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Effect of replacing dietary *Caridina nilotica* (Fishmeal) with *Arthrospira platensis* on water quality parameters during the culture of *Oreochromis niloticus* fingerlings

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Abstract
This study was designed to investigate the effect of replacement of *Caridina nilotica* with *Arthrospira platensis* at four different levels: 10%, 20%, 50% and 100%, as T1, T2, T3 and T4 respectively on water quality parameters, monitored for 8 weeks in triplicate glass tanks with 300 fingerlings of *Oreochromis niloticus* fingerlings. No significant differences were found throughout the experimental period (p>0.05.). Temperature ranged from 27.88^0C to 28.02^0C, DO was 7.22 to 7.41$mgll^{-1}$, pH 7.473 to 7.561 and Total Ammonia and Nitrite 0.37-0.81 respectively. All were within the normal range for tilapia fingerlings which enabled them to grow significantly.

Keywords: *Arthrospira platensis, Oreochromis niloticus,* water quality, fish meal replacement, *Caridina nilotica*, aquaria, tilapia

1. Introduction
The culture of tilapia species has been done by many countries in the world but despite this, most farmers, graduate student and researchers in developing countries lack Information on the culture of tilapia species [1]. Most people also lack the knowledge on the basic requirement or conditions in the culture of tilapia thus hindering the development of aquaculture sector in developing countries [9]. While numerous benefits like cheap labour, favourable climate, high fish demand and underutilized land is available in the sub-Saharan region of Africa, the production of aquaculture is still at its minimum [9]. Optimal production of fish has always been hindered by poor water quality and limited information on the set-up of aquaculture [9].
Moreover, the importance of white meat in human diet cannot be overemphasized. It contains less fat, less cholesterol and fewer calories than red meat. Aquaculture and fisheries products in general are very important globally. Fish is a healthy source of white meat and protein. Other benefits to society include employment, and foreign exchange. Almost 1 billion people worldwide rely on fisheries and aquaculture, indirectly or directly, for their livelihoods [14].
In Kenya, aquaculture production has increased from 160 tonnes in 1980 to 18,658 tonnes in 2015 and it is valued at $21 million [12]. It is projected to reach 20,000 MT/y which represents 10% of national production of fish within the next five years [12]. This can be compared with global aquaculture hereby between 1984 and 1990, the aquaculture sector grew at annual average rate of 16% for the production of fin fish and shell fish [15]. Moreover further report indicates that, an annual growth rate of 6.5% is required so that the demand for the aquatic food can be met by 2025 [4]. This therefore represents a large opportunity for aquaculture to develop in feed, seed sectors and maintenance of good water quality for optimal growth of fish.
Production of aquaculture in Kenya is shown in figure 1 below:

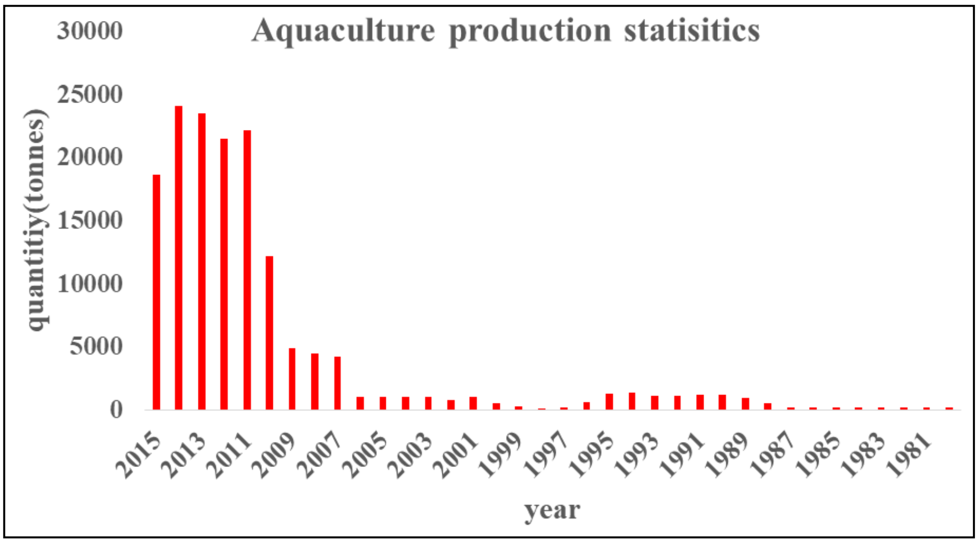

Fig 1: production statistics of aquaculture in Kenya (FAO, 2015)

For aquaculture to be very successful in Kenya, there is need for affordable feed and good water quality which will motivate small scale farmers in aquaculture to meet the demand for fish [13]. The most critical parameters are suspended solids, dissolved oxygen, temperature, nitrite, ammonia and carbon dioxide. Moreover, water quality impacts the general condition of cultured fish as it determines the growth conditions and health of the fish being cultured [13]. Feed quality and feeding regime seriously affects the water quality and the growth performance of cultured fish. Feeding activity has been observed to affect water quality parameters like temperatures, pH, TAN levels and other water quality parameters which may in turn affect the growth parameters of fish [13]

Therefore, maintaining good water quality by cleaning the tank regularly including proper monitoring of the water can improve the fish appetite and enhance its feed conversion ratio, survival rate and the growth performance. This can be achieved by feeding fish more diet during hours which are very hot and less feed during cold hours. Moreover, despite the fact that several research has been carried out worldwide on water quality parameters requirement for tilapia, it is very difficult to obtain specific information on the optimum water quality parameters required for *Oreochromis niloticus* in Kenya. This study therefore, sought to determine the water quality parameters obtained from feeding *Oreochromis niloticus* with different concentrations of *Arthrospira platensis.*

2. Materials and Methods

2.1 Study area

This study was carried out at the university of Nairobi aquaculture lab between the months of January to April 2017.

2.2 Collection of feed ingredient and diet formulation

Ingredients for feed formulation like wheat bran and *Caridina nilotica* were purchased from an agrovet shop in Sagana which is 80km away from Nairobi town while wheat flour used as a binder was sourced from Tuskys supermarket in Nairobi. *A. platensis* was purchased from Dunga spirulina farm in Kisumu (400km from Nairobi) in dried form. These ingredients were grounded separately into very fine powder using a Model BL335 dry mill kitchen blender (Kenwood, Tokyo, Japan). The experimental diets were prepared with *Caridina nilotica*, wheat bran, wheat flour, multivitamin and *A. platensis* as shown in table 1. They were then dried and stored in airtight plastic bottles. Proximate analysis of formulated diets and ingredients were also carried out in the lab and the results are as shown in table 2 and 3.

Table 1: proximate composition of feed ingredients used during the study.

Ingredients (g)	**T0 (control diet)**	**T1 (10% *A. platensis*)**	**T2((20% *A. platensis*))**	**T3 ((50% *A. platensis*)**	**T4 ((100% *A. platensis*)**
A.platensis	0	38.54	77.08	192.7	405.4
Wheat bran	541.3	541.3	541.3	541.3	541.3
Carrideans	486.2	487.17	367.3	229.4	0
Vitamin premix	18	18	18	18	18

Table 2: proximate analysis of formulated diet used during the study.

	T1 (10% *A. platensis*)	**T2 ((20% *A. platensis*)**	**T3 ((50% *A. platensis*)**	**T4 ((100% *A. platensis*)**	**T0 (control diet)**
Moisture (%)	7.773	7.773	8.21	7.67	7.757
Protein (%)	35.19	35.13	35.16	35.13	35.12
Ash (%)	7.643	7.577	8.09	7.87	7.827
Fibre (%)	9.317	8.533	8.317	8.34	4.31
Fat (%)	3.73	3.46	3.21	3.8	3.32
CHO (%)	37.067	37.527	37.013	37.18	36.336
Energy Kcal/100g	322.598	321.768	333.582	323.44	320.20

Table 3: *proximate analysis of ingredients used in diet formulation*

	Wheat	Caridina nilotica	Spirulina
Moisture (%)	10.4	8.27	7.43
Protein (%)	11.73	53.63	66.02
Ash (%)	2.967	15.2	7.287
Fibre (%)	9.767	0.8	0.66
Fat (%)	3.2	4.46	3.97
CHO (%)	61.936	17.64	14.633
Energy (Kcal/100g)	323.464	325.22	358.34

2.3 Collection and stocking of fingerlings
300 fingerlings of *O. niloticus* with initial mean weight of 1.693± 1.424 were obtained from Kiama fish farm in Kirinyaga district, Kenya. They were transported in aerated polythene bags to University of Nairobi which is 80km away. The fingerlings were acclimatized for two weeks while being fed on commercial diet. At the start of the study, the fingerlings were sampled randomly and weighed using Ohaus electronic scale, model AX4201/E manufactured by Ohaus manufacturers while length of fingerlings were also measured.

2.4 Experimental design
Fifteen aquaria measuring 50x 25 x 35 cm was used during the study and twenty fingerlings were assigned randomly to each tank with three tanks per treatment. The aquaria were individually heated with temperature controlled system (heaters) (JAD microprocessor digital heater, DR 9200) and aerated with air pumps (model AP-1688 manufactured by Jeneca independent international, China).

2.5 Feeding protocol
The fingerlings were fed twice daily at 10.00am and 4.00 pm at 10% body weight adjusted weekly. The aquaria were cleaned daily prior to the feeding period by siphoning the faecal matter and wasted feed from the bottom of the tank. Warm (26±2ºC) dechlorinated water was pumped into the tank from a reservoir tank to replace the siphoned water. Measurement of weight and length was done weekly and recorded. At the end of the experiment, fish were harvested and counted to determine their survival rate. Weights and lengths were also measured to determine growth parameters.

2.6 Water quality monitoring
Water quality parameters were measured daily at 9 am, 12noon and 4 pm. Temperature and dissolved oxygen were measured using HANNA DOD meter model HI9142 manufactured by HANNA instruments. The pH was also measured twice daily using pH meter, model H198107 manufactured by HANNA instruments. TAN was determined by titration at the food nutrition lab in university of Nairobi, Kabete campus from water samples collected and transported there from Chiromo campus in small plastic containers in a cooler box.

2.7 Statistical analyses
Water quality results obtained during the study were subjected to one-way ANOVA to test for significant differences between the experimental group ($P \geq 0.05$) and the control group. Whenever the difference were found to be significant ($P>0.05$), the means were then compared using the Tukey's test. The statistical analysis were performed using GENSTAT version 15.

3. Results
The physicochemical water parameters of fries fed on formulated diets were observed over the two months experimental period (Table 4). The temperature ranged from 27.88 ^{0}C to 28.02 ^{0}C in all the tanks and did not differ significantly among the five dietary treatments ($p> 0.05$). The dissolved oxygen (DO) concentration ranged from 7.22Mg/L to 7.41Mg/L and did not differ significantly among the treatments ($p>0.05$) while pH ranged from 7.473 to 7.561 and showed no significant difference among the treatments ($P> 0.05$).

The total ammonium nitrate (TAN) significantly varied among the treatments within the two months of the study ($p<0.05$). The highest value of TAN was observed in T0 (control diet) with 0.37ppm while the lowest in T4 (100% *A. platensis*) with 0.37ppm.

Table 3: results on water quality parameters from the present study

	T1	T2	T3	T4	T0
Temp (^{0}C)	28.02±0.045^a	27.91±0.147^a	27.91±0.083^a	28.01±0.037^a	27.88±0.098^a
DO mg/L	7.41±0.023^a	7.46±0.070^a	7.22±0.181^a	7.30±0.094^a	7.33±0.074^a
PH	7.55±0.007^a	7.561±0.003^a	7.533±0.015^a	7.473±0.051^a	7.482±0.073^a
TAN (ppm)	0.78±0.127^{ab}	0.59±0.342^b	0.49±0.092^c	0.37±0.039^d	0.81±0.172^a

Mean (±SE) values followed by the same superscript letters in the same row are not significantly different ($P < 0.05$).

The results on the water quality parameters is indicated in figure 2 below.

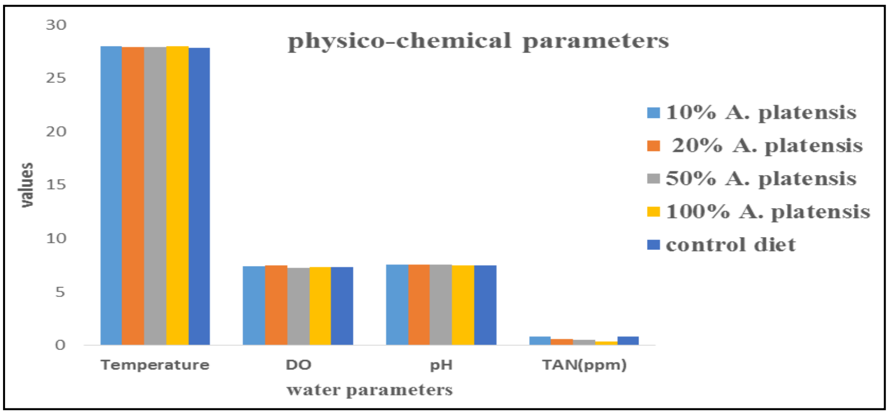

Fig 2: physico-hemical water parameters recorded during the experimental period

4. Discussions

The temperature of the tanks ranged from 27.88 ^{0}C to 28.02 ^{0}C. This indicated that the temperatures of all the tanks were within the observed limits as indicated by (Caulton 1982) [3] who explained that the optimum temperatures for proper feeding, reproduction and growth of *O. niloticus* ranges from 22 ^{0}C and 30 ^{0}C. (Hauser 1977) [7] Further reported good growth of *O. niloticus* on the upper ranger of the temperatures above 26 ^{0}C.

In this study, the concentration of dissolved oxygen ranged from 7.22 to 8.1 mg/l throughout the experimental period and it did not vary significantly among the five treatments. These results are similar to those of (Musa *et al.* 2012) [11] whose results were within similar range. Dissolved oxygen thus is very important water quality parameter required by all fish and its concentration in water also determines the ability of an aquaria and other water bodies to be able to support aquatic life [3]. (Chervinski 1980) [6] Also reported that, the species of tilapia cannot tolerate low levels of dissolved oxygen. This low level of dissolved oxygen as explained further by (Hauser 1977) [7] decreases the growth of fish and also the intake of feed is also reduced.

The pH concentration observed throughout the experimental period ranged from 7.473 to 7.561 in all the tanks. This range is the favourable pH level of tilapia species and it concurred with the results of (Phillippart and Ruwet 1980) [13] who reported that the species of tilapia is able to grow very well at a pH which is close to neutral. Fish at this pH levels is able to grow very well and maintain a good health [10]. Further studies have also shown that the best water for fish to grow well and survive is one with a neutral or alkaline pH that is between 6-9 pH levels [3]. If the pH value falls outside this range, this will result in a reduction on the growth of fish and mortalities when pH levels falls below 4.5 or when it is greater than 10 [3]. Therefore, the results of the present study indicates that the concentration of pH in all the five experimental treatments was alkaline and it was within the tolerable range (6-9) of cultured tilapia. Therefore, the mean values recorded from the experiment are within the acceptable limits for the growth and health of fish [2, 10]. The Total Ammonia and Nitrite levels (TAN) ranged from 0.38 to 0.81 ppm which were within the acceptable limits as reported by (Chapman 1992) [5]. The level of TAN recorded in this study was less than the lethal levels of 2.4mg/L recorded by (Daud *et al*. 1988) [14] for red tilapia, *Oreochromis mossambicus* X *O. niloticus* fry.

5. Conclusion

From the experimental study, water quality parameters like temperature, pH, dissolved oxygen and total ammonium nitrate (TAN) in in the different treatments remained constant throughout the study period. The water parameters were within the recommended range and did not negatively influence the growth of *O. niloticus* fingerlings.

Consequently, we conclude that, the formulated diet is environmentally friendly and can be tested in ponds to grow fish to table size provided the production cost and the market price of the table size fish is mitigated.

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