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Research Article

Enzymes Activities in the plasma of *Clarias gariepinus* and *Heterobranchus longifilis* Reared in Different Culture Systems

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Abstract: This study assessed the enzymes activities in the plasma of *Clarias gariepinus* and *Heterobranchus longifilis* reared in different culture systems. A total of two thousand eight hundred and eighty (2,880) fingerlings of two species consisting of 1440 *Clariasgariepinus*(mean length 5.42cm ± 0.67 and mean weight 3.34g± 0.33SD) and 1440 *H.longifilis* (mean length 5.43cm ± 0.88 and mean weight 3.35g± 0.31SD) were reared in four different aquaculture enclosures namely: earthen ponds, tarpaulin, concrete and plastic tanks of the same dimension (1.0 x 1.0 x1.2m^3) for a period of 12 weeks. The results obtained, indicated that enzymes activities such as Acid Phosphatase (ACP); Alkaline Phosphatase (ALP); Aspartate Transsaminase (AST); Alanine Transaminase (ALT) and Lactate Dehydrogennase were significantly (P <0.05) elevated in the plasma of cultured fish, which was more pronounced in those reared in concrete and plastic tanks. Based on the results of this study, rearing of *C. gariepinus* and *H. longifilis* in tarpaulin tank is most effective and ideal method for fish production if the target is to attain fast growth and good health condition of the fish.

Keywords: Enzymes, Fish physiology, Biomarker, Culture systems, Aquaculture.

1. INTRODUCTION

Currently, the use of biomarkers to monitor the quality of the environment has gained considerable interest worldwide in assessing pollution and stress of fish in the culture medium (Ahmed *et al.*, 2014). "Biomarkers complement and improve the reliability of chemical analysis, thereby providing more in-depth and biologically relevant information on the potential effects of toxic pollutants on organisms' health" (Marcela *et al.*, 2008). Therefore, the use of biomarkers can provide an integrated assessment of the effects of pollutant and or environmental stress on both the artificial and the natural environment and provide a clear picture of the "health status" of the system under study (Lewbart *et al.*, 2005). Pollutants in the aquatic environment are usually a very complex mixture and no biomarker is available to fully diagnose environmental degradation. To overcome this difficulty, the use of complementary biomarkers may be useful in evaluating different responses to mixtures of contaminants in stressed organisms (Som *et al.*, 2009). This multi-parameter approach is widely used to evaluate pollution monitoring programs for aquatic organisms (Gabriel *et al.*, 2010).

Biomarker can be measured at different levels of biological organization which goes from the molecular to whole organism level. Each of them shows a specific response when exposed to stress. These biomarkers are attributed to gills and liver and known as histopathological biomarkers. Histopathological biomarkers are valuable as indicators of the general health of fish and can be used to reflect the effects of exposure to a variety of anthropogenic pollutants (Akram *et al.*, 2016). When a high concentration of chemical pollutants is released in the environment, acute changes can be seen, while for chronic duration information about sublethal aspects of change is required.

Biochemical indicators such as enzymes could be used as biomarkers to identify possible environmental contaminations before the health of aquatic organisms is seriously affected (Siroka, 2004; Ahmed *et al.*, 2014). The determination of alanine transaminase (ALT) and aspartate transaminase (AST) activities in the blood plasma and organs indicate bacterial, viral and parasitic infections, intoxication and water pollution. Toxicants can also inhibit the activity or synthesis of enzymes resulting in decreased activities in the organs (Ahmed *et al.*, 2014). Stress biomarkers in fish specimens can be determined by investigating the changes in alkaline phosphate (ALP), aspartate transaminase (AST), alanine transaminase (ALT), and acid phosphate (ACP) under laboratory conditions. These enzymes assaysalso form part of the standard laboratory tests to detect abnormalities in animals (Ayalogu *et.al.*, 2001). Culture systems in aquaculture have been reported to influence fish physiology. Information on the effects of culture systems enzymes activities of fish in the culture medium is limited. Therefore, this study evaluated the effects of different culture systems on some enzymes activities during the rearing of two catfishes (Clarias *gariepinus* and *Heterobranchus longifilis*) in four culture systems.

MATERIALS AND METHODS

2.1 Project Location and Water Sources

This study was carried out at the premises of Aqua Green Integrated Farming Support Initiative (AGI), Tai L.G.A, Port Harcourt, Rivers State, Nigeria. The water supply to the farm was from a bore hole, the water was treated to make it free from any chemical pollution.

2.2 Sources of Experimental Fish

A total of two thousand eight hundred and eighty fingerlings of two species (1440/ species) were sourced from Momoh Farms Limited, one of the leading fish farms in Rivers State. They were later transported in open container to the experimental site.

2.3 Fish Acclimation

The fish were acclimatized to the laboratory conditions for 14 days following the method of Gabriel *et al*., (2004), who recommended that fish for experimental purposes must be handled carefully and stocked in a well aerated holding tank, so as to reduce the incidence of stress to the barest minimum. During this period the fish were fed daily with Blue Crown Commercial feed (55% Crude Protein) at 5% body weight and the water in the holding tanks were renewed every two days.

2.4 Preparation of Rearing Enclosures

Four rearing enclosures which include tarpaulin, concrete tanks, plastic tanks and earthen ponds were utilized for the experiment. They were designed and constructed with the same dimension: 1.0 x 1.0 x1.2m^3. The tanks and taurpaulin were washed with detergents and thoroughly rinsed with water. The earthen ponds were cleaned and de silted.

2.5 Experimental Design

The design of the experiment was Completely Randomized Design (CRD) having four treatment levels each with three replicates for each of the two species of the clariids. A total of 24 rearing enclosures of dimension (1.0 x 1.0 x1.2m^3) each were used for the experiments. Each species had 27 rearing enclosures comprising nine each in the two species. Each rearing enclosure was stocked with 120 fish per tank. A total of 2,880 fish were stocked.

2.6 Experimental Procedure

Fingerlings of *C. gariepinus* and H. *longifilis* (mean length 5.42cm ± 0.67 and mean weight 3.34g± 0.33) were randomly stocked in the rearing enclosures. The fish were fed with blue crown commercial feed thrice daily at 5% body weight. "The daily ration of 5% body weight was divided into three equal parts each time. The weight of feed fed was adjusted every week. The fish were cultured for a period of 12 (twelve) weeks." The weight of the fish was taken every fortnightly. The fish was weighed with 20 kg top loading weighing scale (Model 1123HK, Digital Scales, Ltd, Beijing, China), while, the length of the fish was measured with transparent metre rule. The water in the rearing enclosures was renewed every two days.

2.7 Analytical procedure

At the end of each experimental period, 2ml of fresh blood sample was collected by making a caudal puncture with the help of fine needle and poured in heparinized sample bottles. Blood samples were centrifuged immediately for 15 minutes at 5000 rpm. Plasma specimens were separated, pipetted into eppendorf tubes and stored in a refrigerator at -20°C until assayed . The results were read using a universal microplate reader on a Jenway visible spectrophotometer (Model 6405). Five enzymes namely, Aspartate amino transaminase (AST), Alanine amino transaminase (ALT), Alkaline phosphatase (ALP), Acid phosphatase (ACP) and Lactate dehydrogenase (LDH) were analyzed in the blood of the exposed *T.guineensis*. The Reitman and Frankel (1957), method was used to analyze AST, because it can be performed as a manual colorimetric end-point technique. While, ALP, ACP and LDH was done by method described by Huang *et al*., (2010).

2.4 Statistical Analysis

All the data were expressed as mean and standard deviation of mean. The statistical package, SPSS Version 22 was used for the data analysis. The means were separated using two ways ANOVA and the two means were considered significant at 5 % ($P<0.05$).

3. RESULTS

The enzymes activities in*C.gariepinus* reared in four different enclosures in the first month are presented in Table 1. The results indicated that significantly ($P<0.05$) higher values of AST, ALT, ALP, ACP and LDH were observed in the fish reared in concrete and plastic tanks, when compared to earthen ponds and tarpaulin tanks. The same trend were however observed in the second month (Table 2), except in LDH which were within the same range in the two species reared in the four culture systems with no difference ($P>0.05$). In the third month (Table 3), higher values of all the enzymes under consideration were also observed in *C. gariepinus* reared in concrete and plastic tanks.

The enzymes activities in *H. longifilis*raised in four different culture systems in the first month are presented in Table 4. The results indicated that significant ($P<0.05$) higher values of AST, ALT, ALP, ACP and LDH were observed in the fish reared in concrete and plastic tanks, when compared to earthen ponds and tarpaulin tanks. The same trend was equally observed in the second month (Table 5), except in ALP where lower values were observed in the fish reared in concrete and tarpaulin tanks. The same trend of increase in enzymes activities was also observed in the third month (Table 6), where *H.longifilis* reared in concrete and plastic tanks consistently recorded higher

values of enzymes activities than those raised in earthen and tarpaulin tanks.

Comparative values of AST activities) in *C. gariepinus*and*H. Longifilis* reared in different culture systems for 12 weeks are shown in Figure 1. The AST values varied considerably among the two species in all the rearing enclosures. The highest activity (16.37 IU/L) of AST was observed in *C.gariepinus* reared in plastic tanks at 12 weeks and the lowest (8.00IU/L) in *C.gariepinus* raised in earthen ponds atweek 12.The comparative values of ALT in *C.gariepinus* and *H.longifilis* raised in different enclosures for a period of 12 weeks are shown in Figure 2. Low values of ALT were observed in fish reared in earthen ponds and tarpaulin tanks. However, the highest value (18.09 IU/L) was observed in *H. longifilis* reared in plastic tanks and the lowest (9.00IU/L) in *C.gariepinus*reared intarpaulin tanks at week 12.

Comparatively, the values of ALP in the two species of clariids reared in four different enclosures are shown in Figure 3. The values of ALP increased as the experimental period increased for the fish reared in plastic and concrete tanks. However, the highest value (29.33 IU/L) was observed in *H.longifilis reared* concrete tanks at 12 weeks, while the lowest (15.00) was in *H.longifilis* reared in tarpaulin tanks. The comparative values in ACP in *C.gariepinus* and *H.longifilis* reared in different culture systems for 12 weeks are shown in Figures 4. The comparative values of LDH in the experimental fish reared for 12 weeks are shown in Figure 5.. Proportionally, higher values of LDH were observed in fishes reared in concrete and plastic tanks when compared to other rearing facilities. The highest value of 340.04 IU/L was observed in *H. longifilis* reared in plastic tanks at week 12, while, the lowest value of 199.07 IU/L was recorded in *C. gariepinus* raised in tarpaulin. at week 4.

Table 1: Enzymes Activities in *C.gariepinus* Reared in Different Culture Systems in the First Month (Mean ±SD)

Enzymes (IU/L)	Culture System			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	10.33 ±0.57^{a}	9.00 ±1.91^{b}	9.33 ±0.57^{b}	11.76 ±0.89^{a}
ALT	12.00 ±2.10^{a}	10.00 ±1.04^{b}	11.00 ±1.42^{b}	13.09 ±1.47^{a}
ALP	20.00 ±1.29^{a}	17.00 ±1.23^{b}	18.00 ±1.21^{b}	22.08 ±3.45^{a}
ACP	22.33 ±0.57^{a}	18.00 ±1.45^{b}	19.00 ±2.64^{b}	24.09 ±2.59^{a}
LDH	220.00 ±1.09^{a}	200.00 ±2.81^{b}	199.67 ± 1.53^{b}	229.08 ± 18.59^{a}

Mean within the same row with different superscripts are significantly different (P<0.05)
Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase

Table 2: Enzymes Activities in *C.gariepinus* Reared in Different Culture Systems in the Second Month (Mean ±SD)

Enzymes (IU/L)	Culture Systems			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	13.00 ±2.72^{a}	10.00 ±1.00^{b}	10.89 ±0.64^{b}	15.00 ±2.05^{a}
ALT	14.01 ±0.57^{a}	11.00 ±1.00^{b}	12.00 ±1.00^{b}	14.99 ±0.69^{a}
ALP	22.33 ±1.53^{a}	17.67 ±1.53^{b}	19.00 ±1.00^{b}	24.39 ±1.88^{a}
ACP	23.00 ±1.37^{a}	19.67 ±1.53^{b}	20.00 ±1.45^{b}	25.09 ±5.45^{a}
LDH	240.00 ±10.43^{b}	230.00 ±1.77^{b}	240.00 ±2.32^{b}	256.00 ± 11.98^{b}

Mean within the same row with different superscripts are significantly different (P<0.05)
Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase

Table 3: Enzymes Activities in *Clarias gariepinus* Reared in Different Culture Systems in the Third Month (Mean ±SD)

Enzymes (IU/L)	Culture Systems			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	15.00 ±1.00^{a}	8.00 ±1.00^{b}	8.67 ±1.87^{b}	16.87 ±1.43^{a}
ALT	12.67 ±1.16^{a}	9.00 ±0.00^{b}	9.33 ±2.89^{b}	14.69 ±1.45^{a}
ALP	21.00 ±2.41^{a}	16.67 ±1.15^{b}	17.00 ±2.34^{b}	25.87 ±2.49^{a}
ACP	22.00 ±1.96^{a}	16.33 ±0.57^{b}	24.00 ±3.87^{a}	27.08 ±7.42^{a}
LDH	300.00 ±11.41^{a}	261.33 ±8.08^{b}	260.00 ±12.75^{b}	310.00 ± 21.45^{a}

Mean within the same row with different superscripts are significantly different (P<0.05)
Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase.

Table 4: Enzymes Activities in *H. longifilis* Reared in Different Culture Systems in the First Month (Mean ±SD)

Enzymes (IU/L)	Culture Systems			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	11.33 ±0.89[a]	9.00 ±1.00[b]	9.33 ±0.62[b]	12.66 ±0.79[a]
ALT	14.67 ±0.54[b]	11.33 ±0.49[b]	12.00 ±1.55[b]	13.88 ±0.31[b]
ALP	20.00 ±1.06[a]	17.00 ±1.00[b]	15.00 ±1.77[b]	25.00 ±1.90[a]
ACP	22.00 ±1.09[a]	19.00 ±1.07[b]	18.33 ±1.53[b]	24.00 ±1.65[a]
LDH	290.00 ±1.55[a]	280.00 ±1.06[b]	286.00 ±1.98[b]	290.00 ±1.82[a]

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

Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase

Table 5: Enzymes Activities in *H. longifilis* Reared in Different Culture Systems in the Second Month (Mean ±SD)

Enzymes (IU/L)	Culture Systems			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	13.00 ±0.59[a]	11.00 ±1.08[b]	11.33 ±0.52[b]	15.00 ±0.88[a]
ALT	18.00 ±1.00[a]	13.00 ±2.02[b]	15.00 ±2.41[b]	18.00 ±1.41[a]
ALP	17.33 ±0.58[b]	20.00 ±1.01[a]	25.00 ±1.08[a]	16.38±0.47[b]
ACP	28.00 ±1.00[b]	25.00 ±1.06[b]	26.00 ±1.06[b]	29.00 ±1.43[b]
LDH	300.00 ±15.07[a]	270.00 ±1.09[b]	299.67 ±1.53[b]	310.07 ±21.43[a]

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

Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase

Table 6: Enzymes Activities in *H. longifilis* Reared in Different Culture Systems in the Third Month (Mean ±SD)

Enzymes (IU/L)	Culture Systems			
	Concrete Tanks	Earthen Ponds	Tarpaulin Tanks	Plastic Tanks
AST	14.33 ±0.98[a]	11.00 ±1.00[b]	12.00 ±4.90[b]	15.38 ±0.91[a]
ALT	15.00 ±1.77[a]	12.00 ±0.00[b]	13.33 ±3.98[b]	18.09 ±1.41[a]
ALP	29.33 ±1.53[a]	22.67 ±0.58[b]	23.33 ±1.53[b]	25.98 ±1.09[a]
ACP	26.00 ±1.45[a]	22.00 ±2.00[b]	23.00 ±1.77[b]	29.00 ±1.34[a]
LDH	320.00 ±1.67[a]	259.33 ±1.15[b]	291.33 ±1.53[b]	340.00 ±1.67[a]

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

Key: AST- Aspartate Aminotransferase; ALT-Alanine Aminotransferase; ALP-Alkaline Phosphatase; ACP- Acid Phosphatase; LDH-Lactate Dehydrogenase

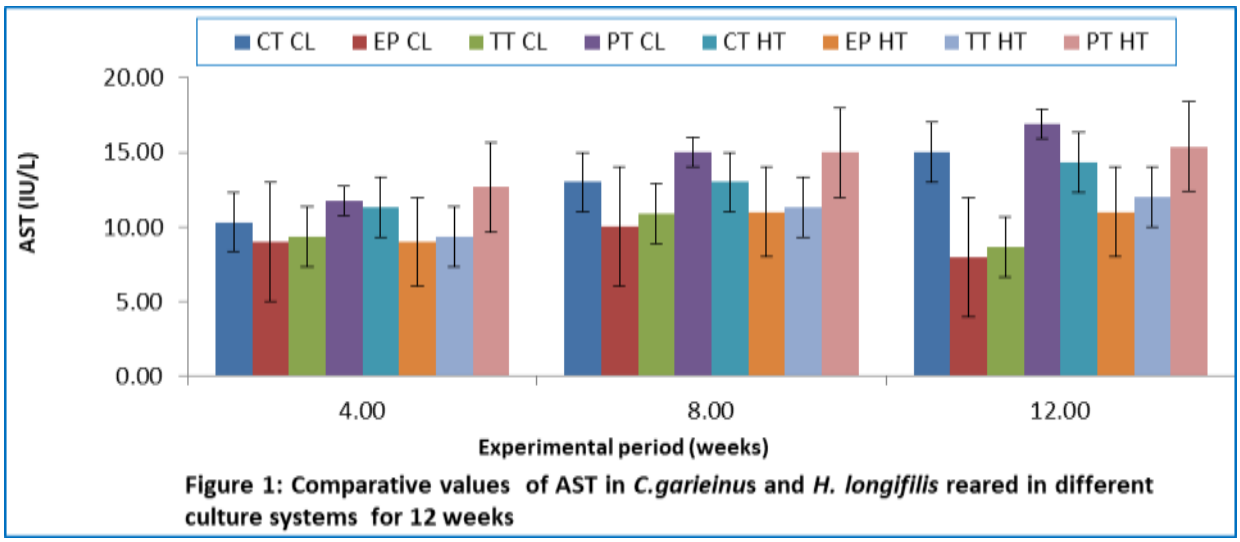

Figure 1: Comparative values of AST in *C.garieinus* and *H. longifilis* reared in different culture systems for 12 weeks

Key: CTCL- *C. gariepinus* reared in Concrete Tanks; **EPCL-** *C. gariepinus* reared in Earthen Pond; **TTCL-** *C. gariepinus* reared in Tarpaulin Tanks; **PTCL-** *C. gariepinus* reared in Plastic Tanks; **CTHT-** *H. longifilis* reared in Concrete Tanks; **EPHT-** *H. longifilis* reared in Earthen Pond; **TTHT-***H. longifilis* reared in Tarpaulin Tanks; **PTHT-** *H. longifilis*reared in Plastic Tanks. Bars ± SD.

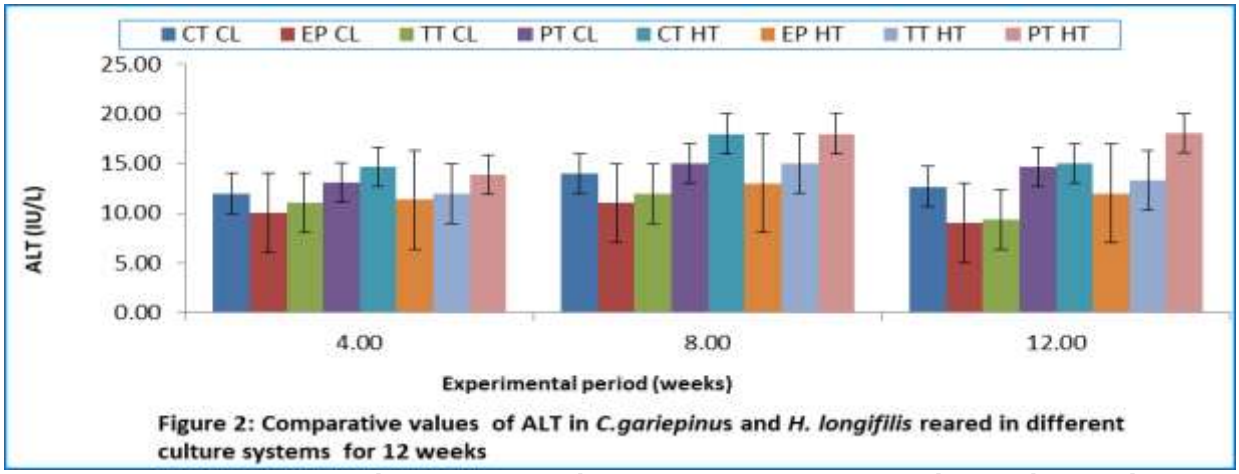

Figure 2: Comparative values of ALT in *C.gariepinus* and *H. longifilis* reared in different culture systems for 12 weeks

Key: CTCL- *C. gariepinus* reared in Concrete Tanks; **EPCL**- *C. gariepinus* reared in Earthen Pond; **TTCL**- *C. gariepinus* reared in Tarpaulin Tanks; **PTCL**- *C. gariepinus* reared in Plastic Tanks; **CTHT**- *H. longifilis* reared in Concrete Tanks; **EPHT**- *H. longifilis* reared in Earthen Pond; **TTHT**-*H. longifilis* reared in Tarpaulin Tanks; **PTHT**- *H. longifilis*reared in Plastic Tanks. Bars ± SD.

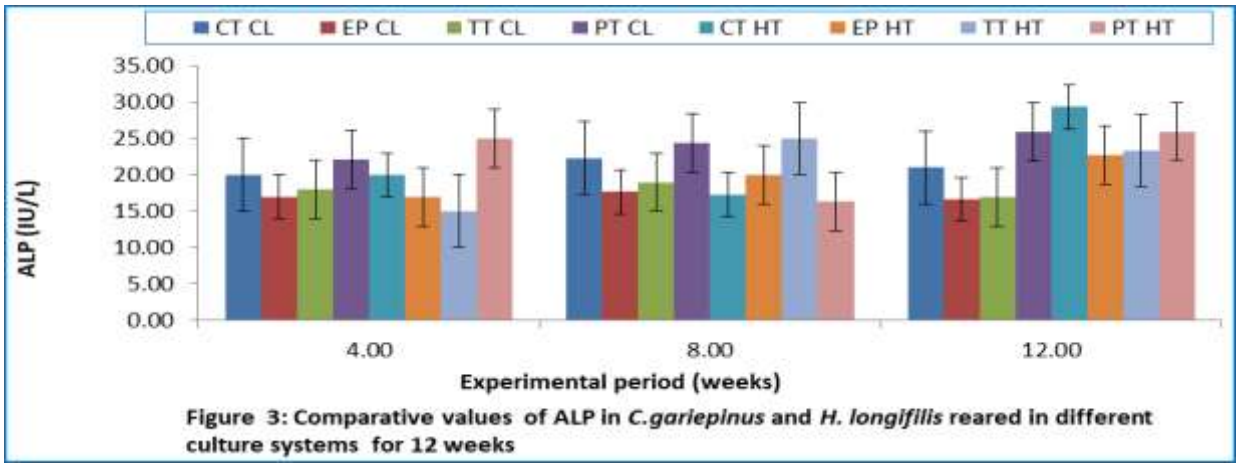

Figure 3: Comparative values of ALP in *C.gariepinus* and *H. longifilis* reared in different culture systems for 12 weeks

Key: CTCL- *C. gariepinus* reared in Concrete Tanks; **EPCL**- *C. gariepinus* reared in Earthen Pond; **TTCL**- *C. gariepinus* reared in Tarpaulin Tanks; **PTCL**- *C. gariepinus* reared in Plastic Tanks; **CTHT**- *H. longifilis* reared in Concrete Tanks; **EPHT**- *H. longifilis* reared in Earthen Pond; **TTHT**-*H. longifilis* reared in Tarpaulin Tanks; **PTHT**- *H. longifilis*reared in Plastic Tanks. Bars ± SD.

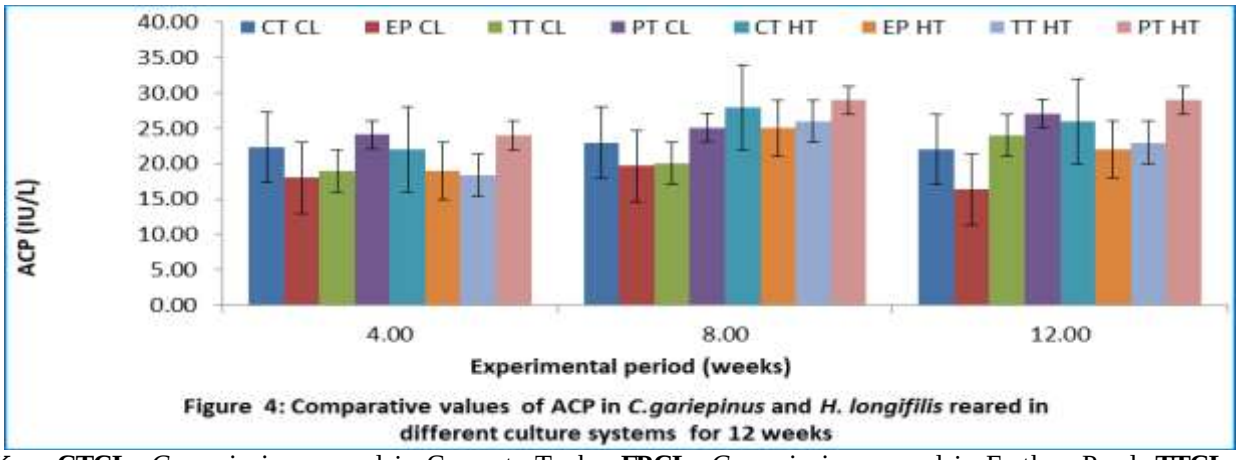

Figure 4: Comparative values of ACP in *C.gariepinus* and *H. longifilis* reared in different culture systems for 12 weeks

Key: CTCL- *C. gariepinus* reared in Concrete Tanks; **EPCL**- *C. gariepinus* reared in Earthen Pond; **TTCL**- *C. gariepinus* reared in Tarpaulin Tanks; **PTCL**- *C. gariepinus* reared in Plastic Tanks; **CTHT**- *H. longifilis* reared in Concrete Tanks; **EPHT**- *H. longifilis* reared in Earthen Pond; **TTHT**-*H. longifilis* reared in Tarpaulin Tanks; **PTHT**- *H. longifilis*reared in Plastic Tanks. Bars ± SD.

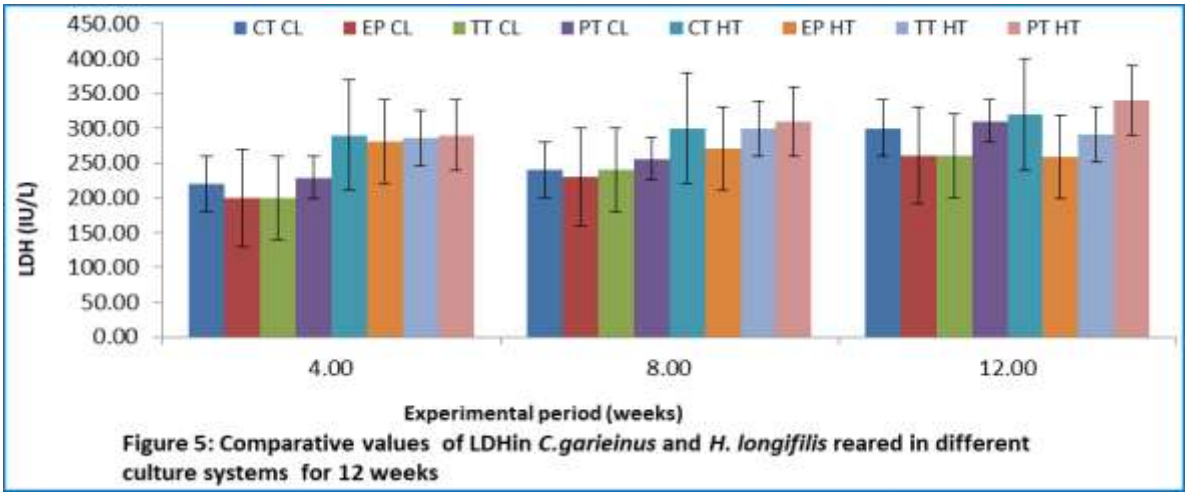

Figure 5: Comparative values of LDHin *C.garieinus* and *H. longifilis* reared in different culture systems for 12 weeks

Key: **CTCL**- *C. gariepinus* reared in Concrete Tanks; **EPCL**- *C. gariepinus* reared in Earthen Pond; **TTCL**- *C. gariepinus* reared in Tarpaulin Tanks; **PTCL**- *C. gariepinus* reared in Plastic Tanks; **CTHT**- *H. longifilis* reared in Concrete Tanks; **EPHT**- *H. longifilis* reared in Earthen Pond; **TTHT**-*H. longifilis* reared in Tarpaulin Tanks; **PTHT**- *H. longifilis*reared in Plastic Tanks. Bars ± SD.

4, DISCUSSION

Enzyme analysis is widely used for rapid detection and prediction of early warning of chemical toxicity in organisms. Enzyme analysis of organs such as kidney, liver in fish can provide important information about any change that occurs in an organism (Somaiah *et al*., 2015). Enzyme activities affect various chemical and biological reactions in the body of fish. A shift in the activities of enzyme from the control is also used as a relevant stress indicator (Lakshmaiah, 2016). Enzymatic activities also provide quick screening methods for assessing the health of fish and can be used to determine the incipient lethal concentration of a toxicant. Therefore, estimating enzyme activities in an organism can be identified as a disturbance in metabolism processes in the system of the organism (Ravindran *et al*., 2012). Amino transferases are widely accepted for their significance in protein metabolism by virtue of their ability to control both synthesis and degradation of amino acids. Alterations in the aminotransferase activities are often associated with changes in several other metabolic functions and thus represent widespread alterations in the organism's physiological state. Aspartate amino transferase (AST) and Alanine amino transferase (ALT) are two essential enzymes mainly involved in the inter-conversion of important compounds such as pyruvate, oxaloacetate, α-ketoglutarate and amino acids thus bringing the protein and carbohydrate metabolism on one hand and aspartate, alanine and glutamic acid on the other hand (Remia *et al*., 2008).

Transaminase play an important role in breakdown of protein to free amino acids which may be used as energy source for glyconegenic pathways or used to synthesis new proteins to repair damaged tissues. So, change in plasma free amino acid levels indicates either an increase or a decrease in protein catabolism or biosynthesis. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are found in the liver, heart, skeletal muscle, kidney, pancreas, spleen, erythrocyte, brain and gills (Jawad *et al*., 2004). When diseases or injuries affect these tissues, the cells are destroyed and these enzymes are released into the plasma (Kavitha *et al*., 2010). In this study, ALT and AST increased more in the fish raised in concrete and plastic tanks. This elevation may be due to increase in reactive oxygen species (ROS). Jones (2002) showed that effects of stress offish in the culture medium can impair the function of the liver in fish, during this process, reactive oxygen species (ROS) are generated. The increase in intracellular levels of ROS may lead to lipid peroxidation resulting in an increased permeability of liver cell membrane. As a result, liver enzymes including AST and ALT are released into the plasma. Similarly, the generated ROS produced from the liver may damage other tissues such as gills, muscle, heart, kidney and spleen causing the leakage of enzymes into plasma. In this sense, if the cellular injury is chronic AST and ALT levels will remain elevated (Maule, 1994).

Acid phosphatase (ACP) and Alkaline phosphate (ALP) are important enzymes in fish physiological study. In the present study slight increases were observed in the values of ALP, and ACP in the serum of *C. gariepinus* and *H.longifilis* reared in concrete and tarpaulin tanks. Similar results were however observed in *Catlacatla* (Tilak *et al*., 2014), *Labeorohita* (Coles, 1986) and *Sarotherodon mossambicus* (Akhilender *et al*., 2014) raised in plastic and concrete tanks. Conversely, stressful aquaculture practices have been reported to affect enzyme profiles in fish (Akinrotimi *et al*., 2012). Ganeshwade (2011) observed that an increase of ACP, and ALP activities in fish stressed by low DO and high stocking density may reflect the use of excess hydrocarbons from amino acids to supply energetic demands. The rise in ACP and ALP in

stressed fish may indicate use of dietary amino-acids for growth as well as for compensatory energy demand as a response to the stressor. These enzymes have no other known functions in the blood other than to provide information about hepatic state and disorders. These disorders could be as a result of injury or liver disease. The injury could be caused by reactive metabolites, resulting from xenobiotic metabolism in the liver (Marigoudar *et al*., 2016). Also, the observed elevated levels of ALP may indicate an increase in the rate of phosphorylation and transport of molecules across the cell membrane, which may result to increased detoxification effects of the kidney and thus a possible stress on the kidney membrane that could cause cell injury (Vineet *et al*., 2008). The increases could also result in a shift in biosynthesis, mixed-function oxidase and energy metabolism pathways (Suneetha, 2012).

Lactate dehydogenase (LDH) is an enzyme that is involved in anaerobic pathway of carbohydrate metabolism. The increase of LDH activity is a diagnostic index widely used to recognize increases of anaerobic metabolism resulting from depletion of energy under anaerobic and environmental stress conditions. The increase of LDH activity can be attributed to the conversion of accumulated pyruvate into lactate which is transported through muscle to hepatopancreas and regenerated glucose and glycogen to supply energy in fish exposed to stress (Trezando *et al*., 2006; Susan *et al*., 2014). In other words, the increase of LDH activity in liver and muscle reflects a possible improvement in tissue glycolytic capacity as observed in this study.

CONCLUSION

All the enzymes activities in both species reared in different enclosures were elevated, this was more pronounced in the fish reared in plastic and concrete tanks than other rearing enclosures.

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