**Effects of Complete and Partial Replacement of Fishmeal with *M. oleifera* Seed on the Growth Performance of *Clarias gariepinus***

**ABSTRACT**

This research was carried out to evaluate the effects of complete and partial replacements of fishmeal with *M. oleifera* seed meal (MSM) on the growth performance of *Clarias gariepinus* fingerlings. One hundred and forty (140) *C. gariepinus* fingerlings were used for this study. The fingerlings reared were randomly assigned to seven dietary treatments namely: control or T1(0% MSM); TC2 (20% cooked MSM), TU3 (20% uncooked MSM); TC4 (40% cooked MSM); TU5 (40% uncooked MSM), TC6 (100% cooked MSM), and TU7 (100% uncooked MSM) respectively. Each treatment was replicated thrice, in a completely randomized design. The experiment lasted for 10 weeks during which the parameters monitored included proximate composition, weight gain, length increase, specific growth rate, and protein efficiency ratio. The data collected were subjected to analysis of variance at 5% significant level. The result showed that diet TU7, T1, TU5, TU3 had the highest dry matter (94.64%), crude protein (49.63%), ash (11.35). The highest fibre (3.73) and lipid was recorded in diet TC4 and nitrogen free extract (43.43%). There was a significant difference between the dry matter, crude protein, fibre, lipid, ash and nitrogen extract of the experimental diets (p=0.00). The results revealed that the highest weight gain was recorded by the fingerlings fed diet T1 (128.40±0.66) followed by diet TC2 (120.70± 0.17) while least in those of diet TC4 (56.87± 0.71). There was significant difference (P<0.05) in the weight gain. The highest length increase was recorded by the fingerlings fed diet TC2 (18.90±4.72) followed by diet T1 (17.57± 2.62) while least in those of diet TU7 (10.73± 0.61). There was significant differences (P<0.05) in the length increase. The fingerlings fed with diet T1 had the highest specific growth rate (6.94**±**0.01) followed by those fed with diet TC2 (6.85**±**0.00) while least in those fed with TC4 (5.77**±**0.02). There was significant difference (P<0.05) in the specific growth rate. The best value for protein efficiency ratio was recorded in the *C. gariepinus* fingerlings fed with diet TC2 (2.98) while poorest in those fed diet TC4 (1.23). There was significant difference (P<0.05) in the protein efficiency ratio (p=0.00) of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal (P=0.54). It was concluded that fish farmers could replace fishmeal up to 20% with cooked *M. oleifera oleifera* seed meal for formulating diets for *Clarias gariepinus*.

**Keywords:** Growth performance, Replacement, Fishmeal, *M. oleifera* seed meal, *C. gariepinus*

**INTRODUCTION**

Growth performance in fish generally depends on many circumstances which include environment, feeds, water quality, stocking density. For feasible fish production therefore, all the necessary factors required to obtain high growth in cultured fish such as *Clarias gariepinus* should be provided to ensure profit maximization (Abdel – Warith *et al.,* 2002)*.* Since factors such as water quality can be maintained at a reasonable cost except feed, urgent provisions must be made to provide optimum amount for the optimal production of fish (Abdel – Warith *et al.,* 2002).

Commercial aquaculture production of African catfish (*Clarias gariepinus*) in Nigeria has increased rapidly in recent years. However, it is clear that fish meal supplies are strictly limited and if aquaculture continues to expand globally, the requirements for fish meal will soon exceed its supplies (FAO, 2006). Because fish meal is a limited primary source of animal protein, the use of plant protein sources that are widely available and reasonably priced should be considered in aqua feeds (Lovell, 1989; Storebakken *et al*., 2000). There has been an increase in the attempt to replace high-priced fish meal with plants which possesses good quality essential amino acids (EAA) such as soybean meal and pigeon pea among others. Soybean meal is utilized with the hope of helping to decrease the cost of feed production, however over-dependence will cause a hike in the price of soybean meal as soya bean also have high demand for human consumption (Storebakken *et al*., 2000). Therefore, utilization of other inexpensive plant protein sources that are not in high demand for human consumption would be beneficial in reducing feed cost (Fuglie, 2001).

Interestingly, certain plant materials offer promising alternatives and among them is the *M. oleifera* seed meal. Moringa is a fast-growing plant widely available in the tropics and subtropics with several economically important industrial and medicinal uses (Ozumba *et al.,* 2009). It is native to Sub-Himalayan parts of northern India with different major Nigerian vernacular names: Okwe Oyibo (Igbo), Ewe ile (Yoruba), Zogalle (Hausa), Gawara (Fulani) (Ozumba, 2008; Igwilo *et al.,* 2011,). *M*. *oleifera* represents a traditionally important food commodity as the leaves, flowers, fruits/seeds and roots of this tree are locally used as vegetables (Siddhuraju and Becker, 2003). Its seeds have been extensively investigated as a source of oil. The seed protein contents are higher than those reported for important grain legumes and soybean varieties (Ferreira *et al.,* 2008).

Previous studies revealed that *M. oleifera* seeds showed high levels of protein with the dry seeds usually containing 332.50 to 383.00g/ kg of protein (Abdulkarim *et al.,* 2005). *M. oleifera* contains an appreciable amount of nutrients that include: crude protein of 25.0%, crude lipid of 10% and crude fibre of 8.4%, beyond some common fruits, milk and carrot. It contains 25 times the Iron of spinach, 17 times the Calcium of milk, 15 times the Potassium of bananas, 10 times the vitamin A of carrots, 9 times the protein of yogurt, 0.5 times the vitamin C of oranges. The Essential Amino Acid (EAA) composition in *M. oleifera* seed cake have high essential amino acid, especially the sulfur amino acids as methionine, cysteine, tryptophan (Makkar and Becker, 1996) except for lysine (15.3 g/kg-1 protein), threonine (30.8g/kg-1) and valine (43.5g/kg-1) (Oliveira and Silveira, 1999). In general, there are low concentrations of antinutritional factors in the plant, although the seeds possess glucosinolates (65.5μ mol g-1) and phytates (41g kg-1) (Ferreira *et al.,* 2008).

Since farming aquatic animals in Nigeria was broadly adopted and improved, it has caused a problem of high priced feed as well as insufficient nutrition. A significant proportion of fish meal possesses a broad range of amino acids that are high priced, hence there has been attempts to replace high-priced fish meal with alternative sources which possesses good quality essential amino acids (EAA) and affordable. In Nigeria, there is little information regarding the utilization of Moringa seed meal in catfish feed hence this study aims to compare the effect of complete and partial replacements of fishmeal with Moringa seed meal (cooked and uncooked) on the growth performance of *Clarias gariepinus* fingerlings.

**MATERIALS AND METHODS**

**Experimental Location**

This experiment was conducted at Okpuno, Awka, Anambra State, South-East of Nigeria for a period of 12 weeks. Awka lies below 300metres above sea in a valley on the plains of the Mamu river with a geographical coordinates of 60 10’ 0’’ North, 70 4’ 0” East. It is in the tropical zone of Nigeria and experiences two distinct seasons brought about by the two predominant winds that rule the area: the South western monsoon winds from the Atlantic Oceans and the north eastern dry winds from across the Sahara desert. The monsoon winds from the Atlantic creates seven months of heavy tropical rains which occur between April and October which are then followed by five months of dryness (November – March) (Okezie and Igbokwe, 2015). The temperature in Awka is generally a comfortable 27 – 30 degrees Celsius between June and December but rises to 32 – 34 degrees Celsius between January and April.

**Procurement of Experimental Fish**

The experimental fish, African catfish (*C. gariepinus)* were obtained from Jupet Fish Farms, Awka in Awka South Local Government Area of Anambra State. A total number of one hundred and forty (140) *C. gariepinus* fingerlings (22.66±2.39g and 13.25±0.23cm) were used for this study. These fingerlings were transported in a 50 litre plastic gallon cut open at the top and then covered with a mesh net held in place by a rubber band from the farm of purchase to the study site at St. Gabriel’s Catholic Church, Okpuno, Awka in Anambra State early in the morning. The plastic aquarium used for the purpose of acclimatization of the fish measured 160 litres in volume, whereas the study plastic aquaria which were fourteen (14) in number measured 60 litres each.

**Source of Experimental Feed Ingredients**

Feed components namely fish meal, soya meal, groundnut cake, corn meal, bone meal, wheat offals, lysine, methionine, fish premise, fish biotics, vegetable oil, kivestovite and salt were purchased from Palmac Business Ventures “Afor – Nnobi” market, while the plastic aquaria and water storage containers were bought from “Ogbo efere” market in Onitsha. The *M. oleifera* seeds were bought from Wuse 2 market, Abuja, Nigeria.

**Experimental Diet Formulation**

Seven diets were formulated using Least Cost Ration formulation which took into consideration the nutritive content of the major ingredients. All the feed ingredients were integrated into computing the required quantities to make up 100 units of the feed (Table 1). The first diet (which is the control diet) was formulated with 0% inclusion of *M. oleifera* seed meal.

**Table 1: Composition of Formulated Diet of Cooked and Uncooked *Moringa oleifera* Seed Meals (% Dry Weight)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Ingredients** | **T1** | **TC2** | **TU3** | **TC4** | **TU5** | **TC6** | **TU7** |
| Maize | 25.0 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| Soya bean | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 |
| Wheat offal | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Fishmeal | 40.00 | 32.00 | 32.00 | 8.00 | 8.00 | 00.00 | 00.00 |
| *M. oleifera* seed meal | 0 | 16.00 | 16.00 | 32.00 | 32.00 | 40.00 | 40.00 |
| Cassava | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Palm oil | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Bone meal | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Pre-mix | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Methionine | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Lysine | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

KEY: Control or T1(0% MSM); TC2 (20% cooked MSM), TU3 (20% uncooked MSM; TC4 (40% cooked MSM); TU5 (40% uncooked MSM), TC6 (100% cooked MSM), and TU7 (100% uncooked MSM).

**Processing of *M. oleifera* Seed and Feed Ingredients**

Prior to feed processing, the experimental *Moringa oleifera* seeds were divided into two equal parts. Half of the experimental *M. oleifera* seeds were cooked for about 30 – 35mins to remove the anti–nutrient inhibitors after which they were properly dried under room temperature to avoid loss of basic nutrients for two (2) weeks. Both the cooked and uncooked *M. oleifera* seeds were ground separately into fine powder and each further divided into three equal parts. Also, other feed ingredients such as bone meal and maize that needed grinding were ground separately into fine powder using hammer mill machine and afterwards each weighed separately using a weighing balance (Model BL 20001of maximum capacity of 2000g) before being divided into seven (7) equal parts. All other study ingredients such as maize, soyabean, wheat offal, cassava, bone meal, pre-mix, methionine, lysine salt and oil were equally divided into seven (7) different parts. Then they were all manually mixed separately according to the stipulated various inclusion levels of 0%, 20%, 40%, and 100% of *M. oleifera* seed meals for both the cooked and uncooked *M. oleifera* seeds. Summarily, feed preparation involved milling the grain ingredients such as *M. oleifera* seeds and maize grains separately, sieving the powder using >1 mm sieve mesh size, mixing of all dry ingredients for both cooked and uncooked *M. oleifera* seed meals, addition of oil before adding hot water (90oC – 95oC) and then mixing to form a dough (Lall, 1991). Adequate water was added gradually during the mixing so as to ensure smooth pelleting and to aid digestibility. The seven (7) different diet mixtures were pelleted using a 3mm diameter pelletizer. The pellets were also sun dried for two days to remove moisture (Eyo, 1996) before being packaged separately in waterproof cellophanes contained in seven (7) plastic containers labelled as T1(control diet of 0% MSM), TC2 (20% cooked MSM), TU3 (uncooked MSM), TC4(40% cooked MSM), TU5( 40% uncooked MSM), TC6 (100% cooked MSM), TU7 (uncooked MSM) and kept dry until usage time.

The test ingredient (Moringa seed meal) served as one of the main sources of protein in the fish feed, and this was used to substitute the fish meal at different levels. The fixed ingredients consisted of cassava starch flour obtained locally from the market and used as the binder for the ingredients for easy pelleting. Other ingredients included vitamins and minerals pre-mix, palm oil, table salt, bone meal, wheat offal and soya bean cake meal which was used to balance the protein content in the feed. Methionine and Lysine were also used to balance the amino acid contents of the feed.

**Feeding**

In this study, the fingerlings were fed with starter vital feed for the first two (2) weeks (Acclimatization period) so as to get them used to their new environment. They were fed the rations (T1, TC2, TU3, TC4, TU5, TC6, and TU7) two times daily at 8.00am and 6.00pm. After the acclimatization, the treatments with the varying *M. oleifera* seed meal inclusions of 0%, 20%, 40%, and 100% representing (T1, TC2, TU3, TC4, TU5, TC6, and TU7 respectively) were administered for 10 weeks.

**Data Collection**

The fishes were fedtwice daily. The water in the fourteen (14) plastic aquariawasemptied completely and re-filledonce a week to prevent diseases and subsequent fish death due to low dissolved oxygen. The length and weight of the fish were measured using a transparent meter rule and an electronic weighing balance of Model BL 20001 respectively and then the readings were recorded on paper on weekly basis. Length of fish was obtained by stretching a fish on the meter rule to take the reading.

**Determination of Proximate Composition of Processed *M. oleifera* Seeds**

The proximate composition (moisture, crude protein, crude lipid crude fibre, and ash and nitrogen free extracts) of both the uncooked and cooked *M. oleifera* seed meals and that of the experimental diets were determined using the methods of the Association of Analytic Chemists (A.O.A.C., 1995). All chemical analyses were replicated twice.

**Monitoring of Water Quality Parameters**

Water quality parameters such as dissolved oxygen (DO), hydrogen ion concentration (pH) and temperature were measured using American Public Health Association (APHA) (1995) methods. The calibrated mercury thermometer was used for measuring water temperature; the pH and dissolved oxygen concentration were measured using the Jenway meters (model 3050 for DO and 9070 for the pH).

**Growth Performance**

The data obtained on the growth performance of *Clarias gariepinus* fed with the formulated diets were analysed as follows:

**1. Weight Gain**

The weight gain was expressed as the weight gain of individual in the organism’s life time (T2 – T1) and was expressed as weekly final mean weight minus initial weight divided by duration of the study.

Weight gain

Where:

= final mean weight (g)

= initial mean weight (g)

= final time (weeks or days)

= initial time

**2. Percentage weight gain (PWG)**

This was determined using the formula below:

**3. Specific Growth Rate (SGR)**

This determines the actual weight gain for the time interval of the study and expressed as:

Where:

W2 = Final weight of fish at time T2

W1 = Initial weight of fish at time T1

e = Base of natural logarithm

**4. Length increase**

Length increase (cm) is calculated as the difference between the initial and final mean lengths values of the fish in the aquarium.

Length increase = L2 –L1

Where L1 = Initial Length

L2 = Final Length

**5. Percentage Length Increase (%LI):-** This is expressed by the equation:

Where: L1 = Initial length and Lt = Length at time t.

**3.11** **Nutrient utilization**

The index of feed utilization calculated was protein efficiency ratio which assesses an individual protein ability to sustain growth. It is also used to evaluate the quality of protein in the diet (Osborne *et al.* 1919). It is expressed as:

**Statistical Analysis**

Data collected from the growth parameters were statistically analyzed with ANOVA using SPSS Computer Software Package (version 20) at 0.05 significant levels. The sample means were separated using Duncan’s Multiple Range Test of significance.

**RESULTS**

**Water Quality Parameters**

The water quality parameters monitored during the study which included temperature, pH, dissolved oxygen, total alkalinity, biological oxygen demand, are represented in Table 2. Temperature was maintained within the range of 25 – 290C, pH 5.40 – 6.10, dissolved oxygen 8.59 – 8.63ppm, total alkalinity 19.90 – 20.00ppm and biological oxygen demand between 0.76 – 0.90ppm. The result shows that pH and dissolved oxygen values are within the acceptable range for fish culture in the tropics as reported by Boyd (1979).

**Table 2: Water Quality Parameters Monitored During the Experimental Period**

|  |  |  |  |
| --- | --- | --- | --- |
| **Water Quality Parameters** | **Range** | **Mean ± SD** | **Range (Boyd *et al.,* 1979)** |
| Temperature (0C) | 25 – 29 | 27.50±0.57 | 25.0 – 32.0 |
| pH | 5.40 – 6.10 | 5.90±0.14 | 6.50 - 9.0 |
| Dissolved oxygen (ppm)/MgL-1 | 8.59 – 8.63 | 8.61±0.03 | 3.0 – 5.0 |
| Total alkalinity (ppm)/ MgL-1 | 19.90 – 20.0 | 19.95±0.07 | 20.0 - 30.0 |
| Biological oxygen demand (ppm) | 0.76 – 0.90 | 0.83±0.10 | 1 – 2 |

**Figure 1: Proximate Composition of uncooked and cooked *M. oleifera* seed meal**

The result of proximate composition of cooked and uncooked *M. oleifera* seed as presented in Figure 1 shows that uncooked *M. oleifera* seed has high protein content (35.21%) than the cooked seeds (30.37%). However, the cooked has a high fat (43.56%) than the uncooked (40.74%). Also the table revealed that uncooked *M. oleifera* seeds had higher moisture content and crude protein values of 9.14% than the uncooked seeds. The cooked *M. oleifera* seeds had higher values of Nitrogen free extract (9.17%), Ash content (4.98%) and fibre content (4.70%) than the uncooked. There were significant differences between the ash (p=0.01), fat (p=0.02), crude protein (0.047), Nitrogen free extract (p=0.01) except moisture (p=0.35) and fibre (p=0.33).

Figure 2 showed that diet TU7 has the highest (94.64) dry matter followed by diet TU5 (94.50) while TU3 had the least (90.60). Diet T1 had the highest (49.63) crude protein followed by diet TU7 while diet TC2 had the least (40.56). The highest fibre (3.73) was recorded in diet TC4 followed by diet T1 (2.75) while least in TU5 (1.61). The highest lipid (6.43) was recorded in diet TC4 followed by diet TU7 (5.12) while least in TU5 (3.52). The highest ash (11.35) was recorded in diet TU5 followed by diet TU3 (10.47) while least in TC4 (7.33). The highest nitrogen free extract (43.43) was recorded in diet TU3 followed by diet TC2 (42.93) while least in TC6 (33.66). There was a significant difference between the dry matter, crude protein, fibre, lipid, ash and nitrogen extract of the experimental diets (p=0.00).

**Figure 2: Proximate Composition of Experimental Diets**

**Growth Performance**

**Weight Gain**

The result in Figure 3 shows that the highest weight gain was recorded by the fingerlings fed diet T1 (128.40±0.66) followed by diet TC2 (120.70± 0.17) while least in those of diet TC4 (56.87± 0.71). There was a significant difference between the weight gain of *C. gariepinus* fingerlings fed varying percentage inclusions of MSM (P=0.00) at 5% level of significance.

**Figure 3: Mean Weight gain of *Clarias gariepinus* Fed different percentage Inclusion of *M. oleifera* seed Meal for 10 Weeks**

**Percentage weight gain**

The result in figure 4 revealed that the fingerlings fed with diet TC2 had the highest percentage weight gain (505.76%) followed by those fed with the control diet (489.74%) while least in those fed with TC4 (296.55%). There was a significant difference between the percentage weight gain of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal (P=0.00) at 5% level of significance.

**Figure 4: Percentage Weight Gain of *Clarias gariepinus* Fed with different percentage Inclusion of *M. oleifera* seed Meal for 10 Weeks**

**Length Increase**

The data presented in figure 5 shows that the highest length increase was recorded by the fingerlings fed diet TC2 (18.90±4.72) followed by diet T1 (17.57± 2.62) while least in those of diet TU7 (10.73± 0.61). There was a significant difference between the length increase of *C. gariepinus* fingerlings fed varying percentage inclusions of MSM (P=0.00).

**Figure 5: Mean length increase (cm) of *C. gariepinus* Fed with different percentage Inclusion of *M. oleifera* seed Meal for 10 Weeks**

**Percentage length increase**

The result in figure 6 revealed that the fingerlings fed with diet TC2 had the highest percentage length increase (146.42±48.71%) followed by those fed with the control diet (128.84±24.12%) while least in those fed with TU7 (80.80±10.58%). There was no significant difference between the percentage length increase of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal (P=0.54) at 5% level of significance.

Figure 6: Percentage length increase of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal

**Specific Growth Rate**

The result in figure 7 revealed that the fingerlings fed with diet T1 had the highest specific growth rate (6.94**±**0.01) followed by those fed with diet TC2 (6.85**±**0.00) while least in those fed with TC4 (5.77**±**0.02). There was a significant difference between the specific growth rate of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal (P=0.00) at 5% level of significance.

**Figure 7: Specific Growth Rate of *Clarias gariepinus* Fed with different percentage Inclusion of *M. oleifera* seed Meal for 10 Weeks**

**Protein Efficiency Ratio**

The data on protein efficiency ratio presented in table 3 showed that the best value for protein efficiency ratio was recorded in the *C. gariepinus* fingerlings fed with diet TC2 (2.98) while poorest in those fed diet TC4 (1.23). There was significant difference in the protein efficiency ratio of *C. gariepinus* fingerlings fed varying percentage inclusions of *M. oleifera* seed meal (P=0.00) at 5% level of significance.

**Figure 3: Protein efficiency ratio of *Clarias gariepinus* Fed with different percentage Inclusion of *M. oleifera* seed Meal for 10 Weeks**

**DISCUSSION**

The result of the physico-chemical parameters of the culture water used for raising the fish revealed that the temperature range obtained was 250C – 290C. This temperature range fall within the acceptable range and did not affect the fish feeding negatively. Auta (1993) also reported a similar temperature range of 250C – 30.00C in a research carried out in static tanks in Zaria. The pH range of 5.40 – 6.10 and Dissolved Oxygen (D.O) range of 8.59 – 8.63ppm recorded during this study suggest that they are within acceptable range for growth and maintenance of *C. gariepinus*. The pH range of 6 – 8.5 and D.O. of 4 – 8.0ppm have been reported by Balogun *et al*. (2004). In view of the fact that all the physico-chemical parameters of the culture water were within acceptable ranges, the fish growth and feed utilization may be affected by other intrinsic and extrinsic factors.

The weight gain was recorded in fingerlings fed with diet T1 (128.40±0.66) followed by diet TC2 (120.70± 0.17) while least in those of diet TC4 (56.87± 0.71). This could be as a result of better utilization of the nutrients in the feed to produce good weight gain. This observation is in line with the report by some authors (Solomon *et al.,* 1996) who stated that diet containing 100% fishmeal gave the best growth performance of fish. Fishmeal has a high crude protein content ranging from 62% to more than 70% (Sauvant *et al.,* 2004) and a high amino acid quality (Medale and Kauslik,2009). In treatments with the same *M. oleifera* seed meal inclusion, treatments with cooked *M. oleifera* seed meal had a higher weight gain compared to the uncooked treatments. The works of Eyo and Olatunde (1999) and Omafuvbe *et al.* (2004) indicated that boiling of soybean and locust bean seeds promoted growth in *Clarias gariepinus*. Hydrothermally processed *Proscopis justiflora* seeds also produced improved growth in *Labeo rohutal* fingerlings (Bhatt *et al.,* 2011). The result of the percentage weight gain of *C. gariepinus* fingerlings showed that those fed with diet TC2 was not significantly higher than other treatments. This indicates that diet TC2 can compare favourably with diet T1 in terms of percentage weight gain. Specific Growth Rate (SGR) of the fingerlings fed with diet T1 had significantly higher specific growth rate (6.94**±**0.01) than those fed with diet TC2 (6.85**±**0.00). This indicates that the diet TC2 does not compare favourably with fishmeal in terms of specific growth rate.

The percentage protein values obtained for the seven various experimental treatments (T1, TC2, TU3, TC4, TU5, TC6 and TU7) in this study were 49.63%, 40.56%, 46.31%, 46.42%, 43.80%, 44.49% and 46.85% respectively. The lower value of the crude protein content in cooked as against uncooked *M. oleifera* seed meal with the same percentage inclusion may be associated with denaturation of protein. Liener (1994) stated that denaturation of protein could occur due to excessive heat treatment which could further cause functional and nutritional changes in the protein source. It could also be due to leaching and solubilization of some protein content in the boiling water. Obasi and Wogu (2008), Udensi *et al.* (2010) and Jimoh *et al.* (2011) stated similar effects on different seeds experimented on. Also, the control diet had the highest protein content and this is because fishmeal has little or no fibre but high protein content in contrast to plant – based ingredients with higher fibre content (Afuang *et al.,* 2003).

The fibre content of the experimental feed was higher in the feed with cooked as against the uncooked *M. oleifera* seed meal. The low crude fibre of the control (2.75) could be accounted for by the fact that fishmeal is derived from fish which are animals and they do not efficiently digest fibre but eliminate it as solid wastes (Afuang *et al*., 2003). The reduction in the lipid contents of the cooked as against the uncooked *M. oleifera* seed meal could be accounted for by release of the lipid molecules into the boiling water or evaporated into the air from the cells. Udensi *et al.* (2010) obtained a similar result with *Mucuna flagellipes*. The low lipid content in the feed with the cooked *M. oleifera* seed as against the one with uncooked *M. oleifera* seed would make the meal acceptable for fish ration formulation since high lipid content in fish rations would affect the feed quality in terms of low floatation in water and possibility of high rancidity during storage (Lall, 1991). The values of the ash content of the different feeds did not follow a specific pattern as well as the free nitrogen extract. This study suggests that a higher PER value indicates a better utilization of the crude protein consumed. The best value for protein efficiency ratio was recorded in *C. gariepinus* fingerlings fed with diet TC2 (2.98) while poorest in those fed diet TC4 (1.23). Kperegbeyi and Ikprite (2009) obtained a similar result using processed *Cajanus cajan* seed meal in the broiler starter chicks feed.

**Conclusion**

This study showed that the best growth in terms of Mean Weight Gain (MWG) and S. G. R., was obtained from the control treatment. The feed utilization in terms of mean Protein Efficiency Ratio was also highest in the control treatment (T1). However, among the formulated diets, fish fed diet TC2 (20% cooked *M. oleifera* seed meal) performed better than other treatments. In view of the fact that the dried sea clupeids are often not readily available, due to the high demand by humans who consume them and animal feed millers who use them for making animal feeds, the *M. oleifera* seed meal – based diet at low amount inclusion would be of great value.

**Recommendations:**

From the findings of this research, it could be recommended that:

1. The replacement of fishmeal up to 20% with cooked *M. oleifera* seed meal in formulating fish feeds is recommended.
2. The establishment of large *M. oleifera* plantations should be encouraged in Nigeria.
3. Further research works are suggested using other processing methods such as soaking and fermentation, and incorporating the processed seed meals in the feeds for other species of fish.

**REFERENCES**

Abdel-Warilth and Abdel Wahab, A. (2002). Suitability of Selected Raw material and By-product in the Formulated feeds for Nile Tilapia (*Oreochromis* *niloticus* and African catfish (*Clarias gariepinus*). Plymouth Electronic Achieve and Research library (pearl) University of Plymonth, UK.

Abdulkarim, S.M; Long, K.O.M; Muhammad, S.K.S; Ghazali, H.M. (2005). Some physic-chemical properties of *Moringa oleifera* seed oil extracted using solvent and aqueous enzymatic methods. *Food Chem., 93* (2): 253-263.

Afuang, W., Siddhurju, P. and Becker, K. (2003). Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of *Moringa* (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile Tilapia (*Oreochromis niloticus* L.). *Aquaculture Research, 34*: 1147 – 1159.

American Public Health Association (1995) 3112B, Cold – Vapour Atomic Absorption Spectrometric Method, standard Method for the Examination of Water and Wastewater, 20th Edition, APHA, AWWA, WEF.

Association of official Analytical Chemist (AOAC) (1995).Official Methods of Analysis of the A. O. A. C. International 16th Ed. (ed. P. Cunniff) *AOAC*, Virginia, U.S.A. 928pp.

Auta, J. (1993). Water quality management in fish pond in: Oniye, S. J. Bolorunduro, P. I., and Auta, J. (Ed.), *Proceedings of National Workshop of Fisheries Extension Delivery, NAERLS, A.B.U., Zaria*. pp 1 – 20.

Balogun, J. K. S., Abdullahi, A. S., Auta, J. and Ogunlade, O. P. (2004). Feed Conversion, Protein Efficiency, Digestibility and Growth Performance of *Oreochromis niloticus* fed *Delinix regia* seed meal. *Proceedings of the National Conference of Fisheries Society of Nigeria (FISON)*, *Lagos, Nigeria*. Pp. 838 – 842.

Bhatt, S. S., Chorativa, S. G. and Shah, A. R. (2011). Evaluation of raw and hydrothermally processed *Prosopis justiflora* seed meal as supplementary feed for the growth of Labeorohuta fingerlings. *Aquaculture Nutrition,* *17*: 104 – 173

Boyd, C. E. (1979). Water quality in warm water fish ponds. Auburn University of Agriculture Experiment Station, Auburn, Alabama.

Eyo, A. A. and Olatunde, S. A. A. (1999).The effect of replacement of soya bean meal with blood meal on the growth of mudfish (*Clarias angularis L)* fingerlings. *Proceedings of 13th Annual Conference of FISON, New Bussa.3rd – 8th Nov. 1996 Ed*. By A. A.Eyo FISON Lagos. PP 232 – 238.

Eyo, A.A. (1996). Feeding practices in fish farming. National Institute for Freshwater Fisheries Research (NIFFR) Extension Guide Series No. 7.

FAO (2005 – 2012). Cultured Aquatic Species Information Programme *Clarias garipienus*. Cultured Aquatic species Information Programme. Text by Rakocy, J.E. In: FAO Fisheries and Aquaculture Department. Rome. Updated 18 February 2005. (cited 11 September, 2012).

Ferreira, P.M.P., Farias, D.F., Oliveira, J.T., Carvalho, A.F.U. (2008). *Moringa oleifera*: bioactive compounds and nutritional potentials. *Rev. Butr., 21*(4): 431-437.

Fuglie, L.J. (2001). *The miracle tree: The multiple attributes of Moringa*. Church World Service, Dakar/CTA, Waheningen, Netherlands, P. 172.

Igwilo, I.O., Ezeonu, F.C., Udedi, S.U. and Ozumba, N.A. (2011). Comparative studies on the amino acid content of different parts of *Moringa oleifera* plant found in Awka, South-East, Nigeria. *Biochem. Indian J., 5*: 124-127.

Jimoh, A.A. and Akintola, S.L. (2011). The challenges and prospects in developing an aquaculture industry in Lagos State, Nigeria. In: *19th Annual Conference of the Fisheries Society of Nigeria (FISON), 29 Nov – 03 Dec 2004, Ilorin, Nigeria*, pp 500-510.

Kperegbeyi, J. I. and Ikprite, S. E. (2009).Chemical composition of differently processed *Cajanus cajan* seed meal and its effect on growth performance of broiler starter chick. *African Journal of General Agriculture, 5*(1): 1595 – 6984.

Lall, S. P. (1991). Concepts in the formulation and preparation of a complete fish diet Fish Nutrition Research. *Asia Proceedings of the fourth Asian fish nutrition workshop*. Special Publication 5. *Asian Fisheries Society* Manila, Philippines. PP 1 – 12.

Liener, I. E. (1994).Implications of anti-nutritional components in soybean foods. *Critical Review in Food Science and Nutrition,* *34*:31 – 67.

Lovell, R.T. (1989). *Nutrition and feeding of fish*. Van Nostrand Reinhold, NY, U.S.A. pp. 240.

Makkar, H.P.S. and Becker, K. (1996). Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. *Anim. Feed Sci. Technol.,* 63 (¼): 211-228.

Medale, F. and Kauslik, S. (2009). Protein sources in feed for farmed fish. Edition(s): Lazard, *Journal of Lesel Resources*. Cahiers Agricultures, *18*(2-3):103-111.

Obasi, N. E. and Wogu, C. O. (2008).Effects of soaking time or the proximate and mineral composition and anti-nutritional factors of yellow maize (*Zea mays*). *Nigeria Food Journal, 26* (2): 67 – 77.

Okezie, I. N. and Igbokwe, J. I. (2015). Investigation of the Use of GPS in Georeferencing Satellite Images of Awka, Anambra Nigeria.*FIG Working Week 2015.From the Wisdom of the Ages to the Challenges of the Modern World Sofia, Bulgaria*, 17-21 May 2015.

Oliveira, J.T.A., Silveria, S.B. Vasconcelos, I.M., Cavada, B.S. and Moreira, R.A. (1999). Compositional and nutritional attributes of seeds from the multiple purpose tree. *Moringa oleifera Lamarck*. *J. Sc. Food Agric., 79*(6):815-820.

Omafuvbe, B. O., Falade, O. S. Oshuntogun, B. A. and Adewusi, S. R. (2004). Chemical and Biochemical Changes in African Locust bean (*Parkia biglobosa)* and melon (*Citrullus vulgaris*) seeds during fermentation to condiment. *Pakistan Journal of Nutrition, 3*(3):140 – 145.

Osborne, T.B., Mendel, L.B. and Ferry, E.L. (1919). A method for expressing numerically the growth promoting value of proteins. *Journal of Biochemistry*

Ozumba, N.A. (2008). *Moringa oleifera:* A review of its medicinal and other uses. Institute for Development Studies. University of Nigeria, Enugu Campus, Nigeria, Enugu Campus, Nigeria, PP: 1-35.

Ozumba, N.A., Nwobi, E.A., Ndiokwelu, C.I., Aribodor, D.N., Igwilo, I.O. and Uzoechina, E.O. (2009).*Moringa oleifera*: A review in medical pharmacopoeia. *Int. J. Pharm. Sci., 1*:73-83.

Sauvant, D., Perez, J.M., Tran, G. (2004).Tables INRA-AFZ composition et de valuer nutritive des matrieres premieres destinees aux animaux d’elevage: 2 eme edition. 306 p.

Siddhurraju, P. and Becker, K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *J. Agric. Food Chem., 51*(8): 2144-2155.

Solomon, S. G., Eyo, A. A. and Sikoki, F. D. (1996). An investigation of the effect of replacing fish meal with soybean meal, groundnut cake and blood meal at varied proportion on growth and food utilization of *C. anguillaris* fingerlings fed in out-door hapas. *Proceedings of the 13th Annual Conference of the Fisheries Society of Nigeria FISON* *New Bussa.3rd – 8th Nov. 1996*, edited by A. A. Eyo.

Storebakken, T., Refstie, S. and Ruyter, B. (2000). Soy-product as fat and protein sources in fish feeds for intensive aquaculture. In: Drackly J.K. (ed), soy in Animal Nutrition *– Federation of Animal Science Societies, Savoy* 11. P. 127-170.

Udensi, E. A., Arisa, N. U. and Ikpa, E. (2010).Effect of soaking, boiling and autoclaving on the nutritional quality of *Mucuna flagellipes* (Ukpo).*African Journal of Biochemistry Research, 4*(2): 47 – 50