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Proximate Analysis and Characterization of Fish Feed Produced From Locally Sourced Materials

OKWU, Kingsley Chidiebere

August, 2021

Proximate Analysis and Characterization of Fish Feed Produced From Locally Sourced Materials

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OKWU, Kingsley Chidiebere
(PG.2018/00236)

A Dissertation Submitted to the Post Graduate School, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt in Partial Fulfillment of the Requirements for the Award of Master of Technology (M.Tech) in the Department of Chemical /Petrochemcial Engineering, Faculty of Engineering.

August, 2021

ABSTRACT

A robust experimental design setup and stepwise procedure for the production of fish feed using different locally sourced feedstock was investigated in this research study wherein the design methodology for the setup was developed in a clear concise manner. In addition, the end product composition of the different locally sourced feedstock (raw materials) was comparatively evaluated in terms of end product composition content of three interest variables of crude content, fibre and fats. Nevertheless, amongst the different feed stuffs, it is observed that blood meal as a feedstock, had the most comparative end product composition of crude protein (CP) content (above 80kg) whereas soybeans feedstuff had the most end product composition content in terms of fibre (about 30kg) and palm kernel cake (PKC) had the most end point composition for fat content (about 50kg) in a 100kg feedstock basis. However, flour as a feed stuff was found to contain approximately zero end product composition content of the aforementioned variables, the obtained results with respect to the three variables of crude protein (CP), fibre and fat contents for all feedstock were comparatively analyzed against standard literature values obtainable and waas found to be consistent to literature and industrial findings. Additionally, an optimum feed rate for the production of fish feed using the different feed stuff was determined wherein it was discovered that 100kg feed rate was the optimum feed rate, furthermore, the cost efficiency was analyzed on a 500kg feed material with foreign feed costing N514, 800 while produced fish feed cost N201,300 which is 50% less production cost against foreign feed .

DECLARATION

I, **OKWU, Kingsley Chidiebere (PG.2018/00236)** hereby declare that the dissertation represents my original work done by me under the through supervision of Profess Dr. Animia A. Wordu and Professor Kenneth .K. Dagde and has not been previously submitted either wholly or in part anywhere else or in this University, by any other person(s) whether academic or otherwise, for any other purpose or the purpose of awarding or Master of Technology Degree in Chemical Engineering.

…………………………. **…………………**

Signature **Date**

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CERTIFICATION

We certify that **OKWU, Kingsley Chidiebere (PG.2018/00236)** carried out this research work titled "**Proximate Analysis and Characterization of Fish Feed Produced From Locally Sourced Materials**. He has been thoroughly examined and meets the requirement governing the award of Master of Technology Degree in Chemical Engineering, Faculty of Engineering, Rivers State University, Port Harcourt.

……………………………….. ………………………..
Dr. A. A. Wordu **Date**
(Main Supervisor)

……………………….. ………………….…..
Prof. Kenneth Dagde **Date**
(Co-Supervisor)

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……………………………. ………….…………
Prof. Kenneth K. Dagde **Date**
(Head of Department)

……………………………. ………….…………
Prof. C. O. Ahiakwo **Date**
(Dean Faculty of Engineering)

……………………………. ….……..………………..
(External Examiner) **Date**

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DEDICATION

I most gratefully dedicate this work to Almighty God who made this work possible to him be all the glor

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I sincerely express my profound gratitude to my main supervisor, Dr. A.A. Wordu, for his encouragement, thoughtful advice and intellectual inputs in this project work. I also wish to thank my Head of Department Prof. K. K. Dagde, who is also my co-supervisor for his fatherly role and deep academic assistance, advice, moral support and inspirations through this academic. They have been so helpful all through the process of this work.

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CHAPTER 1

INTRODUCTION

1.1 Background to the Study

The importance and relevance of fish or fisheries aquaculture is increasing both locally and globally because of its demand and supply chain in quantity. The monetary value to both consumers and farmers respectively. Most Asain countries have integrated fish farming culture into the daily livelihood, activities of the rural farming families, this therefore serving as an avenue for good fish as food and protein supply, poverty emancipation and income generating activating, which is a major source of food security and job creation.

Dey *et al.*, (2002), Edwards (2000) posited that the relent NEPAD – fish for all summit "New partnership for African's Development" NEPAD (2005) held at Abuja Nigeria, indicates present government commitment for exploit the positive elements for fisheries aquaculture to stimulate socio-economic growth and development of fisheries sub-section. To achieve the set goals decision – making based on scientific evidence requires reliable, relevant and timely information (FAO, 2005). Information as a factor of production increases productivity, profitability and socio-economic value of the users.

Hence status reporting has become an issue because of the risk of misinformation (FAO, 2005). Fish farming is said to be more than 2000 years of but started in Nigeria in the early 1950s in panyam plateau state, then spread to Onikan in Lagos and Umuna Okigwe in Imo State according to Wokoma (1986). Though the desired output in terms of fish output and demand satisfaction has not be obtain both by government agricultural scheme and private fish farmers. The popularization of fish farming was solely the responsibility of government until recent times

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when government private fish farmers learnt the skill required to rear fish. Feed provides all the required nutrients needed by fish in a highly digestible form for proper growth.

The feed, supplies the energy requires for movement and other activities engaged by the fish. Feeling increases the fish growth which makes the fish gain weight, grows faster and makes it profitable. Nutrients needed by fish for proper growth includes carbohydrates, fats, protein, vitamins and minerals. Other components of feed are fibre and moisture. For proper growth and optimum harvest the fish diet must contain the entire nutrient in the very right proportion. The rapid growth witnessed globally and locally in our population has raised fears in the areas of availability of infrastructure, housing, security and employment. However food security remains a challenge an out ever growing society. In developing countries 13.6% i.e. one is seven people are considered or termed "Hungry" or undernourished (FAO, 2010).

Protein, Energy, malnourishment is the most lethal form of malnourishment/hunger as protein is vital for key body functions including the provision of essential amino acids and development and maintenance of muscles. Fish is a very important source of animal proteins, as 115 million tons were consumed in 2008 (17kg per capita) all over the world (FAO, 2010; Delgado *et al.*, 2003). In 2007 fish accounted for 15.7% of global animal protein intake and 6.1% of all protein consumed (Delago *et al.*, 2003). According to FAO (2010), aquaculture continues to be the fastest and successes in out aching population growth (Per capita supply increase from 0.7kg in 1970 to 7.8kg in 2008).

The fish farming sector is a contributing significantly to sources of income and livelihood for millions of people around the world as this has increased employment in fisheries and aquiculture which has grown significantly at an average rate of 3.8% yearly since 1980. 1n 2007

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more than 45 million people were directly or indirectly engaged in fish production. Also estimates from the food and agricultural organization show that for every person involved in fish production, about three more job are created in post-harvest, processing, sales marketing and others (FAO, 2010). It is estimated that Nigeria consumes 1.5 million tons of fish annually (About 10kg per capita). But about 579,537 metric tons (2005) are locally produced through capture fisheries and aquaculture (USAID), 2008) and more than 900,000 metric tons are imported. Inspite of the demand and supply gap of fish in Nigeria manage to export aquatic products with more than 56 million US dollars every year (USAID 2008).

Nigeria large dependence on fish imports is seriously affecting the country economy and causing capital flight. But worthy to not or observe that aquaculture is steadily growing in Nigeria. Available data shows a growth from 20,000 metric tons in 1994 to 96,000 metric tons in 2000 (Fagbenro *et al.*, 2003). The artisanal fishing method is decreasing in Nigeria and the trend is towards intensive fish culture. The advantage of the intensive fish culture is that useful man hours are not spent searching for fish in the world. Just that intensive fish culture requires constant and extra feeding in order for the fish to attain table size in a short time.

In large extent, fish seeds (Fryers, Fingerlings) are still imported with emphasis on good hybrids and first shoot out, but with the constraints on importation currently being experienced all over the country, the fish farmer is faced with a major challenge on how to source for seed (Fingerlings) at a better rate in good quantity and quality. The search for rich in protein feed that contains the right ingredients makes aquaculture very expensive and sometimes non profitable all over the world fish feed contributes majorly in aquaculture viability and profitability, because it accounts for at least 40-60% of the total cost of fish production.

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It is expected that the transformation and usage of locally available low protein by products into high quality fish protein can be a major contributor to improving the needed protein supply for local human population. Thus, the requirement of low cost rich n nutrient feed to replace the expensive foreign feed, is to be formulated using locally available feed ingredients are needed to cut down the cost spent in aquaculture locally produced feed reduces the cost of production and thus, provides an alternative means of meeting up the protein requirement, improving food security and reduction in the level of poverty in developing countries. Therefore local and less expensive available feed materials are to be identified for future development of small scale aquaculture system which will thrive on the use of available local ingredients that will reduce the cost of feed production.

1.2 Statement of Problem

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Production of fish feed using local raw materials will help to solve the problem of fish feed importation in Nigeria which has been a major challenge for fish farmers in our country will reduce the rate of unemployment currently faced by young graduate and fish farmers. Following the importance of fish as a high source of protein to both man and livestock is increasingly in demand and the awareness of its protein content is increasing. It's not just enough to produce fish feed, but to produce fish feed using local raw materials that will be globally acceptable, in line with international standard of fish feed production procedure for fish growth and consumption.

1.3 Aim of the Study

The aim of this research is to carry out proximate analysis and characterization of fish feed production from available local raw material that will meet international standard of floating fish feed for fish growth.

1.4 Objectives of the Study

The objectives of this research are as follows to:

i. Formulate procedures for the design of an experimental setup for fish feed production.
ii. Ascertain the end product composition content for fish feed production from locally sourced materials
iii. Evaluate the end product composition content of imported fish feed variables based on varied weights.
iv. Compare the end product composition content of imported fish feed variables with established literature standards.
v. Establish the optimum weight content for the production of fish feed using the obtained standard from foreign feed companies.
vi. Evaluate and compare cost efficient to fish farmers using foreign and local feed
vii. Tabulate, discuss and compare the results with foreign fish feed.

1.5 Significance of the Study

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The design of an experimental setup for the production of fish feed from locally sourced raw materials is nevertheless a great leap in that it will serve as a means for the optimum production of fish feeds and can serve as a basis from which other interested researchers can evaluate other feed stuffs (raw materials) whilst also meeting the goal of dependency on foreign feeds thereby increasing foreign income.

1.6 Scope of Study

The scope of this work is limited to but not exclusively to the robust design of an experimental setup for the production of fish feed from locally sourced materials that will serve as close substitutes for foreign feedstock while considering the optimum weight for the composition content of fish feed based on cost, availability and proximity. The research work involves the sourcing and collection of local machine equipment, local feed materials such as soya beans, groundnut cake, maize, cassava, millet, guinea corn and groundnut at various operating temperatures before crushing into powdery form and drying before carrying out a characterization of their Crude protein, fibre and fat end product contents.

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CHAPTER 2

LITERATURE REVIEW

2.1 History of Fish Farming

Aquaculture is very old and a very highly productive management practice, with a history of at least 4000 years. In the historical past, aquaculture remained multi-locational and isolated, each location having evolved its own pattern. Aqua-farming is believed to have been practiced in 2,500B.C in Egypt where the oldest representation of fish culture practice was observed. The culture of Chinese carp is said to have been widespread in China in about 2000B.C. Aquaculture has ever since been highly developed in Europe, America and in the far East, Asia, where it has a history of 3500 years according to Chua Thai-Eng (1990).

In his own historical view, Jhingran (1987) stated that the art aquaculture is very old. The evidence that the Egyptians were probably the first in the world to culture fish as far back as 2,500B.C came from pictorial engraving of an ancient Egyptian tomb showing tilapia being fish out from an artificial pond. The Romans are believed to have reared fish in circular ponds divided into breeding areas. Writing in India made in 300B.C suggests means of rendering fish poisonous in the India sub-continent in times of war. This implies that fish culture prevailed in some Indian reservoirs. Some historical documents compiled in 11 27AD describe methods of fathering fish in ponds in India. Culture of genetic carps in Bengal in the Indian sub-continent is of historical origin.

Industrialization and hydro-electric dam development, led to restocking of open waters in Europe, This gave a new texture to the development of aquaculture (Jhingran, 1987). The culture of trout in cold waters and black bass in warm waters has already been emphatically developed

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in North America. Channel catfish fanning in the United States is fast developing into integrated agro-based industries. Fish culture has also made phenomenal progress in Israel, but it is only in Latin America and most of the Middle East Chua according to Thia-Eng (1990).

The history of aquaculture in Sub-Sahara Africa is relatively recent compared to Asia. However, some of the aquaculture has been practiced in many African countries for 40 years or more according to Coche *et al.*, (1994). Except for the referred culture of tilapia in Egypt, Kenya has one of the oldest histories of fish farming in Africa dating back to around 1910 as a result of the activities of Kenya Angling Association. In the years that followed, classical fish farming technology was introduced from Europe to various African countries according to Entsua-Mensah *et al.*, (1990). By the late 1950s, according to Satia (1989), about 300,000 fish ponds were productive in Africa.

During the 1 960s aquaculture developments almost came to a standstill with significant declines in many of the countries. Most ponds were abandoned because of poor returns, lack of stocking materials and drought among other reasons. According to Coche *et al.*, (1994) it was not until the late 1960s that aquaculture started to develop again in Africa following increased technical and financial assistance from multilateral and bilateral donors amounting to about 500millions US Dollars over a twenty years period. In-spite of this attempt no African country is included in the top 14 aquaculture producing countries in the world. According to F'AO's statistics of aquaculture production (FAO, 1999), total production by all the Africans countries was 70,317 tonnes. The Chinese carried with them their traditional knowledge of carp culture to the countries they emigrated like Malaysia, Taiwan, Indonesia, Thailand, etc. This constituted 0.45% in 1987 and 0.34% in 1997 of total world production in the indicated years,

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Coche in his argument, argued that aquaculture in Africa is still essentially a rural, secondary and part-time activity that takes place in small farms of small-size fish ponds. Only three main fish species are cultured in Africa even though 20 species are known in the world, to introduced or develop aquaculture, it is essential that the producer has access to production inputs including good seed. According to FAO/UNDPINORAD (1987), in a country where aquaculture is of age, the fish farmer provides the seed and the public sector is not involved. Most African countries have fish breeding centers and hatcheries but many are reported to be in a state of disrepair according to Entsua- Mensua *et al.* (1996). In Nigeria, the supply of fingerlings is mainly an activity of government even though some large scale farmers produced their own feed according to Entsua Mensah *et al.* (1999). However, due to limited demand for fish feed and the high cost of agricultural by-products used in its production, the fish feed industries have not been well developed in most countries. Presently, according to West (1996) fish production from aquaculture in African is between 60,000 and 70,000 tonnes per annual, which implies that the total production is less than 2% of the continent overall fish production. According to Mulonda and Irvire (1999), this however hardly meets projected expectations given that about 5% of Africa is suitable for aquaculture especially small scale project. Kapetsky (1995) is greatly of the opinion that the greatest potentials for increased fish production in Africa lies in culture-based fisheries.

In Nigeria, fish culture has been practiced on a subsistence basis for a long time according to Bolorundiro (2003). However modern fish cultural practices started in 1951 when Nigeria government started the construction of a demonstration fish farm at Panyam, Plateau State as reported by Wokoma (1986). According to Talabi (1987), it was not until 1983 that the impact of aquaculture was felt in Nigeria when a total harvest of 20,476 tonnes of cultured fish was

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recorded. According to Ezenwa (1994), the history of the convectional fish farming in Nigeria falls into two district periods: 1950- 1970 and 1972-1992, while the first period popularized fish farming, the second period expands and established demonstration fish farm in addition to reducing major constraints to aquaculture. In 1975, two fisheries research institute, the Nigeria Institute for Oceanography and Marine Research (NIOMR) and the National Institute for Fresh Water Fisheries Research (NIFFR) were created to take over aquaculture research in the country.

NIFFR was formed by upgrading the Kainji lake research institute according to Shmang (1999). Public sector support for aquaculture in Nigeria is in various and diverse forms. According to Shimang (1999) the FDF does not have a division of extension services. In the past, there were practically no organized aquaculture services until in the late 70s when federal government, through the FDF, embarked on the construction of modem fish farm in several part of the country. This was followed by regular yearly aquaculture training programs aimed at government extension agencies such as research institute; agricultural development programs (ADPs). Shimang (1990) reported that the first FAO intervention in the management of fish farm in Nigeria was in Panyam and Oyo State in mid-1950s. With the return of FAO expert, fingerlings production in Nigeria was intensified. Unfortunately, the infrastructure on the farm began to deteriorate again after the departure of the FAO experts in 1980. According to Howard (1987), the supply of fingerlings was mainly the activity of the government,

Fish can survive on natural food alone if it is abundant in the ponds. However, for practical aquaculture, fish are stocked at very high densities and fertilization of ponds may not reach optimal levels. Also, competition in the pond leads to quick depletion of natural food. Thus, there is need for supplementation of natural food with artificially formulated feeds which must

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contain all essential nutrients. These feeds are compounded from plant and animal sources of nutrients. They are utilized in aquaculture as they enable the farmer to increase stocking density, increase yield and to monitor the fish while feeding (to know when fish are sick or not feeding well). It also promotes faster growth of fish (as feed is always available) while promoting the growth of natural pond organisms (as uneaten artificial feed can help fertilize the pond).

In Peurto Rica, Kohier and PaganFont (1978) evaluated various waste products such as rum distiller's yeast; pharmaceutical wastes, rum distiller's soluble; spent beer plus solids, inorganic fertilizer of NPK (8-8-2); commercial fish feed containing 36.5and 7% crude protein, fat and fibre respectively; and locally manufactured chicken feed containing 18, 2.5 and 4.0% crude protein, fat and fibre respectively. Water quality criteria such as pH, dissolved oxygen and temperature were used as guideline for applying the rum and pharmaceuticals wastes to the pools. They found that survival at harvest ranged from 60.0% for commercial chicken feed to 96.7% for commercial fish feed. The highest mean standing crop was got from the fish fed, the commercial fish feed and this was closely followed by the spent beer treatment. However, the weight of offspring from the spent beer treatment was higher than that from the fish feed treatment. The fish from the unmanaged system yielded the lowest mean standing crop while the other treatments gave moderate yields but the yield from the inorganic fertilizer was greater. There was more than threefold increase of fish weight over that of the unmanaged system in the Turn distiller's yeast treatment; though poor water quality conditions were observed in the water of the pools. They concluded that "some potentials-i 'deists for the utilization of the rum and pharmaceutical wastes for rearing Tilapia in Puerto Rico" and the "dried forms of the by-products should be evaluated for their possible incorporation as part of a local teed". They also suggested that the application of the commercial chicken feed be limited to supplemental feed in conjunction with some intensive fertilization in view of the fact that the bits of hard corn in the chicken feed were not assimilated by the fish.

Tilapia is cultivated in ponds, cages, bypas and concrete tanks. In 2000, more than 14,000 tons were produced. This figure increased to 19,546 tons in 2005 (Fagbenro *et al.* 2011). The African catfish, according to Uclo and Umoren (2011), has been identified as one of the fish species with the greatest potential to contribute to the growth of fish production in Nigeria as it contributed about 35% of total production in 2003. To perpetuate the proliferation of aquaculture in Nigeria and its growth, there is need to tackle the challenges it is currently facing. These include poor management, inadequate supply of good seed stock (estimated minimum fingerling requirement is 4.3 billion while supply is a paltry 55,Xmillion), lack of sufficient capital, faulty data collection, lack of environmental impact assessment, poor marketing skills and importation and subsequently high cost for feed and drugs. Fish feed consist of natural food and artificially prepared rations.

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Natural food includes microscopic plants (phytoplanktdn), microscopic animals (zooplankton), insects, crustaceans, copepods and mollusks. Their presence can be induced or multiplied in a pond by the process called ‘fertilization’. This is accomplished by releasing necessary nutrients required for their optimal growth into the water. Locally, this is achieved by submerging poultry droppings into the pond for about five days before fish is introduced (Sikiru *et al.* 2009; Faruque *et al.*, 2010; Wurts, 2003).

However, Nigerian feed resources have, according to Udo and Umoren (2011) been declining due to the stagnant or diminishing output of important crops. Statistics released by FAO (2008) report a chronic dependence on imports for an expanding livestock/aquaculture industry. This is

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evident in the ever-increasing prices of feedstuff and food stuff in the country. The importation of fish and fish products is an urgent reminder that the demand for aquacukural products is at all-time high and wilt keep increasing. The most important question is “Can aquacutturat products be obtained at a competitive price when compared to imports and capture fisheries? To answer this question, aquaculture costs have to be drastically reduced, Fish require a lot of protein, especially catfish species, which incidentally are increasingly farmed in Nigeria. They also require a source of carbohydrates and fibre. Fats and oil are also required minimally. Out of the 10 Essential Amino Acids (EAA) required for optimum fish growth only three have been exhaustively studied (methionine, lysine and arginine). In order to formulate and compound aqua-feeds that will meet the nutrient requirements of the catfish at affordable cost, several conventional and non-conventional animal by-products and plant residues have been tested to substitute or replace fishmeal. For example, Otele (2011) used earthworms, Nnaji *et al.* (2010) used three leaf meals including Manihotesculena, Effiong *et al.* (2009) used duckweed, Akagbejo Sampson and Fasakin (2008) used rendered animal proteins such as blood meal and meat meal, Fagbenro (1998) tested various oilseeds and cakes, Adebayo et at (2004) used Cassiajlstula meal, Agbebi *et al.,* (2009) used blood meal, Otubusin *et al.,* (2009) used soybean meal and blood meal, and Okanlawon and Oladipupo (2010) investigated snail offal meal, Feeding development has moved from the use of single ingredient, broadcasting un-pelleted meal to use of multiple- ingredient pelleted feeds. Fish may be fed sinking or floating pelleted feeds. The sinking pelleted feeds are fairly common and less costly to manufacture than the floating, or extruded, floating feeds. However, the use of pelleted floating feed has made a big difference to aquaculture development in Nigeria as C. garlepinusis being raised to maturity within 6 months (Sikiru *et al.,* 2009). Better feed conversion ratios (FCR) are obtained in general

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with floating feeds than with sinking feeds as floating feeds offer the fish more time to swallow them. There are a lot of breweries in Nigeria, perhaps on the average of one brewery per State.

These daily turn out several tonnes of brewery wastes such as spent beer plus solids, spent beer, brewery grain waste that hitherto have not been put into any use. They can be incorporated into fish feed. Ezenwa (1979) has reported beer waste to contain 46.4, 22.8, 7.8 and 18.8% carbohydrate, protein, fat, and fibre respectively.

2.2 Constraints to Aquaculture Development in Nigeria

Below are the major constraints facing aquaculture development in Nigeria;

2.2.1 Skilled Personnel

Aquaoulture is a multi-disciplinary endeavor. Therefore, adequately trained personnel with a multi-disciplinary orientation who are capable of identifying and addressing deficiencies in aquaculture productions project are vital. The shortage of such well- trained staff is a major constraint to aquaculture development in Nigeria. In an effort to combat this shortage, the government has established universities which offer fisheries/aquaculture in both undergraduate and post graduate courses,

2.2.2 Fingerlings

At present, wild eggs, fry, fingerlings and juveniles comprise the bulk of fish seed available for subsistence agriculture in Nigeria. Stock quality and quantity are unreliable; they cannot form the basis for commercial/intensive aquaculture. Many rural fish farmers are dependent on government support for fish seed. Even with government subsidy, fish seed prices are generally

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high, constituting 25% of operation costs. Inefficient government breeding and limited supply from private sector keeps fingerlings prices very high.

2.2.3 Fish Feeds

The absence of a fish feed industry is another constraints facing aquaculture development in Nigeria. Semi-intensive and intensive aquaculture production systems involves input of supplementary and complete feeds, which account for up to 40% and 60% of production costs respectively.

2.2.4 Finance

Another limiting factor to aquaculture development in Nigeria is finance. There are both formal and informal sources of finance in Nigeria. Inadequate capital affects the rearing of fish in Nigeria. The relatively ease of obtaining loan without administrative delay, non insistence on collateral collection and flexibility in payment makes the informal sources popular among small scale farmers. However, they have limitation such as small sizes of loans and high interest rate. Formal sources of credit, banks and cooperatives, lend at regulated interest rates but absolutely requires collateral. Bank officials considered aquaculture a high risk business and this does not encourage loan processing.

2.3 Advantages of Fish Farming

One of the main attractions of fish farming is the high efficiency with which fish converts its food to flesh. While beet cattle require about 7kg of feed to produce 1kg of meat, the catfish requires 1.2kg of feed to produce 11kg of flesh. Fish is more efficient in food converting because of its cold bloodedness and for the fact that they live in water and does not extract much energy

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due to sunlight. Some advantages of fish farming are; increasing the level of fish product and animal protein intake diversifies and increases income generation and capacities of rural farmers, optimizes land and water used and recycles agricultural waste and reduces the level of poverty as it creates wealth through employment.

2.4 Fisheries Resources

Pepple and Ebonwu (2001) stated that Nigeria is a coastal state with lots of fisheries resources both in the marine and inland waters. Nigeria has adequate resources for sustained aquaculture. Ita (1993) stated that their full extent cannot be accurately stated as they vary with seasons and from year to year depending on rainfall. These water resources are spread over the country from the coastal region to the arid zone of Lake Chad basin, Nigeria also have some experimental stations, agencies and research institutes which carry out research into methods of improving aquaculture practices. The national research institute and agencies in Nigeria includes; the Nigerian Institute for Oceanography and Marine Resources (NIOMR), National Institute for Fresh water Fisheries Research (NJFFR), etc.

These organizations undertake fisheries research and assignments at different levels. Their research results are made available to the farmers and members of the public through seminars, workshop, and training of extension agents, mobilization and organizations of interested rural and urban people who participates effectively in aquaculture.

At NJOMR, one of the modern methods of aquaculture includes water recirculation system, the technology of which is currently being disseminated to the farmers; NIOMR has equally developed cheap, cost effective supplementary fish feed. The culture of fin-fish is embarked

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upon on small to large commercial scales. Cultured fisheries accounts for about 5% of total domestic production, while capture fisheries account for greater percentage of the nations.

2.5 Fish Production

In Nigeria, inland freshwater, brackish water, fish ponds, reservoirs, fiber glass tank and concrete tanks are the most utilized enclosures for fish rearing. Many farmers now produced fingerlings of culturable fish species such as *Clarias sp.*, *Heterobrachus sp.*, etc.

The culturable fish species above are cultured and trained with different feeds so as to increase their size and maturity.

2.6 Feed Production

Fish feed can be produced basically with the used of the following method

i. Raw Materials Stage: The raw materials are sourced for and are reduced to fine particle size through crushing.
ii. Washing: The raw materials are washed properly in order to remove the dirt's that are present in it.
iii. Drying Stage: This is a stage whereby the raw material is heated to dehydrate the water that is present in it.
iv. Crushing: The dehydrated material is subjected to a crusher into finely particles.
v. Sieving: Sieving of the crushed materials is done with a micro sieve of 7.5 micro meters.
vi. Mixing: This is a stage where the different materials used is blended together to form the raw mixed.

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vii. Moulding: Moulding of the mixed materials is done in this stage. It involves pelleting the materials into its required sized.

viii. Drying: This is the final stage of the production process. It involves the final dehydration of the water being used during the raw mix stage.

2.7 General Information on Feeds and Feeding

What to know about fish to be able to increase production through proper feeding:

i. Biology of the species to be cultured

ii. Nutrient requirements

iii. Feeding habits of the fish, what food it prefers, how it takes in food, what time of the day it eats, what parts of the body are involved in the ingestion of food.

iv. Proper pond management. Ways of developing feeds

v. Imitation of natural diets which is possible when stocking density is low.

vi. Trial and error with existing cheap diets. This is attractive because development costs may be less.

vii. Controlled feeding with nutritionally defined diets. This method appears costly, time consuming, and likely to lead to many problems. However, it is the best approach.

Experience with other animals such as chicken and swine has shown that formulating cheap reliable feed is not possible until the nutrient requirements of the species and the interaction of these nutrients are known for the various life stages.

To achieve increased production through proper feeding, one has to:

i. Study nutritional requirements;

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ii. Understand the digestive processes;
iii. Evaluate feedstuffs;
iv. Develop feeds;
v. Determine good feeding techniques or feeding management schemes. Studies can be done simultaneously if human and budgetary resources are available.

To be able to formulate diets, one has to know the proximate analysis of the feedstuffs either by actually performing the chemical analysis or by relying on feed composition tables.

Some basic concepts in nutrition

i. Adequate nutrition is essential to good health.
ii. Nutrients in the body are in dynamic equilibrium, hence, a deficiency or over supply of one will affect the others.
iii. Dietary intake and nutrient needs should be known.
iv. Nutrient needs vary because of factors such as age, physical activity, body size, state of health, physiological processes like growth, reproduction, and pathological disorders.
v. Nutrient content of food varies and diet preparations should aim to preserve the nutrient in the natural food.
vi. Nutrient requirements are known for some nutrients only and may differ from species to species, thus, requirements and allowances will have to be revised as new knowledge is obtained.
vii. A variety of feedstuffs is better than one source.
viii. The study of nutrition is interrelated with allied arts and sciences.

Nutrition is also an art because there is no single approach to meeting the needs of the animal.

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2.8 Feed Sources Based on Nutrient Content

2.8.1 Animal Protein Sources

Proteins may come from animal or plant sources. Feedstuffs of animal origin have high protein content ranging from 34 to 82%. Proteins from animal sources contribute a mixture of amino acids different from that of proteins from plant sources.

Some examples of animal protein sources are:

i. Fish meal - most common protein source.
ii. Trash fish - no fixed nutrient composition due to variation in the types of fish it includes.
iii. Shrimp meal - excellent source.
iv. Squid meal - excellent source but expensive,
v. Mussel meal - contains growth-promoting factors and attractants.
vi. Poultry by-products.
vii. Milk and milk by-products - essential amino acid content is close to chicken egg protein, the "ideal food."
viii. Meat and bone meal.
ix. Toad or frog meat.

2.8.2 Plant Protein Sources

The common plant protein sources are legumes and oil-bearing seeds. Legumes are potentially valuable as aquaculture feed source in the tropics because of their abundance. Their leaves are also rich in protein and minerals (Shyon et at; Huang & Chen at al. 1998).

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Oil-bearing seeds and oil cakes which are by-products of the vegetable and oil industry are also plant protein sources. They are high in protein and low in carbohydrate. Terms used with these types of feedstuffs are cake or oilcake and meal or oil meal.

Some examples of plant sources are:

i. Soybean meal - high protein, potential partial replacement of fish meal.
ii. Peanut meal - subject to aflatoxin contamination.
iii. Sunflower meal - has no known toxins.
iv. Cottonseed meal.
v. Copra meal - lower protein compared with other plant sources.
vi. Sesame.
vii. Safflower,
viii. Castor oil meal.
ix. Linseed oil meal.
x. Corn gluten meal. I

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2.8.3 Non-Conventional Protein Sources

There are sources that can be used for fish feed formulations but are not yet thlly utilized at present. These are called non-conventional protein sources (Shyon *et al.,* Huang *et al.,* & Chen e*t al.*, 1998).

Some of these sources are:

i. SC? - Algae, fungi (yeasts) and bacteria.

ii. Algae (Skeletonema, Chaetoceros, Scenedesmus, Chiorella, Spirulina) - may be too expensive as feedstuff.

iii. Seaweeds - good sources of trace minerals and Vitamin A.

iv. Ipil-ipil leaf meal - low digestibility and contains toxic mimosine, thus level of incorporation is limited.

v. Earthworm meal - should be dried to inactivate toxin.

vi. Snails should be cooked and dried,

vii. Krill.

viii. Silkworm pupae

ix. Fly larvae.

2.8.4 Lipid or Fat Sources

Lipid or fat sources may also come from animals or plants. Some terms associated with this nutrient group are animal tallows, lards, and oils (Hasan *et al.* 2001)

Some examples of lipid sources are:

i. Animal sources - cod liver oil, squid oil, other fish liver oils, beef tallow.

ii. Plant sources - soybean oil, sunflower oil, peanut oil, corn oil, and linseed oil.

2.8.5 Carbohydrate Sources

Carbohydrates include starches, sugars, and celluloses and are usually the cheapest source of energy for fish. Starch content helps to increase the water stability of the feed especially when heating is included in the processing. Carbohydrates may come from cereals or rootcrops.

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Cereals are important components in aquaculture diets despite their high carbohydrate content. They are the cheapest raw material and are sburces of B vitamins (bran).

Rootcrops are also excellent sources of energy, being rich in carbohydrate. Their value as ingredients for aquaculture feeds is limited because of their use as human food. Besides, most aquatic species cannot digest carbohydrate well, (Hasan *et al.* 2001)

Examples of good carbohydrate sources are:

i. Cereal grains and by-products, rice bran and other rice by-products, corn, barley, millet, wheat, rye, oats, sorghum
ii. Roots and tubers - potato starch, cassava starch, sago palm starch.

2.8.6 Vitamin and Mineral Sources

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Vitamins and minerals are required in trace amounts for normal growth, reproduction, health, and general metabolism. Deficiency symptoms usually occur in intensive system where natural food is not sufficient.

Major natural sources of vitamins are as follows: fish oils, vegetable oils, leaf meals, brans, yeasts, milk and milk products, soybean, cereals, citrus fruits, wheat germ, liver, fish meal and viscera, slaughterhouse wastes, fresh fish tissue, insects, and animal offal.(Hasan, e*t al.* 2001)

2.9 Criteria in Selecting Aquaculture Feeds

Considering the nutritional requirements of prawns, the feed should meet the following criteria:

i) It should be made cheap enough, yet meet the nutritional needs for prawn growth at various stages.

ii) It should contain the necessary components that will make it an attractive food for the prawn.

iii) It should be made in suitable size and form that can be easily consumed by the prawn at various growth stages.

iv) It should have the necessary water stability and should not disintegrate before it is consumed by the prawn; otherwise, it can contribute to the pollution of the pond water.

v) It can be manufactured at acceptable processing cost and necessary skills.

vi) It should have a satisfactory shelf-life to avoid undue loss in nutritional value, and reduction of pellet integrity and general quality under simple packing, normal storage, and handling.

2.10 Manufacture of Feed

The manufacture of the regular type or grade of fish feed involves the following basic steps:

I. Grinding and reducing to uniform size the various feed components.

II. Screening and grading of the components to obtain uniform particle size.

III. Formulation (usually on weight basis) of the ground and screened feed components.

IV. Batch mixing of the formulation.

V. Conditioning of the meal with the introduction of suitable dosing liquids to improve pellet quality.

VI. Pelleting or extrusion of the conditioned meal.

VII. Pellet cooling and cleaning.

VIII. Pellet crumbling, if necessary, to attain the desired feed size not attainable by pelleting.

IX. Screening and sizing of pellets to eliminate the crumbles.

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X. Special feed screening, if necessary, such as by coating, glazing, etc. to improve the quality, physical structure and strength of the feed pellets.

XI. Feed packing (expiry date essential).

XII. Feed storage which should not exceed the period necessary for the projected feed quality/stability.

Certain variations in the foregoing manufacturing process may be considered, depending on the conditions of the feed components as received or are made available at the feed mill. Some manufacturers may find it better to purchase their feed components semi-processed or finished. Some plants may be equipped to handle feed components in very raw form such as the more expensive feed components, the protein-rich materials like fish meal, shrimp or squid meals, etc. It may be more economical if these components were to come from locally available raw materials instead of buying such materials from outside sources.

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2.11 Physical Characteristics of a Feed

Aside from the statement of the major nutrients present in a feedstuff or feed, information is also required on the physical characteristics of the product including color, texture, odor, particle size, pelletability, bulk density, water stability, and attractability (Shyon *et al*.(1998) Huang *et al*. & Chen *et al.* 1998).

2.11.1 Water Stability

One physical property that is necessary in a feed is its water stability. A water-stable diet provides maximum available food to the fish and minimum leaching out of vitamins and other nutrients.

Poor water stability can also impair water quality. Crustaceans such as shrimps, lobsters and crabs grasp their food with the chelae, carry it to the mouth, and tear it into smaller fragments before swallowing. They need relatively more stable pellets than do the finfish. Thus, binders and processing techniques like steaming and extrusion are done to ensure water stability.

Water stability tests are usually done on pellets intended for slow feeders. One gross way of determining the stability of the pellet in the water is by crumbling it or by just feeling the rough edge of the pellet.

2.11.2 Particle Size

Pellets with ingredients that are not finely or uniformly ground tend to be less stable than pellets with uniformly ground ingredients, Hence, ingredients should be finely ground and sieved to uniform particle size before incorporation in the diet.

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The size and shape of feeds should be designed to accommodate and conform to the anatomical organs of the crop animal for seizing, engulfing, or ingesting food. Food particle size in particular is an important parameter in the feeding of cultured species whose mouthparts vary greatly.

2.11.3 Texture

Also an important aspect of a diet is texture - hard, soft, moist, dry, rough, or smooth. Some species appear to avoid hard pellets. Those that tear their food may have to be provided with feed of a texture different from that given to those species that swallow or nibble off small pieces of the food.

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2.11.4 Color

Various species of aquatic animals are able to see colors. Color contrast between the feed and the culture tank may provide greater ease for the fish to capture their food.

2.11.5 Density

As ground feed ingredients are received in the feed mill, bulk density measurement can be done to check on the amount of adukerants present. Bulk density of the ingredient sample should be determined and compared with the bulk density of pure feedstuffs. If contaminants or adulterants are present, bulk density will change. It is a good practice to go back to the sample for closer look by paying particular attention to adulterants. In general, adulterants are ground extra fine to escape detection.

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2.11.6 Pelletability

Depending o their nature, feed ingredients may be of low, medium, or high pelletability. Usually, the finer the particle size, the higher is the pelletability of the ingredient.

2.11.7 Attractability

Both attractability and palatability are critical factors in formulation of diets. An otherwise nutritionally balanced diet may be less effective or marginal in performance due to the absence or minimal concentration of ingredients that stimulate gustatory response in the species. The practical importance of feed attractants and diet palatability is particularly critical during the weaning of marine fish larvae from natural food to artificial diet. In addition, attractants or feed stimulants can reduce the period of time the feed remains uneaten in the water, thus minimizing leaching of nutrients.

2.11.8 Visual Stimuli of Food

The stimuli that food provides and to which fish responds include size, movement, shape, color, and contrast of the food particle.

2.11.9 Size

For fish heavily dependent on vision for location and identification of food, there are upper and lower limits to the size of food items they would respond to positively. The lower limit often depends on visual ability and the upper limit depends on better identification of theitem as food. Often there is a specific size range that evolves a positive response. The size range is inherent in the ability of the fish to capture and ingest the food.

2.11.10 Movement

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Movement is important in the identification of food items. Water does not transmit light as effectively as air does; hence, underwater vision can be greatly impaired. It is only at closer distance when vision becomes accurate that the perception of movement helps in the identification of a food item. For some species, movement is an essential stimulus, while in others only stationary food items are attacked. Some fish react only to fast moving objects while others to slow or intermediate ones. The type of motion is also important. Certain species respond to oscillatory movement, while others to rotatory motion. In goldfish, a unidirectional motion is a powerful stimulus.

2.11.11 Shape

Most fishes are capable of identifying a. wide range of shapes. In the piranha, this ability is important in recognizing a potential food item versus another of the same species. Piranhas have

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egg-shaped bodies and often will attack only other fishes which do not have this characteristic shape.

2.11.12 Color and Contrast

Identification of food items is enhanced further by color and contrast. Laboratory tests show that fish approaches objects of specific colors. For example, a type of bass is attracted to red and yellow but not to black. The rainbow trout is attracted to blue but not to green.

2.12 Limitation of Past Work

The literatures reviewed emphasized materials and production of locally sourced materials and the characterization of the fish feed. The literatures did not show which of the locally sourced materials that gave maximum yield for the crude protein and also the fish feed was not produced.

Different studies over the years by different authors on the subject of fish feed production process have been undertaken. However most of these studies are based on crude experimental procedures with less or little feedstuffs and only a determination of little parameters of interest. Nevertheless, in all this research, it has been shown that a careful experimental setup design of the process for the production of fish feed with all the required procedural steps has been little or not found which leaves a knowledge gap this work has filled. Thus, this research thesis seeks to apply all rudimentary principles of chemical engineering process and design in the optimal experimental setup design of a fish feed production process and wherein the obtained results will serve as the base methodology for the production of fish feed using different feedstuffs. The design of fish feed production process with all clearly laid down procedure that is incorporated into this study will be an additional knowledge in the area of fish feed production from locally sourced feedstuffs within Nigeria and can serve as a referral in the experimental setup design of

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procedural setup for other feedstuffs not mentioned in this thesis in the aforementioned process and also a minimum design basis for other researchers who would want to go a little more detailed in the design of fish feed production process.

2.13 Research Gap

The work focused on the production of fish feed from locally sourced materials. Characterization of these fish feeds locally and to optimized the materials that will give maximum yield of the crude protein and others for the growth of the fish, comparable to the foreign feed produced.

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CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

Materials to be used for this practical include the following

i. Soyabean
ii. Maize

iii. Palm Kernel Cake
iv. Blood meal
v. Groundnut Cake
vi. Rice bran
vii. Cassava flour
viii. Mixer
ix. Pelletizing machine
x. Sieve
xi. Crusher
xii. Water
xiii. Weighing balance
xiv. Extruder etc.

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3.2 Methods

The methods below shows clearly, procedures, and steps followed experimentally on how the fish Feed Formulation was gotten and feed materials carefully selected with respect their nutritional content to Fish growth

3.2.1 Materials Preparation

Feed formulation and preparation is the processes of combining feed ingredients to form mixture that will meet the specific goals of production. It is often a compromise between an ideal formula and practical considerations. While formulating the feed one must take into account some considerations such as price, availability of ingredients used anti-nutritional factors and palatability of mixtures.

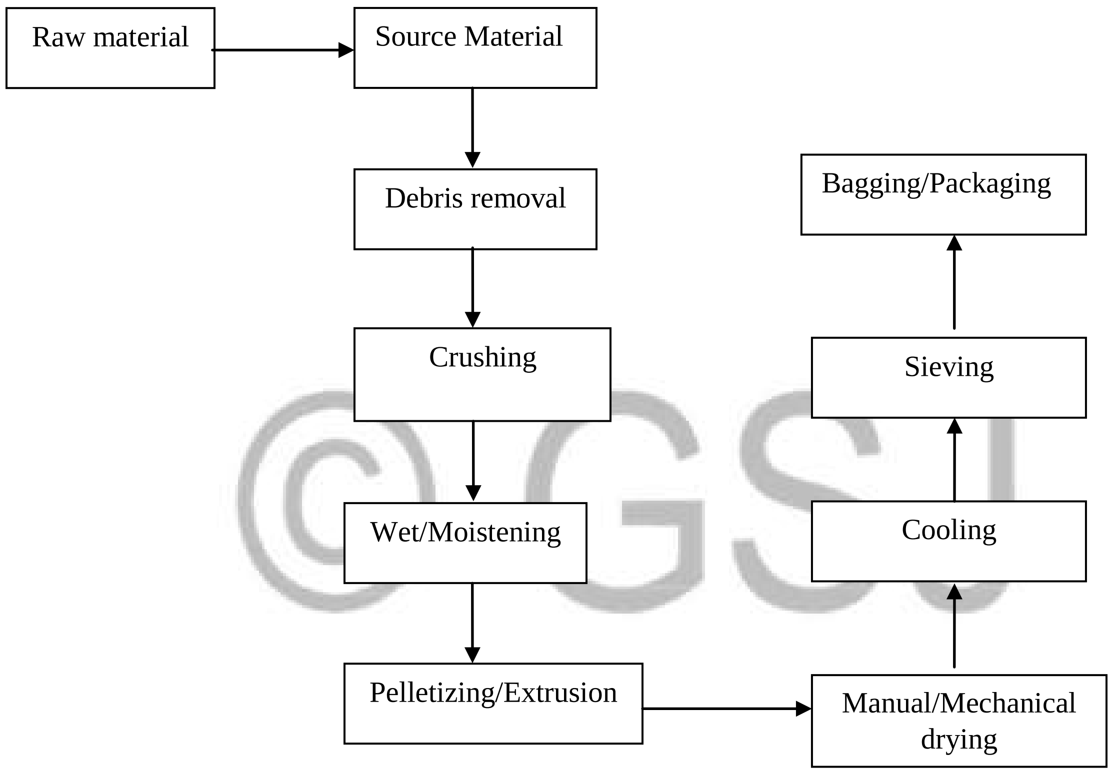

Figure 3.1. Process Flowchart of fish feed production

i. Location and source: A required quantity of these materials (Soya beans, Maize, PKC, Blood meal, cassava flour were bought from the seller at a market in Port Harcourt.

ii. Weigh 200grams of soya beans, 200gram of maize, 200grams of Palm Kernel Cakes (PKC), 100grams of blood meal, 100grams of Groundnut Cake (GNC), 100grams of rice bran and 100grams of Cassava flour

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iii. Washing: This materials were-- washed properly in order to remove the dirts in them

iv. Drying Stage: The raw material were heated to dehydrate the water that is present in it. It is basically done in two stages. The first stage is before mixing, while the second stage is after mixing

v. Crushing: The dehydrated materials was subjected to a finely particle after been crushed

vi. Sieving; The crushed materials is done with a micro sieve of 7.5 micro milimeters. This is required in order to have a fine particle of the same size

vii. Wet Mixing: Different materials were then used to blended together to form the raw mixed. In this stage, after the used of mill, a required volume of hot water is used to mix the mixed materials in order to have a paste. The mixing is done in the varying ratio of 1:1:1:4 and 2:2:2:8. Where the one's and two's are for maize, cassava, blood meal, and soyabean respectively

viii. Pelletizing: Then blended mixed was then subject to pelletizing machine. This is the process of forming a pellet: The purpose of pelleting is to make the fish feed pellet with healthy nutrition and delicious test for the fish by pressing

ix. Extrusion: Thus pellet was the broken down to smaller size. Extrusion involve breaking down the material into it's required size.

x. Manual Drying: This is the final stage of the production process. It involves the final dehydration of the raw mixed. It is done manually or furnace to form fish feed

xi. The process was then repeated for different grams of feeds

3.2.2 Proximate Analysis

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The analysis of proximate composition was done in the laboratory of Chemical analysis, Department of Chemical/Petrochemical Engineering Rivers State University Port Harcourt.

Determination of crude protein: Crude protein was determined followed by Kjeldhal method according to the following formula Nitrogen in the sample was determined by the Kjeldahl method and was multiplied by factors 6.25 to determine the crude protein content of the feed. The representative sample of feed was first weighed and digested with concentrated H_2SO_4 in presence of 10 g anhydrous sodium sulphate and 0.5 g copper sulphate. Digested materials were dissolved in distilled water and collected in a 250 ml volumetric flask. Then, known volume of aliquot was distilled after being made alkaline with 45% sodium hydroxide solution and the liberated ammonia was trapped in 2% boric acid solution. The same was titrated against N/10 H_2SO_4 (standard). Percentage of nitrogen was calculated by the following formula.

$$\% \; of \; Nitrogen$$

$$\frac{Vol.of \; N/10 \; H_2SO_4 used \;\; of \;\; x \; 250 \;\; x \; 100}{Vol.of \; aliquot \;\; taken \;\; (ml) x \; gm \; of \; substance \;\; taken} \quad (3.1)$$

$$\% \; of \; CP = \% \; of \; N, x \; 6.25$$

$$\% \; Crude \; Protein = \% \; of \; N_2 \; x \; 6.25 \quad (3.2)$$

Determination of crude fat: Crude fat was quantified through Soxhlet extraction technique using hexane (65-70°C) as the solvent using the following formula:

1. The fish feed was well grinded in a blender machine and measured by the analytical balance of the sample like 1.5 – 2 grams on hotman paper or filter paper.

2. Then the sample should be placed in the extractor of the distillation point of the succulents apparatus by closing the mouth of the thimble with cotton through the thimble.
3. Then dry a round flax and take the weight. And the amount of hexane in it should be placed below the extractor at the distillation point.
4. And leave the water line of the machine and switch on to distillation with heat for about 1 hour and 20 minutes.
5. After distillation, open the condenser, collect the hexane and pour it. Gently open the bottle plug and keep the fat flakes in the oven at 135 degree Celsius for 30-45 minutes.
6. Then cool in desiccant for 30 minutes. And will have to take the weight of the bottle again.
7. The difference between the next weight and the previous weight is the crude fat.
8. The amount of crude fat is then determined as a percentage from the amount of sample taken.
9. Calculation: Crude Fat (Ether Extract) = {(Dry wt. With fat flask) – (Empty fat flask wt.) / Sample weight} x 100%

Determination of crude fiber: Crude fiber was determined by following the method of AOAC The crude fiber content of feed ingredients was then determined according to the following formula:

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Crude Fibre Estimation

i. The fat-free material transferred into a flask/beaker and 200mls of pre-heated 1.25% H2SO4 is added and the solution is gently boiled for about 30mins, maintaining constant volume of acid by the addition of hot water.

ii. The buckner flask funnel fitted with whatman filter is preheated by pouring hot water into the funnel.

iii. The boiled acid sample mixture is filtered hot through the funnel under sufficient suction Wash the residue several times with boiling water (until the residue is neutral to litmus paper) and transfer back into the beaker.

iv. Added 200ml of pre-heated 1.25% Na2SO4 and boil for another 30 mins. Filter under suction and wash thoroughly with hot water and twice with ethanol.

v. The residue dried at 65 C for about 24hrs and weighed.

vi. Transfer the residue into a crucible and place in muffle furnace at 600 C and ash for 4 hrs, Cool in desiccator and weigh.

$$\% \, Crude \; Fibre \; = \frac{Dry \; wt \; of \; Residue \; before \; ashing - wt \; of \; residues \; after}{wt \; of \; Sample} \qquad (3.3)$$

%Crude fibre =(Dry wt of residue before ashing - wt of residue after ashing) /wt of sample x100

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Experimental Results

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Experimental results obtained on the basis of the stated procedure for the design of a fish feed production was reported. The obtained result was presented in graphical and tabular form with subsequent explanation and evaluation of the results to literature and industrial standards.

Table 4.1 Comparison of Locally produced fish feed with Standard fish feed for 20kg

Feed	Foreign (Ziglar) %	Locally produced %
Crude protein	50	54.2
Crude fat	15	21.4
Crude fibre	1.5%	12.3

Fish Feed Production Using Different Raw (Feedstuff) Materials

The major objective of this thesis is to experimentally design a fish feed production process wherein the required procedural steps as well as their arrangement is undertaken. It is expected that the results obtained from this process is compared with literature and industrial standards in terms of the end product of particular raw materials. Furthermore, the composition of certain parameters of interest from the obtained end products is evaluated to check for conformity with literature and if it does conform, the design will thus serve as the basis for the production of a fish feed from that particular raw material. Nevertheless, the (Table 4.1) gives the obtainable composition of certain parameters of interest from different raw materials (feedstock) that will serve as the standard for evaluation.

Table 4.2: Proximate Contents of some Locally Sourced Raw Materials (Feedstock) Available in Nigeria that can be used in the Formation of Fish Feed

FEED STUFF	% PROTEIN	% FAT	% FIBRE	% DRY	%

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				MATTER	**MINERALS**
Maize (White)	9.3	5	2.4	88	1.8
Maize (Yellow)	10.8	3.6	3.5	88	1.9
Guinea Corn	11.2	2.5	2.3	88	1.8
Palm Kernel Cake	19.1	7.6	43.2		5.5
Cotton Seed Cake	40.1	8.3	31.9	91	5.1
Rice Bran/Hunk	9.9	4.4	40.2	91	21.8
Groundnut Cake (Industrial)	48	13.2	8.1	93	6.3
Groundnut Cake (Kuli-Kuli)	40.6	23.4	6	93	6.2
Raw Soybeans	40.7	22	6.3	90	6.4
Soybean meal (slightly toasted)	46.2	24.8	4.7	90	7.9
Soybean meal (toasted severely)	48.1	23.9	4.1	90	7.9
Fish Meal (Tilapia)	57.7	1.8	5.2	92	33.6
Cow Blood Meal	86	0.7	2.1	92	5
Millet	9	5	0.7	90	2.3
Flour Mill Sweepings	12.5	14.5	7.5		
Brewers Waste	22.8	17.8	18.8	93	
Cassava (Peeled)	2.6	0.5	0.4	88	2.4

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Comparative Analysis of the Different Weights of Feedstock and the Compositional Makeup

Having designed the experimental procedure for the production of a fish feed from a locally sourced feedstock or raw materials, it was hence imperative to review the result to check for its industrial or practical significance as it was never enough to only design but to evaluate result to see if it meets the objectives as clearly stated out. Hence, the obtained results are examined under the following sections:

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From the obtained results and with regards to Figure 4.2 through Figure 4.9, it was observed that each raw material (feedstock) with varying weights had different composition in terms of the amount of crude protein, fiber and fat that was present in the final fish feed.

From Figure 4.2 it was observed that for equal 10kg weight of feedstuff, blood meal had the most composition of crude protein with a numerical value of about 9 and was followed by fish meal with a composition value of about 6.5 while soya bean and groundnut cake (GNC) had a value of 5. Palm kernel cake (PKC) had a value of 2 whereas maize and rice bran had a value of 1with flour having the least crude protein with almost zero value in composition. In addition, regarding the composition of fibres, soya beans had the most compositional value of 3 and was followed by palm kernel cake (PKC) with a composition value of 2 while rice bran, maize and palm kernel cake (PKC) had a value of approximately 1. Further, fish meal, blood meal and flour had almost zero compositional value for fibre present. In similar vein, for the fat content in the feedstock, it is observed that palm kernel cake (PKC) had the most compositional value of about 5 and was followed by rice bran with a compositional value of 4 while soya beans had a compositional value of about 2. Also, fish meal and groundnut cake (GNC) had a compositional value of about 1 while blood meal, maize and flour had almost zero compositional value for fats.

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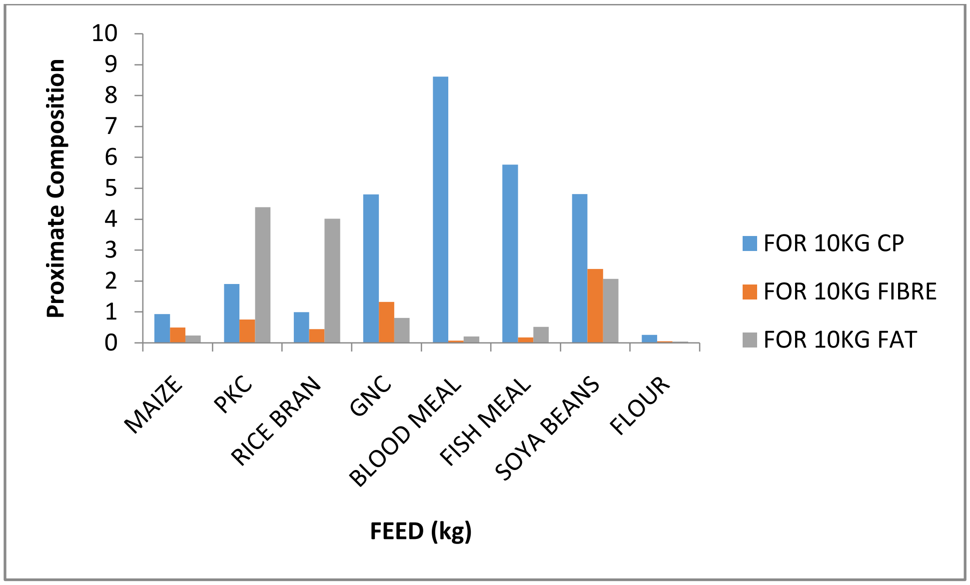

Figure 4.1: Composition of Different Feedstock for Fish Feed Meal Production using 10kg Weight

Figure 4.1, it was revealing that for equal 20kg weight of feedstock, blood meal had the most composition of crude protein with a numerical value of about 18 and was followed by fish meal with a composition value of about 13 while soya bean and groundnut cake (GNC) had a value of 10. Palm kernel cake (PKC) had a compositional value of 4 whereas maize and rice bran had a value of 2 with flour having the least crude protein with almost zero value in composition. In addition, regarding the composition of fibres, soya beans had the most compositional value of 6 and was followed by palm kernel cake (PKC) with a composition value of 4 while rice bran, maize and palm kernel cake (PKC) had a value of approximately 2. Further, fish meal, blood meal and flour had almost zero compositional value for fibre present. In similar vein, for the fat content in the feedstock, it is observed that palm kernel cake (PKC) had the most compositional value of about 10 and was followed by rice bran with a compositional value of 8 while soya beans had a compositional value of about 4. Also, fish meal and groundnut cake (GNC) had a compositional value of about 2 while blood meal, maize and flour had almost zero compositional value for fats.

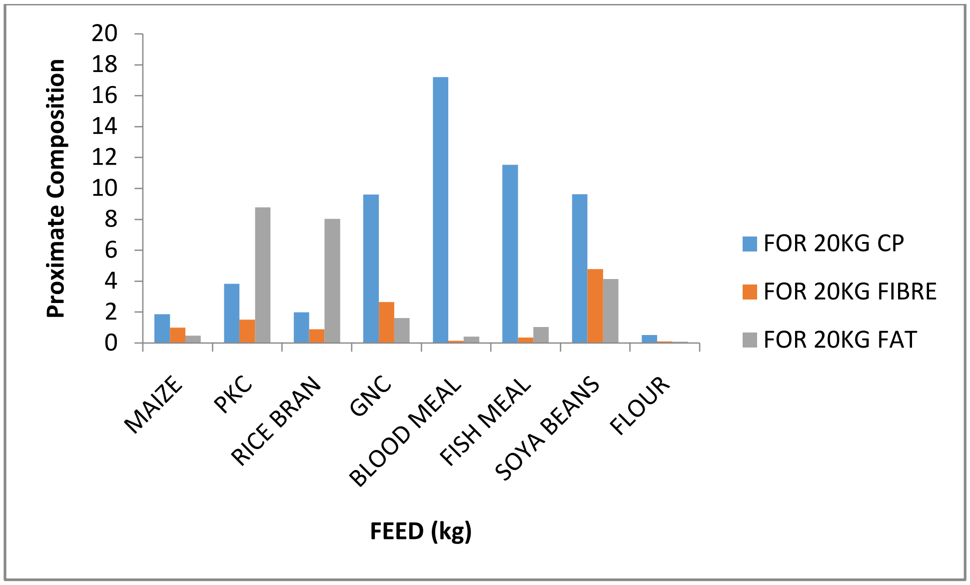

Figure 4.2: Composition of Different Feedstock for Fish Feed Meal Production using 20kg Weight

More so, from figure 4., it was observed that for the same equal amount of feedstock weight of 30kg, it was revealing that blood meal had the most composition of crude protein with a numerical value of about 27 and was followed by fish meal with a composition value of about 20 while soya bean and groundnut cake (GNC) had a value of 15. Palm kernel cake (PKC) had a compositional value of 6 whereas maize and rice bran had a value of 3 with flour having the least crude protein with almost zero value in composition. In addition, regarding the composition of fibres, soya beans had the most compositional value of 9 and was followed by palm kernel cake (PKC) with a composition value of 6 while rice bran, maize and palm kernel cake (PKC) had a value of approximately 3. Further, fish meal, blood meal and flour had almost zero compositional value for fibre present. In similar vein, for the fat content in the feedstock, it is

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observed that palm kernel cake (PKC) had the most compositional value of about 15 and was followed by rice bran with a compositional value of 12 while soya beans had a compositional value of about 6. Also, fish meal and groundnut cake (GNC) had a compositional value of about 3 while blood meal and maize and flour had almost zero compositional value for fats.

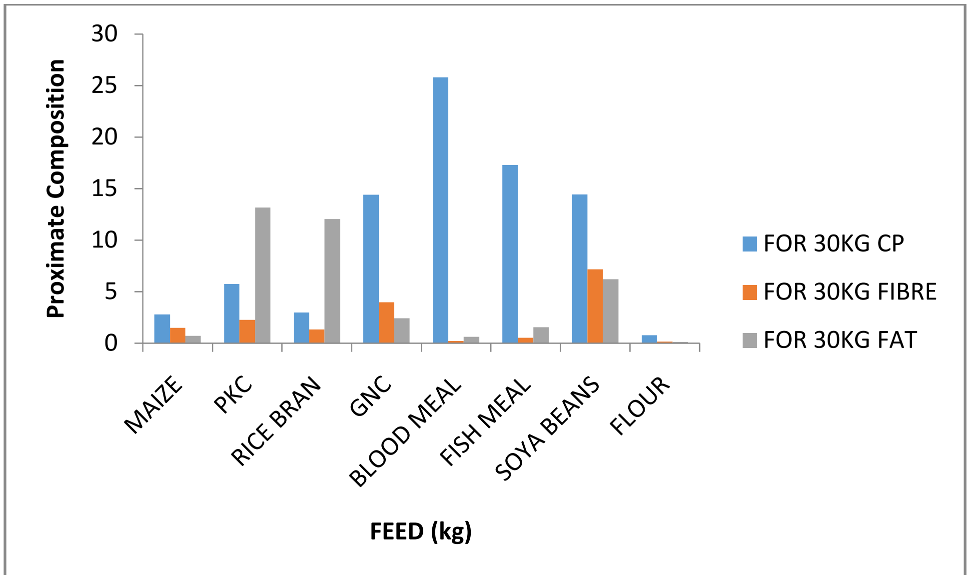

Figure 4.3: Composition of Different Feedstock for Fish Feed Meal Production using 30kg Weight

Notwithstanding, a close observation of Figure 4.3 through Figure 4.9 reveals that the nature of the curve for the crude protein does follow similar trend wherein blood meal has the most compositional value and is approximately a numerical multiple of the initial weight composition. There is however an exception to this phenomenon as observed in Figure 4.8 where maize instead of the usual blood meal had the most compositional value for crude protein with a value of approximately 75 for equal weight of 80kg for all the feedstock.

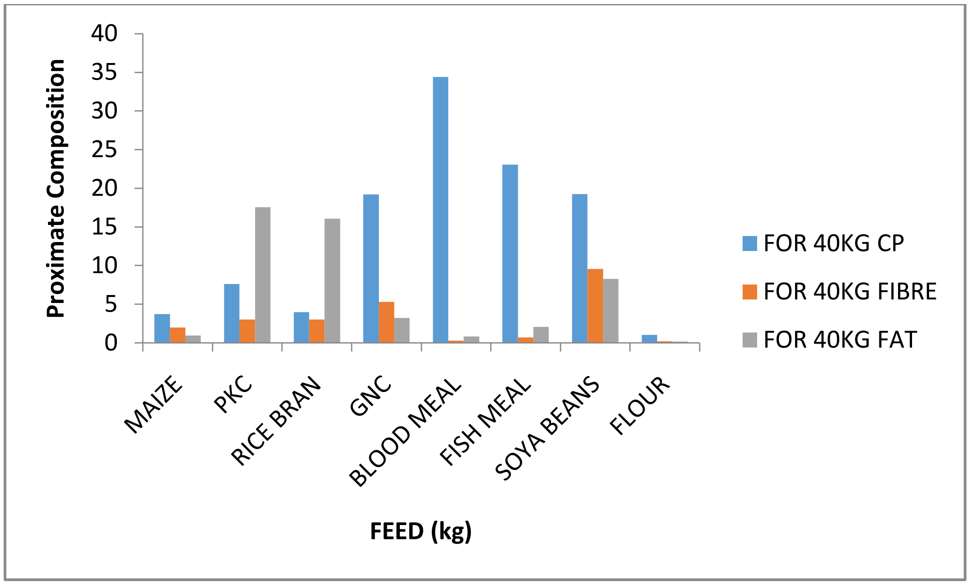

Figure 4.4: Composition of Different Feedstock for Fish Feed Meal Production Using 40kg Weight

Nevertheless, from the observation of the trend of compositional content of fibre of all the feedstock, it was revealing that all the feedstock had similar pattern of the figures discussed above but with an increase in the compositional values which is a directly proportional to the multiples of the increase in weight of the feedstock wherein soya beans has the most compositional value while fish meal, blood meal and flour have little or no compositional value of fibre present

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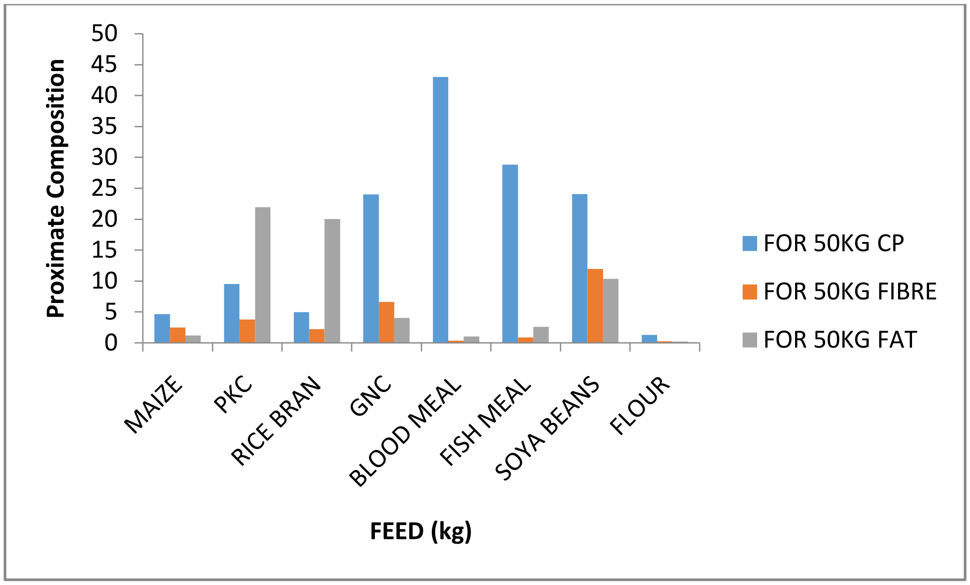

Figure 4.5: Composition of Different Feedstock for Fish Feed Meal Production using 50kg Weight

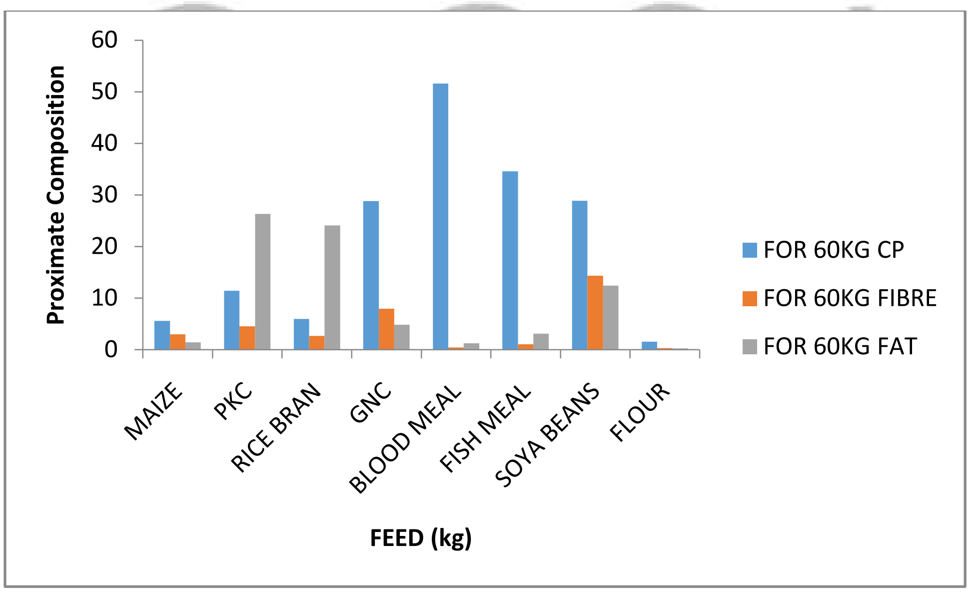

Figure 4.6: Composition of Different Feedstock for Fish Feed Meal Production using 120kg Weight.

In likewise manner, for the fat compositional value of the different feedstock, it was observed that all the figures follow a n analogous pattern in trend and obtained compositional values are

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simple multiples of the increase in weight of the feedstock wherein palm kernel cake (PKC) has the most compositional value while blood meal, maize and flour have approximately zero compositional value. In conclusion, it was noted that from the evaluation of the obtained results, blood meal tends to have the most compositional value of crude protein for all equal weights and thus was considered in its production of fish feed if the target is the production of high content of crude protein. Similarly, if the target of production was a high content of fibre in the fish feed, then the obvious choice is soya beans since it has the most compositional value of fibre for all equal weights

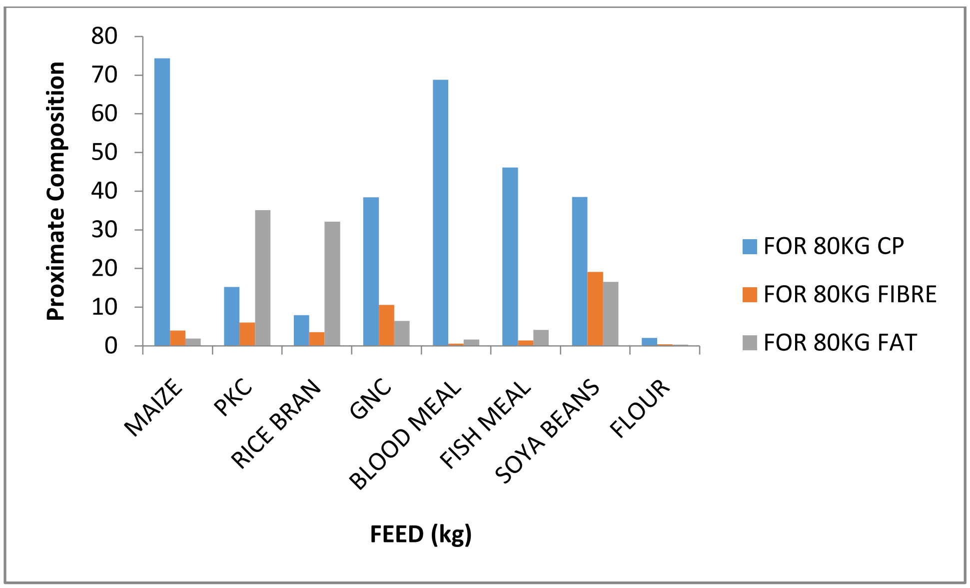

Figure 4.7: Composition of Different Feedstock for Fish Feed Meal Production using 80kg Weight.

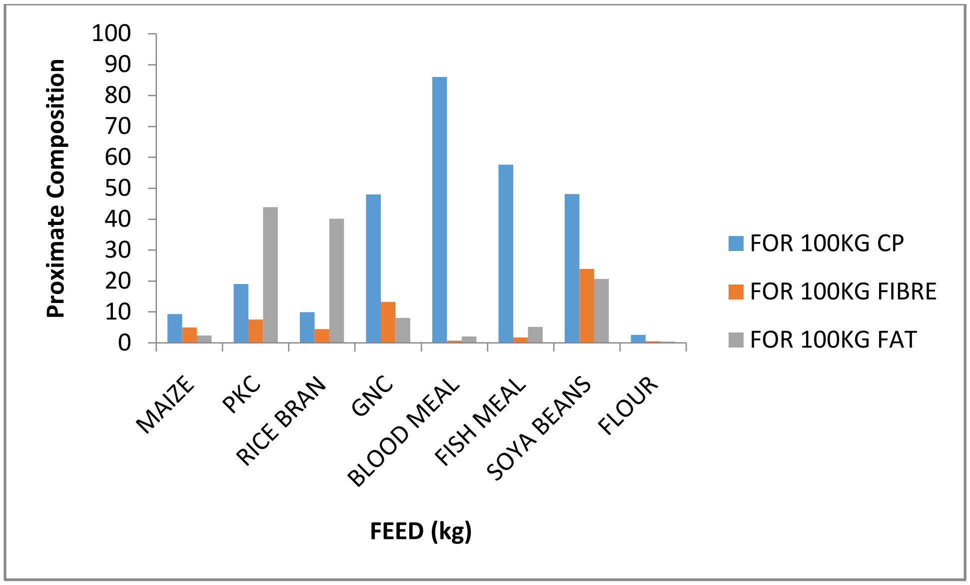

Figure 4.8: Composition of Different Feedstuffs for Fish Feed Meal Production using 100kg Weight.

In likewise manner, palm kernel cake (PKC) is the desired feedstock if the required target is the production of fish feed with a high content of fat since it contains the most compositional value of fats for all equal weights. Nonetheless, it is required also to state that, flour as a fish feed production feedstock was a poor choice since it contains little or approximately zero of all the three variables of crude protein, fibre and fats and thus must be avoided at all cost. Nonetheless, the selection of a particular feedstock due to a required target of variables is subject to its availability and cost and thus a close substitute of a particular feedstock with similar content should be used in place if the other feedstock was not available at quantity required or a mixture of similar feedstuff could be used instead if it is pertinent and necessary.

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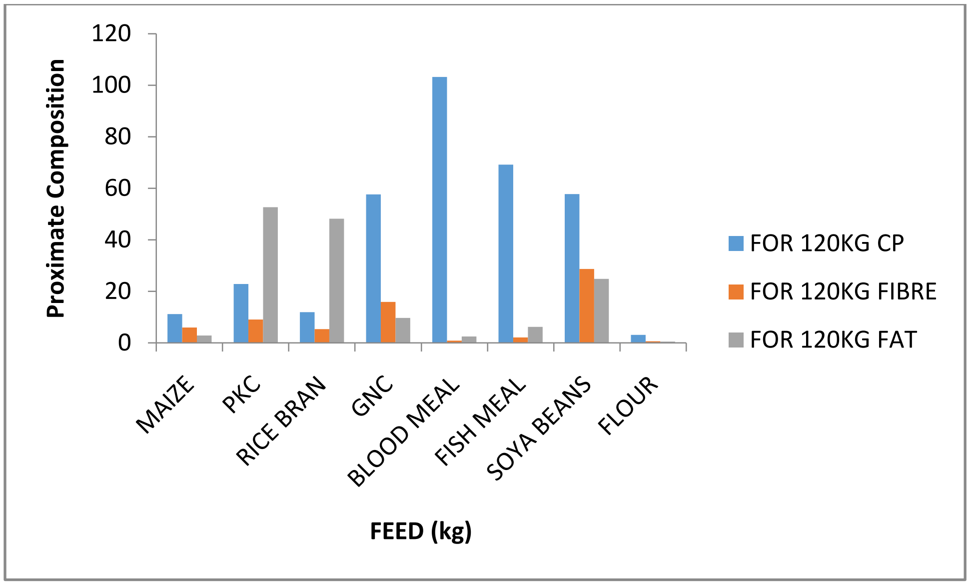

Figure 4.9: Composition of Different Feedstock for Fish Feed Meal Production using 120kg Weight.

Comparative Analysis of Variable Content for the Different Feedstock.

From the obtained results, while considering Figure 4.9 through Figure 4.12, reveals the proportionate amount of each feedstock on a particular variable whether it be crude protein, fibre, and fats. Nonetheless, the results obtained from Figure 4.10 reveals the proportionate amount of crude protein for the different feedstock. A close evaluation of this figure shows that blood meal had the most proportionate amount for all given weights in comparison to the other feedstock for the production of fish feed. Further, the figure also reveals that fish meal had the second most proportionate amount of crude protein for all given weights when compared with the other feedstock while soya beans, palm kernel cake (PKC) and groundnut cake (GNC) had the third, fourth and fifth most proportionate of crude protein respectively. Also, from the figure, maize had the sixth most proportionate amount of crude protein. However, the case for maize is not clear as it had the most content of crude protein amongst all the feedstock at 80kg of given

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weight. In addition, the figure also shows that the feedstock of rice bran, and flour had little or no proportionate amount of crude protein for all the weights given. This result entails that the feedstock of flour and rice bran was not to be whatsoever considered in the production of fish feed that requires relative proportionate amount of crude protein and thus must not be sought after in the production process.

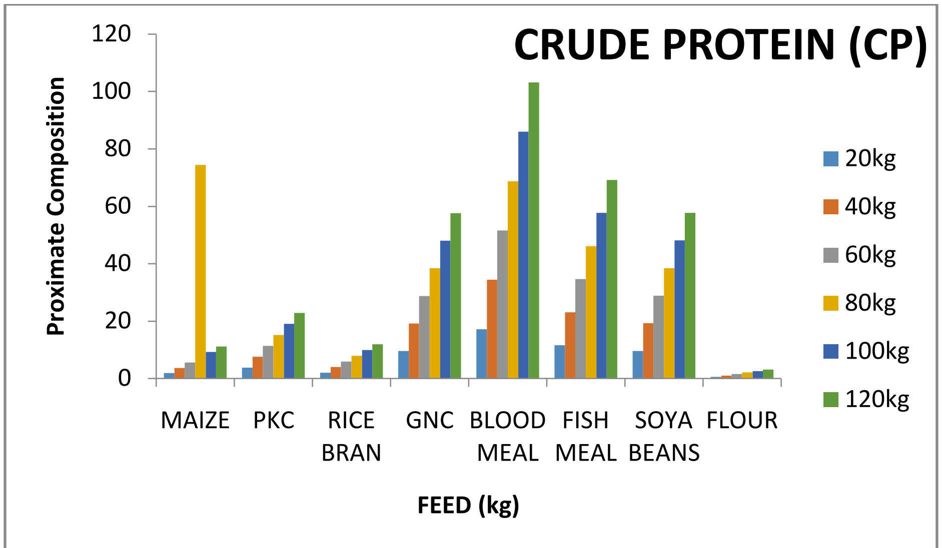

Figure 4.10: Crude Protein Content of Different Feedstock for Fish Feed Meal Production.

Additionally, considering Figure 4.10 which relates the fibre proportionate content of the different feedstock in the production of fish feed, it was revealed that that soya beans had the most proportionate amount of fibre for all given weights in comparison to the other feedstock for the production of fish feed. Further, the figure also reveals that groundnut cake (GNC) had the second most proportionate amount of fibre for all given weights when compared with the other feedstuffs while palm kernel cake (PKC), maize, and rice bran had the third, fourth and fifth most proportionate of fibre content respectively. Also, from the figure, it is revealed that fish meal had the sixth most proportionate amount of fibre amongst the feedstock. In addition, the figure also shows that the feedstock of blood meal and flour had little or no proportionate amount of fibre content for all the weights given. This result entails that the feedstock of flour and blood meal were considered in the production of fish feed for any reason that requires relative proportionate amount of crude protein and thus must not be sought after in the production process.

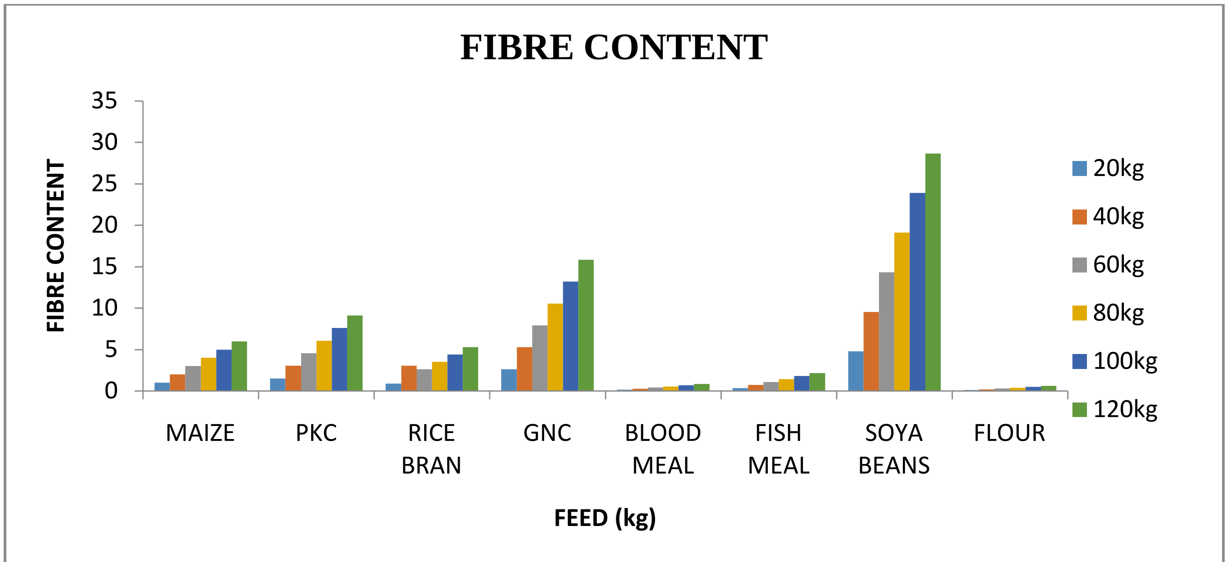

Figure 4.11: Fibre Content of Different Feedstock for Fish Feed Meal Production.

Furthermore, by considering Figure 4.11 which relates the fat proportionate content of the different feedstock in the production of fish feed, it is shown that palm kernel cake (PKC) has the most proportionate amount of fat contents for all given weights in comparison to the other feedstock for the production of fish feed. Further, the figure also reveals that rice bran had the second most proportionate amount of fat content for all given weights when compared with the other feedstock while soya beans, groundnut cake (GNC), and fish meal had the third, fourth and fifth most proportionate of fibre content respectively. Also, from the figure, it was revealed that fish meal had the sixth most proportionate amount of fibre amongst the feedstock. In addition, the figure also shows that the feedstock of blood meal and flour had little or no proportionate amount of fibre content for all the weights given. This result entails that the feedstock of flour and blood meal are not to be whatsoever considered in the production of fish feed for any reason that requires relative proportionate amount of crude protein and thus must not be sought after in the production process.

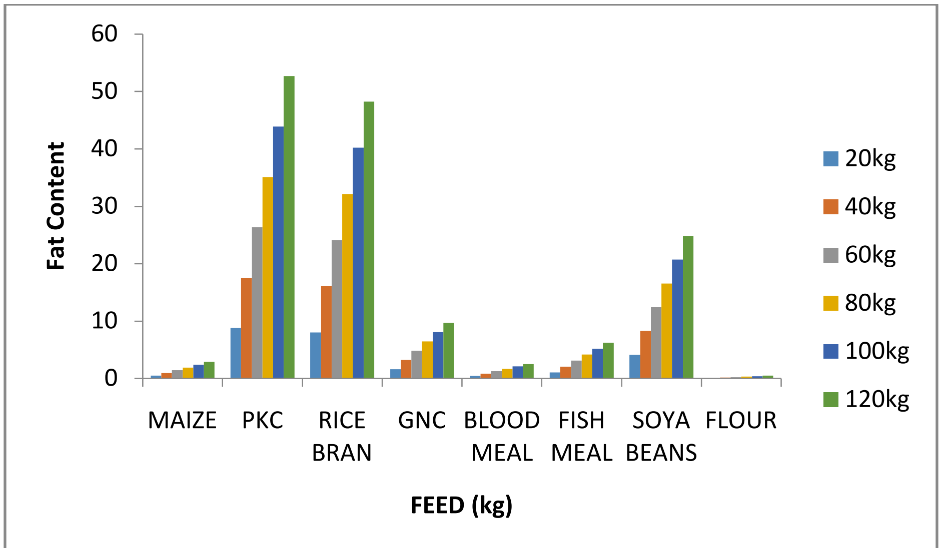

Figure 4.12: Fat Content of Different Feedstock for Fish Feed Meal Production.

4.2 Discussion

Comparative Analysis of Experimental Design Results to Standards Results

It is not enough to design a process with all the required stepwise procedures for the production of fish feed from locally sourced feedstock or raw materials, unless the obtained results are compared in terms of certain variables to that which is obtainable to literature or industrial standards, It is therefore necessary to compare the obtained results with the industrial standards and check for consistency. But if, however, the obtained results do not conform to that obtainable from standards, then the setup experimental design process is wrong and a new setup experimental design process must be incorporated to adequately describe the process which will now serve as the base experimental design methodology for the production of fish feed from the locally sourced materials.

Nonetheless, only three variables of crude protein, fibre and fats were considered in the analysis. In lieu to the above fact, Table 4.1 which list the complete proximate analysis of various variables found in some locally feedstock and the obtained results of the simulation from figure 4.2 through figure 4.12 were compared of these three variables. Considering the blood meal for fish feed production while regarding figure 4.8 which gave 100kg weight, it was observed that the obtained compositional content for crude protein was similar (above 80%) to that which was obtainable from the standard table (86%). Like wisely, the obtained fibre and fat content from the obtained simulated designed results was similar [2, 0.1] to that obtainable from the standards [2.7, 0.7].

More also, in similar manner, considering the fish meal feedstock, it was observed that the obtained compositional content for crude protein was similar (above 55%) to that which was obtainable from the standard table (57.7%). Like wisely, the obtained fibre and fat content from the obtained simulated designed results was similar [5, 10] to that obtainable from the standards [5.2, 1.8] percent respectively. Additionally, by considering the palm kernel cake (PKC), it was observed that the obtained compositional content for crude protein was similar (about 20%) to that which was obtainable from the standard table (19.1%). Further, the obtained fibre and fat content from the obtained simulated designed results was similar [5, 45] to that obtainable from the standards [7.6, 43.2] percent respectively. In addition, by the consideration of groundnut cake

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(GNC), it was observed that the obtained compositional content for crude protein was similar (about 50%) to that which was obtainable from the standard table (48%).

Also, the obtained fibre and fat content from the obtained simulated designed results was similar [18, 10] to that obtainable from the standards [8.1, 13.2] percent respectively. Furthermore, by reviewing the soya bean feedstuff, it is determined that the obtained compositional content for crude protein was similar (about 50%) to that which was obtainable from the standard table (48.1%). Further, the obtained fibre and fat content from the obtained simulated designed results was similar [25, 22] to that obtainable from the standards [4.1, 23.9] percent respectively. More so, in view of the maize feedstock, it was determined that the obtained compositional content for crude protein was similar (above 10%) to that which was obtainable from the standard table (10.8%). Further, the obtained fibre and fat content from the obtained simulated designed results was similar [5, 0] to that obtainable from the standards [3.1, 3.6] percent respectively. Furthermore, by considering the rice bran feedstock for the production of fish feeds, it was revealed that the obtained compositional content for crude protein was similar (above 10%) to that which was obtainable from the standard table (9.9%). Furthermore, the obtained fibre and fat content from the obtained simulated designed results was similar [5, 40] to that obtainable from the standards [4.4, 40.2] percent respectively. Nevertheless, the percentage composition of flour feedstock was not compared since it basically had zero amount of all the three variables from the simulated design process.

In conclusion, it was observed that the experimental design procedure was able to capture the feed content of all the feedstock or raw materials exception of flour in terms of their crude protein, fibre and fat contents. However, it should also be noted that the amongst the variables,

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crude protein content was the most consistent to literature standards from the obtained experimental setup design since it showed only slight deviations whereas the fat and fibre content conforming to some extent was not entirely captured by the experimental design process for the production of fish feed.

Optimum Feed Rate Selection

The selection of an optimum feed rate for the production of fish feed was not subjective but is dependent on parameters that was ascertain the optimal concentration of variables of interest such as the crude protein, fibre and fat contents. These parameters which included proximity to raw materials, cost of raw materials (feedstock) were highly valuable for the consideration of the optimal feedstock rate that was processed. Nevertheless, practically it had always been known that the higher the feed rate to a particular process, the better the profit outcome but at the expense of the capital cost of the process since larger equipment's was required. Furthermore, by considering the obtained results as per the standards table, it wass in clarity that the optimal feed rate that gave a considerable close values to that obtainable was 100kg of the different feedstock. This result was not however not ultimate and may be subject to further review.

4.3 Cost Estimation

Table 4.3 below shows the cost of fish feed produce from locally available materials

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Table 4.3 Cost Analysis

Feed	Price (Naira)	Measurement (kg)
Maize	28,000	100
PKC	25,000	50
Rice bran	4,300	50
GNC	28,000	100
Blood meal	50,000	100
Flour	10,000	20
Fish meal	25000	50
Total	170,000 or $340.6	500

Table 4.4 Foreign Feeds, Sizes, CP Content and their Prices

Feed	Size (mm)	Price (Naira)	Measurement (Kg)	CP (%)
Ziglar	2	16,200	15	45
Coppens	2	15,900	15	42
Alaqua	2	15,200	15	43
Prime	2	15,600	15	45

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Table 4.3 Showed the cost analysis of fish feed produced from local available material (Port Harcourt price list). It can been seen from the table that blood meal had the highest cost (50,000 Naira) for 100kg followed by Groundnut cake (GNC) with a cost price of 28,000 Naira and Rice bran had the least price (4,300 Naira) and a total price for all the feed components is 170,300 Naira (340.6 dollar) for a total of 500kg.

Capital cost = cost of farm + cost of labour + operational cost+ material cost

Capital cost= 5,000+6,000+10,000+170,300

Capital cost=201,300 Naira for 500kg

But 15kg=1bag

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500kg gave 33bags

Cost of 1bag (15kg) was 201,300/33 = 6,100 Naira

Table 4.4 depict the proximate cost analysis of foreign feed. For 2mm pelleted size, Ziglar had the highest price (16,200 Naira) for 15kg (1bag) followed by Coppens with cost price of 15,900 Naira and Alagua had the least cost (15,200 Naira)

Cost of 33bags for each

For Ziglar: 16,200×33 = 534600 Naira

For Coppens: 524700×33 = 524700 Naira

For Alaqua: 15,200×33 = 501600 Naira

For Prime: 15,600×33 = 514800 Naira

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Comparison of the Foreign Fish Feed with the Locally Produce Fish Feed

Ziglar feed vs my locally produced feed

534,600 –201,300 = 333,300 Naira

It was seen that the profit margin between my locally produced feed and foreign feed was huge (333,300 Naira)

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

An experimental setup design process for the production of fish feed using locally sourced feedstuffs at different weights and all the required procedural steps was undertaken in this research work. Further, the experimental setup designed process was analyzed in terms of the obtained chemical composition of all the feedstock and whereby the obtained composition from the experimental setup designed process was plotted using the aid of excel spreadsheet for re-evaluation of the fish feed production process. Additionally, a comparative analysis of all the feedstock composition content based on the weight was carried out to establish a decision based result for the particular fish feed material that is suitable for targeted fish feed production.

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Furthermore, the feed material where weighed from 10-120kg respectively, where the CP, fibre, and fat content of the feeds where evaluated, and to check for optimum yield with comparison to obtained literature and industrial standard, result showed excellent consistency with the standard in comparison with the fish feed production data obtained from olams farms. The cost analysis showed 50% cost reduction in fish feed production for farmers in comparison with foreign feeds.

From the forgoing, the obtained results from the experimental setup designed process were compared with literature standards in terms of what was obtainable and to establish whether or not the design captured the fish feed production process. The obtained results from both the pair wise comparative analysis and to literature standards showed excellent consistency, thus the experimental setup design procedure could serve as the base methodology in the design of a fish feed production process forbearing little adjustments. Hence, it was observed that the optimal feed rate that gave close values to that obtainable standard or result was from 100kg of the different feedstock.

5.2 Contribution to Knowledge

There have been studies on fish feed production which have considered Gas Chromatography analysis on locally sourced materials carried out by various authors, however most of the researches did not consider the impact of CP, fiber and fat with respect to fish growth and cost. Hence this research bridges the knowledge gap and contributes the following to already existing research.

i. The research made selection of fish feed materials easy for large and small scale farmers, and will make the cost of fish affordable.

ii. This research determined the best group of locally fish feed materials that have the best CP, fibre and fat contents.

iii. The research has also determined that blood meal yield the best CP that boast fish growth in 90 days growth plan.

iv. Also this research will reduce the cost of fish feed production cost, using the available local materials.

v. This research provides viable alternative for farmers using foreign feeds which will reduce the importation of fish feeds in Nigeria.

vi. Local materials proves to yield more healthy fish that is devoid of chemicals and is organic for human consumption.

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5.3 Recommendations

Notwithstanding, the accuracy of the experimental setup design of a fish feed production process with all the required procedural steps, there is still need to review some gaps that is to be the interest of the next researcher.

i. The gap areas may include a more robust experimental setup design of the fish feed production process that will be consistent in relating to the obtainable standards of the composition content such as the fibre and fat composition content.
ii. Additionally, the experimental setup design of a fish feed production process that incorporates more property as provided in the literature standards is highly valuable.
iii. Further, the visual simulation through computer aided tools and the sizing of all the required process equipment in the fish feed production process is necessary as obtaining a visual representation of a process and the dimensions of particular process equipment for any process is the basis of design.
iv. Furthermore, the cost analysis of undertaking this process in terms of overall equipment requirement and total capital cost should also be evaluated wherein the type of feedstuff used in the fish feed production process is invaluable areas of interest to the next researcher.
v. More research should be carried out to determine the Algea effect on feeds
vi. Proper packaging and bagging condition to avoid microbial and mist attacks
vii. Fish oil research from the local feeds should be carried out for drug production.

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APPENDIX A

FOR 10KG

FEED	CP	FIBRE	FAT
MAIZE	0.93	0.5	0.24
PKC	1.9	0.76	4.39
RICE BRAN	0.99	0.44	4.02
GNC	4.8	1.32	0.81
BLOOD MEAL	8.61	0.07	0.21
FISH MEAL	5.77	0.18	0.52
SOYA BEANS	4.81	2.39	2.07
FLOUR	0.26	0.05	0.04

FOR 20KG

FEED	CP	FIBRE	FAT
MAIZE	1.86	1	0.48
PKC	3.82	1.52	8.78
RICE BRAN	1.98	0.88	8.04
GNC	9.6	2.64	1.62
BLOOD MEAL	17.2	0.14	0.42
FISH MEAL	11.54	0.36	1.04
SOYA BEANS	9.62	4.78	4.14
FLOUR	0.52	0.1	0.08

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FOR 30KG

FEED	CP	FIBRE	FAT
MAIZE	2.79	1.5	0.72
PKC	5.73	2.28	13.17
RICE BRAN	2.97	1.32	12.06
GNC	14.4	3.96	2.43
BLOOD MEAL	25.8	0.21	0.63
FISH MEAL	17.31	0.54	1.56
SOYA BEANS	14.43	7.17	6.21
FLOUR	0.78	0.15	0.12

FOR 40KG

FEED	CP	FIBRE	FAT
MAIZE	3.72	2	0.96

PKC

7.6 3.04 17.56

66

RICE BRAN	3.96	3.04	16.08
GNC	19.2	5.28	3.24
BLOOD MEAL	34.4	0.28	0.84
FISH MEAL	23.08	0.72	2.08
SOYA BEANS	19.24	9.56	8.28
FLOUR	1.04	0.2	0.16

FOR 50KG

FEED	CP	FIBRE	FAT
MAIZE	4.65	2.5	1.2
PKC	9.5	3.8	21.95
RICE BRAN	4.95	2.2	20.02
GNC	24	6.6	4.05
BLOOD MEAL	43	0.35	1.05
FISH MEAL	28.85	0.9	2.6
SOYA BEANS	24.05	11.95	10.35
FLOUR	1.3	0.25	0.2

FOR 60KG

FEED	CP	FIBRE	FAT
MAIZE	5.58	3	1.44
PKC	11.4	4.56	26.34
RICE BRAN	5.94	2.64	24.12
GNC	28.8	7.92	4.86
BLOOD MEAL	51.6	0.42	1.26
FISH MEAL	34.62	1.08	3.12
SOYA BEANS	28.86	14.34	12.42
FLOUR	1.56	0.3	0.24

FOR 80KG

FEED	CP	FIBRE	FAT
MAIZE	74.4	4	1.92
PKC	15.2	6.08	35.12
RICE BRAN	7.92	3.52	32.16
GNC	38.4	10.56	6.48
BLOOD MEAL	68.8	0.56	1.68
FISH MEAL	46.16	1.44	4.16
SOYA BEANS	38.48	19.12	16.56

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FLOUR	2.08	0.4	0.32

FOR 100KG

FEED	CP	FIBRE	FAT
MAIZE	9.3	5	2.4
PKC	19	7.6	43.9
RICE BRAN	9.9	4.4	40.2
GNC	48	13.2	8.1
BLOOD MEAL	86	0.7	2.1
FISH MEAL	57.7	1.8	5.2
SOYA BEANS	48.1	23.9	20.7
FLOUR	2.6	0.5	0.4

FOR 120KG

FEED	CP	FIBRE	FAT
MAIZE	11.16	6	2.88
PKC	22.8	9.12	52.68
RICE BRAN	11.88	5.28	48.24
GNC	57.6	15.84	9.72
BLOOD MEAL	103.2	0.84	2.52
FISH MEAL	69.24	2.16	6.24
SOYA BEANS	57.72	28.68	24.84
FLOUR	3.12	0.6	0.48

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