THE EFFECT OF DIFFERENT DIETARY PROPORTIONS OF COTTON SEED CAKE AND SOYBEAN MEAL ON THE GROWTH PERFORMANCE OF TILAPIA FRY, *OREOCHROMIS VARIABILIS*

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Keywords: *Oreochromis variabilis*; Dietary proportions; Specific Growth Rates, Aquaculture

**ABSTRACT:**

The effects of different dietary proportions of cotton seed cake and soyabean meal on the growth performance of *Oreochromis variabilis* (Boulenger, 1906) fry (Osteichthyes: Cichlidae) were investigated in a hatchery. The diet experiments were conducted in modified 1000-L circular polytex tanks. *O. variabilis* fry were fed on three different dietary proportions for 84 days. The crude protein content of the tested diets ranged from 40.2% to 58.7%. The diet that contained cotton seed cakes as the main ingredient showed significantly (p<0.05) overall higher specific growth rates (SGR) among other diets including the control fish meal diet. The overall mean for mortality rate was 11 ± 1.74% and was not influenced by diets.

These results suggest that diets containing cotton seed cakes could be used as an alternative diet in feeding *O. variabilis*. This conclusion is based on the fact that growth performance of *O. variabilis* fry fed cotton seed cake meal was better than those fed other experimental diets in this study and it is cheaper than fishmeal and abundant in supply in the area of study.
Introduction

Protein is an important ingredient in fish nutrition, because of its role in growth and its direct relationship to diet cost (Sudaryono, 1999). Rana et al. (2009) noted that one of the major challenges for sustainable aquaculture development is the limited supply and increasing cost of fishmeal, an important source of animal protein in formulated fish feeds. The contribution of aquaculture from Africa to global aquaculture has always remained low (1.8 per cent) despite an increase in its growth rate of 12.6 percent in the period of 1970-2008 (FAO, 2010). The potential for very substantial growth to reach levels such as those of Asia is extremely high. FAO projections show that with just 5% of the suitable areas used, Africa could meet its fish production target (Delgado et al. 2003).

Development of Aquaculture in rural Africa including Tanzania is limited because of the high cost involved, shortage of fish feeds and pond fertilisers, poor financial resources, and lack of appropriate basic knowledge (i.e. management techniques such as feeding etc.) in small-scale fish farming. According to Jamu and Ayinla (2003) the high cost and low quality of fish feeds are major factors limiting the development of aquaculture in Africa. Thus for successful development and commercialization of aquaculture in Africa, nutrition research using natural feeds that will help to reduce the cost of fish feeds without reducing their efficacy was recommended (Jamu and Ayinla, 2003; FAO, 2010). Such feeds may reduce the cost and increase the survival and growth rates of juvenile fish in aquaculture in low income countries such as Tanzania.

In addition fish aquaculture practices in rural areas may increase if indigenous species are used. According to FAO (1994), many indigenous fish species are preferred by consumers but have not yet been fully tested as candidate species for aquaculture. Also Jamu and Ayinla (2003) showed that the trend of market demand dictating the choice of indigenous fish species for culture is likely to continue in the future and will direct aquaculture expansion towards the production of fish for niche markets. Therefore efforts geared towards development of management technologies for indigenous species that have a high local demand was recommended. Studies by Rutaisire et al. (2009) and Mkumbo and Mlaponi (2007) showed that fish production from natural waters has decreased due to several reasons including unsustainable fisheries which threaten the wild fish populations. Thus the development of aquaculture production techniques for local species and their successful culture may also help to protect fish populations from wild.

The present study investigated the effect of formulated feeds based on cottonseed cake, soyabean and Azolla niloticus on growth performance of one of the indigenous cichlid fishes to Lake Victoria, O. variabilis.

Materials and methods

The study was conducted at the Tanzania Fisheries Research Institute (TAFIRI) hatchery at Mwanza which is close to the shores of Lake Victoria in Tanzania.
Experimental animals

Juvenile *O. variabilis* was used in this study. The broodstock was obtained from Mkuyu dam in the Republic of Kenya. The collection and transportation of fishes was carried out as recommended by Mgaya and Tamatamah (1996) and Collart (1997) with some modifications. At Mkuyu dam the fish were caught in a single haul using a beach seine net in the early hours of the day, from 5:00 am to 6:30 am after which the fish were transported to Mwanza. The whole process took about six hours. Upon reaching Mwanza the fish were released into the receiving concrete tanks to acclimatise. The brood stock was left in the receiving tanks for several days where they were fed on fish meal (*Restrineobola argentea* (“dagaa”)) *ad libitum*. The brood fish were then stocked in fish ponds, where they grew and reproduced. The fry obtained from these brood stocks were used for the dietary experiment in this study.

Experimental diets

Cottonseed cake (*Gossypium hirsutum* (L.)) and soyabean (*Glycine max* (L.)) were used as a source of protein, where as *Azolla niloticus* was used both as protein and energy source in compound feeds. *A. niloticus* a fern-like water plant has been previously tested as feed ingredient for Tilapia with positive results (Micha et al., 1988). *Cassava* (*Mannihot esculenta* C.) was used as an energy source. *Restrineobola argentea* (“Dagaa”) fishmeal was used as a control diet.

Cotton seed cakes were sun dried, milled and stored in cool dry place before they were incorporated in feed formulations. Mature dry soyabean seeds were soaked for 24 h in clean tap water at the seed: water ratio of 1:3 by volume. The soaked seeds were then boiled for 45 minutes in tap water at the seed: water ratio of 1:2 by volume. Boiling of soyabeans was aimed at eliminating the enzymes that inhibit the digestion of leguminous plant protein in fish. The soaked and boiled seeds were washed using tap water and sun dried for about 72 h, milled and stored in dry cool place for incorporation in feed formulations. *A. niloticus* were harvested by a scoop net from ponds washed using tap water to remove an adhering dirt and sand. Thereafter *A. niloticus* was spread out to dry in the sun in a layer of 5-10 cm thick and turned over 2-3 times a day (Collart, 1997). It took two to four days to dehydrate the *A. niloticus*. The dehydrated material was then minced using a meat mincer and sieved before it was incorporated in feed formulations. *Restrineobola argentea* (“Dagaa”) obtained from Lake Victoria was sun dried, milled and stored in cool dry place ready for use as the control diet. *Cassava* roots were pealed, sliced to small pieces and sun dried. The dehydrated cassava was milled and stored in dry cool place for incorporation in feed formulations.

Proximate analysis of the ingredients of the experimental diets

Prior to formulation of experimental diets, all the ingredients were analysed for proximate composition. The samples of the ingredients for the experimental diets were analysed for crude protein, crude fat (ether extract), crude fibre, ash and total carbohydrate (% crude protein + % crude fat (ether extract) + % crude fibre + % ash + % moisture) following the AOAC (1990) procedure. The proximate composition
analysis of the ingredients is shown in Table 2.

**Formulations of experimental diets/feeds**

The proximate composition of each dietary ingredient was used in the Simple Pearson square method as described by New (1987) to standardise the protein levels and complement with the basal feeds to supply energy. Each treatment (except for the control diet) was mixed with 0.1% Vitamin-mineral mix as recommended by New (1987). The formulated diets were then analysed for crude protein, crude fat (ether extract), crude fibre, ash and crude carbohydrate following the AOAC (1990) procedure. The formulation and proximate composition of the dietary treatments are presented in Table 1. The prepared fish feeds were stored in a cool and dry area ready for use in the feeding experiment.

**Preparations and operations in the experimental tanks**

The diet experiments were conducted in modified 1000-l circular polytex tanks. In the experimental culture systems the three replicates were arranged in random block design. Before stocking the fish, the tanks were washed thoroughly with fresh water, filled with sand up to 3 cm deep, to simulate the condition that *O. variabilis* is accustomed in nature and left to dry in the sun for a week before being filled with fresh water. Water was supplied from the overhead tanks into the experimental tanks and the water level in the experimental tanks was maintained at 200 l. A compressor was used to supply oxygen into the experimental tanks throughout the experiments. In addition water replacement of 40% per week was adopted to ensure adequacy of dissolved oxygen.

Each tank contained 200 fry at a stocking density of 1 fry per l\(^1\). The average initial weights of the fry were 0.32g ± 0.16g. The fish fry were acclimatised in the experimental tanks where they were fed on control diet (fishmeal) for two weeks. Thereafter the experimental fish were randomly assigned into three replicate fry tanks. The experiment lasted for twelve weeks.

**Feeding regime**

The experimental fish were fed 5% of average fish body weight per day in split dose between 0730 and 0800 hrs and between 1830 and 1900 hrs. Revised feeding allowances were calculated on the basis of the total weight of the fish calculated from the mean weights. The revised feeding allowances were done every 14 days. Thus feeding levels were according to the number and size of the fry in a given tank.

Before fresh food was given, faeces and food remains were removed by using a scoop net made out of cloth material. Feeding of fish was done by hand to enable regular inspection of the fish (New, 1987). Four dietary treatments including the control diet were tested. Diet one (D1) referred here as composite diet contained a mixture of soyabean, cotton seed cake and *A. niloticus*, Diet two (D2) contained cotton seed cakes whereas diet three (D3) contained soyabean. “Dagaa” fishmeal (D4) was used as the control diet. Cassava was maintained to enrich the carbohydrate of the diet. Three replications (4T x 3R) per treatment (feed) were adopted.
Data collection

Fish growth

In order to assess the growth performance, records of individual fish weights were taken from each tank every after two weeks. A sensitive electronic balance (Libror EB-620s SHIMADZU) was used to weigh the sampled fish. A sample of 30% of the stocked fish was taken randomly from each fry tank by using a scoop net. The fish fry were weighed and returned into their respective fry tanks. To achieve accuracy during weighing, the fry were blot-dried before being weighed as recommended by Anderson and Gutreuter (1983). Instantaneous Growth rates (G) which was transformed into Specific Growth Rates (SGR) (Hopkins, 1992) was calculated in every two weeks interval by using the following equation:

Specific growth rate (SCR) \[ = \frac{\ln (W_t) - \ln (W_i)}{t} \times 100, \]

(Hopkins, 1992); where \( \ln (W_t) \) is the natural logarithm of the weight at time \( t \) and \( \ln (W_i) \) is the natural logarithm of the initial weight. Specific Growth Rates (SGR) assumes that fish weight increases exponentially and it was recommended for reporting the growth of small fish cultured for short periods (Hopkins, 1992) such as in this study.

Other growth variables determined in this study included:

a) Apparent feed conversion ratio (AFCR)

\[ \text{AFCR} = \frac{\text{Feed ingested (dry weight in g)}}{\text{Weight gain (wet weight in g)}} \]

(Castell and Tiews, 1990).

b) Apparent protein efficiency ratio (APER)

\[ \text{APER} = \frac{\text{Wet weight gain}}{\text{protein ingested}} \]

(Zeitoun et al., 1973; Castell and Tiews, 1990).

c) Survival rate = % Survival rate \[ = \frac{\text{Number of fish harvested}}{\text{Number of juvenile stocked}} \times 100 \]

Water quality variables

Water quality variables temperature, dissolved oxygen and pH were recorded using water quality checker daily (model U-10 Horiba, Japan). The measurements were taken twice a day during the morning (between 0630 and 0730 hours) and during the evening (between 1730 and 1830 hours). The percentage of un-ionised ammonia (UIA) was calculated from the following relationship as adopted by Ayinla et al. (1994).

\[ \text{UIA} = \frac{100}{1 + \text{antilog} (\text{pKa} - \text{pH})} \]

Where: \( \text{pH} = -\log(H_3O^+) = -\log(H^+) \);

\( \text{pKa} = -\log(K_a) = \text{constant} = 9.25 \)

Data Analysis

Data analysis was done with the Statistical Analysis System (SAS) General Linear Models Procedure (GLM) (SAS, 1992). The performance in growth variables (i.e. specific growth rate, feed conversion ratio and apparent protein efficiency ratio) in \( O. \ variabilis \) cultured under different diet treatments was analysed. Coefficients among the dependent variables investigated were analysed by using Multivariate Analysis of Variance
(MANOVA) which gives the post test where a significant different between the dependent variables is detected. The data on survival rates (%) were analysed using the Instant Statistical package after arcsine transformation to guard against violation of assumptions of ANOVA.

Two statistical models were used to analyse the data. The first model involved an individual fish as an observational unit where as the second model involved a fry tank as an observational unit.

**Growth of fish**

The linear statistical model used to study the effects of different treatments on the growth performance of fish was as follows:

\[ Y_{ijk} = \mu + T_i + R_{ij} + e_{ijk} \]

Where:

- \( Y_{ijk} \) = growth performance from the \( k^{th} \) fry in the \( j^{th} \) replicate fry tank receiving the \( i^{th} \) diet.
- \( \mu \) = general mean common to all observations in the study.
- \( T_i \) = effect due to \( i^{th} \) diet type.
- \( R_{ij} \) = effect contributed by the \( j^{th} \) replication within the \( i^{th} \) type of diet.
- \( e_{ijk} \) = random effect peculiar to each fry.

**Cumulative weights and growth variables**

The following linear statistical model was adopted in analysing these variables:

\[ Y_{ijk} = \mu + T_i + R_{ij} + e_{ijk} \]

Where:

- \( Y_{ijk} \) = growth performance from individual \( k^{th} \) fry tank.
- \( \mu \) = general mean common to all tanks in the study.
- \( T_i \) = effect due to \( i^{th} \) diet type.
- \( R_{ij} \) = effect contributed by the \( j^{th} \) replication within the \( i^{th} \) type of diet.
- \( e_{ijk} \) = random effect peculiar to each fry.

**Results**

**Diet composition**

The results of the proximate composition of the ingredients for the experimental diets used in this study are presented in Table 1. Tables 2 illustrate the percentage composition of the tested feed mixtures and their proximate composition. D4 (control diet) had the highest crude protein (58.7%); followed by diet two (D2) (51.2%) then diet one (D1) (47.0%) and finally diet three (D3) (40.3%).

**Survival**

Generally, the numbers of surviving fry per treatment decreased with the sampling time. The mortality was high during the first two week periods of the experiment and low during the last sampling periods. Hence mortality decreased with time. Overall survival rate was 89 ± 1.74% for all diets and sampling periods combined. The results of ANOVA showed no significant difference (\( P>0.05 \)) in survival and mortality among dietary treatments. The coefficient of determination (\( R^2 \)) for numbers of fish surviving at biweekly intervals ranged from 0.72 to 0.89. This reflects that over 70% of the variation in the variables measured in this study could be explained by the
analytical models adopted. The coefficient of variation (CV) for numbers of fish surviving at biweekly intervals ranged from 9 to 19%. This is a reflection that the experimental material used in the study was fairly homogenous; leave alone the variations caused by experimental treatments.

**Growth performance**

The growth performance of *O. variabilis* fry fed on different diets is illustrated in Figure 1. The overall performance of the study showed that fish fed cotton seed cakes based diet attained significantly (P<0.05) higher growth rates than other diets including the control fish meal diet. Generally growth rates decreased with time where specific growth rates were the highest and lowest during the first and last two weeks of experimentation respectively. Control fish meal based diet (D4) showed higher specific growth rates during the first two weeks of experimentation followed by cotton seed cakes based diet (D2), composite (D1) and soyabean meal (D3) diets in that order. However there was no significant difference (P>0.05) in specific growth rates between diets during the first two weeks of experimentation (Table 3). During the second, third, fourth, fifth and sixth two weeks of experimentation cotton seed cakes based diet (D2) showed the highest specific growth rates compared to composite diet (D1), soyabean meal (D3) and control fish meal diets (D4). Composite diet (D1) showed significantly (P<0.05) lower specific growth rates among all other diets during the second two weeks of experimentation. Cotton seed cakes based diet (D2) showed significantly (P<0.05) higher specific growth rates compared to other diets including the control diet during the rest period of experimentation (Table 3). Better results were obtained from other fish growth variables such as Apparent Food Conversion Ratio (AFCR) and Apparent Protein Efficiency Ratio (APER) as presented in Table 3.

**Water quality under different diet treatments**

The mean values of water temperature, pH, dissolved oxygen and unionised ammonia in fry tanks receiving different treatments are presented in Table 4. The water quality variables recorded in the present study were within the recommended range (Berdach et al., 1972; Balarin and Haller, 1982; Ayinla et al, 1994; Siddiqui and Al-Harbi, 1995). The water quality checker was not available to record the water quality variables during the sixth two weeks of experimentation.

**Discussion**

The feeding experiment was aimed at investigating the growth performance of *O. variabilis* fry fed on different formulated diets. Protein is very important in fish growth and thus a crucial ingredient in fish diets. Except for the control diet, the crude protein content of the experimental diets used in this study was within the range used elsewhere e.g., 38.9% and 52% (El-Sayed et al., 2003; Cavalheiro et al., 2007; Bahnasawy, 2009). The result of this study shows that generally growth rates decreased with time. This is true from the fact that growth rates in living organisms is high at early than later stages of growth. With
respect to the specific growth rates (SGR) and other growth variables, *O. variabilis* fry fed on cotton seed cakes diet showed higher growth performance than those fed on composite diet and soya bean diet. However, there was no significant difference during the first two weeks of experimentation. The most likely explanation for this observation is that during the first sampling period the fry were probably still acclimatising to the tank experimental conditions. This factor could be responsible for the non-significant difference observed during this period.

In developing countries, fishmeal, which forms the potential base for artificial feeds, is scarce and expensive (Jamu and Ayinla, 2003; Rana et al., 2009). Thus, research on using locally available plant protein sources in the production of high-quality fish feed is required (Gabriel et al., 2007). The availability of such feeds will contribute to sustainable development of aquaculture in Africa. The results from the present study suggest that cottonseed cake may be used to replace fishmeal in fish feeds. Since the use of cottonseed meal in raising *O. variabilis* has yielded positive results. Moreover cotton seed cakes are cheaper than fishmeal. Substitutions of fishmeal in fish feeds using cotton seeds cakes in feeding *Oreochromis* spp have been done with successful results by other workers (Mbahinzireki et al., 2001; Rinchard et al., 2002; Dabrowski et al., 2002). However in comparison to the present study in their studies (Mbahinzireki et al., 2001; Rinchard et al., 2002) recommended that cotton seed meal can only partially replace fish meal as a source of protein in compound feed at a limited amount of no more than 50% for tilapia raised in circulating systems. In another study by El-Sayed (1990) replacement of 100% of fish meal in diets fed Nile tilapia did not significantly impaired growth performance.

The use of glandless cotton seed products in fish feeds such as *G. hirsutum* has shown better growth performance than glanded cotton seed products (Robinson *et al.*, 1984b). Robinson et al. (1984b) noted that glandless cottonseed products, which contain less than 100 ppm of free gossypol, should be allowed for use on increasing levels of cottonseed products in fish feeds. High levels of free gossypol content in glanded cottonseeds have been reported to reduce the growth of fish (Ofojeckwu and Ejike, 1984; Robinson *et al.*, 1984a; Mbahinzireki *et al.*, 2001; Rinchard *et al.*, 2002). The good growth performance of *O. variabilis* fry fed on cotton seed cakes reported in the present study may be due to the fact that gossypol in the cotton seed is rendered harmless through heat treatment during oil processing (Sollman, 1957). Though the amount of gossypol content in cotton seed cake was not analysed in the present study it appears that cotton seed cake diet is an acceptable substitute for fishmeal diet in *O. variabilis*. However, lysine supplementation should not be ignored. In the present study lysine was supplemented through vitamin/mineral mix. The present findings agree with the earlier report (Jackson *et al.*, 1982) that tilapia grew well on cotton seed meal based protein, even at 100% level of inclusion. Fowler (1980) found that cotton seed meal was efficiently utilized as a partial replacement (34%) for fish meal protein in diets for chinook and coho salmon.
It is seen from the present study that *O. variabilis* fry fed on soyabean meal gave poor specific growth rate, AFCRs and APERs compared to those fed on cotton seed cakes and composite diets. The present results agree with the findings of other workers (Fowler., 1980; Vanketesh et al., 1986; Ray and Patra., 1989). Fowler (1980) reported that fish fed on diets containing heat-treated soyabean weighed significantly less and suffered higher mortality than those fed on fishmeal control diet. Fowler (1980) further noted that as the level of soyabean meal was increased and that of fishmeal decreased in the diet, growth rate was slower, regardless of degree of heat treatment. Vanketesh et al. (1986) and Ray and Patra (1989) reported retardation in growth of *Clarias batrachus* (Linn) and *Anabas testudineus* when fed on soyabean. Dabrowski and Kozak (1979) reported that Grass carp fry fed with soyabean meal showed poor growth performance than when fed with fishmeal. With increasing levels of dietary soyabean cake, growth rate and feed utilization decreased in the Chinese longsnout catfish (Xie et al., 1998). Detrimental effects on growth performance were obvious when half of the fish meal protein was replaced by soyabean protein in diets of juvenile cobia *Rachycentron canadum* (Chou et al., 2004). Viola et al. (1982) suggested lysine and methionine supplementation and oil enrichment of soyabean based diet to obtain the growth of common carp equivalent to that of fishmeal diet. Also Khan et al. (2003) suggested that soyabean meal can totally replace fishmeal in diets for *Labeo rohita* fingerlings, when supplemented with methionine and fortified with minerals. However, in the present study although lysine and methionine was supplemented by vitamin/mineral mix, performance of fish fry fed on soyabean diet was poor compared with that fed on cotton seed cakes diet. Fowler (1980) reported that supplementing soyabean meal with methionine did not significantly influenced weight gain or survival in chinook and coho salmon. On the contrary, Davis and Stickney (1978) reported an excellent growth of *Tilapia aurea* fry, fed with high-protein soyabean diet supplemented with methionine.

It is speculated that the heat treatment applied to soyabean in the present study was probably inadequate to the enzymes that inhibit the digestion of leguminous plant protein in fish (Smith, 1977). But it has been recommended that, the anti-nutritional factors other than trypsin inhibitors (Wilson and Poe, 1985) contained in soyabean meal may be removed by sufficient heat treatment (Spinelli et al., 1979). Fowler (1980) reported low growth rate in chinook and coho salmon fed on heat-treated soyabean diet with temperature range of 178 to 278 °C. The observations reported by Fowler (1980) support the speculation that the heat applied in the present study to treat soyabean was not sufficient enough to destroy the anti-nutritional factors. However, though soyabean diet performed relatively poor than the other diets in the present study, the AFCRs were relatively better than those reported by Nandeesha et al. (1989). The AFCRs in the present study ranged from 0.85 to 2.76. Nandeesha et al. (1989) obtained a better growth in 'major carp', *Catla catla* (Ham.) fed on soyabean meal with AFCR of 3.64. Portella et al. (2000) reported that artificial diets containing
soyabean oil promoted good growth in fingerlings. The good AFCR obtained from *O. variabilis* fry fed on soyabean diet in the present study suggests that soyabean meal containing diets can be another alternative replacement to fishmeal. However, it is recommended here that the optimum temperature for destroying the anti-nutritional factors in soyabeans without impairing other nutrients such as amino acids should be established.

From the present study the AFCR from the fish meal based diet was much higher (poor) as compared to other diet ingredients such as cotton seed cakes and soyabeans. The “daga” *Restrineobola argentea* meal used in this study was purchased from fish sellers along the beaches. It is speculated that probably the drying and possibly preservation of the “daga” was not performed perfectly to give the good quality representative fish meal. It is possible that the fish oil of the fish meal had become severely oxidized, resulting in significant reduction of the protein digestibility and resulting in the high feed conversion ratios reported in this study.

In the present study it was initially thought that the growth performance of *O. variabilis* fry fed on composite diet would probably be the best because the feed contained a mixture of nutrients from soyabeans, cotton seed cakes and *Azolla niloticus*. However the composite diet showed poor performance than the other diets. It is speculated that probably the incorporation of soyabean meal in the composite diet might have contributed to the poor growth performance obtained in this study. Also the presence of fibrous material in *Azolla niloticus* might have contributed to the recorded poor growth performance of *O. variabilis* fry fed on composite diet. Almazan et al. (1986) showed that Nile tilapia, *O. niloticus* lost body weight when fed on fresh *Azolla* alone or sun-dried *Azolla* powder or *Azolla* pellet. The reason put forward by Almazan et al. (1986) was inability of this species to deal with fibrous material, as it is a microphagous feeder. *Oreochromis* spp. including *O. variabilis* are microphagous feeders and thus the poor growth performance for fish fed on diet with *Azolla niloticus*. The positive growth responses with regards to feeding *Tilapia rendalli* on *Azolla* sp in other studies (Micha et al., 1988) and its cheapness and abundance in supply were the basis for its choice as one of the ingredients in the trial diets in the present study.

From feeding results it is seen that mortality rates ranged from 36.84 % to 0% between sampling periods. *O. variabilis* fry fed on cotton seed cakes showed low overall mean mortality rates (10 ± 2.63%) followed by those fed on soyabean meal (11 ± 2.12%). The results showed increase in mortality rates in all diets during the first and fifth two weeks. The acclimatisation process to the experimental tank conditions by fry contributed to the increase in mortality rates during the first two weeks. The fungal disease that was observed during the fifth two weeks sampling period of the experiments caused the increase in mortality rates during this period. Pauly et al. (1993) noted that disease epidemic causes increase in mortality rates in aquaculture. In the present study the fungal disease that occurred was treated by applying fungicide.
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**Figure 1:** Specific growth rates (%) of *Oreochromis variabilis* fry fed on different diets for twelve weeks in polytex tanks. Vertical bars indicate standard errors.
### Table 1: Proximate composition of the dietary ingredients (% dry matter basis)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>% crude protein</th>
<th>% crude fibre</th>
<th>% crude fat</th>
<th>% ash</th>
<th>% dry matter</th>
<th>% carbohydrate</th>
</tr>
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<tbody>
<tr>
<td>Azolla niloticus</td>
<td>23.8</td>
<td>11.1</td>
<td>2.8</td>
<td>11.6</td>
<td>88.7</td>
<td>39.4</td>
</tr>
<tr>
<td>Cotton seed cakes</td>
<td>35.7</td>
<td>17.6</td>
<td>12.1</td>
<td>7.2</td>
<td>93.5</td>
<td>21.0</td>
</tr>
<tr>
<td>Soyabean</td>
<td>42.2</td>
<td>7.4</td>
<td>20.5</td>
<td>4.0</td>
<td>94.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Dagaa</td>
<td>58.7</td>
<td>0.3</td>
<td>16.1</td>
<td>16.0</td>
<td>92.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Cassava</td>
<td>1.3</td>
<td>-</td>
<td>0.1</td>
<td>2.3</td>
<td>-</td>
<td>84.0</td>
</tr>
</tbody>
</table>

### Table 2: Percentage composition of the tested feed mixtures and their proximate composition (% dry matter basis)

<table>
<thead>
<tr>
<th>Diets (D)</th>
<th>Ingredients (g)/100g diet</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4 (Control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dagaa ‘Fishmeal’</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Soyabean meal</td>
<td></td>
<td>48.2</td>
<td>0.0</td>
<td>94.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Cotton seed cake meal</td>
<td></td>
<td>48.2</td>
<td>89.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Azolla niloticus</em></td>
<td></td>
<td>1.8</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cassava</td>
<td></td>
<td>1.8</td>
<td>10.1</td>
<td>5.6</td>
<td>0.0</td>
</tr>
<tr>
<td>*Vitamin/mineral mix</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>% crude protein</td>
<td></td>
<td>47.0</td>
<td>51.2</td>
<td>40.3</td>
<td>58.71</td>
</tr>
<tr>
<td>% crude fibre</td>
<td></td>
<td>16.3</td>
<td>12.2</td>
<td>7.1</td>
<td>0.3</td>
</tr>
<tr>
<td>% crude fat</td>
<td></td>
<td>14.2</td>
<td>9.9</td>
<td>18.5</td>
<td>16.1</td>
</tr>
<tr>
<td>% ash</td>
<td></td>
<td>6.2</td>
<td>9.3</td>
<td>3.6</td>
<td>16.0</td>
</tr>
<tr>
<td>% dry matter</td>
<td></td>
<td>92.0</td>
<td>92.9</td>
<td>91.3</td>
<td>92.0</td>
</tr>
<tr>
<td>% carbohydrates</td>
<td></td>
<td>7.7</td>
<td>10.4</td>
<td>22</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Vitamin/mineral mix: Vitamin A (15,250,000 iu); Vitamin D3 (4,500,000 iu); Vitamin E (1,335 iu); Vitamin K (4,500 mg); Vitamin B2 (4,500 mg); Vitamin B6 (2,350 mg); Vitamin B12 (11,500 mcg); Vitamin C (1,000 mg); Niacin (16,750 mg); Pantothenic acid (5,375 mg); Methionine (10,200 mg); Lysine (15,250 mg); Zinc Sulphate (12,250 mg); Copper Sulphate (12,250 mg); Manganese Sulphate (12,250 mg); Magnesium Sulphate (912,250 mg); NaCl (50,000 mg).
Table 3: Least square means (± se) for growth variables of *O. variabilis* fry fed on different trial diets.

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Variable</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D₁</td>
</tr>
<tr>
<td>2</td>
<td>SGR (%)</td>
<td>4.40 ± 0.68</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>0.84 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>1.57 ± 0.40</td>
</tr>
<tr>
<td>4</td>
<td>SGR (%)</td>
<td>1.98a ± 0.50</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>2.20a ± 0.18</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>0.59a ± 0.23</td>
</tr>
<tr>
<td>6</td>
<td>SGR (%)</td>
<td>2.59a ± 0.25</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>1.67a ± 0.15</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>0.73a ± 0.10</td>
</tr>
<tr>
<td>8</td>
<td>SGR (%)</td>
<td>1.74a ± 0.25</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>2.80a ± 0.43</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>0.51a ± 0.08</td>
</tr>
<tr>
<td>10</td>
<td>SGR (%)</td>
<td>1.33a ± 0.21</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>1.89a ± 0.33</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>0.71a ± 0.07</td>
</tr>
<tr>
<td>12</td>
<td>SGR (%)</td>
<td>1.84a ± 0.12</td>
</tr>
<tr>
<td></td>
<td>AFCR</td>
<td>2.42a ± 0.27</td>
</tr>
<tr>
<td></td>
<td>APER</td>
<td>0.53a ± 0.04</td>
</tr>
</tbody>
</table>

* a, b, c, Least square means with different superscript letters in a row are significantly different (P<0.05)  D = diets
Table 4: Mean water quality variables (pH, Temperature, Oxygen and un-ionized ammonia) in try tanks receiving different dietary treatments (mean ± se)

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Variable</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D1</td>
</tr>
<tr>
<td>2</td>
<td>pH</td>
<td>6.83 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>Temperature (°C)</td>
<td>23.10 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>5.36 ± 0.08</td>
</tr>
<tr>
<td></td>
<td>Un ionised ammonia</td>
<td>0.36 ± 0.01</td>
</tr>
<tr>
<td>4</td>
<td>pH</td>
<td>7.04 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Temperature (°C)</td>
<td>23.09 ± 0.15</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>5.51 ± 0.20</td>
</tr>
<tr>
<td></td>
<td>Un ionised ammonia</td>
<td>0.59 ± 0.01</td>
</tr>
<tr>
<td>6</td>
<td>pH</td>
<td>6.89 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Temperature (°C)</td>
<td>25.57 ± 1.28</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>5.59 ± 0.10</td>
</tr>
<tr>
<td></td>
<td>Un ionised ammonia</td>
<td>0.40 ± 0.01</td>
</tr>
<tr>
<td>8</td>
<td>pH</td>
<td>6.61 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>Temperature (°C)</td>
<td>22.70 ± 1.17</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>4.79 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>Un ionised ammonia</td>
<td>0.19 ± 0.01</td>
</tr>
<tr>
<td>10</td>
<td>pH</td>
<td>6.82 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>Temperature (°C)</td>
<td>26.63 ± 1.74</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>4.78 ± 0.10</td>
</tr>
<tr>
<td></td>
<td>Un ionised ammonia</td>
<td>0.36 ± 0.01</td>
</tr>
</tbody>
</table>