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Proximate and selected heavy metal composition of crabs from Tagwai reservoir Minna, Nigeria

Abstract

This study conducted in Tagwai Reservoir, Minna, Nigeria from April to September, 2024 focused on the assessment of proximate and selected heavy metals composition of crabs. The specimens were identified using morphometric characters and Google lens, while proximate and heavy metals compositions were determined based on standard procedures. Fifty two (52) individual species were collected. Two species of crabs of the same genus; *Sudanonautes africanus* and *Sudanonautes floweri* were identified. *S. africanus* was more abundant (76%) than *S. floweri* (24%). The results of proximate composition of specimens obtained in April revealed that the crude fibre (9.75%) and ash contents (30.62%) of *S. floweri* were significantly different ($p<0.05$). Crude protein (21.65%), fats (6.85%) and carbohydrate (37.68) contents of *S. africanus* were significantly different. The results obtained in September indicated that the crude fibre (8.32%), ash content (25.37%) and carbohydrate (39.38%) of *S. floweri* were significantly different while moisture content (5.86%), crude protein (19.76%) and fats (4.66%) of *S. africanus* were significantly different. Heavy metal components analyse showed that Lead was not detected. Zinc (17.73%) and Manganese (4.45%) detected in *S. floweri* were significantly higher. The concentrations of Cu, Zn, Fe and Mn detected in these species are within the acceptable ranges for consumption by relevant organizations. The results have indicated that there are two predominant species with high protein and carbohydrate contents. It is recommended that the consumption of *S. africanus* should be encouraged for its higher protein and carbohydrate contents while considering *S. floweri* for its fibre benefits.

Keywords: Crabs, proximate composition, heavy metals, Tagwai reservoir and seasonal variations

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Introduction

Seafood consumption plays a significant role in human nutrition, particularly in developing countries like Nigeria. It provides a rich source of essential protein, vitamins, minerals, omega-3 fatty acid and polyunsaturated fatty acids (PUFAs), all crucial for maintaining good health.[1] Decapods are an order of crustaceans within the class Malacostraca, and include crabs, lobsters, crayfish, shrimps and prawns. Decapods are omnivorous and act as scavengers, they eat both plants and animal's materials.[2] The order is estimated to contain nearly 15,000 extant species in around 2,700 genera with around 3,300 fossil species; and nearly half of these species are crabs, with the shrimp (about 3,000 species) and Anomura including hermit crabs, porcelain crab, squat lobsters (about 2500 species) making up of the bulk of the remainder.[3]

Crabs are decapod crustaceans of the infra-order Brachyura, which typically have very short projecting "tail" (abdomen) usually entirely hidden under the thorax. They live in all the world's oceans, fresh water and on land. Crabs are generally covered with a thick exoskeleton and have a single pair of pincers. Many other animals with similar names such as hermit crabs, king crabs, porcelain crabs, horseshoe crabs, and crab lice are not true crabs. Crabs are mostly marine, although some freshwater and brackish water forms are occupying the littoral, supra-littoral and even up shore zones, they have been found at 580 to 6000m to seas shore and are dominant in many estuarine habitats where salinity and temperature can fluctuate dramatically daily.[4]

Heavy metals are defined as metallic elements with a specific gravity greater than 5g/cm³. They include elements such as mercury (Hg), cadmium (Cd), lead (Pb), arsenic (As), copper (Cu), zinc (Zn), and chromium (Cr), among others.[5] These metals can enter aquatic ecosystems through various natural and anthropogenic sources, including geological weathering, industrial effluents, agricultural runoff, and atmospheric deposition.[6] The study of heavy metals in crabs is of significant importance due to their potential impact on both ecosystem health and human consumption safety. Crabs, as benthic organisms, play a crucial role in aquatic food webs and are widely consumed by humans, making them important bioindicators of environmental pollution and potential vectors for heavy metal transfer to humans.[7] Crabs, due to their feeding habits and habitat preferences, are particularly susceptible to heavy metal accumulation. They are often in direct contact with sediments, where many heavy metals tend to concentrate, and their diet may include smaller organisms that have already bioaccumulated these contaminants.[8] Heavy metals do not accumulate uniformly in crab tissues. Digestive glands (hepatopancreas) and gills often show higher concentrations compared to muscle tissue.[6]

Crabs are one of the aquatic species found in the reservoir that provide a substantial amount of protein and are an important source of income for the local community. They are found in brackish and fresh waters in Nigeria, they are of great importance to human health due to their richness in essential lipids, proteins, and other nutrients such as minerals, vitamins and omega-3 fatty acid, a daily nutrient requirement recommended by the American Health Association which helps in brain development and gives protection against stroke and heart diseases.[9] The nutritional value of crabs has gained increasing attention in recent years due to their high-quality protein content, essential amino acids, and various minerals.[10] Understanding the proximate composition of crabs is essential for assessing their nutritional quality, potential health benefits, and applications in the food industry. Moreover the nutritional value of crabs, determined by their proximate composition including the moisture, protein, fat, ash,

and carbohydrate content, is essential for assessing their role in the diet of the local community. Also, crab species are known to exhibit significant variations in their proximate composition. For instance, a comparative study by Arulkumar *et al*.[11] found notable differences in protein, lipid, and ash content among four portunid crab species from the southeast coast of India and also, different parts of the crab (such as claw meat, body meat, hepatopancreas) can have varying proximate compositions. Although crabs are an essential part of many people's diets, little is known about their proximate composition or the extent of heavy metals contamination in the Tagwai Reservoir. The available species of crabs and their associated health risk factors have been sparingly assessed in the past to have comprehensive data for policy making and proper management strategies. The study on the proximate composition is vital for understanding the nutritional value of crabs. Given that crabs are widely consumed in the region, it is essential to provide comprehensive data on their nutritional contribution to the local diet, which is currently lacking. Crabs may accumulate toxic heavy metals and these poses serious health risks to consumers, making it vital to assess their contamination level in crabs from Tagwai Reservoir. This study, therefore, provides baseline information on heavy metals contamination, proximate and species composition of the crabs found in Tagwai Reservoir.

Materials and methods

Study area

Tagwai Reservoir has a total surface area of 44 hectares and storage capacity of 28.3 million m3 of water. It has highest depth of 25m and a length of 18 Km. The reservoir was constructed in 1980 on longitude 60°39'to 60o44'East, and latitude 34o to 90o 39'North to South-West of Minna. The vegetation in the area is typically grass dominated savannah with scattered tree species.

Sample collection

Fifty-two (52) samples of freshwater crabs were collected from the study location, Tagwai Reservoir between April and September, 2024. The live specimens were either hand- picked or pulled out of their holes. The collected samples were placed in an ice-pack before they were transported to the Department of Animal Biology Laboratory of Federal University of Technology, Minna, Niger State for preservation and further analysis. Crab samples harvested were identified and classified using pictorial, diagnostic, morphological features such as colour of the body parts, external features, shapes of the carapace and dorsal surface a described by Thomas *et al*.[12] Google lens app was also used for confirmation.

Determination of proximate composition

Proximate chemical composition analysis was determined using standard procedures according to Association of Official Analytical Chemists, AOAC.[13] Moisture, ash, fat, crude fibre and protein contents were analyzed using the oven, the Soxhlet, the Kjeldahl and furnace methods, respectively.

Acid digestion of samples and analyses of heavy metals

One (1) g of each sample was digested using a mixture of 3:1 concentrated Nitric acid and concentrated per-chloric acid. The mixture was heated at 200°C in a digestion tube until the sample clarified. Distilled water was then added and it was filtered and finally made up to 50mL. Atomic Absorption Spectroscopy (AAS) technique was used to quantify the concentration of specific heavy metals in the crab sample by measuring the absorption of light at characteristic wavelengths of each element. The elements were detected at these wavelengths: Pb (405.781nm), Cu (324.754nm), Zn (213.857nm), Fe (371.993nm) and Mn (403.076nm).

Data analyses

Data obtained from proximate composition and heavy metal concentration of the crabs encountered were subjected to one-way Analyses of Variance (ANOVA), and were considered significant at 95% confidence intervals. The mean was separated using Duncan multiple range test where significant.

Results

Collection and identification of crab

Fifty-two (52) crab samples were collected, which were different in colourations. *Sudanonautes africanus* and *Sudanonautes floweri* were the identified species of the freshwater crabs from Tagwai Reservoir belonging to the family Brachyura (True crabs). Abundance of *Sudanonautes africanus* indicated 76% and *Sudanonautes floweri*, 24% which shows that *Sudanonautes africanus* is more abundant in Tagwai Reservoir (Table 1).

Table 1 Abundance of Freshwater Crabs Encountered in Tagwai Reservoir from April to September, 2024

Species identified	Number of species	% Abundance
Sudanonautes africanus	40	76
Sudanonautes floweri	12	24

Proximate composition of freshwater crabs sampled in April and September

The results of proximate composition of freshwater crabs obtained from Tagwai Reservoir in April revealed that the moisture content between the two species were not significantly different ($p>0.05$). However, crude fibre (9.75%) and ash content (30.62%) of *S. floweri* were significantly different while, crude protein (21.65%), fats (6.85%) and carbohydrate contents of *S. africanus* were significantly different (Table 2).

Table 2 Mean ± Standard deviation of proximate composition of freshwater crabs sampled in April, 2024 from Tagwai Reservoir

Proximate composition (%)	Sudanonautes floweri	Sudanonautes africanus
Moisture Content	3.50±0.14^a	3.20±0.14^a
Crude fibre	9.75±0.07^a	9.00±0.14^b
Crude protein	20.14±0.03^b	21.65±0.21^a
Ash content	30.62±0.01^a	22.43±0.52^b
Fat content	6.05±0.21^b	6.85±0.07^a
Carbohydrate content	30.81±0.76^b	37.68±0.06^a

Mean values in the same row followed by the same superscript are not significantly different ($P>0.05$).

The results of proximate composition of freshwater crabs obtained from Tagwai Reservoir in September showed that the crude fibre (8.32%), ash content (25.37%), and carbohydrate (39.38%) contents of *S. floweri* were significantly different ($p<0.05$) while the moisture content (5.86%), crude protein (19.76%) and fats (4.66%) contents of *S. africanus* were significantly different ($p<0.05$) (Table 3).

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Table 3 Mean ± Standard deviation of proximate composition of freshwater crabs sampled in September, 2024 from Tagwai Reservoir

Proximate composition (%)	Sudanonautes floweri	Sudanonautes africanus
Moisture Content	5.56±0.01[b]	5.86±0.05[a]
Crude fibre	8.31±0.01[a]	7.88±0.02[b]
Crude protein	17.23±0.03[b]	19.76±0.08[a]
Ash content	25.37±0.08[a]	23.66±0.02[b]
Fat content	4.25±0.04[b]	4.66±0.010[a]
Carbohydrate content	39.38±0.04[a]	38.34±0.010[b]

Mean values in the same row followed by the same superscript are not significantly different (P>0.05).

Selected heavy metal components of crab species obtained from Tagwai Reservoir from April to September, 2024

The result of selected heavy metal components of freshwater crabs obtained from Tagwai Reservoir during the study period revealed that Lead was not detected; and Iron and Copper detected in the two species (*S. floweri* and *S. africanus*) were not significantly different (p>0.05) during the study period. However, Zinc (17.73%) and Manganese (4.45%) found in *S. floweri* were significantly higher (p<0.05) than those detected *S. africanus* (Table 4).

Table 4 Mean ± Standard Deviation of selected heavy metals components of Crabs in Tagwai Reservoir from April to September, 2024

Elements (mg/100g)	Sudanonautes floweri	Sudanonautes africanus
Pb	0.00±0.00a	0.00±0.00a
Zn	17.73±0.64a	12.96±0.84b
Fe	13.54±0.30a	11.46±1.78a
Cu	1.32±0.09a	1.11±0.04a
Mn	4.45±1.54a	3.41±0.27b

Mean values in the same row followed by the same superscript are not significantly different (P>0.05). KEYS: Pb; Lead, Zn; Zinc, Fe; Iron, Cu; Copper, Mn; Manganese.

Discussion

Greater numbers of *S. africanus* were encountered in comparison with the abundance of *S. floweri* in Tagwai Reservoir; probably because of habitat preference of one over another. The abundance of the crab species were probably not affected by the water quality parameters since Mohammed *et al.*[14] reported that the water parameters from the same location were within acceptable range for drinking with the exception of transparency and water hardness. This result aligns with other studies on freshwater crab populations in West Africa. For instance, Cumberlidge *et al.*[15] reported that *S. africanus* is widely distributed across West African freshwater ecosystems and often dominates local crab populations. In like manner, Lawal-Are and Kusemiju[16] stated that *S. africanus* are the most dominant species in freshwater ecosystems across Nigeria due to its ability to withstand fluctuations in environmental condition.

The proximate compositions of both crab species in April (peak of dry season) and September (wet season) revealed seasonal variations in their nutritional contents. In April, there was no significant difference in moisture content between the two species. However, in September, *S. africanus* showed significantly higher moisture content (5.86%) compared to *S. floweri* (5.56%). This seasonal variation in moisture content is consistent with the finding of Adebayo *et al.*[17] who observed fluctuations in the moisture content of freshwater crabs across different seasons. Crude Protein contents in *S. africanus* consistently showed higher crude protein content in both April (21.65%) and September (19.76%) compared to *S. floweri*. This high protein content may be attributed to food preference of this species; since it is known that, animal-based foods tend to have higher crude protein levels, often 15-30%, while plant-based foods range from 5-25% crude protein.[18] This finding suggests that *S. africanus* might be a better source of protein for human consumption. The protein content observed in this study is comparable to that reported by Elegbede and Fashina-Bombata[19] for other freshwater crab species in Nigeria with (24.38%) crude protein content in *Callinectes pallidus*. Crude fibre content in *S. floweri* exhibited higher values in both April (9.75%) and September (8.31%) compared to *S. africanus*. This higher fibre content could be attributed to differences in the dietary habits or physiological characteristics of the two species.[20] Ash Content in *S. floweri* showed significantly higher ash content in both April (30.62%) and September (25.37%) compared to *S. africanus*. This higher ash content suggests that *S. floweri* might be a better source of minerals. Similar variations in ash content among different crab species have been reported by Omotayo *et al.*[21] Fats and Carbohydrates contents in *S. africanus* consistently showed high values in both months. However, carbohydrate content varied, with *S. africanus* having higher levels in April and *S. floweri* in September, respectively. These fluctuations could be related to seasonal changes in food availability or reproductive cycles.[22]

Aquatic decapods are a rich source of mineral element such as calcium (Ca), potassium (K), sodium (Na), iron (Fe), zinc, and copper, vitamins, and macronutrients such as carbohydrate, protein, and lipids.[23] This study analyzed some heavy metals present in the crab samples. While no significant differences were found in Fe and Cu levels between the two species, *S. floweri* showed significantly higher levels of Zn (17.73mg/100g) and Mn (4.45mg/100g) compared to *S. africanus.* Since these two elements are essential in living organisms for various biological pathways and processes it probably suggests the suitability of the crab species in the diets of human population especially at developmental stages. The absence of detectable Pb in both species is a positive finding from a food safety perspective. The higher zinc content in *S. floweri* could be beneficial from a nutritional standpoint, as zinc is an essential trace element. However, excessive zinc intake can have adverse health effects.[24] The manganese levels, which was higher in *S. floweri*, are within the range typically found in crustaceans.[25]

Conclusion

Two predominant species of crabs from Tagwai Reservoir; *Sudanonautes africanus* and *Sudanonautes floweri* were identified and they both belong to the same genus and the family Potamidae. The relative abundance (%) of *S. africanus* is higher than *S. floweri*. The proximate composition analyses revealed that in April, S. africanus had higher crude protein and carbohydrate levels, while *S. floweri* had higher crude fibre and ash contents. By September, the moisture contents of *S. africanus* increased, while *S. floweri* continued to show higher crude fibre levels. The assessment of heavy metals indicated that iron and copper levels were not significantly different between the species. Lead was not detected in this research. *S. floweri* had higher zinc and manganese concentrations than *S. africanus*.

Recommendations

Consumption of *S. africanus* for its higher protein and carbohydrate contents while considering *S. floweri* for its fiber benefits should be

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encouraged for healthy diet. Regular monitoring of heavy metal levels in the Tagwai Reservoir should be conducted to ensure the safety of seafood consumption. Education of local communities on the nutritional benefits and potential risks associated with consuming crab species should be conducted on routine basis.

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None.

Conflicts of interest

We declare that there is no conflict of interest of any kind.

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