The effects of different diets on the growth performance of Tilapia, *Oreochromis variabilis* (Boulenger, 1906) fry under aquaculture conditions

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Abstract

The effects of different diets on the growth performance of *Oreochromis variabilis* (L.) fry (Osteichthyes: Cichlidae) were investigated in a hatchery. The diet trial experiment was conducted in modified 1000 litre circular polytex tanks. *O. variabilis* fry were fed on different diets for 184 days. The diet that contained cotton seed cakes as the main ingredient showed significantly ($p<0.05$) better growth performance than the soyabean meal and composite diet. Fishmeal control diet showed no significant difference ($P>0.05$) over cotton seed cakes. The overall mean (mean ± se) survival rate was 89 ± 1.74% and was not influenced by diets.The conclusion reached was that diets contained cotton seed cakes could be used as an alternative diet in feeding *O. variabilis.* This conclusion is based on the fact that growth performance on cotton seed cake was better than other diets in this study and it is cheaper than fishmeal.

Key words: Oreochromis variabilis, Diets, Growth, Aquaculture, Tilapia.

Introduction

Supplementary feeding is an important tool for augmenting fish production. In fish nutrition, protein is an important ingredient because of its influence on growth and its direct relationship to diet cost. . There are 13 amino acids that are essential for building new tissues in fish (Bowen, 1982). These amino acids cannot be synthesised by fish and must be obtained from the diet. Usmani *et al*. (1997) noted that another major problem in aquaculture is the limited supply and increasing cost of fishmeal, an important source of animal protein in formulated fish feeds.

Development of Aquaculture in rural Africa including Tanzania is limited because of cost, shortage of fish feeds and pond fertilisers, poor financial resources and basic knowledge (i.e. management techniques such as feeding etc.) of small-scale farmers. Considerable success has been achieved in the development of artificial fish diets in temperate fish species (Cho *et al*., 1976; Tacon *et al*., 1983). In the developing countries formulation and preparation of feed has become a major expenditure in fish farming practices (Wanda *et al.,* 1991). Hence, use of natural feeds may increase the survival and growth rates of juveniles (Wanda *et al*., 1991) and reduce the cost of feed.
According to FAO (1994), many indigenous fish species are preferred by consumers but have not yet been fully tested as candidate species for aquaculture. The indigenous Tilapia, *O. variabilis* is one of the cichlid fishes endemic to Lake Victoria.

The present study investigated the effect of soybean, cottonseed cake and *Azolla niloticus* based diet on growth and survival rates of indigenous Tilapia, *O. variabilis.*

Materials and method

Study Site

The study was conducted at the Tanzania Fisheries Research Institute (TAFIRI) hatchery at Nyegezi, in Mwanza, Tanzania.

Source of Experimental Animals

Juvenile *O. variabilis* was used in this study. The broodstock was obtained from Mkuyu dam in Migori district, Nyanza Province in the Republic of Kenya with the assistance and authority of Kenya Marine and Fisheries Research Institute (KMFRI). The collection and transportation of fishes was done as recommended by Mgaya and Tamatamah (1996) and Collart (1997). At Mkuyu dam the fish were caught in a single haul using a beach seine net. The fishing activity was conducted in the early hours of the day, from 5:00 am to 6:30 am after which the fish were transported to Mwanza. This took about six hours. Upon reaching Mwanza the fish were released into the storage concrete tanks to acclimatise. The brood stock was left in the receiving tanks for several days where they were fed on fish meal ("dagaa") *ad libitum*. The brood fish were stocked in the nearby fish ponds, where they grew and reproduced. The fry obtained from these brood stocks were then used for the dietary trial experiment of this study.

Experimental Diets

Cottonseed cake (*Gossypium hirsutum* (L.)) and Soybeans (*Glycine max* (L.)) were used as a source of protein whereas *Azolla niloticus* was used as both protein source and energy source in compound feeds. In addition Cassava (*Mannihot esculenta* C.) was used as an energy source. 'Dagaa' fishmeal (*Restrineobola argentea*) was used as a control diet.

Sources of Experimental Diets

The cotton seed cakes were purchased from an oil ginnery known as VOIL in Mwanza City. The soybean seeds were purchased from a local market in Mwanza City whereas cassava was purchased from a farmer at Luchelele village close to Mwanza City. *Azolla niloticus* was collected from the shores of Lake Victoria by using scoopnet and transported in plastic bags into the nearby fish ponds where they were inoculated. Dagaa was purchased from fishers at Kirumba fish market, Mwanza.

Preparation of Experimental Diets

Cotton seed cake (*Gossypium hirsutum* (L))

The cotton seed cakes were dried, milled and stored before they were incorporated in feed formulations.

Soybean seeds (*Glycine max* (L))

Mature dry seeds of soybean seeds were sorted manually for any impurities. The seeds were then soaked for 24 hours in clean tap water at the seed : water ratio of 1:3 on a volume basis. There after the soaked seeds were boiled in water at the seed : water ratio of 1:2 by volume basis for about 45 minutes. Boiling of soybeans was meant to eliminate the enzymes that inhibit the digestion of leguminous plant protein in fish. The soaked and boiled seeds were washed using clean tap water and spread on a polythene sheets for sun drying for about 72 hours before being milled and stored ready for incorporation in feed formulations.

Azolla niloticus

After three to four weeks the already flourished *A. niloticus* in the fish ponds were harvested by a scoop net and carried in plastic buckets into the polytex tanks. In the polytex tanks *A. niloticus* was washed using clean tap water to remove the adhering dirt and sand. Thereafter *A. niloticus* was spreadout to dry in the sun (on a drying floor made of slightly rough cement) in a layer of 5-10 cm thick and turned over 2-3 times a day (Collart, 1997). It took up two to four days to dehydrate the *Azolla*. The dehydrated material was then minced using a meat mincer and sieved before it was incorporated in feed formulations.

Restrineobola argentea "Dagaa" (Fishmeal)-control diet

The fishmeal described here refers to the ground pelagic "Dagaa" *Resrineobola argentea* obtained from Lake Victoria. The dried "Dagaa" was milled and incorporated in feed formulations.

Cassava (Mannihot esculenta)

Cassava roots were pealed, sliced to small pieces before being spread on the floor to dry as used for *A. niloticus*. The dehydrated cassava was milled and stored ready for incorporation in feed formulations.

Proximate analysis of the ingredients of the experimental diets

The samples of the ingredients of the experimental diets were analysed for crude protein, ether extract (crude fat), crude fibber, ash and total carbohydrate following the AOAC (1984) procedure. Crude protein was analysed by continuous extraction using petroleum ether (40 ^{o}C – 60 ^{o}C B.P) and diethyl ether (34 ^{o}C – 36 ^{o}C B.P) in Soxhelt. Total carbohydrate was calculated by difference i.e. 100 - (% crude protein + % ether extract (fat) + % crude fibre + % ash). The proximate composition analysis is shown in Table 1. The proximate composition analysis was carried out at the Department of Animal Science and Production of the Sokoine University of Agriculture (SUA) in Morogoro, Tanzania.

Table 1: Proximate composition analysis of the ingredients of the experimental diets

Ingredients	% crude protein	% crude fibre	% Crude fat	% ash	% dry matter	% carbohydrate
Azolla niloticus	23.79	11.10	2.80	11.64	88.71	39.38
Cotton seed cakes	35.70	17.60	12.07	7.22	93.48	20.89
Soybeans	42.23	7.40	20.50	4.03	94.21	19.95
Dagaa	58.71	0.32	16.11	16.01	92.04	0.89
Cassava	1.3	0.00	0.10	2.3	0.00	84.3

Formulations of experimental diets /feeds

The proximate composition of protein of each ingredient (Table1) were 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 proximate analyzed for crude protein, crude fate (ether extract), crude fibre and total carbohydrate (Table 3). The prepared fish feeds were stored in a cool and dry area.

Table 3: Formulation and proximate composition (% dry matter basis) of experimental diets.

Ingredients (g)/100g diet	D_1*	D_2*	D_3*	D_4*
Dagaa 'Fishmeal'	0.00	0.00	0.00	100.00
Soyabean meal	48.19	0.00	94.30	0.00
Cotton seed cake meal	48.19	89.91	0.00	0.00
Azolla niloticus	1.76	0.00	0.00	0.00
Cassava	1.76	9.99	5.60	0.00
**Vitamin/mineral mix	0.10	0.10	0.10	0.00
Totals	100.00	100.00	100.00	100.00
Proximate analysis of Diets (% dry diet)				
% Dry matter	91.98	92.89	91.30	92.04
% Crude protein	47.04	51.19	40.26	58.71
% Crude fibre	16.28	12.23	7.08	0.32
% Crude fat	14.21	9.88	18.46	16.11
% Ash	6.21	9.30	3.55	16.01
% Carbohydrates	7.72	10.39	21.95	0.89

*D1= Soyabean meal + cotton seed cake meal + *Azolla niloticus* + cassava + vitamin/mineral mix; D2=Cotton seed cake meal + Cassava + vitamin/mineral mix; D3 = Soyabean meal + cassava + vitamin/mineral mix; D4 = 'Dagaa' Fishmeal.

**Vitamin/mineral mix: Vitamin A (15,250,000 iu); Vitamin D_3 (4,500,000 iu); Vitamin E (1,335 iu); Vitamin K (4,500 mg); Vitamin B_2 (4,500 mg); Vitamin B_6 (2, 350 mg);Vitamin B_{12} (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).

Preparations and operations in the experimental tanks

In the experimental culture systems the replicates were arranged in random block design. Water was supplied from the overhead tanks into the experimental tanks. Before stocking the fish, the tanks were washed thoroughly with fresh water. The tanks were then filled with sand up to 3 cm deep to simulate the condition that *Oreochromis variabilis* is accustomed to in nature. The tanks were left to dry for a week before being filled with fresh water. The water level in the experimental tanks was maintained at 200 l. The compressor was used to supply oxygen into the experimental tanks throughout the experiments except when there was power breakdown. In addition water replacement of 40 % per week was adopted to ensure adequacy of dissolved oxygen.

Each individual tank contained 200 fry at a stocking density of 1 fry per litter. The fish fry were acclimatised in the experimental tanks while feeding on control diet (fishmeal) for two weeks.

Feeding regime

The feeding of 5% of fish body weight per day, as used by Mabrouk *et al*. (2000) was adopted. 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. The feed was divided into two rations. Half of the ration was given between 0730 and 0800 hrs and another half between 1830 and 1900 hrs. Feeding regime of twice a day i.e. morning and evening has been shown to have a higher feed conversion efficiency (Hepher, 1988). Before fresh food was given, faeces and uneaten food was removed by using a scoop net made out of cloth material. Feeding of fish was done by hand as this method enables regular inspection of the fish (New, 1987). Four dietary treatments including the control diet were tested. Three replications (4T x 3R) per treatment (feed) were adopted. The main ingredients in the tested diets included a mixture of Soyabean meal, cotton seed cake and *Azolla niloticus* (D1), Cotton seed cakes meal (D2) and Soyabean meal (D3). "Dagaa" fishmeal (D4) was used as the control diet. Cassava was maintained to enrich the carbohydrate of the diet.

Data collection

Fish growth

In order to assess the growth performance, records of both average individual fish weights and cumulative weights were progressively taken in each fry tank. A sensitive electronic balance (Libror EB-620s SHIMADZU) was used to record weights. 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. The fry were blot-dried before weighing as recommended by Anderson and Gutreuter (1983). To avoid the effects of wind on the weighing balance all the windows and doors in the weighing room were closed (Anderson and Gutreuter, 1983). Sampling was done every 14 days and herein sampling period will refer to two weeks period. There was no feeding during sampling. The following growth variables were determined:

a)

(Hopkins, 1992).

b)

(Castell and Tiews, 1990)

c.

d.

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

e.

Water Quality Variables

Water quality variables were monitored daily. Water temperature, dissolved oxygen and pH were recorded using a water quality checker (model U-10 Horiba, Japan). This was done by immersing the probe into the water. The measurements were taken twice a day during the morning (between 0630 and 0730 hours) and during the evening (between 1730 and 1830 hours). From the daily data, mean values of each variable were calculated in every 14 days. The percentage of un-ionised ammonia (UIA) was calculated from the following relationship as adopted by Ayinla *et al*., (1994):

UIA = 100 / 1+antilog (pKa-pH)

Where:

$pH = -\log(H_3O^+) = -\log(H^+)$

$pKa = -\log Ka = \text{constant} = 9.25$

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, feed conversion efficiency, protein efficiency ratio and survival rates) of *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 difference 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 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} = observation from the k^{th} fry in the j^{th} replicate fry tank receiving the i^{th} feeding type.

μ = general mean common to all observations in the study.

T_i = effect of the i^{th} feeding type.

R_{ij} = effect of the j^{th} replicate fry tank receiving the i^{th} feeding type.

e_{ijk} = random effect peculiar to each fry.

Cumulative weights and growth variables
The following statistical model was adopted in analysing these variables:

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

Where:

Y_{ijk} = record on individual k^{th} fry tank

μ = general mean common to all tanks in the study

T_i = effect due to i^{th} feeding type

R_{ij} = effect contributed by the j^{th} replication within the i^{th} type of feeding

e_{ijk} = random effect peculiar to each fry.

Testing of the Main Effects in the Study

The main effects (cumulative weights and growth variables) in the present study were tested using replication as an error term since the analysis of GLM procedure had shown a significant difference (P<0.05) in growth performance of fish within replications. Therefore replication was used as an error term to take care of that situation and as such reduce the variation between replications.

Results

The coefficient of determination (R^2) for most variables ranged from 0.72 to 0.89 (Table 2). This reflects that over 70% of the variation in most of the variables measured in this study could be explained by the analytical models adopted. The coefficient of variation (CV) for most variables ranged from 9 to 19% (Table 2). This is a reflection that the experimental material used in the study was fairly homogenous, leave alone the variations caused by experimental treatments.

Table 2: Statistics and number of surviving *O. variabilis* (Boul.) fry reared under different diets (D).

Periods (two weeks @)	Diets D1			D2			D3			D4 (Control)			Statistics R^2	CV
	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3		
1	180	190	197	198	198	199	180	198	199	166	165	195	0.89	18.71
2	130	120	128	130	181	140	160	160	130	170	156	100	0.84	9.29
3	99	99	109	86	166	128	130	135	95	140	122	90	0.62	9.36
4	90	92	102	80	152	123	124	129	92	135	118	87	0.46	11.34
5	87	88	96	80	148	118	121	112	87	129	112	93	0.72	12.40
6	82	85	91	75	138	110	113	109	78	121	109	77	0.88	11.50

D=diets R=replication

Growth in Weights

The growth performance of *O. variabilis* fry fed on different diets is illustrated in Figure 1. Cotton seed cakes diet (D2) showed the highest cumulative weight (34.51 ± 3.68 g) compared to composite diet (D1) (31.15 ± 3.68 g) and Soybean diet (D3) (31.18 ± 3.68 g) during the first two weeks of experimentation. However there was no significant difference in growth between cumulative weights (P>0.05) during this rearing period. During the second, third, fourth, fifth and sixth two weeks of experimentation D2 showed highest cumulative weights compared to D1 and D3. During this period the results showed significant difference (P<0.05) in cumulative weights except during the fifth two weeks. During the fifth two weeks of experimentation there occurred a fungi disease.

During the whole period of experimentation, fishmeal (control diet, D4) showed highest cumulative weights of all other diets. However, when Cotton seed cakes diet (D2) was compared with fishmeal (control diet, D4), the results showed no significant difference (P>0.05).

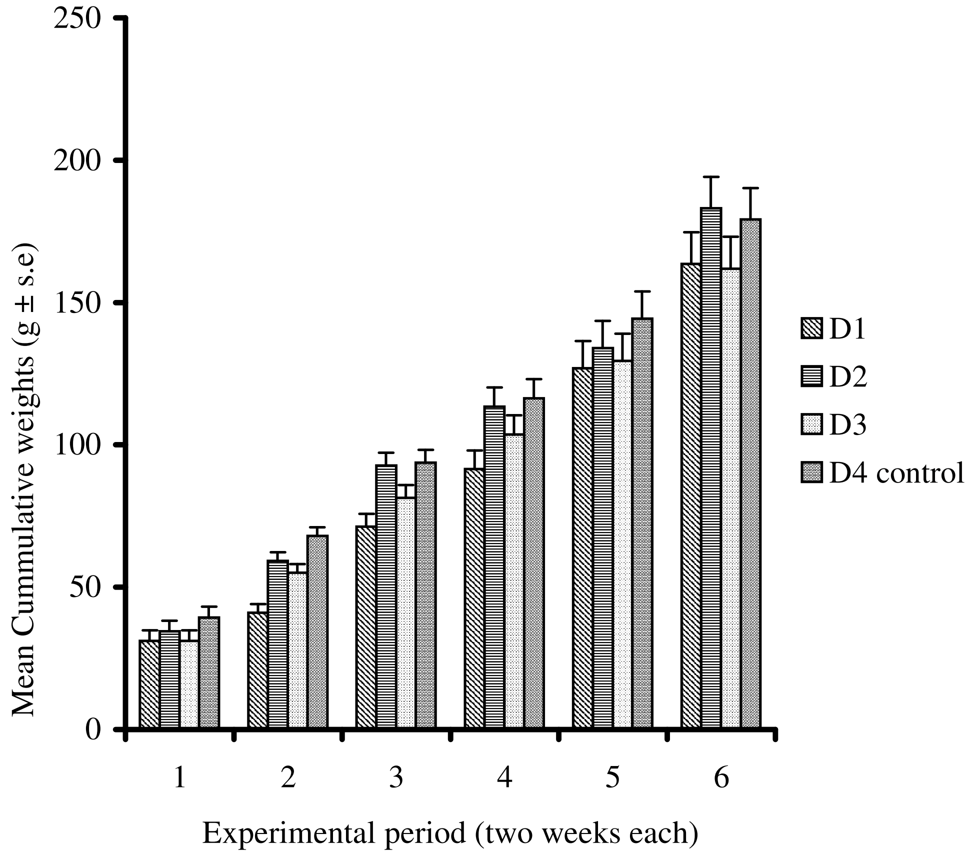

Fig. 1: Mean cumulative weights (g ± s.e) of *Oreochromis variabilis* fry fed on different diets for twelve weeks in polytex tanks. Vertical bars indicate standard errors.

The results show an increase in cumulative weights from the beginning to the end of experiment. The results of multivariate analysis of variance (MANOVA) are presented in Table 4. There was a significant difference (P<0.05) between cumulative weights at the beginning of experiment and at the end of experiment. However, there was no significant difference in cumulative weights (P>0.05) between sampling one and four, two and three and between sampling period five and six in all experimental diets.

Table 4: ANOVA table showing the partial correlation coefficients for the weights used in the analysis

Cumulative weights (CW)	Cumulative weights (CW)					
	CW1	CW2	CW3	CW4	CW5	CW6

CW1	1.00					
CW2	0.007*	1.00				
CW3	0.006**	0.065	1.00			
CW4	-0.062	-0.055***	0.034***	1.00		
CW5	-0.042***	0.018***	0.059***	0.006***	1.00	
CW6	-0.046***	0.016***	0.043***	0.008***	0.414	1.00

significant at (P<0.05), ** significant at (P<0.01), *** significant at (P<0.001)

Growth Variables

The growth performance of *O. variabilis* fry fed on different trial diets with respect to Specific growth rates (SGR), Food Conversion Ratio (AFCR), Food Conversion Efficiency (AFCE) and Protein Efficiency Ratio (PER) is presented in Table 5. D2 showed the highest SGR, AFCE, and PER with better AFCR when compared with other diets, except during the second two weeks of experimentation. The results showed that there was significant difference (P<0.05) in growth variables between trial diets except during the first two weeks. The comparison between cotton seed cake meal (D2) and fishmeal (D4) showed no significant difference (P>0.05) in growth variables during the second two weeks. However, there was significant difference (P<0.05) between D2 and D4 during the rest of the period of experimentation.

Table 5: Least square means for growth variables of *O. variabilis* (Boul.) fry fed on different trial diets

Periods (two weeks each)	Variable	Diets D1	D2	D3	D4 (Control)
1	SGR (%)	4.40 ± 0.68	5.07± 0.68	4.39 ± 0.68	5.92 ± 0.68
	AFCR	0.84 ± 0.11	0.71 ± 0.11	0.85 ± 0.11	0.59 ± 0.11
	AFCE (K_1%)	122.05 ± 31.27	150.6 ± 31.27	122.28 ± 31.27	191.66±31.27
	PER	1.57 ± 0.40	1.93 ± 0.40	1.57 ± 0.40	2.46 ± 0.40
2	SGR (%)	1.98^{a} ± 0.50	3.90^{b} ± 0.50	4.08^{b} ± 0.50	4.03^{b} ± 0.50
	AFCR	2.20^{a} ± 0.18	0.99^{b} ± 0.18	0.94^{b} ± 0.18	1.03^{b} ± 0.18
	AFCE (K_1%)	75.72^{a} ± 17.95	104.68^{b}± 17.95	111.18^{b}± 17.95	111.52^{b}±17.95
	PER	0.59^{a} ± 0.23	1.34^{b} ± 0.23	1.43^{b} ± 0.23	1.43^{b} ± 0.23
3	SGR (%)	2.59^{a} ± 0.25	3.91^{b} ± 0.25	2.78^{a} ± 0.25	2.31^{a} ± 0.25
	AFCR	1.67^{a} ± 0.15	0.98^{b} ± 0.15	1.53^{a} ± 0.15	1.84^{a} ± 0.15
	AFCE (K_1%)	56.94^{a} ± 8.04	101.83^{b} ± 8.04	78.38^{a} ± 8.04	54.46^{a} ± 8.04
	PER	0.73^{a} ± 0.10	1.35^{b} ± 0.10	0.88^{a} ± 0.10	0.70^{a} ± 0.10
4	SGR (%)	1.74^{a}± 0.25	2.84^{b}± 0.25	1.73^{a}± 0.25	1.56^{a} ± 0.25
	AFCR	2.80^{a}± 0.43	1.05^{b}± 0.43	2.60^{a}± 0.43	2.90^{a} ± 0.43
	AFCE (K_1%)	49.78^{a}± 6.31	96.39^{b}± 6.31	39.29^{a}± 6.31	34.93^{a} ± 6.31
	PER	0.51^{a}± 0.08	1.49^{b}± 0.08	0.50^{a}± 0.08	0.45^{a} ± 0.08

5	SGR (%)	$1.33^{a} \pm 0.21$	$2.57^{b} \pm 0.21$	$1.53^{a} \pm 0.21$	$1.54^{a} \pm 0.21$
	AFCR	$1.89^{a} \pm 0.33$	$1.23^{b} \pm 0.33$	$2.98^{a} \pm 0.33$	$3.02^{a} \pm 0.33$
	AFCE (K_1%)	$55.64^{a} \pm 5.60$	$65.19^{b} \pm 5.60$	$34.12^{a} \pm 5.60$	$34.42^{a} \pm 5.60$
	PER	$0.71^{a} \pm 0.07$	$1.45^{b} \pm 5.60$	$0.44^{a} \pm 5.60$	$0.44^{a} \pm 5.60$
6	SGR (%)	$1.84^{a} \pm 0.12$	$1.85^{b} \pm 0.12$	$1.63^{a} \pm 0.12$	$1.22^{a} \pm 0.12$
	AFCR	$2.42^{a} \pm 0.27$	$1.53^{b} \pm 0.27$	$2.76^{a} \pm 0.27$	$3.83^{c} \pm 0.27$
	AFCE (K_1%)	$41.92^{a} \pm 3.14$	$59.23^{b} \pm 3.14$	$36.77^{a} \pm 3.14$	$26.58^{a} \pm 3.14$
	PER	$0.53^{a} \pm 0.04$	$1.54^{b} \pm 0.04$	$0.47^{a} \pm 0.04$	$0.34^{a} \pm 0.04$

[a, b, c,] Least square means with different superscript letters in a row are significantly different ($P<0.05$) D=diets

Survival Rates on Trial Diets

The survival rates (%) of *O. variabilis* (Boul.) fry fed on different trial diets showed a decrease between the first and second two weeks of experimentation. However, there was an increase in survival rates (%) from second to fifth two weeks followed by a decline in survival rates between fifth and sixth two weeks. Survival rates ranged from 64 to 100 % in all diets with substantial amount of high survival rates occurring in all treatments. Overall D2 showed high mean survival rates (91 ± 2.63%) followed by D3 (90 ± 2.12%) and D1 (88 ± 2.64%). The overall average survival rate was 89 ± 1.74% for all diets and sampling period combined. The results of ANOVA however, showed no significant difference in survival rates between different dietary treatments.

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 6. The water quality variables recorded in the present study were within the recommended range (Ayinla, 1994). The water quality checker was not available to record the water quality variables during the sixth two weeks of experimentation.

Table 6: Water quality variables in fry tanks receiving different treatments.

Periods (weeks)	Variable	Diets			
		D1	D2	D3	D4(Control)
1	pH	$6.83^{b} \pm 0.03$	$6.81^{b} \pm 0.03$	$6.71^{a} \pm 0.03$	$6.63^{a} \pm 0.03$
	Temperature (^{o}c)	23.10 ± 0.03	23.01 ± 0.03	23.03 ± 0.03	23.11 ± 0.03
	Oxygen	$5.36^{c} \pm 0.08$	$5.10^{bc} \pm 0.08$	$4.93^{b} \pm 0.08$	$4.86^{a} \pm 0.08$
	Un ionised ammonia	$0.36^{a} \pm 0.01$	$0.35^{a} \pm 0.01$	$0.28^{b} \pm 0.01$	$0.23^{b} \pm 0.01$
2	pH	$7.04^{b} \pm 0.05$	$6.76^{a} \pm 0.05$	$6.70^{a} \pm 0.05$	$6.66^{a} \pm 0.05$
	Temperature	23.09 ± 0.15	23.08 ± 0.15	23.17 ± 0.15	23.29 ± 0.15
	Oxygen	$5.51^{b} \pm 0.20$	$5.03^{b} \pm 0.20$	$4.55^{ab} \pm 0.20$	$4.42^{a} \pm 0.20$
	Un ionised ammonia	$0.59^{a} \pm 0.01$	$0.32^{b} \pm 0.01$	$0.27^{b} \pm 0.01$	$0.24^{b} \pm 0.01$
3	pH	$6.89^{b} \pm 0.05$	$6.81^{b} \pm 0.05$	$6.67^{ab} \pm 0.05$	$6.66^{a} \pm 0.05$
	Temperature (^{o}c)	25.57 ± 1.28	22.86 ± 1.28	22 .9± 1.28	23.02 ± 1.28
	Oxygen	$5.59^{a} \pm 0.10$	$5.23^{a} \pm 0.10$	$4.85^{b} \pm 0.10$	$4.81^{c} \pm 0.10$
	Un ionised ammonia	$0.40^{a} \pm 0.01$	$0.34^{ab} \pm 0.01$	$0.24^{b} \pm 0.01$	$0.24^{b} \pm 0.01$
4	pH	6.61 ± 0.07	6.55 ± 0.07	6.63 ± 0.07	6.56 ± 0.07
	Temperature (^{o}c)	22.70 ± 1.17	22.68 ± 1.17	22.84 ± 1.17	25.11 ± 1.17
	Oxygen	$4.79^{bc} \pm 0.07$	$4.74^{b} \pm 0.07$	$4.52^{a} \pm 0.07$	$4.54^{ac} \pm 0.07$
	Un ionised ammonia	0.19 ± 0.01	0.16 ± 0.01	0.19 ± 0.01	0.17 ± 0.01
5	pH	6.82 ± 0.06	6.86 ± 0.06	6.87 ± 0.06	6.84 ± 0.06
	Temperature (^{o}c)	26.63 ± 1.74	23.29 ± 1.74	23.13 ± 1.74	23.41 ± 1.74
	Oxygen	4.78 ± 0.10	4.77 ± 0.10	4.65 ± 0.10	4.69 ± 0.10
	Un ionised ammonia	0.36 ± 0.01	0.38 ± 0.01	0.41 ± 0.01	0.37 ± 0.01

$^{a,\ b,\ c,}$ Least square means with different superscript letters in a row are significantly different (P<0.05), D=diets

Discussion

The feeding experiment was aimed at investigating growth performance of *O. variabilis* fry fed different diets. Protein is very important in fish growth and thus 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 % (Marais *et al*., 1979; Reintz, 1984; Aneykutty *et al*., 1994; Usman *et al*., 1997). With respect to the cumulative weights and growth variables, *O. variabilis* fed on Cotton seed cakes diet showed higher performance than those fed on composite diet and Soyabean diet. However, there was no significant difference during the first and fifth two weeks of experimentation. The most likely explanation for this observation is that during the first two weeks the fry were probably still acclimatising to the tank experimental conditions and that during the fifth two weeks there occurred a fungi disease outbreak. These two factors could be responsible for the non-significant difference observed during this period.

The analysis of data showed no significant difference between cotton seed cakes diet and fishmeal control diet with respect to cumulative weights. There was no significance difference between cotton seed cakes diet and the fishmeal control diet with respect to SGR, FCR, FCE and PER except during the second sampling period. In developing countries, fishmeal, which forms the potential base for artificial feeds, is scarce and expensive (Mnembuka and Eggum, 1995). Results from the present study suggest that cotton seed cakes may be used to replace fishmeal in fish feeds due to the fact that the use of cottonseed meal in raising *O. variabilis* has shown better growth performance. Moreover cotton seed cakes are cheaper than fishmeal. Substitutions of fishmeal in fish feeds have been done for carp by Viola *et al*., (1982). Comparable to the present study, Fowler (1980) reported better growth performance and survival among chinook and coho salmon fishes fed on cottonseed diet.

The use of glandless cottonseed products in fish feeds such as *G. hirsutum* applied in the present study has shown better performance (Robinson *at al*., 1984b). Robinson *et al*. (1984b) noted that glandless cottonseed products, which contain less than 100 ppm of free gossypol, should allow for use on increased 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). The good 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. 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.

It is seen from the present study that *O. variabilis* fry fed on soyabean meal gave poor growth rate, AFCRs and PERs compared to those fed on cotton seed cakes and composite diets. The current 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 soyabeans weighed significantly less and suffered higher mortality than 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) reported retardation in growth of *Clarias batrachus* (Linn) and *Anabas testudiness* when fed on soyabeans. 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. 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 influence weight gain or survival in chinook and coho salmon. It is speculated that probably the heat treatment applied to soyabeans in the present study was only partial (about 100 °C) such that the enzymes that inhibit the digestion of leguminous plant protein in fish were not destroyed satisfactorily. Fowler (1980) reported low growth rate in chinook and coho salmon fed on heat-treated soybean diet with temperature range of 178 to 278 °C. But it has been recommended that, the anti-nutritional factors other than trypsin inhibitors (Wilson and Poe, 1985) contained in soybean meal may be removed by sufficient heat treatment (Spinelli *et al*., 1979). The observations reported by Fowler (1980) support the speculation that the heat applied in the present study to treat soyabeans was not sufficient enough to destroy the anti-nutritional factors. However, though soybean diet performed relatively poor than the other diets in the present study, the FCRs were relatively better than those reported by Nandeesha *et al*. (1989). The FCRs 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 Soybean meal with FCR of 3.64. Portella *et al*. (2000) reported that artificial diets containing soybean oil promoted good growth in fingerlings. The good FCR 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.

Initially it was 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 pointed out 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. 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.

The present study revealed significant differences in cumulative weights and growth variables not only between treatments but also between replications receiving similar treatments. This is rather surprising as substantial care was taken in controlling the experimental materials. The appearance of significant differences between replicate fry tanks implies the existence of a multitude of local factors operating in the individual fry tanks, which could not be standardized/measured. Other workers (Costa-Pierce *et al*., 1993; Mwangulumba, 1997; Lubambura, 1997) have reported similar results. Weather parameters such as air temperature and sunshine (radiation) could be among these factors and might be responsible for the differences observed between replications. Some of the fry tanks were next to windows; the windows were large and had only wire mesh, which allowed reception of sunshine radiation. Prein and Hulata (1993) argued that weather conditions might affect individual ponds differently. It is difficult to predict or regulate weather effects throughout pond management (Prein and Hulata, 1993). Costa-pierce *et al*. (1993) pointed out the existence of inherent variability in aquatic ecosystems, biological processes, individual fish growth and water quality as being responsible for the significant differences between replications receiving similar treatments. These findings emphasize the need to include an adequate number of replicates in aquatic research. In this case the effects of replications should be used as an error term of testing the main effects of treatments in the nested experiments such as in aquaculture nutrition research.

From feeding results it is seen that survival rates ranged from 63.16 % to 100 % between sampling periods. *O. variabilis* fry fed on Cotton seed cakes showed higher overall mean survival rates (90.70 ± 2.63%) followed by those fed on Soyabean meal (89.63 ± 2.12%). The results showed decline in survival rates in all diets during the first and fifth two weeks. The acclimatisation process to the experimental tank conditions may have contributed to the decline in survival rates during the first two weeks. The suspected fungal disease outbreak that occurred during the fifth two weeks of the experiments might have caused the decline in survival rates during this period. Pauly (1993) noted that disease epidemic causes reduction in survival rates in aquaculture. In the present study the fungal disease occurred but it was immediately treated by applying the fungicide.

Conclusion

From the results of the present study it is concluded that cotton seed cakes containing diet can be used as a better replacement in fishmeal in the fish feeds for feeding Tilapia, *O. variabilis*. However, Tilapia, *O. variabilis* is incapable of manipulating the fibrous material contained in *Azolla niloticus.*

recommendations

i. It is recommended that for better utilisation of the cotton seed cakes a study should be conducted to investigate the optimum level of cotton seed cake protein that would yield maximum growth and production.
ii. Since the cotton seeds lack lysine, the supplementation of this amino acids in cotton seed cake diet should be critically considered.
iii. Soyabean meal containing diet can also be used to replace fishmeal with good results. However, heat treatments for destroying the anti-nutritional factors in soyabean without impairing other nutrients like amino acids should be conducted satisfactorily.

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