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Proteins, Lipids And Minerals Composition Of Eight Fish Species From Cameroon Rivers And Ponds

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Abstract
Environmental factors can promote adaptive differences among fish populations, with local adaptation as a consequence. Diversity of such a population is governed by gene flow, limited genetic variation, temporal fluctuations, or developmental constraints. We use the macro and micronutrient content to investigate differences between fish species from Cameroon rivers and ponds. A total of eight fish species were collected, including four from the Wouri River, two from the Nyong River, and two from Yaoundé ponds. The samples were carried to the laboratory under cool conditions, and sequentially, each fish was cleaned, gutted, trimmed, dried in an oven at 60 degrees and ground to obtain the flour, kept in a fresh area for analysis of minerals with atomic absorption spectrophotometer, crude proteins and lipids, as well as protein fractions following adapted methods. Results show that fish species can be classified into several groups when considering a particular mineral content. The same tendency was recorded while considering the crude protein, the protein fractions, as well as the total lipid content. Of all the fish species from this study, are of good nutritive quality can be used to feed people facing food difficulties, whether particular or general. This study allows us to advice combination of species following the nutrients content to overcome food difficulties.

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I. Introduction

As the world's population explodes to almost 10 billion in 2050, world leaders and scientists are challenged to feed the growing population, concentrated in developing countries and characterized by hunger and malnutrition (UN 2022). Globally, between 800 million people are undernourished, with 50% in Asia and 30% in Africa (WFP and WHO 2022). Furthermore, about 150 million children are involved, 45 million are wasted, and over 2 billion people have micronutrient deficiency (WFP and WHO 2022). In addition, the triple burden of malnutrition, undernutrition, obesity and micronutrient deficiencies is the biggest contributor to poor health worldwide (Obiero et al., 2019). Despite the Sustainable Development Goal initiated by the United Nations with interesting outcomes, queries exist, like how to improve the production and distribution of nutrient-dense food. Fish is a nutrient-dense food that is cheap and commonly available even in countries with food and nutrition insecurity (Lauria et al., 2018; Cleaver, 2006). It is well known for its high nutritional quality with a very good supply of readily digestible proteins, polyunsaturated fatty acids, essential minerals and micronutrients such as iron, calcium, zinc, selenium, iodine, vitamin A, B and D (Fawole et al., 2007; Kawarazuka and Bene, 2011; Pirestani et al., 2009; Reksten et al., 2020). These minerals are essential for biochemical functions of the organism and includ calcium, phosphorus, and magnesium support bone development whereas zinc is necessary for reproductive health. Fish consumption is generally associated with good health as studies have shown that high fish intake reduces chances of getting cardiovascular diseases and regulates blood sugar levels, leading to better weight control and less chances of getting high blood pressure and type II diabetes (Mendivil, 2021). The fisheries and aquaculture sectors in Africa are increasingly contributing to food and nutrition security, foreign exchange, employment, and livelihood support services (De Graaf and Garibaldi, 2014). Globally, there is a believe that total fishery production in the region stands at 10.4 million tonnes comprising of 6.0 million tonnes from marine capture fisheries, 2.8 million tonnes from inland water fisheries, and about 1.6 million tonnes from aquaculture (AUC-NEPAD 2014). Currently, more than 30% of the continent's population, or roughly 200 million people, consume fish as the main animal protein source and micro nutrition (AUC-NEPAD 2014). Besides, 12.3 million people in Africa work in the fisheries and aquaculture sector, with 6.1 million (50%) being employed as fishers, 5.3 million (42%) as processors and 0.9 million (8%) as fish farmers (De Graaf and Garibaldi, 2014). Although this resource is of vital use in solving problems of malnutrition and undernourishment, knowledge of its nutritional potential remains insufficient. The main goal of this study carry a comparative analysis of eight fish species from the Cameroon region, focusing on their proteins, lipids, and mineral contents.

II. Material And Methods

Study site, sample collection and treatment

A total of eight fish species were collected including four from the Wouri river at the Youpwe market (4.00928 latitude, 9.70141 longitude), two from the Nyong River (3.510005 latitude, 11.505456 longitude) and two from ponds in Yaoundé (latitude 3.782069, longitude 11.531930) and (latitude 3.864652, 11.548533 longitude) (Table 1). Selected species were based on the availability and food habits of the population locally. The river fish was collected from the fishermen at the end of the fishing when they reached the coast. Those from the ponds are collected directly to the owners of the farms. The samples were arranged by species in plastic buckets. An exchange between us and the fishermen allows us to set the price by species, proceed to the payment and then take the buckets to the laboratory for pre-treatment and processing. Sequentially each fish was cleaned, gutted, trimmed, dried and grinded to obtain the flour for each species. The flour was kept in fresh area for various analysis.

Table 1: Diversity of fishes and origin.

Fishes	Origin
Clarias gariepinus (**Catfish**)	Pond
Oreochromis niloticus (**Tilapia**)	Pond
Parachanna obscura (**Obscure snakehead**)	River
Heterotis niloticus (**African bonytongue**)	River
Pentanemus quinquarius (**Royal threadfin**)	River
Sarotherodon mossambicus (**Mosambica tilapia**)	River
Pseudotolitus typus (**Longneck croaker**)	River
Chrisichtys nigrodigitatus (**Bagrid catfish**)	River

Proximate composition

The lipid content of fish floor samples was evaluated by the weight difference after extraction in hexane solvent (Folch et al., 1957). Crude protein was estimated after mineralisation of the sample in hot sulphuric acid and nitrogen titration following (Devani et al., 1989). The crude protein was then estimated with the following formula: nitrogen x 6.25.

Protein's fractions

The solubility in different extraction solutions as directed by Osborne fractionation was used to obtain protein fractions (Osborne, 1924; Dias et al. 2023). Fish flour was first defatted, and sequentially undergo extraction with distilled water, 1 M NaCl solution, 70% ethanol, and 0.05 M NaOH at 25ºC for 1 h in each solvent, at the rate of 1:10 (flour/solvent). The mixture was maintained at each step in constant stirring (120 rpm). The supernatant (protein fractions) at each stage in the sequence were decanted by centrifugation (500g, 10 min, 4ºC), and the pellet was re-suspended in the subsequent solvent. The sequential extraction process generated the Osborne fractions: albumin-rich, globulin-rich, prolamin-rich, and glutelin-rich. The inclusion of the suffix "-rich" acknowledges the potential co-extraction of various protein classes in the fractions as no further purification was performed following extraction and decanting. Protein quantification was performed in each fraction following the Bradford dying methods, and the concentration was used to calculate the proportion of protein fraction.

Minerals Content

The samples' mineral content (Na, Ca, Mg, K) was evaluated following the method described by AOAC (2006). Flour samples were first mineralized in hot sulfuric acid until complete, and the mineral titration was determined by atomic absorption spectrophotometer (Shimadzu UNICAM 919, England).

Statistical analysis

Mean values for three measurements were taken and subjected to analysis of variance (ANOVA) using GraphPad Instat software to determine whether or not differences between values were significant. P-values < 0.05 was considered statistically different.

III. Results And Discussion

Mineral content

Table 1: mineral content of eight fish species from ponds and rivers. (n=5)

Fish	Na (mg/100g)	K (mg/100g)	Mg (mg/100g)	Ca (mg/100g)
H. niloticus	69.92^{b}	101.75^{fg}	43.75^{a}	249.66^{f}
P. obscura	51.73^{a}	89.67^{e}	56.26^{b}	225.16^{e}
S. mosambicus	79.29^{d}	102.42^{g}	87.56^{e}	193.48^{b}
P. quinquarius	74.69^{c}	69.85^{d}	75.50^{d}	200.03^{c}
P. typus	74.59^{c}	69.7 5^{d}	100.03^{f}	175.00^{a}
C. nigrodigitatus	79.19^{d}	42.19^{a}	75.33^{d}	212.50^{d}
O. niloticus	88.45^{e}	49.86^{b}	75.33^{d}	212.46^{d}
C. gariepinus	70.64^{e}	54.81^{c}	68.75^{c}	212.46^{d}

H. niloticus =Heterotis niloticus, P. obscura = Parachanna obscura, S. mossambicus = Sarotherodon mossambicus, P. quinquarius = Pentanemus quinquarius, P. typus = Pseudotolitus typus, C. nigrodigitatus = Chrisichtys nigrodigitatus, O. niloticus = Oreochromis niloticus, C. gariepinus = Clarias gariepinus.

The mineral contents of eight freshwater and pond fish species from Cameroon are presented in Table 1. The results show that calcium is the primary mineral largely recorded in the studied fish species, with concentrations greater than 150 ppm. Its content ranges from 175.03% to 249.66 % for *P. typus* and *H. niloticus*, respectively.

Although all fish species accumulate magnesium with a rate lower than 100 ppm, its concentration ranges from 43.75 to 100.03 ppm for *H. niloticus* and *P. typus*, respectively. The species *P. quinquiarius, O. niloticus, C. nigrodigitatus*, and *C. gariepinus* accumulate magnesium at the same rate.

The sodium content of the fish species ranges from 51.73 to 88.45 ppm for *P. obscura*, and *O. niloticus*, respectively. The species *H. niloticus*, *S. mossambicus*, *P. quinquiarius*, *P. typus*, *C. nigrodigitatus*, and *C. gariepinus* accumulate sodium with a concentration ranging from 69 to 70 ppm.

The potassium content ranges from 42.19 to 102.42 ppm in the studied species *C. nigrodigitatus* and *S. mossambicus*, respectively. *S. mossambicus* and *H. niloticus* have the same cumulative mode of this mineral. The same observation is also record for *P. quinquiarius* and *P. typus* species.

Crude Protein, lipids and Protein fractions

Table 2: protein and lipid content of eight fish species from ponds and rives. (n=5)

Fish	Proteins (%)	Glutelin (%)	Globulin (%)	Prolamin (%)	Albumin (%)	Lipids (%)
H. niloticus	30.46^{c}	1.64^{a}	1.76^{a}	2.79^{c}	6.06^{h}	13.10^{e}
P. obscura	71.44^{f}	2.86^{e}	1.76^{a}	3.06^{d}	2.65^{a}	13.29^{e}
S. mossambicus	30.01^{c}	2.55^{d}	3.28^{e}	3.25^{e}	4.16^{e}	11.04^{d}
P. quinquarius	65.19^{e}	2.14^{c}	2.77^{d}	2.81^{c}	3.91^{d}	4.38^{a}
P. typus	18.88^{a}	1.78^{b}	2.65^{c}	2.15^{a}	3.15^{b}	14.33^{f}
C. nigrodigitatus	28.46^{b}	6.63^{f}	2.39^{b}	2.75^{c}	3.53^{c}	9.98^{c}
O. niloticus	54.25^{d}	2.94^{e}	2.39^{b}	2.40^{b}	5.80^{g}	8.86^{b}
C. gariepinus	70.64^{f}	2.93^{e}	2.39^{b}	3.41^{f}	5.05^{f}	21.70^{g}

H. niloticus =Heterotis niloticus, P. obscura = Parachanna obscura, S. mossambicus = Sarotherodon mossambicus, P. quinquarius = Pentanemus quinquarius, P. typus = Pseudotolitus typus, C. nigrodigitatus = Chrisichtys nigrodigitatus, O. niloticus = Oreochromis niloticus, C. gariepinus = Clarias gariepinus.

The total protein, four protein fractions, and total lipid contents of eight freshwater and pond fish species from Cameroon are presented in Table 2. Statistical analysis of the result showed that fish species significantly ($p < 0.05$) affected the content of the various studied parameters. The results show that the total protein content ranges from 18.88 to 71.44% for *P. typus and P. obscura*, respectively. Overall, fish species with high protein content, such as *P. obscura*, *P. quinquiarius*, *C. gariepinus*, and *O. niloticus*, can be distinguished from those with low protein content, such as *H. niloticus, S. mossambicus, P. typus*, and *C. nigrodigitatus*.

Total lipid contents range from 4.38 to 21.7% for *P. quinquiarius* and *C. gariepinus* species respectively. Based on the total lipid content, we can distinguish two groups of species, those with relatively high lipid content including *P. typus and P. obscura H. niloticus C. gariepinus*, and those with relatively lower lipid content including *O. niloticus, C. nigrodigitatus P. quinquiarius*.

Albumin content ranged from 2.65 to 6.06% for *P. obscura* and *H. niloticus*, respectively. Four fish species, including *H. niloticus, S. mossambicus, O. niloticus,* and *C. gariepinus*, produced more than 4% of albumin, and four other species, including *P. obscura*, *P. quinquiarius*, *P. typus*, and *C. nigrodigitatus*, have less than 4% albumin.

Glutelin content, on the other hand, ranged from 1.64 to 6.63% for *H. niloticus* and *C. nigrodigitatus*, respectively. The content of this protein fraction allows us to classify these species into two groups, including those with a content greater than 2%: *P. obscura*, *S. mossambicus*, *P. quinquiarius*, *O. niloticus*, *C. nigrodigitatus*, *C. gariepinus* and those with a content less than 2%: *H. niloticus* and *P. typus*.

The globulin content ranges from 1.76 to 3.28% for *H. niloticus* or *P. obscura* and *S. mossambicus*, respectively. Based on the content of this protein fraction, we can distinguish species with a content greater than 2% including *S. mossambicus*, *P. quinquiarius*, *P. typus*, *O. niloticus*, *C. nigrodigitatus*, *C. gariepinus* and species with a content less than 2% *H. niloticus* or *P. obscura*.

The prolamin content varies from 2.15 to 3.41% for the species *P. typus* and *C. gariepinus* respectively. Depending on the content of this protein fraction, we can distinguish species whose content is higher than 3% including *P. obscura*, *S. mossambicus* and *C. gariepinus*, and those whose content is lower than 3% such as *P. quinquiarius*, *P. typus*, *O. niloticus*, *C. nigrodigitatus*, *H. niloticus*.

Principal Component Analysis

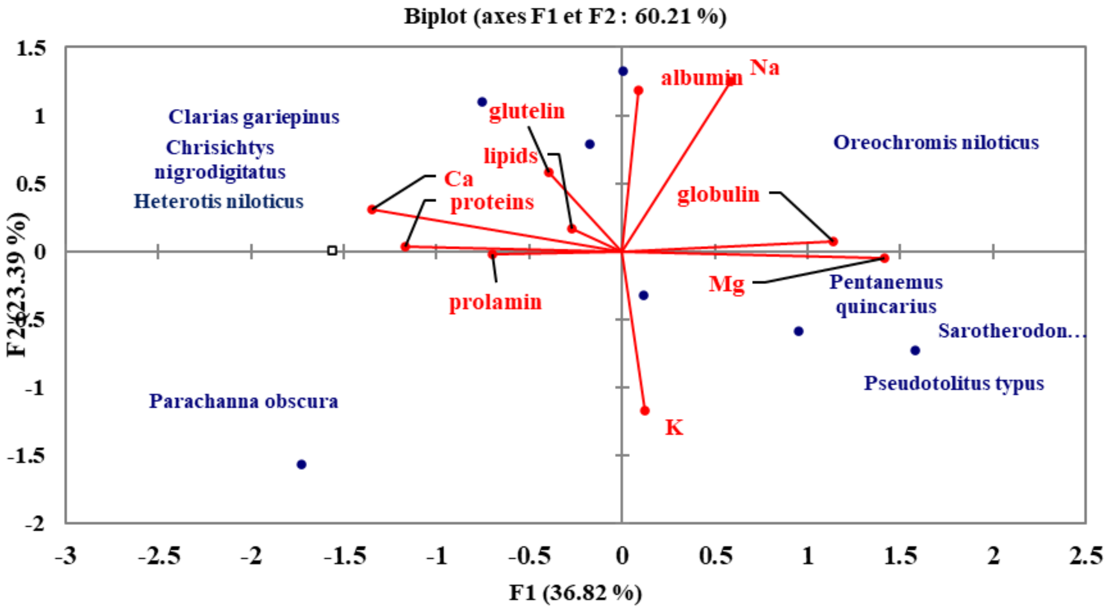

Figure 1: Principal Component Analysis

Principal component analysis of the data shows that the affinity with the ordinate axis (F2) is 23.39%, and the abcis axis (F1) is 36.82% (figure 1). This analysis allows us to classify the fish species into four groups as follows:

H. niloticus, *C. nigrodigitatus*, and *C. gariepinus*, which recorded the highest levels of total lipids and proteins, glutelin, and calcium.

O. niloticus, which recorded the highest levels of albumin, globulin, and sodium.

P. quinquiarius, *P. typus*, and *S. mossambicus*, which recorded the highest levels of magnesium and potassium.

P. obscura, which cumulate none of the studied nutrient with notice amount.

Discussion

In Africa, the growing contributions of the fisheries and aquaculture sectors to food and nutrition security, foreign exchange, employment, and livelihood support are increasingly noticeable (De Graaf and Garibaldi, 2014). This study reveals the distribution of minerals across the involved fish species. This observation falls in line with those from many studies which target fish species as a rich source of minerals, including sodium, potassium, calcium, magnesium, phosphorus, Sulphur, iron, manganese, zinc, copper, and iodine (Dana et al., 1985; Mohanty et al., 2015; Egun & Oboh, 2022). Moreover, the minerals accumulate in studied fish species depend on the type of mineral. Hence, large variations in Ca, Mg, Na and K compositions among species was recorded, with fish from rivers intercalating those from pond in regard of the concentrations. High variation in Ca and Mg minerals were observed previously within fish species in Zambia (Nolle et al., 2020). The concentration of Na and K is lower than Ca in this study. Those ions are important for intracellular ion balance and the maintenance of acid–base balance in the human body, even if the recommended daily intake is less than 2000 mg for Na and 3,510 mg for K (Eti et al., 2019; WHO, 2012a). Previous studies indicated that Na and K work in tandem in our body system, and food meals containing Na/K ratio of less than 1 is ideal for a good and healthy diet to significantly improve the mineral intake of the consumers (Ullah et al., 2022; Nolle et al., 2020). Such observation may be related to the growing environment including locations, trophic levels, and the genetic constitution of the investigated species like age and gender. The crude protein and lipid content in the investigated samples were shown to largely varied according to species, with the highest value recorded with *C. gariepinus* and the lowest with *P. typus* for protein and *P. quinquarus* for lipid. Such finding makes fish species highly suitable for food application especially for the development of protein-enriched food commodities. Many finding show that the protein contents differ with fish species involved due to obvious factors such as the effect of spawning, migration and food availability (Mahmud et al. 2019). Although the lipid content of our species is low compared to protein, they go up to 21% supporting the fact that fish oil especially omega-3 polyunsaturated fatty acids occupy enormous important roles in humans, prevent several diseases, contribute to the human health and nutritional improvement throughout the life (Islam et al. 2018). The protein and lipid contents of potential dried fish powders from those species are decent and the application in daily life food commodities will be the top notch to remove the low scale protein energy malnutrition. The crude protein content was the sum of all protein fractions in each fish species. Four fish protein fractions were recorded in each fish species, including glutelin, globulin, prolamin, and albumin, with variable concentration according to fish species. Both of them are credited with biological function in consumers' organisms. Albumins, always known as the most abundant plasma protein in animals, serve as carrier proteins and regulate blood volume by maintaining oncotic pressure in body fluids (Kovyrshina and Rudneva, 2012). Fish albumin is a bioactive protein useful for pharmacological applications and has become a commercial nutritional product (Chasanah et al., 2015a). Glutelin and prolamin were shown to influence the pasting properties of rice flours. Research is consistent with the fact that higher glutelin and globulin contents could compete with water molecules, reducing the availability of water, with the reduction of the viscosity peak (Martin, 2002; Baxter, 2014). Thus, the fish species studied is a potential source of food or ingredients able to improve the quality of the population's diet for optimal feeding. Principal component analysis of the data shows that three of the fish species studied including *C. gariepinus, H. niloticus, C. nigrodigitatus* are credited with the capacity of accumulating most of the nutrients, followed by *O. niloticus*, which accumulate three nutrients of all (Figure 1). Such observation provides basic information useful for the potential involvement of these fish in the diet of a given population in need of a general or specific diet.

IV. Conclusion

The main goal of this study was to compare eight fish species from the Cameroon region and highlight their proteins, lipids, and mineral contents. Depending on the mineral involved, fish species can be classified into several groups, whether they come from ponds or freshwater. The same observation is recorded, whether it is the content of total proteins or lipids, protein fractions. While consider the hole datas, the *O. niloticus* species is capable of accumulating two protein fractions which are globulin and albumin, followed by the species *C. gariepinus*, *C. nigrodigitatus* and *H. niloticus* which accumulates a protein fraction which is glutelin. It would be interesting to combine the fish studied in case we wish to use them to cover nutritional needs.

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