Reference Diet

4.6 Effects of Shea Nut Residue (SNR) Based Diets on Body Composition

From the result in Table 4.5 the values of body composition of crude protein, crude lipid, ash and moisture, shows significant difference ($P<0.05$) among the shea nut residue based experimental diets.

The body crude protein of fish fed diet 10 containing 40 % protein and 20 % lipid of (Shea nut residue), recorded highest body crude protein (63.57 %) and the least was diet 8 (58.32 %).

There was significant difference ($P<0.05$) in lipids, with fish fed diet 10 (17.06 %), had the highest lipid and least diet 1 (16.36 %).

There was significant difference ($P<0.05$) in the crude ash content. However, fish fed diet 9 (7.23 %) had the highest ash content and diet 2 (6.13 %) was the least.

There was significant difference ($P<0.05$) in the moisture content with fish fed with shea nut residue based diets. Diet 4 (10.57 %) recorded the highest body moisture content and least was diet 10 (9.28 %).

There was no significant difference ($P<0.05$) in the crude fibre content with fish fed with shea nut based diets. Diet 5 (2.49 %) recorded the highest fibre content and least was diet 1 (1.24 %).

There was no significant difference ($P<0.05$) in the NFE content of fish fed with shea nut residue based diets. Diet 1 (7.90 %) recorded the highest NFE content and least was diet 10 (0.50 %) as shown in Table 4.5.

4.7 Mean Weight (g) of *Clarias gariepinus* Fed with Shea Nut Residue (SNR) Based Diets

There was no significant difference in the initial weight of *Clarias gariepinus*. The weight of fish increased significantly from week 2 to week 8. However, in week 4 diet 1 (4.65 g) gave the highest weight which differed significantly ($P<0.05$) with diets 2, 4, 5 and 7. Comparatively at 4 weeks diets 1, 6 and 9 enhanced weight gain better than diet 2 and 7. At 6 and 8 weeks diet 7 significantly gave the least weight while diet 1 significantly gave the highest mean weight of 11.15 g and 12.29 g. Generally, diet 1 and 9 showed consistent increase in all the weeks compared to diet 7 and 2. This result shows that diet 1 (12.29 g) in the 8 weeks period gave the best weight gain (Figure 4.2).

Table 4.5: Body Composition of *Clarias gariepinus* Fingerlings Fed Shea nut Residue Based Diets for 56 Days

parameters %	INITIAL CARCAS	D1 (CRD)	D2	D3	D4	D5	D6	D7	D8	D9	D10
CP	48.32±0.31^{f}	58.67±0.49^{e}	59.54±1.35^{d}	60.79±0.77^{c}	59.75±0.77^{d}	63.53±0.63^{a}	63.20±1.03^{a}	62.22±0.82^{b}	58.32±0.13^{e}	59.60±0.41^{d}	63.57±0.63^{a}
LP	15.33±1.10^{f}	16.36±1.11^{c}	17.91±0.73^{d}	18.64±0.39^{c}	19.11±0.79^{b}	17.36±0.32^{d}	18.20±0.03^{c}	17.73±0.54^{d}	20.17±0.09^{a}	19.88±0.20^{a}	17.06±0.46^{d}
MC	15.64±1.4^{a}	9.35^{c}±0.13^{b}	9.28±0.15^{c}	9.99±0.18^{c}	10.57±0.13^{b}	9.42±0.06^{c}	9.81±0.57^{c}	10.25±0.06^{b}	9.43±0.05^{c}	9.46±0.08^{c}	9.80±0.08^{c}
ASH	4.25±0.11^{c}	6.48±0.30^{b}	6.74±0.25^{b}	6.24±0.09^{b}	7.10±0.12^{a}	6.39±0.04^{b}	6.13±0.07^{b}	7.08±0.06^{a}	7.12±0.07^{a}	7.23±0.04^{a}	6.93±.06^{b}
CF	1.14±0.05^{b}	1.24±0.056^{b}	1.91±0.01^{b}	2.16±0.07^{a}	2.22 ±0.08^{a}	2.49±0.32^{a}	2.29±0.21^{a}	2.12±0.05^{a}	2.29±0.06^{a}	2.13±0.04^{a}	2.14±0.02^{a}
NFE	15.33±1.81^{a}	7.90±1.88^{b}	4.61±1.50^{c}	2.18±0.59^{e}	1.26±1.59^{g}	1.02±0.25^{g}	0.37±0.27^{h}	0.60±0.13^{h}	2.67±0.07^{d}	1.69±0.42^{f}	0.50±0.43^{h}

Mean data on the same row carrying different superscripts differ significantly from each other (p<0.05).

D: - Diet **D1**: - Commercial Reference Diets **D2**: - 10 L: 30 CP Inclusion
NFE: - Nitrogen Free Extract **D3**: - 15 L: 30 CP Inclusion **D4**: - 20 L: 30 CP Inclusion
CP: - Crude Protein **D5**: - 10 L: 35 CP Inclusion **D6**: - 15 L: 35 CP Inclusion
CF: - Crude Fiber **D7**: - 20 L: 35 CP Inclusion **D8**: - 10 L: 40 CP Inclusion
LP: - Lipid **D9**: - 15 L: 40 CP Inclusion **D10**: - 20 L: 40 CP Inclusion

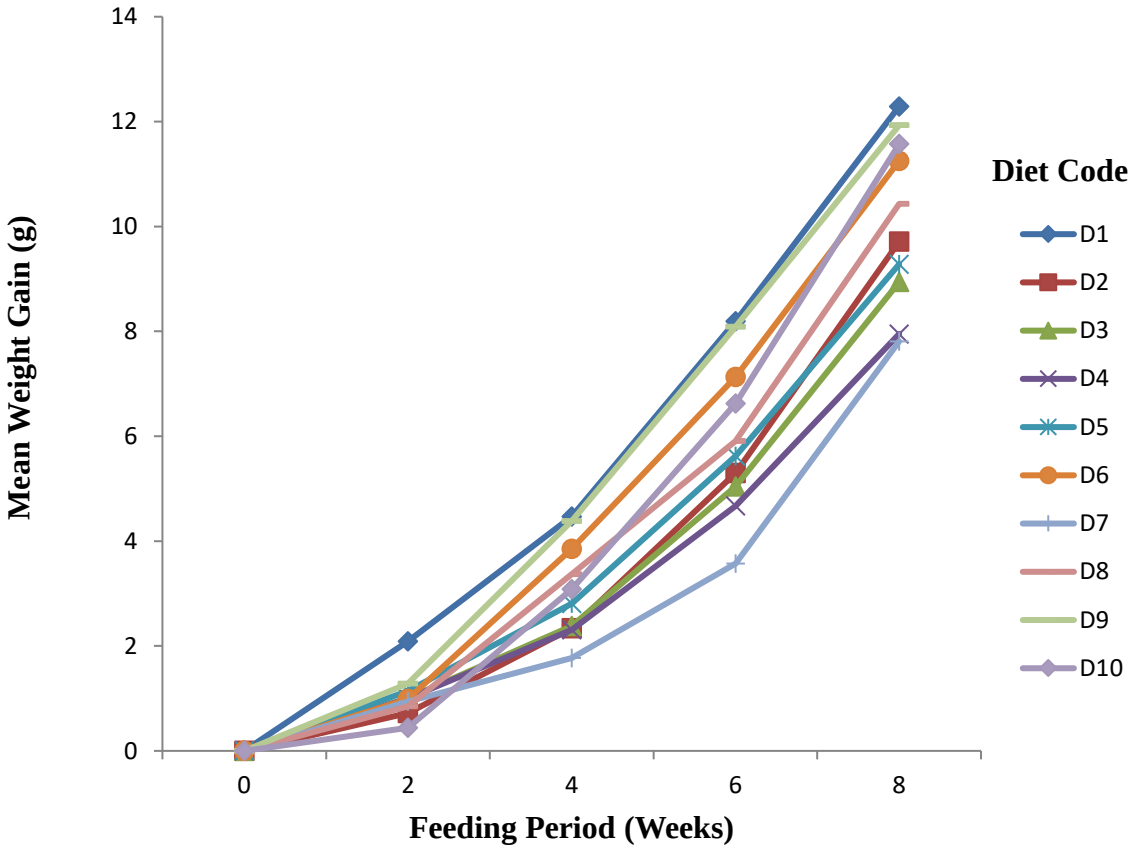

Figure 4.2: Growth Response of *Clarias gariepinus* Fingerlings Fed Shea Nut Residue (SNR) Based Diets as a Lipid Source For 8 Weeks

CHAPTER FIVE

5.0 DISCUSSION

5.1 Discussion

The present study investigated the mineral composition of shea nut meal, shea nut residue, proximate composition, nutrient utilization or growth performance and body composition of *Clarias gariepinus* fingerlings fed combine source of lipid and protein at different ratio. It has been reported by Okullo *et al*. (2004), that plant lipid source provides essential minerals which help in nutrient utilization and growth performance of *Clarias gariepinus*. Essential mineral like sodium, magnesium, calcium, iron and potassium were found to be abundant in Shea nut fraction (shea nut meal and shea nut residue) which agreed with findings of Okullo *et al*. (2004) and Mbaiguinam *et al*. (2007) who states that the most predominant mineral in shea product are sodium, magnesium, calcium, iron and potassium.

Crude protein (CP) contents of the shea nut fraction (Shea nut meal and Shea nut residue) used in this study were (9.80 % and 10.73 %) crude protein. Similar to the values of 11 - 15 % CP reported by Agbo and Prah (2014), and 15 - 30 % CP by (Dei *et al.,* 2008), but lower than the (20 - 35 % CP), Comparing the Crude Protein levels in the Shea nut fraction (Shea-nut meal and Shea residue) obtained in this study with other oilseed meals like groundnut cake and soya bean meal from the work of Agbo *et al*. (2009), the values were far lower than those of this study. National Research Council (1993) reported that, an ingredient is considered a protein source when it has not less than 25 % Crude Protein. Lovett (2004) and Bake *et al*. (2009) also reported that nutrient composition of feedstuffs depends on the origin or processing methods used. Gross energy level followed the same trend as the lipid content, probably because, lipid is a very good source of energy in fish feed and high inclusions lead to higher energy

feed. Solomon *et al*. (2012), states that Crude lipid in Shea nut meal was high almost double that of Shea nut residue, this could be attributed to the oil extraction, and method of extraction in the case of shea nut residue based diets compared to shea nut meal based diets where the whole Shea nut were crushed together and this added more fiber to its composition.

The use of shea nut meal (SNM) in the diet of *Clarias gariepinus* fingerling improve growth performance and nutrient utilization, in this study as some diets with various inclusion levels of shea nut meal performed better than the control diet without shea nut meal (Table 4.2). This may have been as a result of the energy provided by the shea nut meal for metabolism, hence, allowing the use of the lipid/protein component of the feed for growth and development. It may be inferred that, increased lipid level spared dietary protein conversion into energy (Chou & Shiau, 1996; Regost *et al*., 2001). Solomon *et al.* (2012), had earlier concluded that plant based lipid diets such as groundnut oil, palm oil, and Shea nut oil are well utilized by *Clarias gariepinus* which was confirmed in this study. Also plant lipid sources have been reported to be good natural source of carotenoids, tocopherols and tocotrienols which function as natural antioxidant, hence conferring beneficial effects on growth and flesh quality (Lim *et al*., 2001).

The mean initial weight (MIW) of the fishes used in the experiment does not differ significantly ($p>0.05$) from each other. All the ten diets performed well but diet 9 performed best. This implies that diets 9 containing 15 % lipid and 40 % protein is as good as the commercial reference diet. The performance was an indication of positive contribution to growth and survival of the fish which is in agreement with the findings of (Nwanna *et al*., 2009). The growth response of fish fed shea nut meal based diets. Diet 1(commercial reference diet), diet 7, diet 8 and diet 9 peaked faster than other

diets, while diet 3 with 10 % lipid and 30 % protein of Shea nut meal was the lowest in growth phase. This could be attributed to low percentage of lipid/protein ratio in the diet (Table 4.2) which could be as a result of presence of high fibre content of the diet which is in agreement with the reports of Orire and sadiku (2011),

There was no significant difference ($p>0.05$) between FCR, SGR and PER of Diets 7, 8 and 9, this indicates that the fish was able to digest the diets and converts it into body tissue with same degree of efficiency. In the first two weeks of the experiments, their growth dropped drastically (Table 4.2). It was probably due to the fact that the fishes were getting acclimatized to the formulated diets. Thereafter, all fishes picked up and started utilizing the diets better which agrees with the findings of Orire *et al.* (2013).

The growth-response curve showed slow growth phase from week 0 - 2, while from week 6 - 8, marginal growth phase was recorded. This is in line with natural growth situation, as growth in fish is exponential Nwanna *et al*. (2009), Orire *et al.* (2013). This implies that, as the fishes grow bigger, the conversion rate of feed to flesh increases. This was good enough especially at fingerlings stage when the fish is still going through the lag phase. The fast growth rate could be attributed to the level of lipid and protein ratio in the diets as the percentage inclusion level increases. *Clarias gariepinus* has been reported to have poor handling of high level of fibre in its diets.

Carcass analysis (Table 4.3) showed significant difference ($p<0.05$), between the commercial reference diet and other diets, in terms of crude lipid, crude protein, crude ash and moisture. The crude protein values of diet 4 was lower than that of commercial reference diet (58.26 %), while diets 8 and 9 also have better growth ratio which is in agreement with Aderolu *et al*. (2011), the experimental diets performed better than the

reference diet (D1) in terms of growth and nutrients utilization (Sogbesan, 2006 and Bake *et al.*, 2015).

There is no significant difference ($p>0.05$), observed in the mean initial weight (MIW) of the fish used in the experiment of shea nut residue inclusion (SNR). All the ten (10) diets performed well but D1 (commercial reference diet) performed better than all other diets in experiment two, followed by diet 9 containing 15 % lipid and 40 % protein. The performance was an indication of positive contribution to growth of the fish which agree with the findings of (Orire & Abubakar, 2013), that catfish fingerlings tends to grow as they absorb required nutreint at particular period of time with mean initial weight (MIW) of 3.4 g, 3.5 g and 3.2 g and final weight gain was 6.6 g, 5.9 g and 5.7 g respectively. Diet 1 (reference diet), diet 9 and diet 10 peaked faster than other diets, while diet 4 with 15 % lipid and 30 % protein of Shea nut residue was the lowest in growth phase. This could be attributed to low percentage of lipid/protein ratio in the diet (Table 4.4) which could be as a result of presence of high fibre content of the diet Orire and Sadiku (2013).

There is no significant difference ($p>0.05$) between FCR, SGR and PER of Diets 1 and 9, this indicates that the fish was able to digest the diets and converts it into body tissue with same degree of efficiency. In the first two weeks of the experiments, their growth dropped drastically (Table 4.4 and Figure 4.2). It is probably due to the fact that the fish were getting acclimatized to the formulated diets. Thereafter, all fish continued growth normally and started utilizing the diets better.

Carcass analysis (Table 4.5) showed significant difference ($p<0.05$) between the commercial reference diet and other diets, in terms of crude lipid, crude protein, crude ash and moisture. The crude protein values of diet 1 was lower than that of diet 10

(63.57 g), while diets 9 (D9) and (D10) also have better growth ratio which is in agreement with Aderolu *et al*. (2011). The experimental diet also performed better in terms of growth and nutrients utilization as observed in this study.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The minerals found in shea nut and shea nut residue were sodium, magnesium, calcium, iron and potassium which are known for their growth enhancement properties. Formulated diets from both shea nut fractions (shea nut meal and shea nut residue) are efficiently utilized by *Clarias garipinus* fingerlings. Shea nut meal and shea nut residue are promising plant based lipid sources to aquaculture, since most of their nutrients are utilized and they had excellent feed conversion and growth in terms of weight gain. However, the best diet in shea nut meal and shea nut residue experiment was diet 9, with mean weight gain (13.70 g), specific growth rate (2.81 $\%day^{-1}$), fed conversion rate (0.85) and percentage survival rate (80.00 %), at 15 % lipid and 40 % protein inclusion level.

6.2 Recommendations

i. Due to its importance in growth enhancement, the mineral compositions of shea fractions from other location should be investigated.
ii. 15 % lipid and 40 % crude protein ratio of both shea nut fractions (shea nut meal and shea nut residue) is recommended for the diet *Clarias gariepisnus* respectively both in terms of growth and nutrient utilization.
iii. Further studies should be carried out on utilization of shea nut fraction (shea nut meal and shea nut residue) as lipids sources for aquaculture species.
iv. Further studies on different processing methods should be carried on its utilization in the practical diets of *Clarias gariepinus* and other fish species.

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