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ORIGINAL RESEARCH ARTICLE

Influence of Culture Tank Colours on the Water Quality, Growth Performance and Feed Utilization of *Oreochromis niloticus* (Linnaeus, 1758) Juveniles

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ABSTRACT
The study was conducted over a period of fifty-six (56) days to investigate the effects of different colours of culture tanks on the water quality, growth, and feed utilization of Nile tilapia (*Oreochromis niloticus*) juveniles. *O. niloticus* of mean body weight of 8.5g were stocked and fed twice daily with a commercial diet containing 42% crude protein. The experiment had four treatments based on tank colours; white, green, black and blue coloured tanks. Some water quality indices were assessed once in a week while the fish were weighed at the end of the experiment to compute the performance indices. The data were presented using mean and standard error and comparative analysis was done using one way ANOVA at 95% confidence interval with Duncan multiple range test as the follow up test. The water quality parameters examined during the study were not significantly different among the treatments. All the selected water quality parameters were within the acceptable range for tropical fish culture. While there was no significant difference in final weight, weight gain, percentage weight gain, and specific growth rate among the treatments, black tanks showed slightly higher values with 10.89±0.89 g, 2.54±0.94g, 30.47±11.43%, and 0.47±0.16%/day, respectively. Higher feed intake and FCR were recorded in green tank (10.08±0.61 g and 7.92±2.70 respectively) and the least was observed in black tank (9.32±0.12g and 4.23±1.51). The percentage survival of the fish was different significantly among the treatments ($P<0.05$). Fish reared in white background showed the highest survival (100%) which was different significantly from all other treatments. The blue and black tanks showed slightly higher values of viscerosomatic index and hepatosomatic index with 7.22±1.00% and 2.02±0.25%, respectively, while black and white tanks had the least values with 4.44±1.11% and 1.64±0.15%, respectively. The results showed that *O. niloticus* juveniles can be reared in all the tanks with no negative implication on their performances. However, black and white tanks showed better potential towards improved growth and feed utilization, while white tank led to better survival rate and tended towards better well-being as indicated by the skin pigmentation and hepatosmatic index. Therefore, rearing of *O. niloticus* juvenile in white tank is recommended over other colours.

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INTRODUCTION
Aquaculture is the practice of raising fish for commercial purposes in environments where the basic requirements of production are maintained and farmers get the best possible economic returns (Tunde *et al.*, 2015). Aquaculture is becoming increasingly important in the world's fisheries as capture fisheries struggle with overfishing, aquatic pollution, and climate change, all of which result in lower fish catches (Dauda *et al.*, 2018). The Nile Tilapia (*Oreochromis niloticus*), which produces over 75% of the world's total tilapia production and 8.3% of all aquaculture productivity in 2018, is regarded as the most significant farmed tilapia in the world (FAO, 2020).

Nile tilapia grows fast under different environmental conditions and production under different culture systems (FAO, 2017), including; flow-through system, recirculating system, stagnant renewal system etc. Intensive tank culture offers several advantages over pond culture. Tilapia, which is seen as aquatic chicken, is a key player in alleviating hunger, ensuring food security, and generating income from aquaculture particularly in poor nations (Dauda *et al.*, 2014; Wally, 2016). According to Dauda *et al.* (2017a), fish culture has been effectively carried out in a variety of holding structures including natural water bodies, earthen ponds, concrete tanks, fiber

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tanks, plastic tanks, etc. The resources that are accessible, the scale of the operation, and the level of skill of the farm manager all have a role in the choice of the culture facility (Akinwole *et al*., 2014). According to FAO (2017), Nile tilapia grows quickly in a variety of environmental settings and production settings like stagnant renewal, recirculating and other systems. More recently, people are exploiting fish culture in plastic tanks as it encourages urban and peri-urban aquaculture and the system can be moved from one place to another with ease (Akinwole *et al*., 2014; Dauda *et al*., 2017a). Nigeria is reputed for the culture of mostly African catfish and the needs to diversify and masssively promote other fish species has been well elaborated by Dauda *et al.* (2018). Nile Tilapia is good aquacultural candidate in Africa and across the world, studies to understand the best condition for its culture, for optimal growth and survival performance will be a great contribution to the development of Nigeria's aquaculture industry.

In contrast to system design, however, comparatively a few researches have been undertaken to examine the potential advantages that varying tank colours may have on the performance characteristics of specific species cultivated fish such as *Oreochromis niloticus* (McLean *et al* 2008). Despite Nile tilapia being successfully produced in tanks, the colours of the tanks used to raise the fish have always been decided based on availability and convenience, irrespective of the potential implications they may have on fish growth, survival and feeding (El Sayed *et al*., 2021). Optimizing the environment is essential to achieving high growth rates and survival, particularly in tank culture of juvenile fish as this will help fish feed more efficiently. Since Nile tilapia juveniles feed visually, this process includes among other things figuring out the ideal stocking density for the tank and the best contrast amongst feed particles and culture medium walls (Abd El-Hack *et al*., 2022). Although few researches have documented influence of tank colours on different fish cultured, the results so far are tending towards species-specific effect (Lutaaya, 2021: Alabi *et al.* (2018) and Karakatsouli *et al.* 2007). Hence, the need for this research to examine effect of varying tank colours on the overall performance of *Oreochromis niloticus* juveniles culture in a stagnant renewal system with four different tank colours.

MATERIALS AND METHODS

Study Area and Material Source

The research was carried out at the mini research laboratory of the Department of Fisheries and Aquaculture, Federal University Dutsin-ma Katsina State, Nigeria. The rearing of the fish was done using twelve (12) rectangular shaped plastic tanks of 44 cm length, 29 cm breadth and 25 cm depth, with capacity of 30L of water. The volume capacity of the tank can conveniently support the number and size of the fish stocked as previoulsy documented by Dauda *et al*., (2022). Fresh borehole water was used for all the treatments.

Experimental fish

One hundred and twenty (120) *O. niloticus* juveniles of mean body weight of 8.5g each were obtained from a private farm in Kaduna State and transported to Dutsin-Ma in plastic kegs with the top opened.

The study was approved by the Scientific Research and Ethics Committee of Federal University Dutsin-Ma (FUDMA/R&D/SREC/2021/005) and the experiment was carried out in line with the approved guidelines.

Experimental Unit and Research design

Oil-based paints were used to paint the tanks backgrounds four weeks before the experiment began and they were exposed to air for proper drying and to allow the escape of the smell that might affect the fish. All other necessary precautions were taken to ensure the pigments wouldn't harm the fish, pollute or contaminate the culture water.

The research design employed was completely randomized design (CRD) with four treatments (white, blue, black, and green coloured tanks) that are replicated three times each for a period of eight weeks. The juvenile of *O. niloticus* fish were divided into the three replicated treatments of four different colours (12 tanks), each unit contained ten fish with 20 liters of water in each tank. Before the trial started, the fish were acclimated in the tanks for sevan days, as a rugular procedure to get the fish used to the new environment and observe for any abnormality or disease.

Fish Feeding

All the fish stocked were fed commercial extruded pellets of 2mm size and 42% crude protein that was purchased in Kaduna State. They were fed to apparent satiation everyday (morning and evening) and the amount of feed was recorded.

Monitoring of Water Quality

Three times a week, the bottom debris (faecal matter, uneaten food) was sucked out of the tanks to maintain the water quality, and the water level was then corrected by replenishing the tanks with fresh water. Twice a week, the water in the tanks was fully replaced. Temperature, pH, dissolved oxygen (D.O), ammonia, and alkalinity were measured following the description of Dauda *et al.* (2017b).

Growth Performance and Feed Utilization

Initial body weight and weekly weight gain were monitored for 8 weeks using a sensitive weighing balance and the juveniles were returned to the appropriate tanks after weighing. The fish were observed for mortality, feed intake and behavior on a daily basis (Dauda *et al*., 2022). At the end of the experiment, bulk weighing was first done for each tank, then, twelve fish were sampled from each treatment (four per tank) for individual weight and length, then the fish were dissected for removal of liver and intestine for the evaluation of hepatosomatic index and viscerosomatic index. The data obtained was used to compute the performance indices; final weight, weight gain, specific growth rate (SGR %/day), feed conversion

ratio (FCR) and survival. Calculations was done following the description of Dauda *et al.* (2022):

Table 1: Summary of Parameters used to Determine the Growth Performance and Feed Utilization

Parameters	Formulae
Weight gain (g)	final weight (g) – initial weight (g)
Mean weight gain	Weight gain (g)/Number of fish
Specific growth rate (%/day)	(Ln W2 – Ln W1) x 100/Number of Culture days
	Where W1 = initial weight W2 = final weight Ln = Natural logarithms
Feed conversion ratio	Dry weight of feed consumed (g)/Wet weight gain (g)
Condition factor (k)	W x 100/L3
	Where w= weight of fish L= standard length of fish
Survival %	Total number of fish harvested x 100/Total number of fish stocked
Hepatosomatic index	Liver weight (g) x 100/weight of the fish (g)
Viscerosomatic index	Visceral weight (g) x 100/fish weight (g)

Data analysis

The data was presented using descriptive statistics (mean±SE), for growth, feed utilization and water quality performance indices. One-Way (ANOVA) was used to assess the difference among the means for each of the variables at $p < 0.05$. In order to identify the precise means that were different, significant results from the ANOVA test were further examined using Duncan's multiple range test (DMRT). All analysis was conducted using IBM SPSS 22.

RESULTS

Water Quality

The results of the water quality parameters are shown in Table 2. Mean temperature values in all the treatments were similar and ranged from 23.19-23.40^{o}C with blue tank having a slightly higher temperature value (23.40±0.74^{o}C) and white tank having the least (23.19±0.69^{o}C) but the difference was not significant among the treatments. The highest D.O concentration was recorded in black tanks (5.10±0.54 mg/l) while the green tanks had the least D.O concentration (4.27±0.30 mg/l) however, there was no significant difference among the treatments (P>0.05). Ammonia-nitrogen values in all treatments were similar (P>0.05). The pH values in the treatments ranged from 8.27-8.33, although it was slightly higher in blue tank (8.33±0.10) and lowest in white tank (8.27±0.12) but there was no significant difference among the treatments (P>0.05). The alkalinity values in the treatments ranged from 21.00-23.33 mg/l. The green tank had the highest (23.33±1.59 mg/l) but it was not different significantly (P>0.05) from other treatments.

Table 2: Mean(±SE) water quality parameters in cultured tanks of *Oreochromis niloticus* with different background colours

Parameters	White	Green	Black	Blue
Temperature(^{o}C)	23.19±0.69	23.34±0.69	23.35±0.84	23.40±0.74
Dissolved oxygen (mg/l)	4.47±0.44	4.80±0.40	5.10±0.55	4.27±0.33
Ammonia-nitrogen (mg/l)	0.35±0.03	0.38±0.01	0.37±0.02	0.36±0.02
pH	8.27±0.12	8.32±0.09	8.31±0.12	8.33±0.10
Alkalinity (mg/l)	22.00±1.07	22.67±1.53	21.00±1.00	23.33±1.59

Different letters as superscript across the rows indicate significant difference (P<0.05)

Skin pigmentation

Background colour affected skin pigmentation of the fish reared. Fish exposed to black coloured tank had a relatively higher colour change with reddish pupils (Plate 1) followed by blue and green tank while fish reared in white tank maintained it silverish colour with bright eyes (Plate 2).

Growth performance

Table 3 showed the growth performance for the various treatments. The result showed that fish cultured in black tank had a slightly higher final weight (10.89±0.89 g), mean weight gain (2.54±0.94 g), percentage weight gain (30.47±11.43%) and specific growth rate (0.47±0.16%/day). However, the difference was not significant (P>0.05) among the different colours.

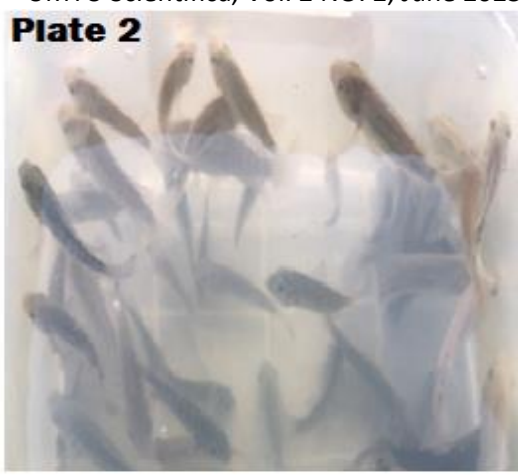

Plate 1: Fish cultured in black tanks, and **Plate 2**: Fish cultured in white tanks

Table 3: Mean±SE Growth performance, Feed utilization and Survival of *O. niloticus* juveniles reared in tanks with different colours for 8weeks

Parameters	White	Green	Black	Blue
Initial weight(g)	8.30±0.25	8.73±0.22	8.35±0.05	8.43±0.08
Final weight (g)	10.43±0.48	10.38±0.75	10.89±0.89	9.72±0.09
Weight gain (g)	2.13±0.45	1.64±0.56	2.54±0.94	1.29±0.15
WG percent (%)	25.79±5.68	18.58±6.00	30.47±11.43	15.29±1.95
SGR (%/day)	0.41±0.08	0.29±0.09	0.47±0.16	0.25±0.30
Feed intake (g)	9.70±0.10	10.08±0.61	9.32±0.12	9.56±0.73
FCR	4.95±0.98	7.92±2.70	4.23±1.51	7.72±1.25
Survival (%)	100.00±0.00	96.67±3.33	95.00±5.00	86.67±8.82

Different letters as superscript across the rows indicate significant difference (P<0.05)

Feed Utilization

At the end of the experiment (Table 3), highest feed intake (10.08±0.61 g) and feed conversion ratio (7.92±2.70) were observed in green tanks while the lowest were observed in fish reared in black tanks. However, there was no significant difference (P>0.05) in either of the feed intake or FCR among the treatments.

Survival

Survival (%) of Nile tilapia juveniles in all the treatments was above 96% (Table 3). White tanks had the highest survival rate (100%), which was significantly higher (P<0.05) than other treatments.

Body indices

Table 4, showed the body indices observed during the experiment was not different significantly among the treatments (P>0.05). Higher values of viscerosomatic index was recorded in blue tanks (7.22±1.00%) and hepatosomatic index in black tanks (2.02±0.25%) and the least value of VSI was recorded in black tanks (4.44±1.11%) and HSI in white tanks (1.64±0.15%).

Table 4: Mean body indices of *O. niloticus* juveniles reared in different background colours

Parameters	White	Green	Black	Blue
Viscerosomatic index (%)	5.93±1.02	6.20±0.90	4.44±1.11	7.22±1.00
Hepatosomatic index (%)	1.64±0.15	1.95±0.35	2.02±0.25	1.72±0.25

Different letters as superscript across the rows indicate significant difference (P<0.05)

DISCUSSION

Water quality is essential to ensure effective growth and development of all fish species. The range for the examined water quality parameters in this study were all within tolerable ranges for culture of Nile tilapia (Towers, 2015; Ajani *et al.*, 2011). However, D.O was higher in black tank (5.10±0.55 mg/L), this might be associated with lower feed wastage as evident in the reduced FCR observed. Ammonia-nitrogen values were within tolerable ranges of 0.35-0.38mg/l, although it is slightly higher in green tanks (0.38±0.01). This might be due to high amount of faecal waste in the tank which is associated with high feed intake in the tank. This is supported by Solomon *et al.*, (2018) who recorded ammonia ranges between 0.2-0.3mg/L, which was due to increase in biomass and consequential higher feed intake. However, the results from this research is in support of the findings of Aly *et al.* (2017) who found no significant differences in water quality parameters from Hybrid Red Tilapia (*Oreochromis niloticus x Oreochromis hornorum*) reared in saline well water under different colours of artificial light on the

pigmentation and growth performance. The potential to change body colour in response to the environmental condition such as in the case of dark or bright backdrops, is known as background adaptation and is frequently seen in fish. Aquaculturists use this trait to enhance skin pigmentation (Vissio *et al.,* 2021). In this study, fish cultured in black tanks had the darkest colour change and fish reared in white tank was the lightest. The reason behind that could be the proper light penetration in the tanks which might help in developing vibrant colours on fish skin. A similar observation was noted in the skin colour of hybrid catfish (*Clarias macrocephalus* x *Clarias gariepinus*) cultured in white tanks which was the lightest followed by those cultured in red, green and blue, while black tanks had the darkest skin colour (black) (Parichart *et al*., 2022). Another study found that *Lophiosilurus alexandri* raised in dark-coloured tanks had higher plasma cortisol levels and a drop in skin brightness, whereas the use of light colours led to paler body (Costa *et al.,* 2017). Black backgrounds cause skin darkening and a more stressed response in *Oreochromis mossambicus*, but white and grey backgrounds cause skin lightening (Van der salm *et al.,* 2005). This knowledge could be helpful to significantly increase the economic value of the animal in the aquaculture market as an appealing and colourful ornamental species with an easy and affordable raising methods because animal colouration affects its aesthetic appeal (Tomas *et al.,* 2019). In this experiment, all the growth parameters were slightly improved in fish reared in a black blackground in comparison with the others. A similar observation was made by Solomon *et al*., (2018) and (Jegede, 2011), who reported the best growth performance in *Heterobranchus bidorsalis* and *Oreochromis niloticus* fingerlings (Nile tilapia) reared in black-coloured tanks and this may be explained by this fish species' behavior, which favours dark environments over those with intense lighting (Jegede, 2011). This contradicts the findings of Lutaaya (2021), who reported a better growth performance of *Oreochromis niloticus* in blue-coloured tanks compared to white and black tanks. According to Abou et al. (2007), low food efficiency is indicated by a high FCR, which has been linked to ineffective feed searching or poor quality of water. Higher feed intake and FCR were recorded in green tanks. Increased FCR in this study is in agreement with findings of Parichart *et al.* (2022) and Okomoda *et al*., (2018), who recorded the highest feed intake and FCR of fish reared in green tanks when rearing juvenile hybrid catfish and *Clarias gariepinus*. This indicated poor feed utilization and perhaps responsible for the slightly higher ammonia-nitrogen in green tanks in this study. Survival of *O. niloticus* was higher significantly in white tanks against other treatments. This is in line with the observations of Alabi *et al.* (2018) and Karakatsouli *et al.* (2007) who recorded the highest survival in fish cultured in white tanks. This contradicts the findings of Lutaaya, (2021) and Okwiri, (2015) who recorded a high survival rate of *O. niloticus* fry in blue tank background compared to other colours. In relation to digestion and absorption of feed, synthesis and release of digestive enzymes as well as the carbohydrate metabolism, the study of viscerosomatic and hepatosomatic indices is crucial to fish metabolism (Keri *et al.,* 2014). The least hepatosomatic value in the white tanks might be an indication of least stress as it reflected in the brighter appearance and least aggression compared to other tanks. Previous researchers have reported similar results of the least HSI in the least stressed fish indicating a better well-being (Dauda *et al.,* 2017b; Romano *et al.,* 2018; Dauda *et al*., 2022). Rearing tank colour has been considered to be an important factor influencing fish rearing success in aquaculture. Our results also substantiated the fact that rearing tank colour affects the survival and slightly affected growth of fish.

CONCLUSION

The findings of this study showed that *O. niloticus* juveniles can be cultured in all the tanks with little or no negative implication on their performances. However, black and white tanks showed better potential towards improved growth and feed utilization, while white tank led to better survival and tends towards a better well-being as shown by the skin pigmentation and hepatosomatic index. Rearing of *O. niloticus* juvenile in white tank is therefore recommended over other tank colours in Nigeria for better growth, feed utilization, survival and overall well-being of the fish.

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