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COMPARATIVE ANALYSIS OF THE NUTRITIONAL COMPOSITION OF *Clarias gariepinus* FROM A LENTIC AND LOTIC FRESHWATER ECOSYSTEM

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ABSTRACT

Water quality has been considered a major factor in fish meat quality. The objective of the study was to determine the effects of different water quality sources on the nutrient composition of Clarias gariepinus from Ikpoba Reservoir and Owan River. Physico-chemical parameters of water samples, proximate and mineral contents of the fish collected from both locations from February 2018 to January 2019 were determined as outlined by standard methods. Results showed that the Ikpoba Reservoir is highly polluted with low dissolved oxygen content and high nitrate, phosphate, iron, zinc and copper contents; while nitrate, phosphate, iron, zinc and copper contents are low with elevated dissolved oxygen content in Owan River. The moisture, protein, lipid, ash and mineral contents in Clarias gariepinus were significantly (p < 0.01) influenced by the prevailing water conditions of the study locations. Clarias gariepinus obtained from Owan River had moisture (68%), protein (16.52%) and lipid (7.18%) contents that were significantly higher than the moisture (61%), protein (15.15%) and lipid (6.03%) contents in Clarias gariepinus from Ikpoba Reservoir. Protein and lipid contents showed positive correlation with water dissolved oxygen content. Clarias gariepinus obtained from Ikpoba Reservoir has significantly higher contents of ash, iron, zinc, calcium, sodium and copper in comparison to fishes from Owan River. This study has broadened the knowledge on effect of water quality on the nutritional composition of fish meat, thereby assisting in determining the suitability of different aquatic ecosystems for the production of quality fish meat.

Keywords: Nutritional Composition, *Clarias gariepinus*, Water Quality.

INTRODUCTION

Fishes are one of the important and cheapest source of animal protein and essential nutrients needed in human and animals' diets (Sadiku and Oladimeji, 1991; Adeniyi *et al.,* 2012). Its abundance, palatability and wide acceptance among consumers confers an advantage on fish meat over other animal sources (Holma and Maaleku, 2013). The quality of water is considered the main factor in fish quality, which affects the fish normal health and reproductive performance (Balogun, 2015). The nutritional composition of fish muscles have been reported to be influenced by exogenous factors such as water quality, seasonality and feed availability for the fish (Varljen *et al*., 2003; Fanuel *et al*., 2017). The nutritional composition of freshwater fishes has been found to differ between geographical localities (Zenebe *et al.,* 1998), and throughout the year due to significant fluctuations and environmental changes in the aquatic habitat which affect their proximate and mineral composition (Olsson *et al.,* 2002). Although several nutrient composition studies have been carried out on various fish species from different aquatic habitats in Nigeria (Adewumi *et al.,* 2014; Enuneku and Adelusi, 2015; Job *et al.,* 2015; Olopade *et al*., 2016; Egun and Oboh, 2022), there is paucity of research literature which have attempted to relate the nutritional quality of fish populations in different freshwater systems to the prevailing water quality.

Association analysis, using a selection of sites with very similar habitat but a wide range of water quality, would provide a useful approach to determining the quantitative relationships between fish nutritional status and water quality (Mainstone and Gulson, 1990). River systems are known to undergo self-purification because of their lotic nature, but this is different for reservoirs which are lentic, and are known to accumulate/concentrate pollutants which get into them. Therefore, the choice of Ikpoba Reservoir and Owan River as locations for this study in ascertaining the effects and suitability of the different ecosystems in the production of nutritious fish meat. Also, *Clarias gariepinus* was selected for this study due to its consumer preference and commercial importance.

MATERIALS AND METHODS

Description of Study Locations: This study was carried out at the Ikpoba Reservoir (Latitudes 006°22'50" N and 006°22'43" N and Longitudes 05°38'36" E and 05°38'46" E) situated in Benin City and Owan River (Latitudes 006° 45' 36.5" N to 006° 45' 52.8" N and Longitudes 05° 45' 40.6" E to 05°46' 21.8" E) in Owan Village Edo State. Ikpoba Reservoir was established in 1977 as a result of the impounding of Ikpoba River by a weir, which separates the downstream from the upstream sections of the river. The reservoir is about 3 km long and 0.6 km wide, and covers a total surface area of about 1.1 million m^2. It impounds 1.5 million m^3 of water at full capacity (Akujieze, 2004). The Owan River transverses through several rural communities and serves as a source of commercially important fish species to the artisanal fishing households and the agrarian communities.

Collection of Water and Fish Samples: Water and fish samples were collected monthly (February 2018 to January 2019) from both locations. The water was collected into duplicate sterile sample bottles, stored in ice chest, and transported to the laboratory for analysis.

Samples for dissolved oxygen (DO) determination were collected in plain glass bottles, fixed in the field using 0.1 ml each of Winkler solutions A and B and determined titrimetrically in the laboratory using the Azide modification technique of the Winkler method (APHA, 2012). Samples for biochemical oxygen demand (BOD) were collected in amber 250 ml reagent bottles and taken to the laboratory for a five-day incubating period before analysis using the Winkler's method. The fish samples were harvested with the assistance of artisanal fishermen and properly identified using taxonomic guide (Idodo-Umeh,2003). The samples were packed in polyethylene bags and preserved in ice blocks before transported to the Benin Owena River Basin Authority/ University of Benin Analytical laboratory for analysis.

Sample Preparation: In the laboratory, the fish samples were thoroughly washed with distilled water to remove any adhering contaminants and drained under folds of filter paper. The fish samples were dissected and fish fillets were collected along the lateral line. All collected fillet samples were washed with distilled water, packed in polythene bags and stored in a deep freezer at 18 °C prior to analysis. For analysis, fillet samples were homogenised and subsamples of the homogenate were taken for respective analytical tests.

Analytical Methods: Collected water samples were analyzed for physico-chemical parameters following appropriate quality assurance and quality control standard protocol (APHA 2012). Fish samples were subjected to proximate and mineral content analysis as described by AOAC (2010) and Reksten *et al*. (2020).

Data analysis or Statistical analysis: All statistical analysis were computed using Microsoft® Office Excel 2013 version and Statistical Package for Social Sciences (SPSS) version 21. Independent T- test ($p < 0.01$) was used to compare the means of the proximate composition of *C. gariepinus* from the two water bodies. Pearson's correlation analysis was used to determine relationship between proximate and mineral composition of fishes and water quality parameters. The data are presented as means ± SD per 100 g of the three composite fish samples and reported to the same units of expression.

RESULTS

Table 1 shows the mean physico-chemical content of water from the two study locations. Owan River had higher pH and dissolved oxygen (DO) content; while water from Ikpoba Reservoir recorded higher amount of biochemical oxygen demand (BOD_5), nitrate, phosphate, iron, zinc and copper. Table 2 shows the analytical results of the proximate and mineral composition of *C. gariepinus* from the two water sources. Significant higher moisture and protein contents were recorded in *C. gariepinus* samples from Owan River, while significant higher contents of ash, iron, zinc, calcium, sodium and copper were recorded for fish samples from Ikpoba reservoir ($p < 0.01$).

Table 1: Mean Physico-chemical parameters from Ikpoba Reservoir and Owan River February 2018 to January 2019

Parameter	Ikpoba Reservoir	Owan River	*p* -Value	FMEnv. Limits
	Mean ± SD	Mean ± SD		
pH	5.87 ± 0.07^a	6.13 ± 0.10^b	$p < 0.05$	6.5 – 8.5
DO (mg/L)	4.57 ± 0.17^a	6.57 ± 0.13^b	$p < 0.01$	7.5
BOD_5 (mg/L)	4.17 ± 0.13^b	1.89 ± 1.34^a	$p < 0.05$	5.0
Nitrate (mg/L)	16.23 ± 0.45^b	4.79 ± 0.48^a	$p < 0.05$	10
Phosphate (mg/L)	3.85 ± 0.13^b	1.77 ± 0.13^a	$p < 0.05$	5.0
Iron (mg/L)	0.90 ± 0.09^b	0.27 ± 0.02^a	$p < 0.01$	0.3
Zinc (mg/L)	1.47 ± 0.17^b	0.42 ± 0.04^a	$p < 0.05$	3.0
Copper (mg/L)	1.28 ± 0.04^b	0.36 ± 0.04^a	$p < 0.05$	1.0

Note: $p < 0.01$ – Highly Significant Difference; $p < 0.05$ – Significant Difference; $p > 0.05$ – No Significant Difference. Similar superscript indicates no significant difference, dissimilar superscript indicates significant difference across rows.

Table 2: Proximate and mineral content of *Clarias gariepinus* from Ikpoba Reservoir and Owan River February 2018 to January 2019.

Parameter	Ikpoba Reservoir	Owan River	*p* -Value
	Mean ± SD	Mean ± SD	
Moisture (%)	61.09 ± 3.81^a	68.00 ± 1.41^b	$p < 0.01$
Protein (%)	15.15 ± 0.40^a	16.52 ± 0.70^b	$p < 0.01$
Lipid (%)	6.03 ± 0.25^a	7.18 ± 0.47^a	$p < 0.01$
Ash (%)	4.58 ± 0.29^b	3.56 ± 0.40^a	$p < 0.01$
Iron (mg/kg)	74.34 ± 6.73^b	48.37 ± 3.17^a	$p < 0.01$
Zinc (mg/kg)	31.63 ± 3.01^b	20.50 ± 2.06^a	$p < 0.01$
Calcium (mg/kg)	51.28 ± 5.15^b	34.32 ± 5.96^a	$p < 0.01$
Sodium (mg/kg)	48.68 ± 2.82^b	43.59 ± 2.50^a	$p < 0.01$
Copper (mg/kg)	9.24 ± 1.53^b	5.06 ± 0.62^a	$p < 0.01$

Different superscript across row (Mean±SD) indicate significant difference ($p < 0.01$)

Association analysis using Pearson correlation (r = 0.05) was used to determine the relationships between the nutritional composition of *C. gariepinus* and water quality from both study locations (Tables 3 and 4). Protein content correlated positively with dissolved oxygen and negatively with phosphate, zinc and copper levels in water. Lipid content showed positive correlation with dissolved oxygen, and negative correlation with phosphate and iron levels in water. While ash content correlated positively with iron and copper; and negatively with dissolved oxygen. The mineral contents in *C. gariepinus* showed positive correlation with the mineral contents in the water bodies.

Table 3: Correlation table of *Clarias gariepinus* from Ikpoba Reservoir with Water Physico – chemical parameters.

	Moisture	Protein	Lipid	Ash	Fe	Zn	Ca	Na	Cu
pH	0.27	- 0.05	- 0.08	- 0.07	- 0.14	- 0.25	- 0.24	0.11	- 0.01
DO	0.28	0.15	0.16	- 0.19	- 0.16	0.01	- 0.04	0.20	0.03
BOD	- 0.47	- 0.04	- 0.24	0.32	0.30	0.30	- 0.17	0.21	- 0.21
Nitrate	- 0.27	- 0.02	- 0.30	- 0.22	0.35	- 0.20	- 0.35	0.22	- 0.18
Phosphate	- 0.42	- 0.28	- 0.37	- 0.47	0.30	- 0.27	- 0.40	0.33	- 0.33
Iron	- 0.41	- 0.01	- 0.22	0.22	0.17	0.05	0.04	0.07	- 0.30
Zinc	- 0.26	- 0.17	- 0.34	0.44	- 0.03	0.38	- 0.40	0.23	- 0.38
Copper	- 0.02	- 0.41	- 0.14	0.12	- 0.02	0.09	0.32	- 0.39	0.13

Correlation is significant at the 0.05 level (two-tailed)

Table 4: Correlation table of *Clarias gariepinus* from Owan River with Water Physico – chemical parameters.

	Moisture	Protein	Lipid	Ash	Fe	Zn	Ca	Na	Cu
pH	0.25	- 0.17	- 0.34	- 0.01	- 0.19	- 0.04	0.50	- 0.27	0.30
DO	- 0.04	0.30	0.14	- 0.32	- 0.24	0.40	- 0.27	0.43	- 0.18
BOD5	0.06	- 0.01	0.06	- 0.06	0.19	-0.07	0.10	- 0.10	0.30
Nitrate	- 0.33	- 0.32	- 0.03 ’	- 0.06	- 0.03	0.38	- 0.27	0.40	- 0.32
Phosphate	- 0.10	- 0.25	- 0.14	0.01	- 0.12	0.08	0.08	- 0.14	- 0.07
Iron	0.04	- 0.07	- 0.13	0.22	0.40	- 0.02	0.10	- 0.09	0.01
Zinc	- 0.15	- 0.28	- 0.01	0.11	- 0.34	0.20	0.03	0.12	- 0.10
Copper	- 0.15	- 0.21	- 0.05	0.27	- 0.14	0.06	0.12	- 0.02	0.15

Correlation is significant at the 0.05 level (two-tailed)

DISCUSSION

From the results of the study, the elevated levels of certain physico-chemical parameters recorded in Ikpoba Reservoir as compared to Owan River and the permissible limits for surface water (FMEnv., 2007) is an indication that the lentic water body is exposed to high influx of pollutants from anthropogenic activities within the reservoir watershed. As study on the water quality of the reservoir reported that the water body is highly polluted (Egun and Oboh, 2022). While the elevated dissolved oxygen levels and below permissible limit values of nitrate, phosphate, iron, zinc and copper in Owan River is indicative of minimal influence of anthropogenic activities on the River. Also, Egun and Oboh (2023) reported that Owan River is slightly polluted.

Freshwater fishes generally contain protein content in the range of 16 – 20% of their wet weight (Ninan, 2003; Babji et al., 2015). The mean protein content of *C. gariepinus* from Owan River (16.52%) indicate that it has an adequate protein content. However, the protein content of *C. gariepinus* from Ikpoba Reservoir (15.15%) was slightly below 16%, which implies that its protein content is inadequate. Fishes are classified based on their lipid content. The lipid content of *C. gariepinus* from Ikpoba Reservoir (6.03%) and Owan River (7.18%) classifies them as intermediate (2 – 8 % total fat), which implies that they are good sources of fish oils (European Food and Safety Authority, 2005).

The results of the nutritional composition of *C. gariepinus* samples were significantly influenced by the prevailing water conditions of Ikpoba reservoir and Owan River. As the low levels of pollutants and the lotic nature of Owan River relative to Ikpoba Reservoir positively influenced the moisture, protein, and lipid content of fish from Owan River. Significantly higher contents of ash, iron, zinc, calcium, sodium and copper were recorded in fishes from Ikpoba Reservoir when compared to fishes from Owan River. This could be attributed to the higher levels of these mineral elements in the water of Ikpoba Reservoir. According to Fanuel *et al.* (2017), the concentration of minerals in the harvest waters influences the content of those minerals in the habitat fish.

In this study, the observed differences in the nutritional composition of fish from the two ecosystems can be attributed to the influence of their varying concentrations of physico-chemical parameters on the fish physiology. The lentic nature of Ikpoba Reservoir and high level of pollution caused by municipal and industrial effluents from the surrounding urban centres, resulted in the decreased the concentration of dissolved oxygen and higher amounts of nitrates and phosphates in the water. While the self-cleansing ability of the Owan River improved it water quality. Consequently, the nutritional composition of *C. gariepinus* from the Ikpoba Reservoir was negatively affected.

CONCLUSION

This study has broadened the knowledge on the proximate and mineral composition of *Clarias gariepinus* under different aquatic ecological conditions. The effect of water quality on the nutritional composition of fish meat has been clearly demonstrated. *Clarias gariepinus* obtained from the Ikpoba Reservoir which is highly polluted had significantly inferior nutrient composition when compared to *C. gariepinus* obtained from Owan River. Information provided in this study will assist in the determination of the suitability of different aquatic ecosystems for the production of quality fish meat.

AUTHORS CONTRIBUTION

ENK and IPO designed the study; ENK and OCU experimented and collected the data. ENK analysed the data and wrote the draft of the manuscript. All authors approved the manuscript for submission.

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