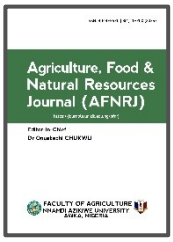
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Original Article

Physico-chemical properties of pond water as influenced by different inclusion levels of cultured *Chlorella vulgaris* in *Clarias gariepinus* feed

OPEN ACCESS

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ABSTRACT

This study investigated the Culture and inclusion rate of Chlorella vulgaris in the diet of Clarias gariepinus. Pure sample of C. vulgaris isolate liquid of 50mls were each dissolved in 30% of pure poultry manure which were later filtered and each poured into 70 liters fish tanks that contained 50 liters of water each and allowed to be illuminated by sunlight for 16 days to enhance C. vulgaris multiplication. The C. vulgaris matrix was harvested, filtered and incorporated in fish feed at 0%, 10%, 20%, 30% and 40% inclusion rates as feed supplement. The experiment was laid in a completely randomized design and treatments were replicated 3 times in 15 fish tanks. Ten juveniles of Clarias gariepinus were stocked per tank and fed for 16 weeks at 5% body weight per day. Proximate analysis of C. vulgaris matrix showed, Ash(30%), Fibre (10.48%), Protein(32.41%) and metabolizable energy(262kcal/g).The water samples analyzed for various physico-chemical parameters like temperature (26.79 ± 27.130 C), pH (5.92 ± 6.34), dissolved oxygen (5.82 ± 6.05mg/l), transparency (15.84 ± 16.70cm) and ammonia (0.13 ± 0.24mg/l) were within the recommended range for Clarias gariepinus culture. Lower values of dissolved oxygen (5.80 ± 0.20 mg/l) and turbidity (5.57 ± 0.45cm) were observed in the control tanks. These optimal physico-chemical parameters showed that the diet did not significantly deteriorate the water quality as it contained no potential pollutants and were consumed optimally by the fish. This study recommends the use of C. vulgaris matrix supplement at 20-30% in the diet to improve the growth of C. gariepinus owing to their higher nutritional content.

KEYWORDS: *Feed additive, Fish nutrition, Micro algae, Water quality parameters*

INTRODUCTION

Fish is one of the most important alternative sources of dietary protein required to meet the increased human population demand for protein. Increasing aquaculture production is clearly needed to meet this demand because capture fisheries is showing precipitous decline due to climate change, over fishing and pollution (Olukunle & Oyewumi, 2017). The utmost aquaculture goal is the production of high quality, high quantity, and low-cost fish in short possible time. This can be achieved by careful species selection, good water quality, appropriate feeding and suitable stocking density ((Magouz *et al.*, 2019) Feed is the single most expensive factor in aquaculture production and the protein component of fish diet constitutes the highest cost. The nutrition is one of the most important factors

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to consider in fish farming, because it contributes up to 50 % of fish production costs (FAO,2018). Microalgae have recently garnered interest in food and nutrition due to the presence of high amounts of proteins, vitamins, minerals, essential fatty acids, essential amino acids and polyunsaturated fatty acids and antioxidants (Abdel-Tawwal *et al.*, 2020). *Chlorella. vulgaris* is a green alga and is widely distributed in freshwater, marine and terrestrial environments and has high photosynthetic ability and the capability for rapid growth under autotrophic, mixotrophic and heterotrophic conditions (Borowitzka,2018). In contrast to the production and maintenance cost of fish meal, microalgae require fewer resources and are extremely valuable (Mohanty and Samanta,2018). All of these characteristics have made it one of the first microalgae considered for large-scale cultivation and commercial production (Olukunle & Oyewumi,2017). African catfish (*Clarias gariepinus*) is an endemic popular aquaculture species largely distributed in most African and Asian countries ((Magouz *et al.*, 2019). It is widely cultured in freshwater ponds because of its high growth rate with excellent quality meat, ability to accept a wide variety of feed, resistance to diseases, easiness in reproduction and its ability to tolerate adverse environmental conditions, and high stocking densities under poly-culture conditions (Yamaguchi 1996; Magouz *et al*., 2019).The determinant of good growth in water body includes dissolved oxygen, hardness, turbidity, alkalinity, nutrients, temperature, etc. Since fishes' lives in water, any characteristics of water that affects the survival, reproduction, growth, production, or management of fish in any way is a water quality variable (Ehiagbonare *et al*., 2020). Physico-chemical parameters of pond water are very important in fish culture environment because it determines the state of the water which, in turn serves as their physical support to carry out the life function such as feeding, growth, excretion and reproduction. The main aim of this study is to determine pond physico-chemical properties as influenced by different inclusion levels of cultured *Chlorella vulgaris in Clarias gariepinus* diet.

MATERIALS AND METHOD

Study Area

The research was carried out at the Department of Fisheries and Aquaculture Wet laboratory, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Experimental Materials

Materials used for the experiment include: Poultry waste, Microalgae (*Chlorella sp*), *Clarias gariepinus* juveniles, Weighing scale, Scoop net, Feed pelleting machines, 15 Plastic tanks (75 liters each), feed ingredients, commercial feed, water quality test kits etc. Pure sample of *C. vulgaris* isolate liquid of 200cl were sourced from the limnology unit of National Institute for Freshwater Fisheries (NIFFR), New Bussa, Niger State, Nigeria.

Preparation of the Poultry or chicken manure

30**%** of dried poultry droppings was soaked in 10 liters of water in an aquaria tank for two hours. Then, the debris was filtered with a filter net (2mm mesh size) and the filtrate used for the culture.

Culture of *C. vulgaris* in plastic tanks

Fifteen (15) plastic circular tanks of 70L capacity were well cleaned, rinsed and sun dried. Then the plastic tanks were filled with clean water up to 50L of clean water. Two liters of the poultry waste filtrate was introduced into each of the fifteen (15) plastic tanks and inoculated with 50ml of the isolate green water containing the pure sample of C. vulgaris. The water was illuminated under the sunlight (photosynthesis) for 16 days. Then, the *Chlorella sp* were harvested by pouring the water into a filter net and it was collected, air dried and analyzed to estimate the proximate composition. One hundred and fifty (150) *Clarias gariepinus* juvenile were procured from a reputable fish farm and were transported to the Department of Fisheries and Aquaculture Wet Laboratory, Nnamdi Azikiwe University, Awka. The fish were acclimated to laboratory conditions for two weeks and fed twice daily (mornings and evenings) with a 2mm commercial feed (45% CP?) at 5% body weight.

Experimental Design

The design of the experiment was a Completely Randomized Design (CRD) with five treatment and three replicates each based on the rates of inclusion of *C. vulgaris.*

Experimental Procedures

The fifteen (15) plastic tanks of 70 liters each were stocked with 10 juveniles per tank. The experimental tanks were designated as T_1-0% inclusion of C. *vulgaris;* T_2-10% inclusion of C. *vulgaris*; T_3-20% inclusion of C. *vulgaris*; T_4-30% inclusion of C. *vulgaris*; and T_5-40% inclusion of C. *vulgaris*.

Evaluation of Water Quality Parameters

Six physico-chemical parameters were analyzed by standard methods. pH was measured using pH meter with glass electrode (state the model). The electrode was calibrated against pH 4.0, 7.0 and 9.2 buffer each time before analysis. The water temperature was measured with a mercury-in-glass thermometer (Digitalized). The water quality parameters in the experimental tanks were assessed every two weeks until the end of the experiment, turbidity was measured with secchi disc, while the dissolved oxygen, nitrate and ammonia were evaluated with fresh water test kits (Lammotte Water Kits, Beijing, China). Nitrate and ammonia were determined by colorimetric method through measuring 10 ml of the sample into a Nessier tube and the same amount of distilled water was measured into a Nessier tube, 0.5 mL of brucine and 20 mL of concentrated sulphric acid was added to each sample thereafter the turbidity of colour produced by each tube was measured using a spectrophotometer (Hach 3900) at a wavelength of 470 nm (Olukunle & Oyewumi,2017). Dissolved oxygen was determined by adding two (2) ml of manganese sulphate and

2ml of alkali iodide azide reagent to the 20 ml of pond water measured and a brownish colour was obtained (Olukunle & Oyewumi,2017).

Data Analysis

The data obtained from the study were collated and analyzed using SPSS software 22.0 for windows. Data was first tested for normality (Kolmogorov - Smirnov test) and homoscedasticity of variance (Bartetts test). When these conditions were satisfied, a one-way analysis of variance (ANOVA) was employed to reveal significant differences in measured variables among control and experimental groups. When a difference was detected ($P < 0.05$), Tuckey's multiple comparison test was applied to identify which treatments were significantly different.

RESULTS AND DISCUSSION.

1.Proximate Compositions of wet and dry *C.vulgaris matrix*

Proximate composition of the dry *C.vulgaris* matrix indicated that the crude protein value (32.41%) is within the protein requirement (30%-40%) that is recommended for growth performance in *Clarias gariepinus* as reported by Mbagwu *et al (*2022). *C. vulgaris* matrix Proximate composition is close to that of commercial Vital feed (Crude Protein (%) 40.00 Crude Fiber (%) 5.33, Ash (%) 7.50, Moisture (%) 12.17, Dry Matter (%) 93.16, Caloric Value (kcal/g)10.44) (Mbagwu *et al.*,2022) and so can serve as a stand-alone feed for fish rearing as shown on Table 1.

Proximate Compositions of the Experimental diets at various Inclusion rates of *C. vulgaris.*

The ash content of the experimental diet at 30g/kg (T4) inclusion rate was the highest 18.52% followed by the control(T1) 18%. The least was found in T2(15.5%) The crude fat was highest in T2 (15.21%) followed by (T1) 14.82%. Crude protein was highest in T5(28.77%) followed by T4(27.56%) other inclusion rates were not significantly different. Fiber and total carbohydrate contents were also higher in T5(15.21%) and 28.53% respectively as shown on Table 2. And also, T5 had the highest metabolizable energy value of 338.23kcal/g while T1(311.24kcal/g) had the least. These values are in accordance with values in the fish industry and the findings of (Mbagwu et al.,2022). The knowledge of the proximate composition of fish feed contents (protein, fat, ash, dry matter, fibre and moisture content) are very important because it gives a reflection on the dietary and health importance of these nutrients in fish and also to the final consumers (Magouz et al.,2019). Fish feeds components play a vital role in growth response, body development, metabolisms, repair of worn-out tissues and survival of fish (Mbagwu et al.,2022).

Table 1: Proximate Compositions of wet and dry *C. vulgaris matrix*.

Proximate Composition	Wet Weight	Dry Weight
Ash (%)	27.11± 2.98^{a}	30.33± 5.05^{b}
Crude Fibre (%)	10.41± 1.55^{a}	10.48± 1.44^{a}
Moisture (%)	24.77± 2.03^{b}	9.03± 1.11^{a}
Crude Protein (%)	26.03± 5.22^{a}	32.41± 6.04^{b}
Crude Fibre (%)	11.21± 1.03^{b}	6.78± 0.99^{a}
Dry Matter	26.71± 2.99^{a}	53.00± 4.22^{b}
Total Carbohydrates (%)	10.06± 1.04^{a}	13.90± 1.22^{a}
Metabolizable Energy (Kcal.g)	253.11± 20.66^{a}	262.12± 22.05^{a}

Table 2: Proximate Composition of Experimental Feed at Various Inclusion rates of *C. vulgaris* (Mean±SE)

Inclusion rate (g/Kg)	Ash content (%)	Crude Fat (%)	Moisture content (%) (Dry weight)	Crude Protein (%)	Fiber content (%)	Dry matter (%)	Total carbo hydrate (%)	Meta bolizable energy (Kcal/g)
(T1) 0.00	18.00± 1.71^{a}	14.82± 1.09^{c}	9.53± 1.00^{a}	23.56± 1.03^{a}	13.21± 1.04^{a}	90.59± 1.88^{a}	20.94± 1.55^{a}	311.24± 21.79^{a}
(T2) 10.00	15.50± 1.00^{a}	15.21± 1.66^{c}	9.56± 1.04^{a}	23.09± 1.55^{a}	13.27± 1.54^{a}	91.55± 1.09^{a}	24.01± 1.41^{b}	325.29± 33.04^{a}
(T3) 20.00	16.88± 1.79^{a}	13.27± 1.44^{b}	9.57± 1.99^{a}	23.09± 1.31^{a}	13.23± 1.01^{a}	91.65± 1.01^{a}	24.01± 1.89^{b}	325.24± 11.73^{a}
(T4) 30.00	18.52± 1.66^{a}	11.82± 1.03^{a}	9.55± 1.71^{a}	27.56± 1.88^{b}	14.99± 1.89^{b}	90.58± 1.55^{a}	27.64± 1.43^{c}	327.88± 22.09^{a}
(T5) 40.00	17.99± 1.32^{a}	13.99± 1.49^{b}	9.53± 1.54^{a}	28.77± 1.77^{b}	15.21± 1.05^{b}	90.53± 1.55^{a}	28.53± 1.87^{c}	338.22± 18.88^{a}

Mean within the same column with different superscripts are significantly different (P<0.05)

The Physico-Chemical Parameters of Water in Experimental Tanks of *C. gariepinus* Fed with Varying inclusion rates of *C. vulgaris* at 4 Weeks

The values of physico-chemical parameters of water in experimental tanks of *C. gariepinus* fed with varying levels of *C. Vulgaris* at week 4 as presented in Table 3. The results showed that the values obtained for dissolved oxygen (DO) varied significantly (P<0.05). It was higher but similar in T4 (7.12mg/l) and T5(7.10mg/l). The least was in T1(5.8mg/l).T2 (6.10mg/l) and T3 (6.70mg/l) were not significantly different (P<0.05). Turbidity was also higher but similar in T4 (7.33mg/l) and T3(7.33mg/l). Other treatments were not significantly different(P<0.05). The results from this study indicated that dissolved oxygen in the rearing tanks of fish fed with varying concentration of *C. vulgaris* were higher than the control tanks. The range was in line with the findings of (Mbagwu *et al.*,2022) who reported the same trend in rearing tanks of fish fed with *C. vulgaris*. The differences may be due to the higher photosynthetic activities of the microalgae which increased the level of DO (Abdel-Tawwab *et al*., 2007). The higher values of turbidity in T3 and T4 tanks might also be attributed to high *C. vulgaris* population and growth-related activities (Olukunle & Oyewumi, 2017).

Table 3: Physico-chemical Parameters of Water in Experimental Tanks of *C. gariepinus* fed with Varying Levels of *C. vulgaris* at Week 4 (Mean±SE)

Levels rate of Inclusion (%) (g/Kg)	Dissolved Oxygen (mg/l)	Nitrate(mg/l)	Temperature ºC	pH	Ammonia(mg/l)	Turbidity (cm)
0.00	5.8 ± 0.20[a]	0.76 ± 0.01 [a]	28.50 + 0.36 [a]	6.64 ± 0.40 [a]	1.67 ± 0.05 [a]	6.77 ± 0.15 [a]
10.00	6.10 ± 0.27 [b]	0.81 ± 0.02 [a]	28.73 + 0.06 [a]	6.56 ± 0.02 [a]	1.67 ± 0.06 [a]	6.40 ± 0.07 [a]
20.00	6.50 ± 0.47 [b]	0.83 ± 0.01 [a]	29.17 ± 0.24 [a]	6.61 ± 0.02 [a]	1.67 ± 0.06 [a]	6.83 ± 0.47 [a]
30.00	7.10 ± 0.20 [c]	0.84 ± 0.01 [a]	28.77 ± 0.30 [a]	6.67 ± 0.03 [a]	1.67 ± 0.02 [a]	7.33 ± 0.12 [b]
40.00	7.12 ± 0.35 [c]	0.76 ± 0.01 [a]	28.03 ± 0.05 [a]	6.63 ± 0.04 [a]	1.63 ± 0.02 [a]	7.33 + 0.12 [b]

Mean within the same Column with different superscripts are significantly different (P<0.05)

The Physico-Chemical Parameters of Water in Experimental Tanks of *C. gariepinus* Fed with Varying Levels of *C. vulgaris* at 8 Weeks

At week 8 Table 4, the values obtained for dissolved oxygen (DO) varied significantly (P<0.05) with the highest value(7.12mg/l) recorded in T5(40g/kg) and T4(07.10mg/l),the lowest value(5.8mg/l) was also in T1(5.8mg/l) Also, the values obtained for nitrate (N), temperature, pH and Ammonia were within the same range with no significant difference (P>0.05). The results from this study indicated that dissolved oxygen in the rearing tanks of fish fed with varying concentration of *C. vulgaris* were higher than the control tanks. The range is in line with the findings of (Olukunle & Oyewumi,2017) who reported the same trend in rearing tanks of fish fed with *C. vulgaris*. The differences may be due to the photosynthetic activity of the microalgae which increases the level of DO (Abdel-Tawwab *et al*., 2007). The physicochemical parameters investigated in this study were within the range recommended for good fish production, indicating that the environmental conditions in these pond waters offer conducive conditions for fish survival and growth which can increase productivity fish ponds (Olukunle & Oyewumi, 2017).

Physico-chemical Parameters of Water in Experimental Tanks of *C. gariepinus* fed with Varying Levels of *C. vulgaris* at Week 8 (Mean±SE)

Levels of Inclusion (g/Kg)	Dissolved Oxygen (mg/l)	Nitrate(mg/l)	Temperature ºC	pH	Ammonia(mg/l)	Turbidity (cm)
T1(0.00)	5.80 ± 0.20[c]	0.76 ± 0.01 [a]	28.50 + 0.36 [a]	6.64 ± 0.40 [a]	1.67 ± 0.05 [a]	6.77 ± 0.15 [a]
T2(10.00)	6.10 ± 0.27 [b]	0.81 ± 0.02 [a]	28.73 + 0.06 [a]	6.56 ± 0.02 [a]	1.67 ± 0.06 [a]	6.40 ± 0.07 [a]
T3(20.00)	6.70 ± 0.47 [b]	0.83 ± 0.01 [a]	29.17 ± 0.24 [a]	6.61 ± 0.02 [a]	1.67 ± 0.06 [a]	6.83 ± 0.47 [a]
T4(30.00)	7.10 ± 0.20 [a]	0.84 ± 0.01 [a]	28.77 ± 0.30 [a]	6.67 ± 0.03 [a]	1.67 ± 0.02 [a]	7.33 ± 0.12 [b]
T5(40.00)	7.12 ± 0.35 [c]	0.76 ± 0.01 [a]	28.03 ± 0.05 [a]	6.63 ± 0.04 [a]	1.63 ± 0.02 [a]	7.33 + 0.12 [b]

Mean within the same Column with different superscripts are significantly different (P<0.05)

The Physico-Chemical Parameters of Water in Experimental Tanks of *C. gariepinus* Fed with Varying Levels of *C. vulgaris* at 12 Weeks

While at week 12 (Table 5), the values obtained for dissolved oxygen (DO) varied significantly (P<0.05) with the highest value(8.33mg/g) recorded in T5(40g/kg) and the lowest value(6.33mg/l) in T1(control). Similarly, the values obtained for nitrate (N), temperature, pH and Ammonia were within the same range with no significant difference (P>0.05). The differences in dissolved oxygen may be due to the photosynthetic activities of the microalgae which increases the level of DO (Abdel-Tawwab *et al*., 2007). Therefore, the

average water temperature obtained in the present experiment was suitable for all chemical, physical and biological processes in pond water and favourable for fish culture. Nevertheless, the values obtained for Turbidity varied significantly (P<0.05) with the highest value recorded in T5 (10.50mg/l) and the lowest value recorded in T1 (7.17mg/l). Thus, good pond productivity and fish health can be maintained Magouz *et al.* (2019).

Table 5: Physico-chemical Parameters of Water in Experimental Tanks of *C.gariepinus* fed with Varying Levels of *C.vulgaris* at Week 12 (Mean±SE)

Levels of Inclusion (g/Kg)	Dissolved Oxygen (mg/l)	Nitrate (mg/l)	Temperature ºC	pH	Ammonia (mg/l)	Turbidity (cm)
T1(0.00)	6.67 ± 0.72[a]	0.75 ± 0.05 [a]	25.73 ± 0.06 [a]	6.99 + 0.11 [a]	1.67 ± 0.02 [a]	7.17 ± 0.31 [a]
T2(10.00)	7.77 ± 0.63 [b]	0.73 ± 0.06 [a]	25.43 ± 0.02 [a]	7.19 + 0.01 [b]	1.70 ± 0.04 [a]	8.33 ± 0.31 [b]
T3(20.00)	6.33 ± 0.24 [a]	0.72 ± 0.01 [a]	25.23 ± 0.06 [a]	6.62 ± 0.02 [a]	1.73 ± 0.05 [a]	8.50 ± 0.20 [b]
T4(30.00)	8.33 ± 0.24 [c]	0.73 + 0.01 [a]	25.27 ± 0.06 [a]	6.64 ± 0.02 [a]	1.70 ± 0.04 [a]	7.83 ± 0.62 [a]
T5(40.00)	7.70 ± 0.79 [b]	0.70 + 0.03 [a]	25.53 ± 0.10 [a]	6.76 ± 0.12 [a]	1.73 ± 0.02 [a]	10.50 ± 0.16 [c]

The Physico-Chemical Parameters of Water in Experimental Tanks of *C. gariepinus* Fed with Varying Levels of *C. vulgaris* 16 Weeks

Moreover, at week 16 (Table 6), the values obtained for dissolved oxygen (DO) varied significantly (P<0.05) with the highest value recorded in T5(8.00mg/l) and the lowest value in T1 (6.50mg/l). The results from this study indicated that dissolved oxygen in the rearing tanks of fish fed with varying concentration of *C. vulgaris* was higher than the control tanks. The range is in line with the findings of (Bai *et al*.,2021) who reported the same trend in rearing tanks of fish fed with *C. vulgaris* as shown in Table 6. The differences may be due to the photosynthetic activity of the microalgae which increases the level of DO (Abdel-Tawwab *et al*., 2007). During the study period, water turbidity in the experimental tanks that contain varying levels of *C. vulgaris* were higher when compared to the control which was similar to the findings of Cho et al. (2019) who observed the same in the rearing Olive flounder fish fed with *C. vulgaris*. The higher values of turbidity in T4 and T3 tanks were attributed to high photosynthetic activities and growth of the microalgae. This is in tune with the findings of Abdl-Yawaab *et al*. (2002). Other Physico-chemical parameters of water of the pond water were within the acceptable range (Olukunle & Oyewumi, 2017).

Table 6: Physico-chemical Parameters of Water in Experimental Tanks of *C. gariepinus* fed with Varying Levels of *C. vulgaris* at Week 16 (Mean±SE)

Levels of Inclusion (g/Kg)	Dissolved Oxygen (mg/l)	Nitrate (mg/l)	Temperature ºC	pH	Ammonia (mg/l)	Turbidity (cm)
T1(0.00)	6.50 ± 0.20[a]	0.71 ± 0.06 [a]	26.60 ± 0.08 [a]	6.81 + 0.06 [a]	1.70 ± 0.00 [a]	5.57 ± 0.45 [a]
T2(10.00)	6.83 ± 0.51 [a]	0.65 ± 0.03 [a]	26.27 ± 0.05 [a]	6.81 ± 0.03 [a]	1.70 ± 0.00 [a]	6.33 ± 0.20 [b]
T3(20.00)	7.17 ± 0.62 [b]	0.69 ± 0.01 [a]	26.37 ± 0.06 [a]	6.89 ± 0.02 [a]	1.67 ± 0.02 [a]	6.43 ± 0.53 [b]
T4(30.00)	7.67 ± 0.54 [c]	0.73 ± 0.02 [a]	26.30 ±0.04 [a]	6.89 ± 0.03 [a]	1.70 ± 0.04 [a]	6.63 ± 0.53 [b]
T5(40.00)	8.00 ± 0.54 [c]	0.72 ± 0.03 [a]	26.20 ± 0.04 [a]	6.86 ± 0.01 [a]	1.73 ± 0.02 [a]	6.67 ± 0.31

CONCLUSION AND RECOMMENDATION

C. vulgaris matrix were harvested, filtered and incorporated in fish feed at 0g/kg, 10g/kg, 20g/kg, 30g/kg and 40g/kg inclusion levels as feed additive of *C. gariepinus* feed. Proximate analysis of *C. vulgaris* matrix Ash (30%), Fibre (10.48%), Protein (32.41%) and metabolizable energy (262kcal/g) showed that it can serve as stand-alone feed for fishes. Supplementation of the microalga *Chlorella vulgaris* at this rate had no negative impacts on the pond water physico-chemical properties rather it enhanced some beneficial pond parameters like dissolved oxygen, etc. Physical and chemical variables such as temperature, dissolved gases and nutrients influence water quality directly or indirectly, which ultimately govern the healthy surviving of organisms in aquatic ecosystem. The water samples analyzed for various physico-chemical parameters like temperature (26.79-27.13^0 C), pH (5.92-6.34), dissolved oxygen (5.82 - 6.05mg/l), transparency (15.84 – 16.70cm) and ammonia (0.13 – 0.24mg/l) were within the recommended range for *Clarias gariepinus* culture. Higher levels of dissolved oxygen and turbidity were observed in the tanks supplemented with varying levels of *C. vulgaris* which might be due to high photosynthetic and growth activities of the micro algae. These optimal physico-chemical parameters showed that the diet did not significantly deteriorate the water quality as it contained no toxic substances and were consumed optimally by the fishes. This study recommends the use of *C. vulgaris* matrix supplement at 20 -30g/kg in the diet to improve the growth of

C. gariepinus. owing to their higher proximate content especially protein.

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Authors' contribution

Authors ICC & UEF managed data collection, interpretation of data and writing of manuscript, ICF & NCF sourced the raw materials and reviewed of manuscript. HO assisted in alga culture/ type setting, ICC managed the literature searches and data analysis, development of methodology and data analysis. All authors read and approved the final manuscript.

Ethical Approval

Not Applicable.

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