Water and Sediment Qualities Issues and Growth Performance of Pond-Cultured Oreochromis Niloticus Fed Different Dietary Protein Levels

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Abstract:

The physico-chemical and bacteriological quality of water and sediments and the growth performance of fish following administration of *Oreochromis niloticus* feeds of two different dietary protein levels were studied in Hapas set in four 200 m2 ponds. Results indicate that water quality parameters monitored were within environmental tolerable limits and for the growth of *Oreochromis niloticus*. For all the feeds, water temperature was in the range of 27.83 ℃ - 28.67 ℃, dissolved oxygen 5.01mg/L - 6.11 mg/L and pH 5.4 - 7.01. The levels of biochemical oxygen demand, nitrogen, phosphorus and dissolved organic carbon as well as Salmonella sp, Staphylococcus aureus and Pseudomonas sp were generally beyond acceptable limits with projections of the levels of the physico-chemical parameters indicating further increase. There were no statistical significant differences (P>0.05) in the levels of total nitrogen, phosphorus, biological oxygen demand, dissolved organic carbon and bacteria load before the administration of treatments and at the end of the study.

Keywords:

Water Quality, Nutrient, Protein, Growth, *Oreochromis Niloticus*

1. Introduction

The price of fish feed contributes 40-50% to variable operation cost in aquaculture [1]. The feed contains crude protein which contributes 60%or more to its price; notwithstanding, fish need sufficient dietary protein for optimum growth [2]. Fish need 25-50% crude protein in feed for growth. However, excessive amounts of dietary crude protein suppress their growth [3]. [4] Noted that crude protein in feed if not efficiently used by the fish pollutes water, stresses fish, results in poor growth, increases mortality and outbreak of diseases. The growth performance of fish in response to different levels of dietary protein is influenced by fish size, protein quality, water temperature, feed allowance, amount of non-protein energy in the feed and natural food availability [3].

Not all the feeds given to fish are used for growth; some are lost in to the water and sediments [5].The feed is the primary source of nitrogen and phosphorus to fish ponds [6]. Usually 20-40% of nitrogenand10-30% of phosphorus in feed given to fish is used for growth [5]. It also contains organic carbon that introduces various microorganisms into fish ponds [7]. Sediments have higher concentrations of nutrients, organic carbon and microorganisms than water [8]. Although sediments have high concentrations of organic carbon, they are mostly of plant remains that are quite resistant to decomposition by bacteria and other microbes [9].

The qualities of pond water and sediment affect feed efficiency, growth rates, survival and general wellbeing of fish [10]. Good water and sediment qualities in ponds are essential for increased production [9]. Undesirable water and sediment qualities stress fish causing reduction of their immune system and increasing their vulnerability to attack of opportunistic bacteria [11]. Different dietary protein levels impact on pond water and sediment qualities to certain degree and this in turn exerts different levels of effect on fish growth.

However, elimination the presence of nutrient pollutants can limit the growth performance of the cultured species and hence the profitability of the aquaculture. There is therefore the need to study the extent to which different levels of protein of a diet impact on the physico-chemical and bacteriological qualities of pond water and sediment and on the growth of fish, *Oreochromis niloticus* to inform best management practices for optimum fish production.

2. Materials and Methods

2.1. Study area

The study was carried out at the Faculty of Renewable Natural Resources (FRNR) farm, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi (Figure 1). The farm lies on longitude 06°43'N and latitude 01°36' W [12] and located within the tropical wet and dry/savanna climate (Köppen-Geiger classification: Aw) near the university's waste treatment plant.

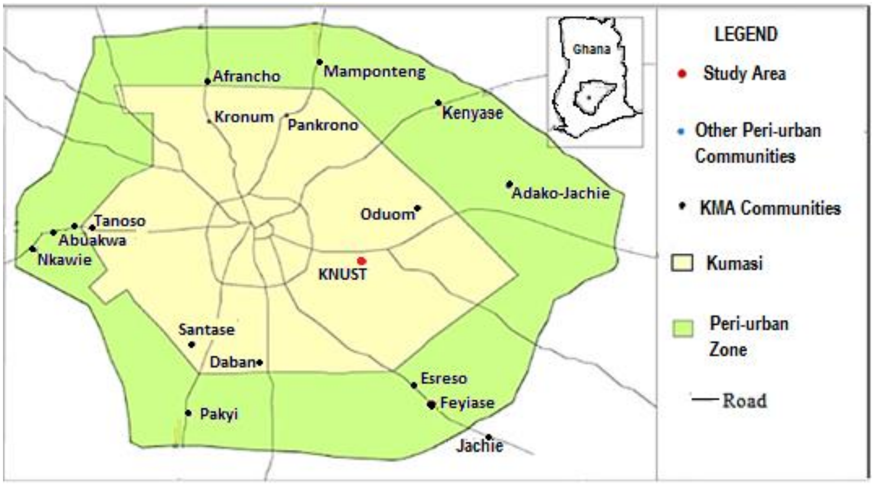

Figure 1. *Map of Kumasi showing KNUST in which the study area is located*

2.2. Experimental Design and Ponds Layout and Preparation

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Two growth trials were conducted with *Oreochromis niloticus* to evaluate effects of varying dietary protein levels (25% and 30%) on the water and sediment qualities as well as the growth performance of the fish. Completely randomized design was used to allocate in replicates, the two diet containing 30% dietary crude protein (the control) and 25% dietary crude protein (the test diet) fed to fish in ponds of surface area of 200m^2 and an average depth of 1.5m. The ponds were completely drained, dried, and limed with agricultural limestone at a rate of 1kg/10m^2 after their bottom sediments were scooped out.

2.3. Experimental Procedure

Hapas of dimensions 2.5m $\times$ 2.5m $\times$ 1m were set-up in each pond filled with water. The ponds were fertilized with mono ammonium phosphate and urea at 2g/m2 and 3g/m^2 respectively. Fingerlings of *Oreochromis niloticus* of average weight 10g were stocked in the hapas at a density of 3 fingerlings/m^2 and conditioned with commercial floating feed of 33% crude protein feed of pellet size 2.5mm for six weeks to an average size of 40g. The fingerlings were hand-sexed and the males stocked into the ponds at a density of 2fingerlings/m^2 and fed at 3% body weight (pellet size 4.5mm) twice daily at 10:00am and 3:00pm for two months.

2.4. Data Collection

Prior to stocking two sets of water and sediment samples were taken randomly in each pond using amber bottles before treatments were applied for the determination of the initial levels of biological oxygen demand, total nitrogen, phosphorus, dissolved organic carbon and bacteriological load at the laboratory of the Faculty of Renewable natural Resources, Kwame Nkrumah University of Science and technology, Kumasi. At the end of two months of treatment application, two sets of water and sediment samples were randomly taken again from each pond using for the determination of the final levels of the selected parameters. The results before treatments application and at the end of the study were compared. The levels of temperature, dissolved oxygen and pH were taken in situ using the Hannah (HI 9828) Multi-Parameter Probe. The contribution of treatments to the bacteriological nutrients build up in the water and sediments was calculated by subtracting the initial levels from the final levels.

$$Nutrient\ retained = \frac{Final\ level\ of\ parameters - Initial\ level\ of\ parameters}{nimber\ of\ months\ of\ treatment\ administration} \qquad (1)$$

The monthly nutrient build up was extrapolated to cover the full production cycle (6 months) for the growth of O. *niloticus* using the formulae:

Monthly nutrient build up $\times$ 6

2.5. Determination of Growth

Fish sampling was carried out monthly during the study using seine net. Thirty fish in each pond were sampled and their average weight determined with a weighing balance (MITSUBA model: MB – 320). This was done to monitor growth and adjust feed given. The growth performance and feed utilization of *O. niloticus* from each pond was calculated as described by [13] as follows:

$$\text{Weight Gain (WG)} = \text{Final weight (WF)g} - \text{Initial weight (WI)g} \qquad (2)$$

$$\text{Specific Growth Rate(SGR)} = \frac{Log\ WF - LogWI}{Time\ interval\ (days)} \qquad (3)$$

$$\text{DailyWeight Gain (DWG)} = \frac{\text{Weight gained(WG)g}}{\text{Time day)}} \quad (4)$$

$$\text{Protein EfficiencyRatio(PER)} = \frac{\text{Final weight gained(WG)g}}{\text{weight of protein in feed administered}} \quad (5)$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Weight of feed administered}}{\text{weight gained by fish}} \quad (6)$$

2.6. Statistical Analyses

Data collected were subjected to various statistical analyses at 5% significance level using the Graphpad Prism version 5 and were also presented in tables and figures as means ± SD. The levels of temperature, pH, dissolved oxygen in ponds as well as the growth performance of *Oreochromis niloticus* between the treatments were analyzed using T-test. The levels of total nitrogen, phosphorus, biological oxygen demand, dissolved organic carbon and bacteriological qualities of pond water and sediments before and at end of two months of treatments administration were analyzed using Wilconxin matched pairs test.

3. Results and Discussion

Among the major water quality parameters those usually described as controlling variables to their ability to exert strongly influence on other water quality parameters are pH and temperature. The level of the measured total nitrogen, phosphorus, DOC and BOD in the pond water and sediments did not differ significantly (Figures 2 to 10).

A rather narrow range of water temperature (27.83 ℃ - 28.67 ℃) was recorded in this study. Although the results of temperature are within limits of 28 ℃ - 30 ℃ by the [14], 31 ℃ and 36 ℃ by [15] and comparable with 20 ℃ and 35 ℃ by [16], they were higher than that the 25 ℃ - 27 ℃ by [17].

pH, which was generally within acceptable limits of 6.5-8.5 by the [14], exhibited a relatively wider range (5.4 to 7.01) when compared to those recorded by other researchers such as [18] and [19] who reported a range of 6.32 - 6.76 and 6.52-7.34 respectively for pond culture of tilapia but was narrower than the 5.5 - 9.0 set by [20] and the 6.5 – 9.0 by [21]. [22] Posited that for most fish pond culturing medium of pH near 7.0 is suitable but growth is impaired at less than 6.0.

[23] Noted that dissolved oxygen is one of the most important environmental factors considered a limiting factor for success or failure in intensive culture. Although DO level above 5 mg/L has been prescribed for optimum growth of tilapia [24], [25] is of the view that the lowest of 3 mg/L should be the minimum for optimum growth of tilapia. [18] Reported DO levels (10.6 ± 8.4 mg/L) for a control earthen pond and lowest levels of 4.9 ± 2.8 mg/L in test ponds. The concentration of Dissolved oxygen recorded in the present study ranged from 5.01 mg/L to 6.11 mg/L with the highest occurring as 5. 7 ± 0.068 mg/L, a range that indicates the suitability of the water for pond culture of tilapia.

Table 1. *Some water quality parameters and their effects on cultured fish*

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Parameter	Recommended Range	Effect when < recommended Value	Effect when > recommended Value
Dissolved Oxygen	4 mg/l to saturation	0 – 1.5 mg/l is lethal (for long periods of exposure); 1.4 – 5 mg/l - reduced feed intake and higher FCR, slow growth, stress, increased susceptibility to disease, accumulation of toxins	Gas bubble trauma at supersaturated
Temperature	26 to 32^{o}C	Below 15 – no Growth, stress, increased susceptibility to disease, high risk of eutrophication and death occurs at extremes 15 to 26 C - reduced feed intake, higher FCR, slow growth	Lower solubility of oxygen, stress and death at extreme temperatures.
pH	6.5 to 9	Below 4, acid death point; 4 – 6.0 - stress, slow growth, reduced feed intake, higher FCR.	9 – 11 Stress, slow growth rate; above 11 alkaline death point occurs; death of all life including bacteria; buildup of TAN (toxic to fish).
TAN	0.3 – 2 mg/l of NH_3.	Fish is healthier	Fish is susceptible to attacks by parasites; inability of fish to excrete ammonia

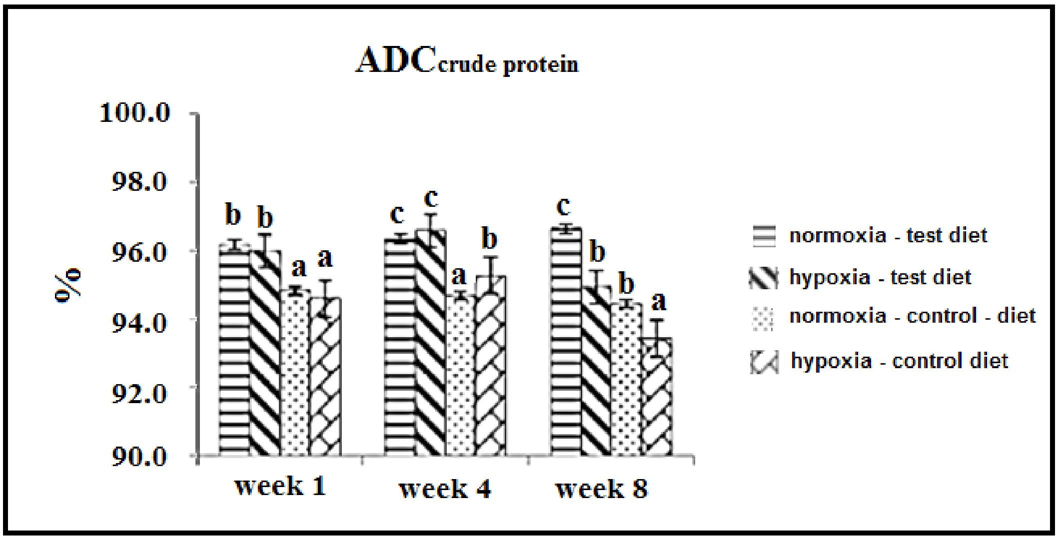

Figure 2. *Effect of diet composition and oxygen levels on ADC of crude protein over time in Nile tilapia. Each bar shows overall mean main effects between oxygen and diet for each week with standard deviation represented by error bar. Bars within weeks having different lower case letters are significantly different (n =3; P<0.05)*

Source: [26]

3.1. Nitrogen and Phosphorus

The level of total nitrogen before the application of 25% dietary crude protein (0.002±0.0070%) and the level of total nitrogen in pond water at the end of two months of the application (0.005±0.0015%) (Figure 3) did not differ significantly (P = 0.0975). Similarly, no significant difference (P = 0.0975) were observed in the application of 30% of these parameters before (0.002±0.0017%) and at the end (0.004±0.0000%) (Figure 4).

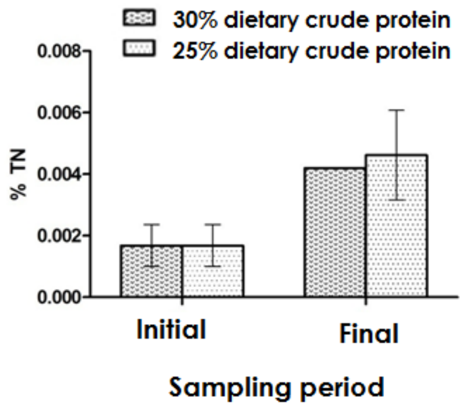

Figure 3. *Total Nitrogen levels in pond water at FRNR Farm*

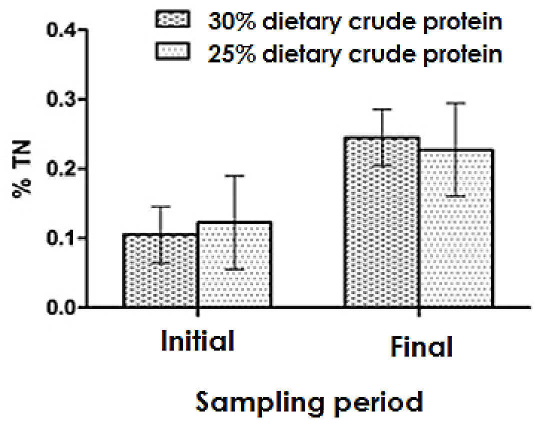

Figure 4. *Total Nitrogen levels in pond sediments at FRNR Farm*

A similar trend was observed for the sediment quality analyses. At 25% dietary crude protein and total nitrogen application, the initial (0.123±0.6702%) and final (0.228±0.6702%) did not differ significantly (P = 0.0719). Also and (0.105±0.0404%) and (0.245±0.0404%) for initial and final did not differ significantly (P = 0.2500) in pond sediment (Figure 4).

Again, no significant difference (P = 0.1250) was observed in final and initial levels of phosphorus in either of pond and sediment samples; 3.90±0.097mg/L and 13.79±0.546 mg/L, and 3.93±0.105mg/L and 13.32±2.515mg/L for the 25% and 30% respectively (Figure 5). Similarly, at P = 0.0975; 0.01±0.002% and 0.04±0.001% for the 25% and 0.01±0.003% and 0.05±0.006% for the 30% phosphorus were recorded for pond water and sediments respectively (Figures 6).

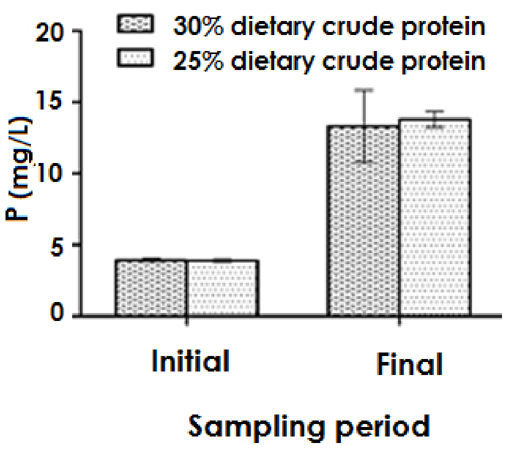

Figure 5. *Phosphorus levels in pond water at FRNR Farm*

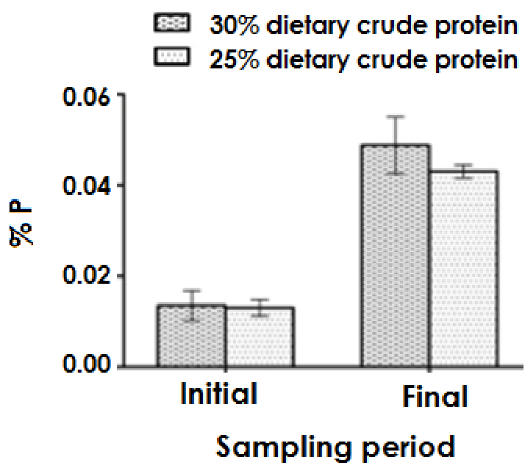

Figure 6. *Phosphorus levels in pond sediments at FRNR Farm*

Treatments were the main source total nitrogen and phosphorus in ponds [6]. [13] noted that diets represent the major contribution of pollutants in effluent water, and dietary protein is the main source of nitrogenous wastes in culture systems [27]. The stocked fish being of averaged sizes 10.0 g required a diet higher in protein

[28]. Not all the total nitrogen and phosphorus in treatments were used for growth; some were lost into the water and sediments [5]. The unused amount of these nutrients could remain up in the culturing system, or/and the receiving environment through discharged effluents. The quantity of a given protein in diets is a major factor in growth and water quality during fish production [29, 30]. The statistically insignificant of the difference ($P<0.05$) observed for total nitrogen and phosphorus levels in water and sediments in ponds before treatments were applied and at the end of the study suggests that *O. niloticus* used similar amounts of total nitrogen and phosphorus in treatments for growth [5].

The levels of nitrogen and phosphorus in water and sediments in all the ponds at the end of six months of production cycle is expected to be greater than 0.1mg/L (Tables 2 and 3) which poses threat to receiving streams [31]. This therefore calls for adoption of measures including treatment of the pond effluents to remove nitrogen and phosphorus before discharge into streams [6, 31].

Table 2. *Summary of quality of ponds water and monthly and build-up and projected levels*

Parameter	**% Crude protein**	**Stage of experiment**		**Monthly build-up**	**Projected level**
		Final	Initial		
Total Nitrogen (mg/L)		0.005	0.002	0.0015	0.009
Phosphorus (mg/L)	25	13.790	3.900	4.947	29.680
BOD (mg/L)		16.220	13.050	1.585	9.51 0
DOC (mg/L)		1.870	0.0100	0.930	5.580
Total Nitrogen (mg/L)		0.004	0.002	0.001	0.006
Phosphorus (mg/L)	30	13.320	3.900	4.695	28.170
BOD (mg/L)		16.430	11.090	2.670	16.020
DOC (mg/L)		1.910	0.000	0.960	5.760

Table 3. *Summary of quality of ponds sediment and monthly and build-up and projected levels*

Parameter	**% Crude protein**	**Stage of experiment**		**Monthly build-up**	**Projected level**
		Final	Initial		
Total Nitrogen (mg/L)		0.228	0.123	0.0525	0.315
Phosphorus (mg/L)	25	0.010	0.040	0.015	0.090
BOD (mg/L)		2.330	1.630	614.250	3685.500
DOC (mg/L)		1470.000	241.500	0.350	2.100
Total Nitrogen (mg/L)		0.245	0.105	0.070	0.420
Phosphorus (mg/L)	30	0.0500	0.0100	0.018	0.108
BOD (mg/L)		1524.000	201.000	661.500	3969.0
DOC (mg/L)		2.330	0.630	0.850	5.100

The initial and final levels of DOC at 25% (0.01±0.002%) and 30 % (1.87±0.031%) and at 30% (1.91±0.012%) and (1.87±0.031%) did not differ significantly ($P=0.1250$) (Figure 7). Also DOC levels at 25% (1.63±0.475%) and 30 % (2.33±0.332%) and at 30% (2.33±0.116%) and (1.87±0.031%) did not differ significantly ($P=0.1250$) (Figure 8).

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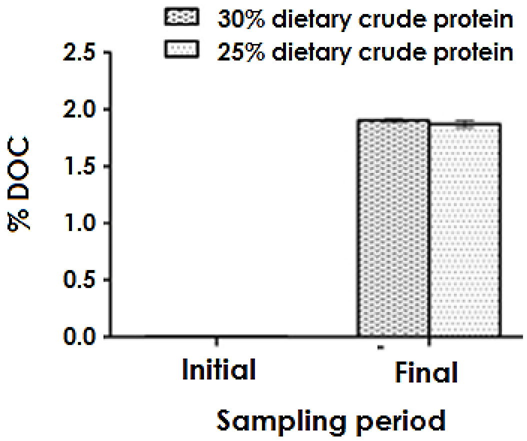

Figure 7. *Dissolved Organic Carbon levels in pond water at FRNR Farm*

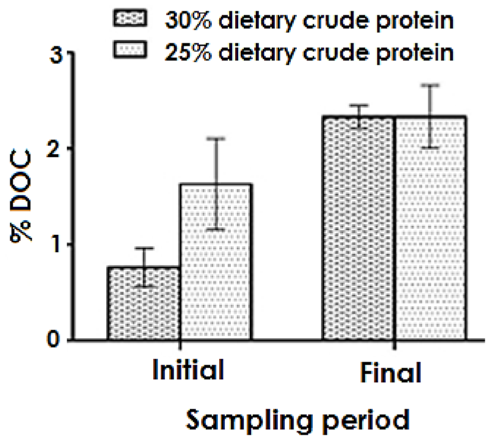

Figure 8. *Dissolved Organic Carbon levels in pond sediments at FRNR Farm*

Dissolved organic carbon levels in pond water and sediments may have affected bacteriological properties of pond water and sediments as bacteria used DOC as food [9]. Dissolved organic carbon increases may alter the microbial loop and hence, the structure of pelagic communities [32] and may increase the toxicity of copper [33]. The projected DOC levels in the study suggest a detrimental situation. Therefore, in an attempt to address the observation by [34] that the environmental impact of dissolved constituents including dissolved organic carbon, ammonia, phosphorus, nitrogen and lipids released from the diet depends on the rate at which those products are diluted before being assimilated by the pelagic ecosystem, adoption of best management practices is a necessity.

3.2 Biological Oxygen Demand

The initial and final pond water levels of BOD followed the same trend; at 25% (13.05±1.328 mg/L) and % (16.22±1.219 mg/L) and at 30% (11.09±2.968 mg/L) and (16.43±0.709 mg/L) did not differ significantly (P = 0.1250) (Figure 9). Also BOD levels at 25% (241.50±122.400 mg/L) and 30 % (1470.00±75.740 mg/L) and at 30% (201.00±10.390 mg/L) and (1524.00±111.000 mg/L) in sediments did not differ significantly (P = 0.1250) (Figure 10).

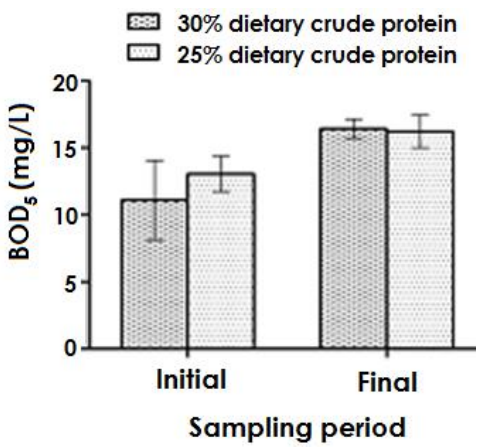

Figure 9. *Biological Oxygen Demand levels in pond water at FRNR Farm*

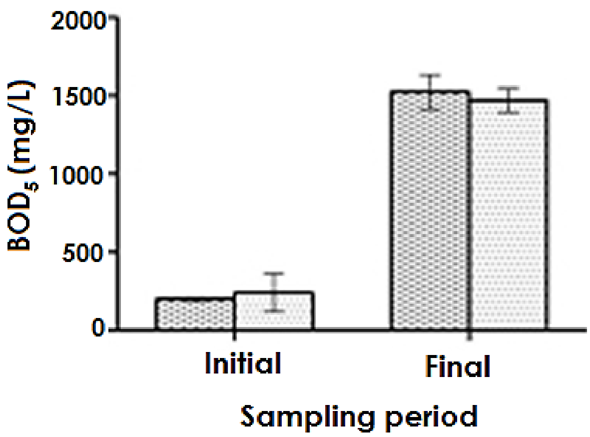

Figure 10. *Biochemical Oxygen Demand levels in pond sediments at FRNR Farm*

Treatments could introduce organic carbon to ponds [6] water and sediments, which in turn affect BOD [9]. The observed similarity in the effect of BOD in water and sediments of ponds before the application of treatments and at the end of the study without any statistically significant difference (P>0.05) could also contribute to the similarity in the growth of the cultured fish [5]. Moreover, since the water quality parameters monitored were generally within tolerable limits for the growth of *Oreochromis niloticus* [5], the observed similarity in growth was not surprising. However, results indicate the possibility of the BOD levels in all the ponds at the end of six months increasing with large amounts of organic materials above 10mg/L (Tables 2 and 3), a phenomenon that can be described as very poor quality condition [5] and a situation that calls for treatment of the effluent before discharge [5, 31].

3.3 Bacteriological Analyses

The mean total bacteria counts, *Salmonella sp.*, *Staphylococcus aureus*, *Pseudomonas sp.* and *E. coli* in pond water before the administration of treatments was not statistically significant (P>0.05). *Pseudomonas sp.* were absent in water of all the ponds used for this study. Although *Pseudomonas sp* were present before the administration of treatments, they were absent at the end of the study (Table 4).

Table 4. *Bacteria counts (cfu/ml) of pond water at FRNR farm before the administration of treatments and at the end of the study*

Bacteria Species	30%Dietary Crude Protein		25%Protein Dietary Crude	
	Initial	Final	Initial	Final
Total Count	1931±827.1	1961±123.9	3294±348.2	2616±536.4
Salmonella sp.	*705±549.1*	*0±0.0*	*440±100.7*	*0±0.0*
Staphylococcus aureus	696±594.0	756±73.2	569±182.4	525±164.8
Pseudomonas sp.	0±0.0	0±0.0	0±0.0	0±0.0
E.coli	659±792.5	939±60.3	885±256.4	851±103.3

The mean total bacteria counts, *Salmonella sp.*, *Staphylococcus aureus*, *Pseudomonas sp.* and *E. coli* in pond sediments before the administration of treatments was not statistically significant (P>0.05).*Salmonella sp.* were absent at the end of the study in spite of their presence of Salmonella sp. Before the treatment was administered (Table 5).

Table 5. *Bacteria counts (cfu/ml (g)) of pond sediments at FRNR farm before the application of treatments and at the end of the study*

Bacteria Species	30%Dietary Crude Protein		25%Protein Dietary Crude	
	Initial	Final	Initial	Final
Total Count	4258±259.6	2871±164.3	4374±305.2	2874±105.4
Salmonella sp.	2180±934.7	0±0.0	1070±406.3	0±0.0
Staphylococcus aureus	985±481.8	628.8±252.6	2173±285.6	649±275.8
Pseudomonas sp.	153±305.0	313±362.0	565±490.5	0±0.0
E.coli	2218±535.5	760±364.7	2155±553.1	1756±103.1

Among the four types of bacteria present in the ponds (*Salmonella sp*, *Staphylococcus aureus*, *Pseudomonas sp.* and *E. coli*), *E. coli* was absent in borehole which supplied the ponds water [35]. The presence of *E. coli* in ponds just before treatments were applied may be due to fecal matter from *O. niloticus* during conditioning period in hapas [36]. *Staphylococcus* could have also entered the pond during sampling and/or hand sexing [37]. *Salmonella* could get into the ponds through various animal wastes such as droppings of birds and frogs [38]. During conditioning period in hapas, faeces egested by fish could introduce *Pseudomonas* in the ponds [36]. Also *Pseudomonas* is a free-living opportunistic bacterium usually present in pond water and sediments [39] thus its presence in ponds was not surprising.

3.4. Growth Performance of Oreochromis Niloticus

At the end of the study, the mean weight of *O. niloticus* administered with 30% dietary crude protein was 85.55±15.830g whilst that administered with 25% dietary crude protein was 73.08±12.050g (Figure 11). There was no statistically significant difference infish growth when administered with 30% or 25% crude protein feed (P = 0.5449).

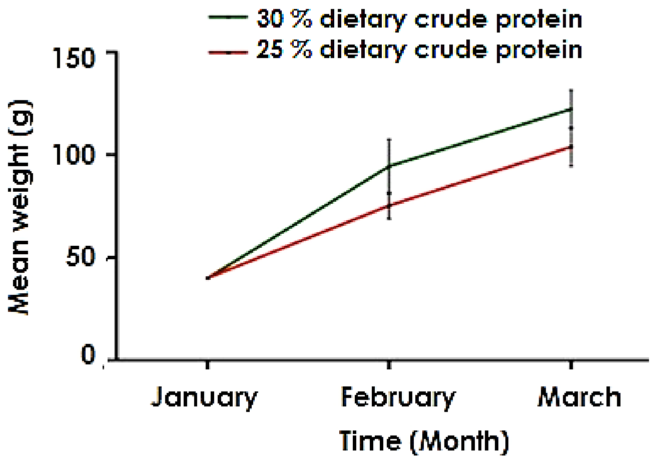

Figure 11. *Growth performance of O. niloticus administered with different dietary protein levels in ponds at FRNR Farm*

The growth performance of *O. niloticus* administered with two different dietary protein levels was presented as Mean Weight Gain (MWG), Specific Growth Rate (SGR), and Daily Weight Gain (DWG) (Table 6). These growth parameters were comparable to those obtained by other authors (Table 7).

Table 6. *Growth Performance of O. niloticus administered with different dietary protein levels in ponds at FRNR farm*

Parameter	**Treatment**	
	25% dietary Crude protein	30% dietary crude protein
Weight Gain (WG)	73.08±12.050g	85.55±15.830g
Mean Weight Gain (MWG)	66.78±4.150	79.64±6.215
Specific Growth Rate (SGR)	1.76±0.085	1.79±0.005
Daily Weight Gain (DWG)	1.13±0.070	1.35±0.110

Table 7. *Growth performance of Nile tilapia fed with different levels of protein mixed diet (T)*

Treatments	**T1**	**T2**	**T3**	**T4**	**T5**
Weekly average weight gain (%)	75.325	82.306	100.391	102.99	127.463
Daily average weight gain (%)	1.416	1.525	1.794	1.836	2.11

Source: [40]

There was no statistically significant difference (P > 0.05) between the treatments with respect to MWG, SGR and DWG. This agrees with [35], who researching on the Nile tilapia to analyze the availability of 18, 36, 54, inclusion of levels of sugarcane yeast for 45 days, did not observe any statistically significant difference (P > 0.05). Also [41] observed a level of 25.44% best level of inclusion of protein source for tilapia. This suggests that administering the diet with 25% crude protein represents the best for economic decision. [42] indicated that the use of some ingredients in farmed tilapia diets leads to reduced feed efficiency and growth and also the competing demand for these fish feed stuff has made feed production expensive.

3.5. Feed Utilization of Oreochromis Niloticus

Results of the study also indicate that the cultured species, O. niloticus accepted all the experimental diets (Table 8) suggesting that the palatability of the diets was not affected by the different experimental feed ingredients, an observation that might be attributed to possible reduction of some of the anti-nutrient factors in the feed ingredients as a result of the effectiveness of the processing methods [43, 44, 45].

However, in spite the similarity in similar water quality parameters alongside growth rate, survival and weight gain of O. niloticus observed in the present study. In a study by [46] the use of two diets resulted in similar water quality parameters and phytoplankton composition, biomass and abundance which caused similarity in growth performance and yield of the cultured O.niloticus. However [47] recounted similar levels of water quality parameters, but different growth rate, survival and weight gain of O. niloticus.

Table 8. *Feed Utilization of O. niloticus administered with different dietary protein levels in ponds at FRNR Farm*

Parameter	**Treatment**	
	25% dietary crude protein	30% dietary crude protein
Feed Conversion Ratio (FCR)	1.44	1.33
Protein Efficiency Ratio (PER)	2.68	2.66

Feed containing 30% dietary crude protein yielded the lowest Feed Conversion Ratio (FCR) and the highest and Protein Efficiency Ratio (PER) (Table 8). There were no statistical significant differences the levels observed for measured parameters (FCR and PER) at the selected crude protein levels (P < 0.05). The difference in quality of supplemental diets in terms of nutrient composition might account for the variation in growth performance and feed utilization efficiency. A similar observation was made by [45].

The lower growth performance and feed utilization efficiency as reflected by lower FCR and higher PER exhibited by fish fed with diet containing 25% dietary crude protein could be attributed to higher fiber level and anti-nutritional factors present, a result that is in agreement with [38, 48 49].

4. Conclusions

The current levels of the measured parameters are generally within the limits needed to obtain the ideal protein concept in aquaculture feed formulation; that aims at providing the exact balance of amino acids to cover fish requirements for optimal growth and maximum production which in turn leads to a reduction of dietary protein content, reduce the high production costs and overcoming environmental pollution from nitrogenous products of protein metabolism that characterizes intensive fish farming. The studied commercial *Oreochromis niloticus* feed containing 25% and 30%

dietary crude protein did not impact the quality of water and sediments of the production system and the growth of the cultured fish differently indicating that each of such feeds are feeds for the potential fish. However, the diet with 25% dietary crude protein is the best choice, for prudent economic decision.

Conflicts of Interest

There is no conflict of interest regarding the publication of this article.

References

[1] Gandotra, R.; Kumari, R.; Parihar, D.S. Impact of Varied Dietary Protein on the Growth Performance of the Juveniles of Labeo rohita. *JEB,* 2015, 2(3), 652-655.

[2] Ahmad, M.H.; Abdel-Tawwab, M.; Khattab, Y. Effect of Dietary Protein Levels on Growth Performance and Protein Utilization in Nile Tilapia. Proceedings of The 6th International Symposium on Tilapia in Aquaculture, Manila, Philippine. September 12-16. 2004, 249-263.

[3] Lovel, T. Nutrition and Feeding of fish, 2nd ed.; Kluwer Academic Publishers. Boston. 1998, 267.

[4] Stone, N.; Thomforde, K. Understanding your Fish Pond Water Analysis Report. University of Arkansas Cooperative Extension Program Printing Service. 2004, 34.

[5] Boyd, C.E.; Tucker, C.S. Pond Aquaculture Water Quality Management. Kluwer Academic Publishers, Boston, MA. 1998, 700.

[6] Lazur, A. Growout Pond and Water Quality Management. *JIFSAN.* 2007, 1, 7-8.

[7] Niemirycz, E. Variability of Organic Carbon in Water and Sediments of the Odra River and Its Tributaries. *Pol. J. Environ, Stud.* 2006, 15(4), 557-563.

[8] Schober, J.; Lima, G.; Focken, U. Analysis of Soil Nutrients and Organic Matter in Organic and Conventional Marine Shrimp Ponds at Guaraira Lagoon, Rio Grande does Norte State, Brazil. In: Zikeli S, Claupein W, Dabbert S (eds) Beiträge zur 9. Wissenschaftstagung Ökologischer Landbau "Zwischen Tradition und Globalisierung", Universität Hohenheim, 20.-23. März 2007; Bd. 2. Berlin: Köster. 2007, 931-934.

[9] Boyd, C.E.; Wood, C.; Thunjai, T. Aquaculture Pond Bottom Soil Quality Management. Pond Dynamics/Aquaculture CRSP, Corvallis, Oregon. 2002, 41 pp.

[10] Auburn University. Manual for Commercial Pond Production of the African Catfish in Uganda. Water Quality and General Pond Management. 2007, 70-96.

[11] Erondu, E.; Anynawu, P. Potential Hazards and Risks Associated with Aquaculture Industry. *Afr. J. Food Agric. Nutr. Dev.* 2011, 4(13), 1622-1627.

[12] Nkyi, K.; Oduro, W.; Gyedu O. Effect of Collar diameter and lifting

Period on Shoot Biomass Production of Teak (Tectona grandis) Stumps. JEB. 2011, 31(3), pp. 21-29.

[13] Lawrence, A.L.; Castille, F.L.; Samocha, T.; Velasco, M. "Environmentally Friendly" or "Least Polluting" Feed and Feed Management for Aquaculture. In

C.L. Browdy and D.E. Jory (eds.), The New Wave, Proceedings of the Special Session on Sustainable Shrimp Culture, Aquaculture 2001, WAS, Baton Rouge. 2001, 84-95.

[14] Department of Water Affairs and Forestry (DWAF), South African Water Quality Guidelines (second edition). Volume 6: Agricultural use: Aquaculture. DWAF. 1996, 15-185p.

[15] FAO. Fisheries and Aquaculture Department. 2011. Available online: http://www.fao. org/ fishery/ culturedspecies/Oreochromis_niloticus/en (accessed on 26, December, 2017).

[16] Ngugi, C.C.; James, R.B.; Bethuel, O.O. A New Guide to Fish Farming in Kenya, Oregon State University, USA. 2007.

[17] Kausar, R.; Salim, M. Effect of water temperature on the growth performance and feed conversion ratio of Labeo rohita. *Pak Vet J.* 2006, 26, 105-108.

[18] Makori, A.J.; Abuom, P.O.; Kapiyo, R.; Anyona, D.A.; Dida, G.O. Effects of water physico-chemical parameters on tilapia (Oreochromis niloticus) growth in earthen ponds in Teso North Sub-County, Busia County. Fisheries and Aquatic Sciences. 2017, 20(30).

[19] Shaheen, F.; Kousar, R.; Raza, S.I.; Mahmood, T.; Hassan, S.W. Effects of salinity and hardness on the growth of Nile Tilapia (Oreochromis niloticus) in Northern Punjab Region of Pakistan. *International Journal of Fisheries and Aquaculture Research,* 2017, 3(1), 21-32.

[20] Rebou ças V.T.; Dos Santos Lima R.F.; Cavalcante D.D.H.; Do Carmo e Sa M V. Reassessment of the suitable range of water pH for culture of Nile tilapia Oreochromis niloticus L. in eutrophic water. Acta Scientiarum. *Animal Sciences.* 2016, 38, 361-368.

[21] Weiner, E.R. Applications of Environmental Aquatic Chemistry A Practical Guide Third Edition. Taylor & Francis Group, Boca Raton. 2013, pp 588.

[22] Bryan R.; Soderberg W.; Blanchet H.; Sharpe W.E. Management of Fish Ponds in Pennsylvania. 2011. Available online: http://www.water-rresearch.net/Waterlibrary/ Lake/waterqualityponds.pdf (accessed on 27, December, 2016).

[23] Ghozlan, A.; Zaki, M.A.; Gaber, M.M.; Nour, A. Effect of Different Water Sources on Survival Rate (%) Growth Performance, Feed Utilization, Fish Yield, and Economic Evaluation on Nile Tilapia (Oreochromis niloticus) Monosex Reared in Earthen Ponds. *OFOAJ.* 2017, 4(4).

[24] Riche, M.; Garling, D. Fish: Feed and Nutrition. Feeding Tilapia in Intensive Recirculating Systems. (2003). Available online: http://www.hatcheryfeed.com/ hf-articles/141/ (accessed on 25, December, 2017).

[25] Ross L.L. Environmental physiology and energetic. Fish and Fisheries Series. 2002, 25, 89-128.
Available online: http://link.springer.com/chapter/10.1007%2F978-94- 011-4008-9_4 (accessed on 14, September, 2013).

[26] Kim, T.N.T. Feeds, water quality, gut morphology and digestion in Nile tilapia (Oreochromis niloticus) PhD Thesis. Wageningen University. 2017. Available online: http://edepot.wur.nl/410628 (accessed on 26, December, 2017).

[27] Moeckel, J.L.; Lawrence, A.L.; Crockett, J.; Lingenfelter, B.A.; Patnaik, S.; Pollack, J.B. Effect of Dietary Protein on Growth and Survival of Juvenile Litopenaeus vannamei in a Zero Water (Biofloc) Exchange System 9th International Conference on Recirculating Aquaculture. Virginia, USA. August 2012, 24 - 26, 173-210.

[28] FAOSTAT. Food and Agriculture Organization of the United Nations. 2013.

[29] Kureshy, N.; Davis, D.A. Protein Requirement for Maintenance and Maximum Weight Gain for the Pacific White Shrimp, Litopenaeus vannamei. *Aquaculture.* 2002, 204, 125-143.

[30] Bender, J.; Lee, R.; Sheppard, M.; Brinkley, K.; Philips, P.; Yeboah, Y.; Wah, R.C. A Waste Effluent Treatment System Based on Microbial Mats for Black Sea Bass Centropristis Striata Recycled-Water Mariculture. *Aquacult. Eng.* 2004, 31, 73-82.

[31] MissouriDepartment of Natural Resources. Water Quality Parameters (2016). Available online: http://dnr.mo.gov/env/esp/waterquality parameters. html (accessed on 24, November , 2016).

[32] Valiela I. Marine Ecological Processes 2nd ed. Xiv. 1995, 686p. New York: Springer-Verlag.

[33] Brooks, D.B. Fresh Water in the Middle East and North Africa. In: Lipchin, C.; Pallant, E.; Saranga, D.; Amster, A. (Eds.), Integrated Water Resources Management and Security in the Middle East Dordrecht. Springer, The Netherlands. 2007, 1-29.

[34] Black, K.D. (Ed.), Environmental Impacts of Aquaculture. Sheffield Academic Press, Sheffield, UK. 2001, 214.

[35] Sey, S.E. Assessment of Bacterial Load on Spring Onions (Allium cepa) Cultivated under Vegetable-Fish Integration System. BSc. Thesis. Kwame Nkrumah University of Science and Technology. 2016.

[36] Patra, S.; Loir, L.; Shelby, R. Cadmium tolerance and antibiotic resistance Pseudomonas sp. Isolated from Water, Sludge and Fish Raised In Wastewater-fed Tropical ponds. *Indian J Exp Biol.* 2010, 48(4), 383-393.

[37] Douglas, I.; Isor, S.; Faith, N. Bacteriological Investigation of Pond Water Quality from Ogoniland, Nigeria. *JESTFT.* 2015, 9(2), 2319-2399.

[38] Ali, I. Salmonella in Fish and Fishery Products. *J Appl Microbiol.* 2010, 4(13), 1-6.

[39] Bisht, A.; Singh, U.; Pandey, N. Comparative Study of Seasonal Variation in Bacterial Flora Concomitant with Farm Raised Fingerlings Of Cyprinus carpio at Tarai Region of Uttarakhand. *JEB,* 2014, 3(12), 363-367.

[40] Choudhary, H.R.; Sharma, B.K.; Uppadhyay, B.; Sharma, S.K. Effect of different protein levels on growth and survival of Nile tilapia (Oreochromis niloticus) fry. *International Journal of Fisheries and Aquatic Studies*, 2017, 5(3), 480-484.

[41] Ribeiro R.P.; Hayashi, C.; Furuya, W.M.; Furuya, V.R.B.; Soares, C.M. Utilização de diferentes níveis de levedura seca, Saccharomyces mcerevisiae, em dietas para alevino de tilápias do nilo, Oreochomis niloticus, em cultivo monossexo. In: Simpósio Brasileiro De Aqüicultura, 9, Sete Lagoas, Resumos.. Sete Lagoas, Simbraq. 1996, 99.

[42] Ali, A.E.; Mekhamar, M.I.; Gadel-Rab, A.G.; Osman, A.G.M. Evaluation of Growth Performance of Nile Tilapia Oreochromis niloticus niloticus Fed Piophila casei Maggot Meal (Magmeal) EFASA 2016 119 Diets, Department of Zoology, Faculty of Science, AlAzhar University, Assiut, Egypt. *AJLS.* 2015, 3(6-1), 24-29.

[43] Medri, V.; Medri, W.; Filho, M.C. Growth of Nile Tilapia Oreochromis niloticus Fed Diets with Different Levels of Proteins of Yeast. *Braz. Arch. Biol. Technol.* 2009, 52(3), 721-728.

[44] Azzaza, M.S.; Dhrajef, M.N.; Krajem; M.M. Effects of Water Temperature on Growth and Sex Ratio of Juvenile Nile Tilapia: Oreochromis niloticus (Linnaeus) Reared in Geothermal Water in Southern Tunisia. *J Therm Biol.* 2008, 33, 98-105.

[45] Workagegn, K.B., Ababbo, E.D.; Tossa, B.T. The Effect of Dietary Inclusion of Jatropha curcas Kernel Meal on Growth Performance, Feed Utilization Efficiency and Survival Rate of Juvenile Nile Tilapia. *J Aquac. Res Development.* 2013, 4, 1-6.

[46] Limbu, S.M.; Shoko, A.P.; Lamtane, H.A.; Kishe-Machumu, M.A.; Joram, M.C.; Mbonde, A.S.; Mgaya, Y.D. Supplemental effects of mixed ingredients and rice bran on the growth performance, survival and yield of Nile tilapia, Oreochromis niloticus reared in fertilized earthen ponds. *Springer Plus.* 2016, 5(5).

[47] Shaari, N.F.I.; Zain, R.A.M.M.; Amin, M.F.M.; Wei, L.S.; Jani, M. Effect of Azolla Supplementation on Growth Performance and Survival of Red Hybrid Tilapia (Oreochromis Niloticus). *Fish Aqua J.* 2017, 8, 235, DOI: 10.4172/2150-3508.1000235.

[48] Mishra, J.P.; Vaithiyanathan, S.; Mishra, S.; Prasad, R.; Misra, A.K. Effect of transinoculation of subabul (Leucaena leucocephala) Leaves Fed Goat Rumen Liquor into Sheep Rumen on Haematobiochemical Parameters in Sheep. *Indian J. Small Rumin.* 2002, 8(1), 19-22.

[49] Workagegn, K.B.; Ababboa, E.D.; Yimer, G.T.; Amare, T.A. Growth Performance of the Nile Tilapia (Oreochromis niloticus L.) Fed Different Types of Diets Formulated from Varieties of Feed Ingredients. *J Aquac Res Development*, 2014, 5, 235.

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