Nutrient Utilization And Growth Responses In Tilapia Niloticus Fed Cottonseed And Palmkernel Cakes Based Diets.

Paul Chuks Onuoha

Abstract— Nutrient utilization and growth responses in fingerlings of Nile Tilapia Oreochromis niloticus fed cottonseed and palmkernel cakes based diets were investigated using iso-nitrogenous (32%) and iso-calorific (425 kcal/100g diet) diets for 70 days. The diets were formulated with cottonseed and palm kernel cakes at inclusion levels of 39(D1), 31(D2), 28(D3), 22.98(D4) and 0% (control-D5) respectively, and fed to the fish twice daily at 5% body weight. Percentage weight gain, feed utilization efficiencies and survival of O. niloticus increases as inclusion levels of cottonseed cake decreases from 39% (D1) to 0% (D5) – control diet (fish meal) and vice versa for palm kernel cake. Fish fed on diet D1 (28.80% cottonseed and 28.80% palmkernel cakes) had highest growth responses and nutrient utilization followed by D2 (31.62% cottonseed and 21.68% palmkernel) cakes, while the least occurred in diets with either cottonseed (D1) or palmkernel (D4) cakes respectively. The higher weight gain and feed utilization observed in diet D1 could be as a result of higher diet palatability due to optimum presence of dietary fibre, amino acid composition and reduction in gossypol content of the diet. The result of this study indicated that diet of O. niloticus could be substituted with cottonseed and palmkernel cakes at inclusion levels of 28.80% respectively to give optimum growth.

Keywords— growth, nutrient, utilization, cottonseed, palmkernel

I. INTRODUCTION

Fish occupies an enviable position in the economy of any nation, by the provision of the cheapest source of animal protein (Orta and Sado, 1985). The popular artisanal fishing which formerly provides the bulk of fish protein needs of the teeming population is now giving to intensive aquaculture where faster growth is obtained with intensive feeding (Cantom et al 1974; Heinisah 1979; and Oyetayo 1985). This new trend in fish production is as a result of over exploitation of most of the valuable stocks in the wild, leaving relatively few new species for fishing (Oyetayo, 1985).

In Nigeria the recent dwindling economy has made the Federal government to ban the importation of frozen, dried fish together with the commercial feeds for fish feeds and other livestock. This motivated the Federal and state government, individuals and bodies to make concerted alternative efforts toward increasing fish production.

This took the form of integration of fish development project into water irrigation project spread all over the hinterland for freshwater fish cultivation. Marine and brackish waters fish cultivation were also carried out along the coastal areas of the country. Fish culture management practices involving the techniques of feeding and fertilization began in Nigeria in 1954 at Panyam fish farm.

The total annual production of fish since the proliferation of these farms has not met the ever increasing protein needs of the population. The cost of feed has been the largest component in recurrent cost of fish production. Cost of these items often becomes prohibitive and unaffordable to producers in many parts of the country. The establishment of economically viable fish culture production enterprises therefore requires the incorporation of cheap, locally available feedstuffs and agricultural farm waste products as components or supplemental constituents of locally manufactured feeds. Hence many researchers investigated other alternative sources of fish feed ingredients to supplement fish meal in order to reduce cost without necessarily reducing the biological quality of the feed.

Fish require protein, lipid, carbohydrates, vitamins and minerals in their diet to meet the physiological needs of growth and reproduction. The requirements vary from species to species and with fish age, sex, reproductive state and environmental factors.

Protein is a major constituent of any animal body and is essential in the diet of all fishes as a source of essential amino acids which are the building blocks for eggs, milt, antibodies and hormones.

The range of protein requirement for optimal growth and feed efficiency of juvenile fishes has been established as 35-59% depending on temperature, age and species (Militkan, 1982). Jauney and Ross (1982) noted that Tilapia are able to utilize protein levels below the optimum and still produce good growth.
Ofojekwu (1989) obtained optimum growth response and feed utilization with 35% crude protein on *O. niloticus* fed on 5 – 10% dietary blood meal. Ufodike and Ekoktu (1986) showed that the best growth response was obtained with 32% algae and 52% blood meal diet using *Clarias lazera* at 50% crude protein.

The amount of protein that should be provided in practical diets depends largely upon the protein requirements, digestibility and amino acid composition. Protein with lower digestibility has to be included at higher dietary level to achieve the same level of protein uptake by fish.

The utilization of dietary protein by fish is mainly affected by its amino acid composition. Helver (1957) identified the following ten essential amino acids indispensable for the culture of fishes- arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and Xaline. Jauncy and Ross (1982) observed that deficiency of these essential amino acids results in loss of appetite, reduced growth and poor feed conversion.

The most ranking fish protein sources include fishmeal, soybean meal, shrimp waste, bloodmeal, cottonseed cake and palmkernel cake. Jobiling (1981) working with plaice (*pleur-a rectes plateses*) noted that animal protein was better digested than those from plant sources. This is because almost all animal protein containing all the essential amino acids.

Cottoned seed cake is locally available and relatively cheaper than other vegetable oil cakes in Northern and South-West part of Nigeria, but does not satisfy quantitative dietary requirement of cultured fish species. Gohl (1981) determined the nutrient composition of soxhlet oil from palmkernel nut. It is a cheap to obtain particularly in the southern part of Nigeria.

Gohl (1981) noted that palmkernel is made up of the following nutrient components: protein – 20.4% carbohydrate – 56.6%, fat 8.3% and fibre 15%. He noted that despite the low protein content, palmkernel cake is of high quality with methrone as the only limiting amino acid. The ratio of calcium to phosphorus is more favourable than in many other oil seeds residues (Gohl 1981). Despite that palm kernel is not a promising protein source for fish feeds, partly due to its high fibre content (Jauncy and Ross, 1982). However, Kamara (1982) found the growth performance of *S. nitoticus* fingerlings fed on a 59% protein diet in which half of the fish meal components was replaced by palm kernel was only 50% of those fed fish meal control diet.

*Oreochromis niloticus* belong to the Tilapia group of fishes which serve as a major source of protein in many parts of the world. It is one of the most widely cultured species in the tropics (Berdach et al 1972; win free and Stickney, 1981). This is as a result of their great adaptability, high fecundity and rapid growth rate. They occur in variety of habitats- freshwater, brackish and marine waters and exhibit predatory, herbivorous and omnivorous mode of feeding. They tolerate a wide range of temperature, ammonia and dissolved oxygen concentrations (Mirens, 1983). They are resistant to many diseases and parasites (Huat, 1972). To add to their success, is their ability to convert food efficiently accepting artificially formulated diets, coupled with rapid growth rate.

This study was designed to test the suitability of cottonseed and palm kernel cakes as possible supplementary sources of protein for the culture of *Oreochromis niloticus*. The experiment was designed to investigate;
1. The differences in growth response of Oreochromis niloticus fed different levels of cottonseed and palm kernel cakes based diets.
2. The level of utilization of test diets at different inclusion levels.
3. The digestibility of the nutrients in the different experimental diets.

II. MATERIALS AND METHODS

2.1 Source And Maintenance Of Experimental Fish

Oreochromis niloticus fingerling weighting 2.0-2.4g was collected from rock water fish farms in plateau state. The fish were transported in oxygen bags to the University of Jos hydrobiology and fisheries research laboratory. They were then guarantied for 14 days in rectangular glass aquaria which have been treated with 1ppm malachite green solution. This was to ensure that any parasite that might be present was killed. The water was aerated with 50Hz Charles Austum pump. Fish were fed twice daily at 2% of their body weight with commercial feed from NIOMR (Nigeria institute of oceanography and marine research).

The protein content of the commercial feed fed to the experimental fish was 30%. The fish were treated with 1ppm of malachite green solution during the first 3 days of acclimation period. Thereafter, treatment was done once every week.

The fish were transferred to the experimental tanks and allowed to acclimate for one week at a water temperature of 23-25 °C.

2.2 Experimental Facilities And Methodology

The experimental tanks consisted of 12 green plastic circular tanks with a water recirculation system. Each tank had a capacity of 15.6 liters and was continuously fed with water from the header tank. The flow of water into the tanks was maintained at the rate of 0.98 to 1.10 liters per minute.

The over flown water from the experimental tanks flowed into the biological filter through two faecal traps. The biological filter measures 60 x 50 x 91 L and was three-quarter filled with gravel clips. The faecal traps were cleaned every week. The filtered water was pumped from the bottom of the filter into head tank with a force which helps to aerate the water.

The metallic head tanks with capacity of 273 litres were supplied with make up water from a tap connected to a higher reservoir. From the head tank, water flowed to a carbon filter which eventually supplied the green experimental tanks.

Excess water from the head tank overflowed into the biological filter. The presence of a stand pipe at the middle of each tank and the angle at which water spurted into the fish tanks from the inflow taps, helped to recirculate the water.

Throughout the experimental period, constant effective recirculation was maintained by connecting the water pumps to electrothermal regulators. The recirculation was put off every night to allow the pumps to cool and also during feeding.

At the beginning of the experiment, 8 fish were randomly selected from the total of 96 fish used for the experimental tank. The 12 experimental tanks were made up of two replicates for each of the six experimental diets (Table I).

2.3 Diet Component And Treatment

The experimental diets were composed of cottonseed cake, palmkernel cake, fish meal, groundnut cake, maize flour, cassava flour, cellulose, corn oil vItayte and chronic oxide (Table I). All these ingredients except cottonseed were obtained from the local market. The cottonseed was obtained from the Nigerian Cottonseed Board Kuru, as ordinary seed. This was then boiled, dried ground and sieved. The oil contained in the sieved materials was soxhlet extracted after the method of AOAC (1980). The resulting residue (cottonseed cake) was dried and preserved for the formulation of the experimental diets. The boiling, drying and extraction of oil helped to reduce the toxic gossypol to a very low level (Watts, 1970).

The palmkernel bought from the local market were cracked to obtain the nuts. These were ground and the oil content removed by soxhlet extraction using AOAC (1980) method. The palmkernel cake resulting after the extraction was dried and sieved, ready for inclusion with the exception of; vitalyte and cellulose were ground and sieved to enhance their palatability and digestibility.

2.4 Feed Formulation And Storage

Six experimental diets were prepared to contain 33% crude protein with varying proportion of cottonseed cake and palmkernel cake (Table 1). The sixth diet containing only fish meal as essentially the protein source, serve as the control diet. The inclusion levels of cottonseed cake and palmkernel cake in each experimental diet required to make iso-nitrogenous diets were calculated. Groundnut cake, maize flour, fish meal and cassava were included in equal proportions respectively. The diets were made isocaloric using corn, oil and the cellulose.
All the calculated proportions were weighed out correctly. They were placed in a good mixer and thoroughly blessed for 10 minutes. Boiling water was added carefully and mixing continued by switching the mixer into a high speed until complete homogenization was ensured. The semi-moist paste diet obtained was extruded through a mincer using 3mm die. They were dried in a cabinet for 24 hours with an electric oven fan set at 40°C. Long pellet were broken into shorter ones and put into polythene bags, sealed and stored at 6°C for the experimental period. Samples of each dried experimental diets were collected for proximate analysis.

2.5 Feeding, Anaesthesia And Weighing

The fish were fed 3% of their body weight daily. The feed was divided into two equal parts and fed twice daily at about 9.00am and 4.00pm respectively. Big pallets were broken down into smaller sizes and scattered into the experimental tanks. The fish were not fed every weighing day to avoid further stress resulting from the anaesthesia after weighing.

Prior to each weekly weighing of fish on a top load balance, through the 10 weeks experimental period, they were anaesthesized with benzocaine solution. The benzocaine solution was made by dissolving 0.1g of benzocaine powder (Ethyl-p-aminobenzoate) in 1ml of ethanol and then diluted into 4 litres of water in a plastic container. The fish were anaesthetized in the resulting solution until they become calm but still breathing. They were then blotted dry on a damp towel and individual weights were noted to the nearest 0.1g using the top loading balance, Mettler P. 1210. The weighed fish were then transferred to a well aerated water to revive before being returned to their respective experimental tanks.

Table 1:
Composition of Experimental Diets (% by Weight) Fed to Oreochromis niloticus For 70 Days

<table>
<thead>
<tr>
<th>COMPOSITIONS</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6 (CONTROL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed cake</td>
<td>39.00</td>
<td>31.62</td>
<td>28.80</td>
<td>22.98</td>
<td>----</td>
<td>------</td>
</tr>
<tr>
<td>Palm kernel cake</td>
<td>---</td>
<td>21.98</td>
<td>28.80</td>
<td>31.62</td>
<td>39.00</td>
<td>-------</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>5.54</td>
<td>5.54</td>
<td>5.54</td>
<td>5.54</td>
<td>26.47</td>
<td>5.54</td>
</tr>
<tr>
<td>Maize flour</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
</tr>
<tr>
<td>Cassava flour</td>
<td>4.04</td>
<td>4.04</td>
<td>4.04</td>
<td>4.04</td>
<td>4.04</td>
<td>4.04</td>
</tr>
<tr>
<td>X-cellulose</td>
<td>0.50</td>
<td>0.50</td>
<td>2.0</td>
<td>1.00</td>
<td>1.67</td>
<td>16.21</td>
</tr>
<tr>
<td>Vitalize</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
</tr>
<tr>
<td>Corn oil</td>
<td>19.00</td>
<td>8.00</td>
<td>7.00</td>
<td>6.00</td>
<td>0.50</td>
<td>18.00</td>
</tr>
<tr>
<td>Totals</td>
<td>100.20</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

2.7 Determination Of Proximate Composition

Prior to the experiment, the carcass of the fish and samples of the dried experimental diets were assayed for proximate composition. At the end of the experiment, carcass of the experimental fish on each diet was subjected to the analysis using the AOAC (1980) methods. The composition analyzed were mixture content, fat, crude protein, ash and nitrogen free extract (carbohydrate).

2.7.1 Moisture Content

Each of the samples was accurately weighed initially before even drying them to a constant weight at 105°C for 24 hours. They were then removed cooled and weighed again for final weight. The amount of moisture was estimated as the difference between the final and initial weights, expressed as a percentage of the initial weight of the sample.
2.7.2 Crude Protein

Microkajdelahi distillation techniques which involved the determination of the nitrogen content of the sample and multiplied by a factor 6.25. The factor was based on the fact that average pure protein contains approximately 16% N.

A known weight or 0.3500g of a sample was digested by boiling with 10ml of concentrated sulphuric acid for 24 hours. This converts the nitrogen ammonia. Excess of the acid fixed the ammonia as ammonium sulphate. The resulting solution was cooled and diluted with distilled water to 100ml. 10ml of the aliquot solution was neutralized with 10ml of sodium hydroxide solution in the distillation chamber. The fixed ammonia was determined by liberating it by addition of excess of sodium hydroxide and distilling it into excess boric acid solution containing bromoerimol blue indicator. 50mls of the distillate collected was titrated with standard hydrochloric acid solution (0.01 N HCl) percentage of the crude was determined by:

\[
\frac{(a - b) \times 0.01 \times 14.01 \times c \times 100 \times 6.22}{d \times e}
\]

a = sample titre value (ml)  
b = blank titre value (ml)  
c = volume of which the digest was made up (ml)  
d = volume of aliquot taken for distillation (ml)  
e = weight of the test sample (g)  
i = litre of NHCL = 14.01gm nitrogen

2.7.3 Crude Fat

A slight modification of the soxhlet petroleum ether extraction as adopted by Ufodike and Matty (1983) was employed for proximate fat estimation of fish and diets. Dried samples weighing between 2 and 3 grams wrapped in filter paper were used. Extraction with petroleum ether of 60 – 80°C boiling point range, instead for 8 hours.

The means of the loss in weight of the filter paper and contents, and the gain in weight of extraction flask was regarded as the fat content of the sample.

2.7.4 Ash Content

This was obtained by incinerating weights of samples between 3 and 4 grams, in a muffle furnace at 600°C for 24 hours. All the ashed samples were allowed to coil in a desiccators, weighed and the difference in weight was expressed as percentage of the weight of original sample.

2.7.5 Carbohydrate

This was carried out after the anthrone reagent method. A sample weight of 1 to 2 grams was suspended in 10 ml anthrone (0.2g of anthrone in 8ml absolute alcohol, 30ml distilled water and 100ml concentrated sulphuric acid. The content of the test was mixed and heated for 7 minutes in a boiling water bath. The test tube was immediately cooled, configured and the absorbence of the supernatant read in a spectrophotometer at 620m. A calibration curve was prepared using glucose standard solution.

Carbohydrate, also known as Nitrogen free by the difference of the sum total of the ash, crude protein, lipid, fibre and moisture.

2.7.6 Crude Fibre

This was carried out using modified AOAC, (1980) method. A known weight (1-2grams) of defatted materials (ether extracted) was taken and boiled with 200mls of hot 1.25% sulphuric acid, for 30 minutes. This was refluxed for 30 minutes and filtered through a Whatman No. 4 filter paper. The residue on paper was washed several times with hot distilled water and few mls of HCl. The residue was then treated with 200ml boiling sodium hydroxide (1.25%) and refluxed again for 30 minutes and filtered through a weighed filter paper No. 4. The filter paper and the residue was carefully folded and put into a crucible and dried at 80 – 100°C in hot air oven for 12 hours to remove any traces of water. This was then cooled to a constant weight in a desiccators. The sample weight was then determined. The difference between the weight of crucibles plus samples and crucible plus ash represents the crude fibre content which is the portion of total carbohydrate of a sample that is resistant to acid and alkali treatment.

2.8 Water Quality Parameters

2.8.1 Water Temperature

This was determined by the use of dry bulb thermometer at 1cm depth, below the water surface in the tanks.

2.8.2 pH

The pH of the water was determined by dipping the electrodes of the pH meter in the water sample contained in a container.

2.8.3 Dissolved Oxygen

This was determined by Winkler technique against 0.01 N Na₂S₂O₃
2.8.4 Free Carbondioxide

This was determined by titrating 100ml of water sample against a standard solution of Sodium hydroxide (N/44 NaOH). The titre value was multiplied by a factor 10 to give the free carbondioxide in the water.

2.9 Determination Of Growth Indices And Feed Utilization

Formulae of various growth, feed utilization parameters and digestibility were as in Ufodike and Matty (1983).

2.9.1 Indices Of Growth

2.9.1.1 Percentage Weight Gain (%)

This was calculated as follow:

\[
\text{Percentage Weight Gain} = \frac{\text{Weight gain (gm)}}{\text{Initial weight (gm)}} \times 100
\]

2.9.1.2 Mean Growth Rate (MGR)

The mean growth rate was expressed as average relative growth and was calculated as follows:

\[
\text{Mean growth rate (mg/g/day)} = \frac{W_2 - W_1}{0.5(W_2 + W_1)t} \times 100
\]

Where:
- \(W_1\) = initial weight of fish (gm)
- \(W_2\) = final weight of fish (gm)
- \(t\) = experimental period in days

2.9.1.3 Specific Growth Rate (SGR)

This is average percentage increase in body weight per day over a given time interval and was calculated as follows:

\[
\log \frac{W_2}{W_1} x 100
\]

Where \(\log\) = base of nature/logarithm
- \(W_2\) = final weight of fish (gm)
- \(W_1\) = initial weight of fish (gm)
- \(T\) = final time in days
- \(t\) = initial time (o)

2.9.2 Indices Of Food Utilization

2.9.2.1 Food Conversion Efficiency (FCE)

This is the average weight of fish produced per unit weight of fish and was calculated as follows:

\[
\text{Weight gain (gm)} / \text{Food consumed (gm)}
\]

2.9.2.2 Protein Efficiency Ratio (PER)

This gives the weight of the fish produced per unit weight or dietary protein and was calculated as follows:

\[
\frac{\text{Weight gain (gm)}}{\text{Crude protein fed (gm)}}
\]

Where crude protein fed is = Total feed fed (gm) x % crude protein in diet.

2.9.2.3 Apparent Net Protein Utilization (ANPU)

This is a better indication of how well the protein in the diet was utilized by the experimental fish. It was computed as follows:

\[
\text{ANPU (%)} = \frac{\text{carcass protein at end}}{\text{carcass protein at beginning}} \times \frac{\text{Protein fed (gm)}}{100}
\]

2.9.4 Statistical Analysis

Analysis of variance (ANOVA) for completely randomized design was used at 5% level of significance to determine significant difference between variables.

Least significant difference (LSD) was used to test which pair of the treatment mean differed significantly from each other.

Standard error of means (SEM) was calculated using the relationship below:

\[
\text{SEM} = \frac{s}{\sqrt{n}}
\]

Where:
- \(s\) = standard deviation of sample
- \(n\) = sample size

III. RESULTS AND ANALYSIS OF EXPERIMENTAL DATA

3.1 Mortality

Experimental fish showed good appetite and appeared in healthy condition. However, out of the total of 96 fish used in the experiment, only 8 died representing a mortality of 8.3%. Post-mortem examination of the dead fish could not reveal any pathological cause. The death however, suspected to have been caused by the stress from the weekly anaesthesiation and weighings.

3.2 Water Quality Records

The mean weekly water quality record during the experimental period is shown in table 2.
The water temperature and pH varied from 24 to 25.4°C and 6.5 to 7.3 respectively throughout the experimental period. Dissolved oxygen and free carbon dioxide of the water varied from 6.6 to 7.8 and 3.8 to 4.3 respectively.

### 3.3 Proximate Composition Of Experimental Diets

The result of proximate composition of experimental diets containing different levels of cottonseed and palmkernel cakes as supplementary basal protein sources are shown in table 3. The crude protein and lipid contents ranged from 32.57–34.75% and 12.91–13.59% respectively, while the moisture and ash content ranged from 8.95–10% and 8.93–11.05% respectively.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>25.0</td>
<td>24.7</td>
<td>25.3</td>
<td>25.3</td>
<td>25.4</td>
<td>25.1</td>
<td>24.8</td>
<td>24.8</td>
<td>24.5</td>
<td>24.4</td>
<td>24.0</td>
</tr>
<tr>
<td>pH</td>
<td>6.7</td>
<td>6.9</td>
<td>6.5</td>
<td>6.7</td>
<td>6.7</td>
<td>6.9</td>
<td>7.3</td>
<td>7.4</td>
<td>7.0</td>
<td>7.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>6.6</td>
<td>7.0</td>
<td>6.8</td>
<td>6.8</td>
<td>6.8</td>
<td>7.0</td>
<td>7.3</td>
<td>7.8</td>
<td>7.0</td>
<td>7.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Carbonhydrate (mg/l)</td>
<td>4.3</td>
<td>3.9</td>
<td>4.0</td>
<td>4.0</td>
<td>4.1</td>
<td>4.2</td>
<td>3.8</td>
<td>3.9</td>
<td>4.0</td>
<td>4.3</td>
<td>4.0</td>
</tr>
</tbody>
</table>

3 NFE = Nitrogen Free Extract obtained by subtraction of subtotals from 100%.
3.4 Proximate Carcass Composition

The means of extract and final proximate carcass composition of experimental fish are shown in Table 4. The result indicated that there were general increases in protein; lipid and carbohydrate content of fish fed the various experimental diets as weight increased (Table 4). Moisture and ash contents showed a general decrease in compositions as weight increased.

Fish fed diets D₁ and D₃ did not show any significant difference (P > 0.05) between their initial carcass protein and final carcass protein contents. Those fed diets D₂, D₃, D₄ and D₆ showed significant difference (P < 0.05) between their initial and final carcass protein content. There was no significant difference (P > 70.05) between the final carcass protein of fish fed diets D₂ and D₃, although these were significantly different from those fed fishmeal control diet. The same trend was observed in their lipid content, except for the slight fall in those fed diet D₅.

No trend was observed in the carbohydrate carcass composition of the experimental fish (Table 4).

<table>
<thead>
<tr>
<th>COMPOSITIONS</th>
<th>INITIAL</th>
<th>D₁</th>
<th>D₂</th>
<th>D₃</th>
<th>D₄</th>
<th>D₅</th>
<th>D₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>70.80</td>
<td>70.49</td>
<td>69.45</td>
<td>69.01</td>
<td>70.11</td>
<td>70.74</td>
<td>67.51</td>
</tr>
<tr>
<td>Crude protein</td>
<td>16.87</td>
<td>17.17</td>
<td>18.26</td>
<td>18.66</td>
<td>17.88</td>
<td>16.98</td>
<td>19.64</td>
</tr>
<tr>
<td>Lipid</td>
<td>5.02</td>
<td>5.08</td>
<td>6.13</td>
<td>6.20</td>
<td>6.01</td>
<td>4.14</td>
<td>6.47</td>
</tr>
<tr>
<td>Ash</td>
<td>3.26</td>
<td>4.37</td>
<td>2.76</td>
<td>2.63</td>
<td>3.20</td>
<td>5.77</td>
<td>2.21</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>3.95</td>
<td>2.89</td>
<td>3.40</td>
<td>2.50</td>
<td>2.80</td>
<td>2.47</td>
<td>4.17</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
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<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Significance differences exist in the final carcass ash and moisture contents of experimental fish fed the different diets.

3.5 Growth Performance

The results of the mean weekly growth rate of O. niloticus fed the different experimental diets are shown in fig. 1. Fish fed on the control diet D₆ showed a consistent greater increase in weekly growth rate than the cost of the fish fed diets containing palm-kernel and cottonseed cakes. This was followed by fish diet D₃, while the least occurred in fish fed diet D₅ statistical analysis using the analysis of variance and (LSD) showed that there was significant difference in the mean weekly growth rates of the fish.

There was no significant difference (P > 0.05) among the initial weights of the experimental fish, while significant differences (P < 0.05) occurred among their final weights. The best growth performance in terms of percentage weight gain, mean growth rate and specific growth rate was recorded in fish fed diet D₆ which was the control (figures 2, 3 and 4).
Figure 1: Mean weekly growth responses of *O. niloticus* fed diets containing different levels of cottonseed and palmkernel cakes for 70 days.

Figure 2: Percentage weight gain of *O. niloticus* fed diets containing different levels of cottonseed and palmkernel cakes for 70 days.
Figure 3: Mean growth rate of *O. niloticus* fed diets containing different levels of cottonseed and palmkernel cakes for 70 days.

Figure 4: Specific growth rate of *O. niloticus* fed diets containing different levels of cottonseed and palmkernel cakes for 70 days.
This fish fed on diet D_6 ranked next to those on the control diet, while the least growth performance occurred in diet D_5.

Statistical analysis using the analysis of variance (ANOVA) and least significant difference (LED) showed that there were gains in the differences (P < 0.05) among the percentage weight gains in the different groups of fish fed the different test diets. The fish on control diet D_6 had the highest percentage weight gain followed by those on D_3, while the least occurred in fish fed diet D_5.

There were significant difference (P<0.05) between the mean growth rates of fish fed the control and those fed on the test diets. The best mean growth rate among the fish fed the diets containing supplementary protein sources occurred in diet D_3, although this was not significant (P > 0.05) from those fed D_2. There were no significant difference (P > 0.05) in those fed diets D_1 and D_5.

3.6 Feed Utilization Parameters

3.6.1 Food Conversion Efficiency (FCE)

The highest food conversion efficiency was recorded in fish fed control diet D_6, followed by those in diet D_3. The least food conversion efficiency occurred in fish fed diets D_5 (Fig. 5).

The food conversion efficiency values were found to be significantly different (P < 0.05) among the fish fed different diets. Increasing palmkernel cake and reducing cottonseed up to diet D_3, increased the food conversion efficiency. Thereafter, it started to decrease in the fish fed cottonseed and palmkernel based diets.

![Figure 5: Food Conversion Efficiency in O. niloticus fed cottonseed and palmkernel based diets for 70days.](image)

3.6.2 Protein Efficiency Ratio (PER)

The control diet D_6 gave the highest protein efficiency ratio, followed by the fish fed diet D_3, with the least occurring in those on diet D_5 (Fig. 6).

The protein efficiency ratio values for fish fed on diets containing cottonseed and palmkernel cakes were significantly different (P < 0.05) from that of the fish fed the control diet D_6. Those fed on diets D_2 and D_1 were not significantly different (P > 0.05).
These were however, found to be significantly different from those of diets D₁ and D₃. Protein efficiency values increased with increased palmkernel and decrease palmkernel up to diet D₃.

Figure 6: Protein Efficiency Ratio in *O. niloticus* fed cottonseed and palmkernel based diets for 70days.

**3.6.3 Appendix Net Protein Utilization (ANPU)**

The values of apparent net protein utilization indicates that protein was better utilized in fish fed diet D₆ (control), followed by those fed diet D₃. The least protein utilization occurred in those fed diet D₅ (Fig. 7).

Significant differences (P 0.05) were found among the ANPU values of fish fed the different experimental diets.

Figure 7: Apparent net Protein Utilization in *O. niloticus* fed cottonseed and palmkernel based diets for 70days.
IV. DISCUSSION AND CONCLUSIONS

Generally, the research involving the use of cottonseed and palmkernel cakes as supplementary source of protein to Oreochromis niloticus, showed some clear trends. The seen weekly water temperature of 24.65°C and dissolved oxygen of 6.91mg/l are within the optimal tolerance range for tilapia species (Dekimpe and Micha, 1974; Shireman et al, 1977).

The growth responses observed in Oreochromis niloticus were found to have a direct relationship with the proximate compositions of the experimental diets. The averaged protein level of 35.74% in the experimental diets was the optimal protein level for the growth of tilapia species ranging from 0.5-35 (Jauncey and Rose, 1982), while the energy levels of 382.9460 kcal/100g diet to 453.9340 kcal/100g diet were within the optimum energy level for the culture of carp and similar species (Takeuchi et al, 1979). The quality of protein in the different experimental diets might have played a major role in the differential growth observed in O. niloticus, since the diets were isonitrogenous and isocaloric.

The percentage weight gain of the fish fed fishmeal control diet was significantly higher (p<0.05) than those of other fish. The agreed with the work of wee et al (1986) and Ofojekwu (1989) who observed a better growth response on fish fed fishmeal diet, than those containing plant protein sources.

As the level of cottonseed and palmkernel cakes increased, up to diet D3, the growth rate increased. This trend might have to do with the individual nutrient quality in these two ingredients. From the proximate compositions of the experimental diets (Table 2), it could be observed that the level of dietary fibre increased with increase in the level of palmkernel. The optimum growth recorded in diet D1 must have resulted from the optimum dietary fibre of 14.33% in this diets which enhances the digestibility of nutrients in fish fed this diet. This was within the recommended dietary fibre level of 15-20% in herbivorous fish diets (Edwards et al 1985). Furuichi and yone (1989) observed that low levels of dietary fibre helped to increase digestibility of nutrients through increased gut transit time and enzymatic activity. Jauncey and Ross (1982) observed that despite the high quality protein of palmkernel cake, it could be a promising source of protein for fish diets at low inclusion levels with adequate supplementation with fishmeal. This was as a result of impalatability and high fibre content of palmkernel.

Cottonseed cake on the other hand has a lower fibre content and more limiting amino acids than palmkernel (Cohi,1981).

Despite the more limiting amino acids in cottonseed, it has been found to be more palatable than palmkernel cake (Gohi 1981). But O. niloticus being a herbivore, would have been expected to thrive best in the diet containing the highest level of dietary fibre. This was explained by Stickney and Shuway 1974; Buddington 1980; David et al, 1985; and Furuichi and Yone 1989, when they noted that high level of cellulose in herbivorous fishes impaired digestibility and assimilation of nutrients due to limited ability of the fish to maintain balance symbiotic bacteria capable of hydrolyzing cellulose.

The toxic gossypol content and limiting amino acids of cottonseed, had no adverse growth effect on O. niloticus, probably due to the treatment it was given and its supplementation with lysine and methionine content of the vitalyte. This was in consonance with the work of Herman (1980) Jauncey and Ross (1982), who noted that the gossypol content of cottonseed had no depressive effect on the growth of tilapia.

The growth responses of fish fed only cottonseed diet D1 and palmkernel diet D2 were significantly different (>0.05), from those fed combination of cottonseed, palmkernel and fish diets. This was in consonance with Jauncey and Ross (1982) who observed that no single oilseed can completely supply the protein requirements of tilapia. Igbinosun 1976; Bryant et al, 1980, and Jauncey and Ross 1982, suggested combination of various sources of protein to compensate for the individual differences.

The percentage weight gain of 38.62% obtained with palmkernel diet D5, differed from the 50% obtain by kamara (1982) on S. niloticus. The difference could be attributed to the 50% level of protein he used, against the 33.73% used in this experiment. Differences could also arose from the initial size of the fish, and experimental period.

The best food conversion efficiency of 0.65 obtained in fishmeal diet D1, could be attributed to the high quality of protein of fishmeal, low level of fibre and appropriate level of carbohydrate in the fishmeal diet. The low food conversion efficiency values obtained in diets containing cottonseed and palmkernel cakes at high inclusion levels could be attributed to the findings of Bromley and Adkins (1984); Appler 1986; Alexis et al 1986; and Wee and Wang 1987 who reported reduced growth and feed conversion efficiency in diet with high level of plant protein incorporation. Poston (1986), also noted suppressed growth and feed conversion efficiency in lake trout, salvelinus namacucysh fed high levels of plant protein sources.
The best protein efficiency ratio of 1.94 was recorded in the fishmeal control diet. This was found to be significantly different (P < 0.05) from other fish, fed the supplementary protein sources. Protein efficiency ratio of 1.94 in the control diet compared favourably with that of Mazid et al. (1979) and Jauncey and Ross (1982). For T. Zilli and S. Mossambicus respectively. Increasing the palmkernel component of the diets resulted in increased protein efficiency ratio up to diet D3 where it started decreasing. The utilization of a diet depends on the degree of digestion. Low digestibility and hence feed utilization obtained at higher levels of palmkernel substitution might be attributed to the complex structural carbohydrate present in palmkernel (kamara 1982).

The highest apparent net protein utilization of 77.38% recorded in fishmeal control diet indicated that protein was better utilized by fish fed on this diet, that those fed on diet containing supplementary protein sources. Ufodike and Matty (1983) obtain the highest apparent net protein utilization of 46.10% on fish fed fishmeal diet than those fed on cassava and rice based diets. This is due to the higher quality of amino acids in fishmeal than in the plant substitutes.

The increase in the final carcass protein, with increased percentage weight gain, recorded in the experiment, has been reported by nose and Aral 1972 and Takeda et al 1975/. Also the decrease in by Ufodike and Watty (1983). The inverse relationship between moisture content and lipid content recorded in the final carcass of experimental fish has been reported by other worker like Jauncey (1981), Winfree and Stickney 1982 and Appler, 1985.

Of all the six diets fed to O. niloticus, diet D3 appeared to be the most inferior based on the least percentage weight gain, mean growth rate, specific growth rate, food conversion and protein efficiency ratio, when compared with those if the other diets. The inadequacy of the diet could be attributed to its low palatability resulting from high fibre content. Diet D3 and D2 gave fairly good results when compared to the control diet D6. In view of the relative cheapness of cottonseed and palmkernel cakes, the growth performances recorded in D3 and D2 are recommendable when compared to the high cost of fish meal.

Based on these findings diet D3 could be conveniently recommended as suitable diet for the rearing of Oreochromis niloticus weighing 2.0 - 2.4g. from the study, the following general conclusion could be drawn. Significant growth in O. niloticus could only be obtained with palmkernel diet at low inclusion with adequate supplementation with fishmeal.

The relatively poor growth performance of fish fed cottonseed cake diet, did not suggest it, to be very good diet for the experimental, except if adequately supplemented with fishmeal.

The appreciable growth recorded in diets D1 and D2 when compared with the control fishmeal diet D6; suggested that these two diets were possible combinations of cottonseed and palmkernel for the culture of fingerling of O. niloticus.

REFERENCES


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