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Growth performance of juveniles *Oreochromis niloticus* (Nile Tilapia) reared in concrete tanks with two different diets

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Abstract
This research was carried out to study growth performance and survival rates of Juveniles *Oreochromis niloticus* L fed with two different diets: aqualis feed (AF) a commercial feed and University Fish feed (UFF) formulated using locally available ingredients. The study was carried out at Umaru Musa Yar'adua University Katsina State Nigeria between June - September, 2017. Three hundred (300) fishes having an average weight of (2.50- 2.75g) were randomly distributed into twelve (12) concrete ponds measuring (0.98m x 1.07m x 0.70 m) in quadruplicates. The fish were fed two (2) times based on 10% of their cumulative body weights for a period of fifteen (15) weeks. Water parameters of the experimental ponds were monitored and measured regularly using standard methods. Results indicated significant differences in growth performance between the fish fed with two different diets and the control. The highest growth performance in terms of final body weight, weight gain, specific growth rate were observed in the fish fed with aqualis (173.00±21 g, 170.40±19.8, 3.99±0.38% day-1), followed by the UFF (98.12±5.8 g, 96.62±4.1 g, 3.49±0.95% day-1), while the control had the lowest (75.65±6.8 g, 72.95±5.85 g, 3.17±0.42% day-1). Logarithmic 'b' values ranged between (0.89±0.30 - 1.43±0.59) and indicated negative allometric growth pattern in all the fishes. Condition factor ranged from 2.42 to 3.48. Temperature, pH, dissolved oxygen and transparency of the ponds were within the recommended levels for the survival of *O. niloticus.* Further research is recommended using local ingredients to complement the expensive fish feeds available in our markets.

Keywords: Aqualis fish feed, condition factor, growth performance, university fish feed

Introduction
Worldwide, Tilapia is the most common farmed fish because of their enormous ability to withstand to a wide range of physical and environmental conditions, ability to reproduce in captivity, resistance to handling stress and microbes compared to other farmed finfish species (Welker and Lim, 2011) [33]. They are presently cultured in almost all types of fish farming systems (both fresh and salt water) and in tropical, subtropical and temperate climates and environments (Fitzsimmons, 2006) [19]. The genus *Oreochromis* is the most commonly reared and the species *niloticus* was the first species to be farmed in Africa (Thomas and Michael, 2005) [32]. *O. niloticus* can survive a wide range of pH, resists low levels of dissolved oxygen (DO) and consumes on a variety of food items (Balirwa, 1998) [8].
Worldwide tilapia production has increased considerably during the last few decades with total outputs increasing from 830,000 tons in 1990 to 5.3 million metric tons in 2014(FAO 2015) [18]. The low trophic level and the omnivorous feeding habits of this species make them a relatively cheap fish to feed, unlike other strictly carnivorous finfish, such as salmon and cat fish that rely on high protein and lipid diets which are largely based on fish or animal sources (Mjoun, *et al.,* 2000) [29].
One of the major problem affecting aquaculture is high protein cost in fish feed which results into unprofitable venture in fish farming (FAO, 2014) [17]. Studies have reported that the feeding cost accounts for about 30-70% of the total operational cost in a fish farming venture (El-Sayed, 2006) [15].
Many fish farmers in developing countries including Nigeria are finding it difficult and very expensive to use fish meal from the manufacturers as a main protein source in fish farming (Goda *et al.,* 2007) [23]. Replacement of fish meal in fish farming with cheaper ingredients from

plant sources or locally processed fish meal / feed is required for the reason of reducing operational cost and increasing the margin turnover (Bhosale *et al.*, 2010) [10].

Over the years, numerous studies by many researchers such as Saad *et al.*, (1997) [30]; Lim *et al.*, (2001) [28]; Garduño-Lugo and Olvera-Novoa (2008) [22]; Santos *et al.*, (2009) [31]; Agbo *et al.*, (2011) [2] ; Guo *et al.*, (2011) [24] and Bwathondi and Abdulkarim (2017) [14] have evaluated the nutritional value of low-cost plant ingredients in tilapia diets, using digestibility, growth performance and feed intake as measurement endpoints in different parts of the world. However, little is done on the growth performance of *O. niloticus* with locally formulated diet and commercial diet in Nigeria as most researchers gave more attention to the *Clarias gariepinus* species.

Therefore, as part of the larger investigation to reduce dependency of fishmeal in the steadily increasing aquaculture sector and to provide affordable feeds for farmers, the present study was aimed to investigate growth performance of Juveniles *Oreochromis niloticus* (Tilapia) reared in concrete ponds/ tanks with two different diets.

Materials and Methods

Study Site

The study was conducted at the Biological garden of the department of Biology Umaru Musa Yar, adua University Katsina, Katsina State Nigeria located at Latitude 6° 40' 0" S and Longitude 39° 13' 0" E.

Source of experimental fishes

Five hundred (500) juveniles of *O. niloticus* were used in this study. They were obtained from National Biotechnology Centre along Dutsinma road Katsina. The collection and transportation of the fishes were done as recommended by Bolorunduro (2001) [11]. Upon reaching UMYU the fishes were released into the storage tanks/ ponds for acclimatization for two (2) days before the beginning of the experiment.

Experimental materials and layout

The experiment / study was done in 10 concrete tanks/ ponds (labelled P1- P10) with sizes of 3.2ft x 3.5ft x 2.3ft (L x Bx H) which is equivalent to (0.98m x 1.07m x 0.70 m) respectively. Water level in the ponds were maintained nearly full throughout the study and replaced at 50% every 2 weeks to ensure adequacy of oxygen. Each pond was stocked with 25 juveniles in quadruplicates. Growth of the fishes were assessed with Aqualis (AF) used as commercial feed and Umaru Musa Yar'adua feed (UF) as locally formulated feed over a period of fifteen (15) weeks

Control

Five experimental tanks labelled T11- T15 were set as control. Each tank was stocked with 25 Juveniles in quadruplicates and fed with domestic feed remnants thrice in a week at 08.00 hrs.

Feed Formulation

35 % crude protein of Umaru Musa Yar'adua locally made feed (UF) was formulated using Pearson Square Method. Ingredients used in the formulations were maize bran, fish meal, cotton seed cake, vitamin premix and mineral premix. Aqualis feed proximate contents on the label were 35% crude protein, 25% carbohydrate, 7% lipid and 8% fibre. Ingredients used in its preparations were fishmeal, Soy bean, rice bran, cassava, lipids, vitamin premix and mineral premix.

Proximate Compositions of the Experimental Feeds

The proximate composition (moisture, crude protein, lipid, carbohydrates and ash) of the two fish feeds ie. Aqualis and Umaru Musa Yar'adua University locally made feed (UF) were determined using the standard methods of the Association of Official Analytical Chemists (AOAC, 2000) [3]. Moisture content was determined based on the differences between the wet weight and the weight after drying to a constant temperature (at 100^0C). Each sample was put in an oven at a constant temperature (100^0C) until constant weights were obtained. It was later removed and placed in a dessicator and weighed (W_1). Five grams (5 g) of the sample was placed in the weighed crucible (W_2). The crucible containing the sample was kept in an oven at 100^0C for 24 hours and then weighed. It was kept back in the oven and reweighed after about 3 hours to ensure a constant weight (W_3). Loss in weight was equal to water content of the original sample. The percentage moisture content was calculated as follows:-

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \text{ x } 100$$

Where: W_1 = Weight of an empty crucible
W_2 = Weight of known amount of sample (fresh) + crucible
W_3 = Weight of oven dried sample

The protein content was determined in three stages digestion, distillation and titration by micro-kjeldhal method and multiplied by 6.25 to estimate the crude protein content (AOAC, 2000) [3]. Percentage of crude protein was determined with the following calculation:

$$\% \text{ Nitrogen} = \frac{\text{Titre value (A-B) X Normality of acid X vol of dilute X } N_2 \text{ x } 100}{\text{Sample wt (mg) X vol of digest (aliquot)}}$$

$$= \frac{\text{Titre value X } 0.01 \text{ X } 100 \text{ X } 14.007 \text{ X } 100}{\text{Sample wt (mg) X } 10}$$

Where: A = Titre value for the digestion sample
B = Titre value for the blank
% crude protein = % N_2 X 6.25

The lipid was determined by extraction with petroleum ether in a Soxhlet extractor for 4-8 hours. The ash content was determined when the white ash was formed and a constant weight maintained. Ten grams of dried powder was placed in a pre-weighed porcelain crucible and ignited in an ashing furnace maintained at 600ºC until a constant weight was obtained. Crude carbohydrate was calculated by the difference method. The sum of the percentage moisture, ash, crude lipid, crude protein was subtracted from 100 (AOAC, 2000) [3].

Feeding of fish

The experimental fishes were fed at 10% of their cumulative body weight throughout the experiment. Feeding was done at 08.00 hrs and 16.00 hrs daily (twice a day). Juveniles in tanks 1 to pond 5 were fed with Aqualis commercial feed (AF), while juveniles in tanks 6 to pond 10 were fed with Umaru Musa Yar'adua Locally Formulated fish feed (UFF).

Water parameters analysis

During the study period physico–chemical parameters of water samples including water temperature, pH, dissolved

oxygen, were measured using multi-probe water checker U-10 (HORIBA) following standard methods (APHA 2005) [4] bi-weekly. Transparency /turbidity was measured using a Secchi disc.

Data collection

Growth performance(s)

In order to assess the growth performance lengths and weights were taken in each tank. A sensitive electronic balance (Model number YP 500 IN) was used to measure the weights. The Total Length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin using meter rule calibrated in centimeters. Fifteen (15) Juveniles from the stocked ones were sampled randomly from each tank by using a scoop net. The fish weight and length measurements were taken and returned into their respective tanks. Sampling was done after every 21 days (3 weeks). Fish mortality was also recorded throughout the experiment.

The statistical relationships between these two parameters were established by using the parabolic equation by Froese (2006) [20]:

$$W = aL^b$$

Where, W = Weight of fish (g)

L = length of fish in cm

a = constant, b = (slope) exponential expressing the relationship between length and weight.

The relationship ($W = aL^b$) when converted into the logarithmic form gives a straight line relationship graphically as: LogW= Log a+ b Log L

Where, b= slope, Log a= constant.

Fulton's condition factor (k)-The coefficient of condition (K) was calculated using Fulton's (1904) [21] formula as follow:

$$K = \frac{Wx100}{L^3}$$

Where, W= weight of the fish in gram, L = length of the fish in cm, 100 = is a factor to bring the value of K near unity.

Specific Growth Rate (%SGR)

Specific Growth Rate was calculated using formula adopted from Hopkins (1992) [25]:

$$SGR = \frac{\text{In Final weight} - \text{In Initial weight}}{\text{Number of rearing days}} \times 100$$

Survival Rate

Percent Survival Rate was calculated using a formula:

$$\% \text{ survival rate} = \frac{\text{Number of fish harvested}}{\text{Total number of juvenile stocked}} \times 100$$

Statistical analysis

Analysis of variance (ANOVA) was performed to determine variations in 'b' values and determine differences in weights and lengths of the species fed with the two different diets and the control. Significant differences were set at $p \leq 0.05$. All the statistical tests were performed using a graph pad s Statistical Software version 7.04.

Results

Table 1 shows the experimental diet (UF) compositions. The formulation of the diet involves roasted soybean meal, fishmeal, yellow maize, wheat offal, premix, oil and binder. The protein complements which are roasted soybean meal and fishmeal were 25.62%, while basal feed yellow maize and wheat offal were 24.35% each. Premix was 0.025g and binder was 0.5 kg respectively.

Table 1: Formulation of Experimental diet (UF) with 35% Crude Protein per 100kg.

Nutrients	Quantity(100kg)	Quantity used
Roasted Soya bean meal	25.62kg	2.56kg
Fish meal/Clupeid	25.62kg	2.56kg
Yellow Maize	24.35kg	2.44kg
Wheat	24.35kg	2.44kg
Premix	0.025g	0.025
Vegetable Oil	50ml	5.0ml
Binder/ Cassava Flour	0.5kg	0.05 kg

Table 2 shows the proximate compositions of the Aqualis i.e. commercial diet and the university formulated diet (UFF). Protein content of the Aqualis feed was 41.5g/100g while that of the University diet was 37.01 g/100g. There was no significant difference in the protein contents between the two feeds. (P= 0.25, Wilcoxon matched-pairs signed rank test).Lipid content in Aqualis feed was 6.17 g/100g while that of the University formulated feed was 11.5 g/100g. There was significant differences in Fats/ lipids contents between commercial (Aqualis) and the University formulated feed (T-test, df=2, t= 12.09 and P= 0.00068).

Moisture contents of Aqualis feed was 8.5 g/100g and 6.7 g/100g for the UL locally formulated feed. There was significant difference in moisture contents between commercial (Aqualis) and University formulated feeds (T-test, df=2, t= 4.679 and P= 0.0428).

Table 2: Proximate Compositions of Aqualis (AF) and (UFF) formulated Fish Feeds.

S/No.	Proximate	Aqualis Feed (g/100g)	UL Formulated Feed (g/100g)
1	Protein	41.15±0.18a	37.01±0.18a
2	Fat/ lipid	6.17±0.29a	11.5±0.50b
3	Moisture	8.5±0.50a	6.7±0.19b
4	Fibre	7.28±0.25a	4.63±0.03b
5	Carbohydrate	36.9±0.13a	40.16±0.29b

Values in the same row having the same letters are not significantly different (p>0.05).

Fibre contents in Aqualis were 7.28 g/100g and 4.63 g/100g for the UL feed. There was significant difference in fibre contents between commercial (Aqualis) and UL formulated feed (T-test, df=2, t= 17.67 and P= 0.0032).Contents of carbohydrate were 36.9 g/100 g in Aqualis and 40.16 g/100 g in UL feed and there was significant difference in carbohydrate contents between the two feeds (T-test, df=2, t= 10.09 and P= 0.0005).

The mean values of the growth performance, condition factor and survival rate of Juvenile *O. niloticus* fed with two different diets are summarized in Table 3. The highest growth performance in terms of final body weight (FBW), final body length (FBL) as well as specific growth rate (SGR) was observed on the fish fed with Aqualis feed, followed by fish fed with University locally formulated diet or feed (ULF) and least and poor growth performance was recorded in the control. There was extremely significant differences in the final body weight (FBW) between the two experimental diets

and the control (f=892.58, df=176, p<0.0001). Similarly, significant difference was observed in the final body length (FBL) between the two diets and the control (f=540.79, df=176, p<0.0001).

The 'b' values recorded in both the experimental diets and the control ranged between 0.89±0.30-1.43±0.59 indicating negative allometric growth in all the experimental fishes. There were statistical significant difference in the values between the two diets and the control (f=5.186, df=45, p=0.0094). The Fulton's condition factor in both the experimental diets and the control is above 1 (2.42-3.48) indicating the wellbeing of the fishes during the study.

Table 3: Values of Growth Parameters of Juvenile *O. niloticus* Fed with Two Different Diets

Growth Parameters	Aqualis feed	Univ. Fish feed	Control diet
Initial mean body weight (g fish-1)	2.60±1.2a	2.50±1.7a	2.75±0.95a
Initial mean body length (cm)	6.30±0.73a	6.27±0.99a	5.98±0.97a
Final mean body weight (g fish-1)	173.00±21a	98.12±5.8b	75.65±6.8c
Mean body weight gain (g fish-1)	170.40±19.8a	96.62±4.1b	72.95±5.85c
Final mean body length (cm)	17.65±0.95a	14.77±0.68b	12.73±0.79c
Mean body length gain (cm)	11.35±0.22a	8.50±0.31b	6.75±0.18c
Specific growth rate (% day-1)	3.99±0.38a	3.49±0.95b	3.17±0.42c
Values of 'b'	1.43±0.59a	1.15±0.48b	0.89±0.30c
Type of Growth	NA	NA	NA
Condition Factor (K)	2.42±0.00	3.05±0.00	3.48±0.00
Survival rate (%)	100.00±0.00a	100.00±0.00a	90.00±0.00b

Values in the same row having the same letters are not significantly different (p>0.05).
NA= non-allometric. b=3 (isometric growth), b<3 (negative allometric growth,) b>3 (positive allometric growth).

The growth trends of *O. niloticus* in terms of weight gain for the experimental feeds (diets) for the period of the study i.e. 15 weeks is shown in Figures 1, 2 and 3. The initial weights of the juvenile *O. niloticus* at 0 week (beginning of the research) were 2.60 g, 2.50 g and 2.75 g for the Aqualis feed, University formulated feed and the Control respectively (Figure 1). There were no significant differences (p>0.05) in the weights among the three groups. There were progressive increases in the weights at 3 weeks to 9.57g, 7.96 g and 5.69 g in the fishes for the Aqualis feed, University formulated feed and the Control diet respectively.

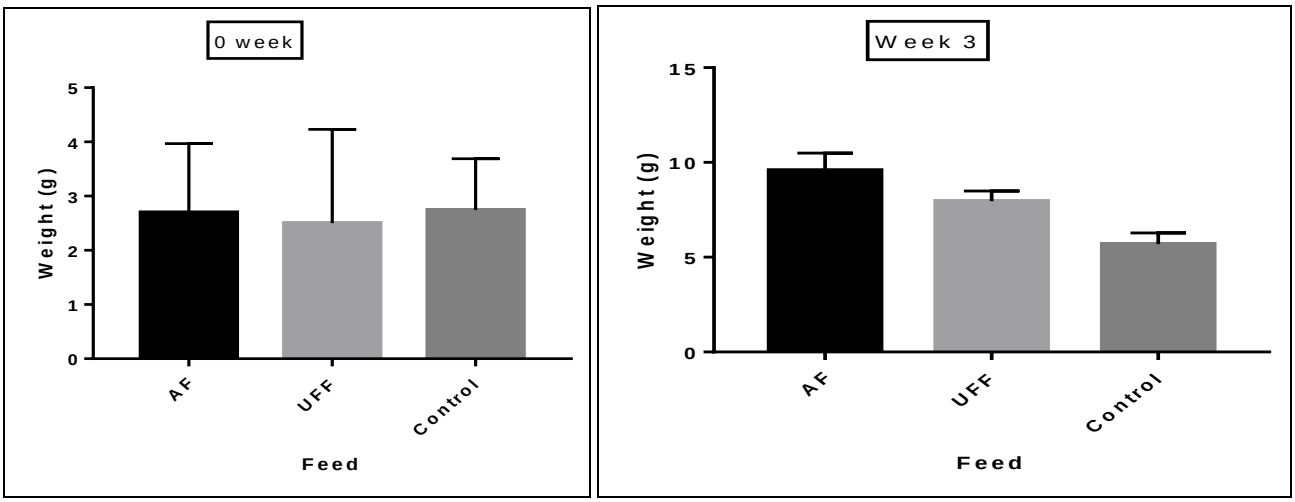

Fig 1: Growth trend of Juvenile *O. niloticus* in 0 and 3 weeks.

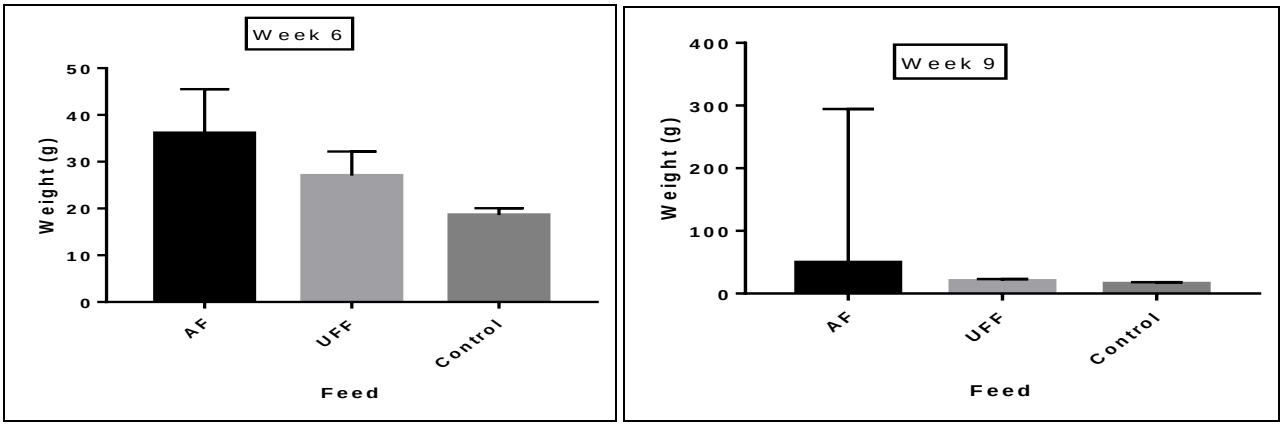

Fig 2: Growth trend of Juvenile *O. niloticus* in 6 and 9 weeks.

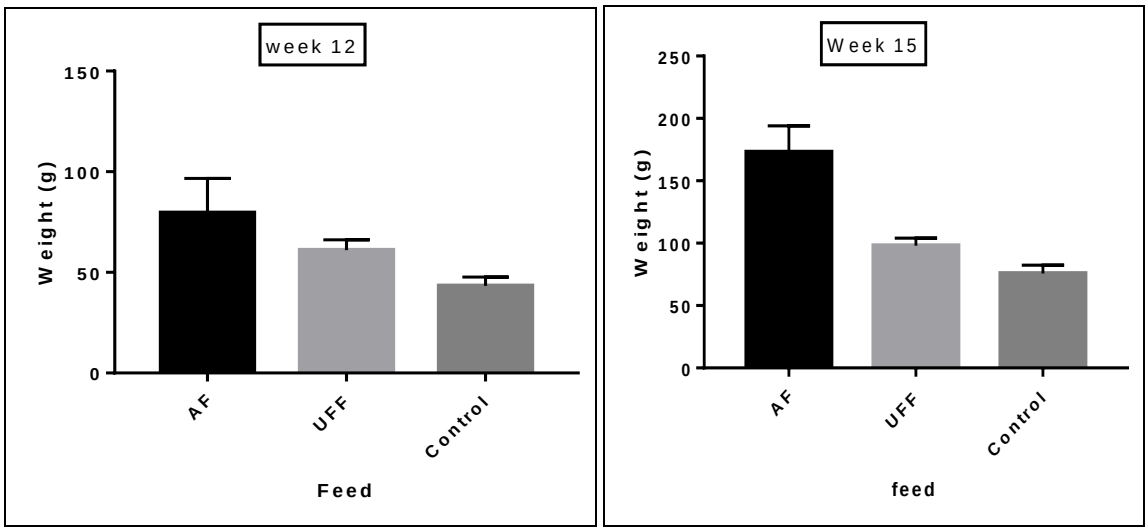

Fig 3: Growth trend of Juvenile *O. niloticus* in 12 and 15 weeks.

At sixth (6) week the growth performance increased to 36.08 g, 27.01 g and 18.58 g in the fishes fed with the Aqualis feed, University formulated feed and the Control diet respectively. There were recorded increases in the weight thereof at week 9th to 49.38g, 20.10 g and 15.39g for the three experimental diets respectively. Further increased in the weights were recorded at 12th week to 79.56 g, 61.01 g and 43.35 g in the fishes for the Aqualis feed, University formulated feed and the Control diet respectively. Final weights recorded at the 15th week of the experiments were 173.00 g, 98.12 g and 75.65 g in the fishes for the Aqualis feed, University formulated feed and the Control diet respectively. No mortality was recorded in AF as well as UF experimental set up.

The physico-chemical parameters of the ponds treated with the three (3) experimental feeds is presented in Table 4. Temperature ranged between 26.27 to 28.88 ^{o}C and there were significant differences among the treatments (Kruskal wallis test, f=9.649, p=0.0008).pH was between 8.94 to 9.48 and there were no significant differences (p=0.1484) among the treatments / experimental ponds and the control.

Table 4: Physico-chemical Water Parameters of Ponds Stocked with Juvenile *O. niloticus* and Fed with Two Different Diets

Parameter/ Treatment	AF Ponds	UF ponds	Control ponds
Temperature ^{o}C	28.88±1.61a	26.27±2.26b	26.49±2.33a
pH	8.94±1.24a	9.05±1.32a	9.48±0.81a
Dissolved Oxygen (mg/l)	7.73±1.88a	5.23±2.49b	8.5±71.19a
Transparency (cm)	24.59±0.834a	28.26±1.89b	21.12±1.36c

Values in the same row having the same letters are not significantly different (p>0.05)

Dissolved oxygen ranged between 5.23 to 8.5 mg/l and differences existed among the treatments (ANOVA, F (2,25)= 7.316, P=0.0032). Higher dissolved oxygen was observed in control and AF ponds respectively. Transparency ranged between 21.12 to 28.26 cm and significant differences existed among the treatments.

Discussion

The results of the present study revealed that all the experimental diets (Aqualis and the University formulated feed) were accepted by juvenile *O. niloticus*. This implies that the different experimental feed ingredients did not affect the palatability of the diets. The reason might be due to the various processing techniques employed in the processing of Aqualis by the factory and in this study for the formulation of the university feed which might have reduced some of the anti-nutrient factors in the feed ingredients. This result is in line with the previous work of Azzaza *et al.,* (2008) [7] and Workagegn *et al.,* (2013) [35] who reported that different processing techniques can reduce anti-nutritional factors and thereby increase palatability.

Growth rates and performances were more achieved in fish fed with Aqualis feed than with the university feed and the control. This might be attributed to the fact that *O. niloticus* is a top feeder and feeds predominantly on the floating fish feed (Aqualis) for quite longer time than the university feed a sinking feed that do not float for longer time. Furthermore, variation in growth performance and feed utilization efficiency might have been caused due to differences in the quality of supplemental diets in terms of nutrient composition and feeding habits of the fish. However, this finding is not line with the findings of Workagegn *et al.,* (2014) [35] who reported higher growth performance *O. niloticus* in control feeds in Ethiopia as well as Bwathondi and Abdulkarim (2017) [14] who reported higher performance of growth in locally formulated feed than Agric Aqua Eden Feed in Tanzania.

Specific growth rate (% body gain per day) in this study (3.17-3.99 % day) was in line with the findings of Workagegn *et al.,* (2014) [35] who reported SGR of 3.43-3.96 % day in *O. niloticus* fed with different formulated diets from Ethiopia. The findings are also higher than those reported by Asadi *e t al.,* (2012) [5] who reported SGR of 1.60-1.74 % day. However, the finding of this study was lower than those reported by Bwathondi and Abdulkarim (2017) [14] in *O. niloticus* fed with two different diets in Kunduchi Ponds Dar es Salaam Tanzania. The differences observed in this study and others might be due to different nutrient compositions of the different experimental diets and the rearing period or culture days.

Growth is said to be positive allometric when the weight of an organism increases more than length (b>3) and negative allometric when length increases more than weight (b<3) (Wootton, 1992) [36]. Logarithmic b values in this study 0.89-1.43 indicated that all the fishes in the experimental set up undergone negative allometric growth. Negative allometric growth pattern have been reported in *O. niloticus* by King (1991) [26] and Zenebe (1997) [37]. Negative allometric growth has also been reported by Ayoade and Ikulala (2007) [6], in *Chromidotilapia guntheri* as well as Bwathondi and Abdulkarim (2017) [14] who reported negative allometric growth in *O. niloticus* in Dar es Salaam. However, this finding contradicted the findings of Abdulkarim and Jabir (2013) [1] who reported positive allometric growth in *O. niloticus.*

Condition Factor is an indicator of the general fish condition (Bwathondi and Abdulkarim, 2017) [14]. The Condition factor (CF≥1) indicated that the fishes are in good condition. The finding in this study (CF: 2.42-3.48) indicated all the fishes were in good condition during the study period. This was in line with the findings of Kwasi *e t al.,* (2016) [27] and Bwathondi and Abdulkarim (2017) [14]. This might be attributed to the acceptable and palatable fish feeds as well as good quality water (physico-chemical parameters' of the water).

The growth performance of juvenile *O. niloticus* were affected by different environmental factors such as water quality parameters including water temperature, pH, dissolved oxygen concentration, transparency etc. The average values of all water quality parameters recorded during this study were within suitable range for the normal growth performance and survival of *O. niloticus*. The average values of pH ranged from (7.32 to 7.84) and dissolved oxygen concentration ranged from (6.75-6.95 mg/l) and all were in agreement with the previous work of El-Sheriff and El-Feky (2009) [16] *(*Azzaza *et al.,* 2008) [7] and Bahnasawy *e t al.,* (2003) [9]. The dissolved oxygen and temperature recorded in this study were in line with the findings of Bwathondi and Abdulkarim (2017) [14]. The physiochemical parameters monitored in the experimental ponds showed that water pH, DO, Temperature and Transparency varied among the treatments and was is in accordance to findings of Boyd (1999 and 2003) [12], [13] who stated pH should be 6.0 -9.5. DO should be above 3mg/l, temperature 28 ± 1.0 ^{0}C.

Conclusion

This study has shown that growth performance of *O. niloticus* was better with the Aqualis (commercial feed) followed by the University feed (UF). In addition, all the fish feeds both the commercial and locally formulated were very palatable and accepted by *O. niloticus* without any feed related mortality. The appreciable growth exhibited by the fishes fed with the two diets indicated that the water environment and the necessary water parameters were within normal level for the successful survival of the fish species.

Recommendation(s)

The study therefore, recommends as follows:

1. University Fish feed (UFF) be utilized for the culture of *O. niloticus* as it is acceptable, palatable and supports appreciable growth performance
2. Further studies be carried out on the use of locally available ingredients for fish feed formulation with the intention of coming out with best, less cost effective fish feed in the country that will compete with the expensive and foreign fish feeds.
3. That at the process of fish feed formulation factors peculiar to our tropical countries and environments should be given more attention. This is because most of this techniques of fish feed formulations were devised for the western countries.

Conflict of interest

No conflict of interest whatsoever among the authors.

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