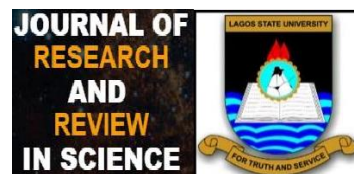


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DOI: [10.36108/jrrslasu/4202.11.0160](https://doi.org/10.36108/jrrslasu/4202.11.0160)**ORIGINAL RESEARCH**

Comparative Fatty Acids Compositions in *Coptodon zillii*, *Heterobranchus bidorsalis*, *Chrysichthys nigrodigitatus* and *Clarias gariepinus* found in Ojo Lagoon, Lagos, Nigeria

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Abstract:

Introduction: Species of *Coptodon zillii*, *Heterobranchus bidorsalis*, *Chrysichthys nigrodigitatus* and *Clarias gariepinus* are four of the most significant and popular fish species cultivated in the tropics due to their commercial and consumers' acceptability, thus there is need to study their fatty acids composition, being one of the most important nutrients in fish, and establish its effect on consumers.

Aims: To determine the species with the healthiest categories of fatty acids which could be used to support dieticians' recommendations for dietary inclusion.

Materials and Methods: The fish species were procured from Ojo landing site, Ojo, Lagos, stored in an ice chest at 4°C and conveyed to the Biochemistry and Pharmaceutical laboratory sections of the College of Medicine University of Lagos, Idi-Araba, Lagos, Nigeria, for fatty acid evaluation. The saturated, monounsaturated and polyunsaturated fatty acids were determined using gas chromatography method.

Results: There was no significant difference ($P=0.05$) in fatty acid compositions of all the species examined. The Polyunsaturated fatty acid/Saturated fatty acid ratios were above FAO recommended value of 0.4. The ratio ranges from *C. gariepinus* 0.4, to 1.95 in *C. nigrodigitatus*, 2.04 in *H. bidorsalis*, and 6.59 in *C. zillii*. It also shows that these species are rich in polyunsaturated fatty acids (PUFAs) such as eicosapentanoic acid (EPA), docosahexaenoic acid (DHA) and linoleic acid (LA).

Conclusion: The species are safe and healthy for consumption and can be incorporated into the diet by dieticians as a food material containing appreciable measures of healthy fats.

Keywords: Fatty acids, *C. zillii*, *H. bidorsalis*, *C. nigrodigitatus*, *C. gariepinus*, health.

All co-authors agreed to have their names listed as authors.

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1. INTRODUCTION

Nigerian waters are home to many fish species that the nation uses as food and source of revenue. Fish is one of the most nutrient-dense, delectable, and readily digestible foods. A significant portion of the population of the world, especially in developing nations, is very interested in it. It is preferable to hog, beef, and mutton because it is not constrained by culture or religion [1]. Nearly 80% of individuals in most affluent countries get less than 20% of their animal protein from fish, compared to an estimated 60% of people in many underdeveloped countries who depend on fish for more than 30% of their protein needs. Significant levels of beneficial fatty acids, such as omega 3 fatty acids, are also present in fish. Croakers, catfishes, tilapias, threadfin soles, and clupeids are a few of the most significant species, making up about 90% of Nigeria's fisheries [2]. Of the overall fish supply available to Nigeria, freshwater fish make up 69.6% of the total harvested fish [3]. Due to its tolerance for a wide range of temperatures, rapid development, adaptability to a variety of settings, as well as low oxygen and high salinity levels, African catfish (*Clarias gariepinus*) and tilapia (*Coptodon zillii*) have seen an increase in aquaculture in Nigeria [4].

Additionally, fish serves as a significant supplement to the diets of many Nigerians, who eat primarily carbohydrates [5]. A large number of essential amino acids are also present in fish, and specific amino acids, such as aspartic acid, glycine, and glutamic acid, are also recognized to be important in the process of wound healing [6]. Minerals and other micronutrients are found in fish. According to reports, micronutrients are crucial for boosting immune function and preventing or treating disease [7]. The texture, flavor, and look of fish in its fresh state are barely altered. Typically, processing techniques affect these traits, causing the fish's attributes to change in accordance with the method utilized [8].

The main elements of lipids are fatty acids. They are typically composed of chains of 14 to 24 carbon atoms with varying degrees of saturation in fish and other marine creatures [9]. Fish and human diets must include lipids as sources of fatty acids (FA) and energy [10]. Saturated, monounsaturated, and polyunsaturated fatty acids (PUFA) are the three main categories of fatty acids. The omega3 and omega6 polyunsaturated fatty acids have received special attention among the fatty acids. Eicosapentaenoic acid (EPA, C-20:5) and docosahexaenoic acid (DHA, C-22:6) are two polyunsaturated omega-3 fatty acids that are highlighted because they lower the risk of cardiovascular illnesses [11, 12]. Long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid, are abundant in fish lipids (DHA). Humans are unable to produce long chain, n-3 PUFA; they must instead receive them from diet [13]. Polyunsaturated fatty acids are known to control prostaglandin synthesis and hence promote wound healing [14, 15].

It has been reported that the polyunsaturated fatty acids (PUFA) -3 and -6 are beneficial for treating cancer and cardiovascular disease [16]. Therefore, it is crucial to increase the diet of fish and fish products that are high in polyunsaturated fatty acids for human health [17]. The content of PUFA in freshwater and marine fish can differ between species of fish [18]. Fatty acids like linoleic and linolenic acids, which are crucial for preventing skin illnesses, are regarded as essential in human diet because the body is unable to synthesize them. When compared to many vegetable oils, these fatty acids make up only a small portion of the total lipids in marine fish roughly 2%. However, in addition to linoleic and arachidonic acids, fish oils also include other "essential" polyunsaturated fatty acids that function similarly. They also promote children's neurological development. Danish researchers have reported a high proportion of eicosapentaenoic (C20:5) in the diet of a group of Greenland Eskimos who are essentially free from arteriosclerosis [17]. There is now strong evidence supporting the important roles that fish and fish oils play in reducing the risk of cardiovascular disease and enhancing fetal brain development [19]. According to [20], fish muscle is a major part of fish used for human consumption, and when fish is recommended as a way to improve health, its composition in fatty acids and amino acids should be taken into account. Fish lipids and proteins have been acknowledged as being advantageous for human health [19].

Additionally, food scientists and nutritionists want information on the content of fatty acids to help them with dietary formulation, processing, and product development [21]. It is crucial to ascertain both the lipid content and the PUFA distribution since the composition of these fatty acids can differ between fish species.

C. gariepinus, *H. bidorsalis*, *C. nigrodigitatus*, and *C. zillii* are four of the most significant and popular fish species in the temperate zone like Nigeria, and they were selected for this study because they are commercially feasible and well-liked by consumers. Additionally, they are the most widely cultivated fish in

tropical areas and the primary source of fish protein [22]. Their nutritional profile is still underrepresented in literature. Numerous studies have been conducted on the biology of tilapia species found in the Lagos lagoon [23, 24], their abundance in Lake Kainji [25], their abundance in Anambra River Basin 2 [26], and the fatty acids of smoked *C. gariepinus* in Northern Nigeria [27]. Therefore, in South-West Nigeria, where they are widely consumed, there is the need for exact data on the nutrient composition of these fish species. This study thus seeks to establish the different categories of fatty acids present in these fish species and to determine the species with the healthiest category of PUFA which could be used to support dieticians' recommendations for dietary inclusion to increase the consumption of healthy fatty acids and improve overall human health.

2. MATERIAL AND METHODS

2.1 Source of the study species

Ten samples of each species of fish (*C. gariepinus*, *H. bidorsalis*, *C. nigrodigitatus*, and *C. zillii*) were obtained from fish sellers at the fish landing site in Ojo, who deals with the sales of freshly caught fish from the freshwater habitat in Lagos. The sellers are located at Iyana Iba market, Ojo, Lagos.

2.2 Preparation of Sample

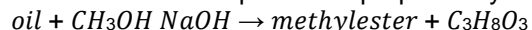
Each sample of the species (four treatments and three replicates) was carefully placed on the dissecting tray in the laboratory. A part of the flesh was then cut out of each species using a scalpel, the cut-out flesh was then placed in test tubes and refrigerated until it was time for analysis. The same procedure was carried out on the bone of each of the species.

2.3 Fatty Acids Determination

Fatty acids were quantified using gas chromatography (Model: 7890 GC system Agilent Technology, USA) and 5975C inert MSD with a triple-axis detector (Agilent Technology, USA). HP-5ms was used as a column in GC/MS (5%-diphenyl, 95%-dimethylpolysiloxane, 30 m x 0.250 mm ID x 0.25 μ m).

The temperature program was set up from 50 °C to 250 °C with 4 °C/min, both the injector and detector temperatures were 280 °C, and He was used as carrier gas. The injection volume was 2 μ L. Ionization energy EI of 70 eV was used for mass spectroscopy detector [28, 29, 30].

Clarias gariepinus, *Heterobranchus bidorsalis*, *Chrysichthys nigrodigitatus*, and *Coptodon zillii* samples were used. Oil samples were prepared by esterification according to the equation:



Ten (10) ml of oil sample was heated to 55 °C, added was CH₃OH/NaOH and the mixture was stirred for about 10 minutes. After the reaction, the solution was centrifuged to separate the layers. Samples of FAME were diluted with cyclohexane and prepared for GC analyses.

For calibration, a series of standard mixtures were prepared from AOCS Low Erucic Rapeseed Oil (Sigma-Aldrich) with analytical grade cyclohexane (Sigma-Aldrich) in the concentration of solution from 1.5 – 10 mg/mL. For quantification of FAME in selected oil samples, quantification by external standard was made in duplicate [28, 29, 30].

3. RESULTS AND DISCUSSION

The fatty acid composition of *C. zillii*, *H. bidorsalis*, *C. nigrodigitatus*, and *C. gariepinus* is presented in Table 1. The fats comprise of saturated, monounsaturated, and polyunsaturated fatty acids. In some species, the fatty acids show significant differences towards each other ($P < 0.05$), while some are not significantly different towards each other ($P > 0.05$). However, some fatty acids were not detected in some species such as Butyric acid in *C. gariepinus* and *C. zillii* as well as Octanoic acid in *H. bidorsalis*.

Table 1: Fatty acid composition of *C. gariepinus*, *H. bidorsalis*, *C. nigrodigitatus*, and *C. zillii* from Lagos Nigeria.

| Group name | <i>C. zillii</i> | <i>H. bidorsalis</i> | <i>C. gariepinus</i> | <i>C. nigrodigitatus</i> |
|---------------------------------------------------|-------------------------|-------------------------|-------------------------|--------------------------|
| Butyric Acid, Methyl Ester | NIL | 0.97±0.01 ^a | NIL | 1.13±0.01 ^b |
| Hexanoic Acid, Methyl Ester | 0.47±0.01 ^a | 1.48±0.00 ^b | 11.31±0.09 ^c | 4.61±0.05 ^d |
| Octanoic Acid, Methyl Ester | 0.09±0.00 ^a | NIL | NIL | 0.30±0.05 ^b |
| Decanoic Acid, Methyl Ester | 0.28±0.01 ^a | 0.38±0.01 ^b | NIL | 0.18±0.01 ^c |
| Undecanoic Acid, Methyl Ester | 0.02±0.00 ^a | 0.19±0.01 ^b | 0.11±0.00 ^c | 0.20±0.01 ^b |
| Dodecanoic Acid, Methyl Ester | 1.97±0.01 ^a | 1.67±0.01 ^b | NIL | 1.27±0.01 ^c |
| Methyl Myristate | 0.36±0.01 ^a | 0.30±0.00 ^b | 38.86±0.03 ^c | 0.48±0.01 ^d |
| Methyl Myristoleate | 0.62±0.01 ^a | 1.39±0.00 ^b | 0.08±0.00 ^c | 0.70±0.04 ^d |
| Pentadecanoic Acid, Methyl Ester | 3.74±0.01 ^a | 0.56±0.01 ^b | 0.04±0.01 ^c | 1.02±0.01 ^d |
| Palmitoleic Acid, Methyl Ester | 0.20±0.01 ^a | 0.66±0.00 ^b | 0.09±0.00 ^c | 0.60±0.01 ^d |
| Heptadecanoic Acid, Methyl Ester | 0.15±0.00 ^a | 0.11±0.00 ^a | 15.36±0.02 ^b | 0.29±0.01 ^c |
| Palmitic Acid, Methyl Ester | 1.21±0.00 ^a | 7.14±0.00 ^b | 0.49±0.00 ^c | 0.66±0.00 ^d |
| Linoleic Acid, Methyl Ester | 22.21±0.00 ^a | 33.41±0.10 ^b | 0.03±0.00 ^c | 23.07±0.07 ^d |
| Gamma-Linolenic Acid, Methyl Ester | 0.31±0.00 ^a | 0.87±0.01 ^b | 0.19±0.00 ^c | 0.27±0.01 ^a |
| Oleic Acid, Methyl Ester | 2.16±0.00 ^a | 8.47±0.00 ^b | 10.10±0.01 ^c | 6.63±0.07 ^d |
| Arachidonic Acid, Methyl Ester | 1.87±0.01 ^a | 0.72±0.00 ^b | 20.85±0.04 ^c | 0.28±0.00 ^d |
| Methyl Stearate | 0.97±0.01 ^a | 0.45±0.00 ^b | NIL | 0.81±0.01 ^c |
| 5,8,11,14,17-Eicosapentanoic Acid, Methyl Ester | 0.96±0.00 ^a | 1.37±0.00 ^b | 3.13±0.00 ^c | 1.46±0.01 ^d |
| 8,11,14-Eicosatrienoate | 53.56±0.01 ^a | 2.86±0.00 ^b | 0.14±0.00 ^c | 6.06±0.01 ^d |
| 11,14-Eicosadienoate | 2.67±0.00 ^a | 3.55±0.00 ^b | 0.19±0.00 ^c | 12.31±0.01 ^d |
| Methyl-11-Eicosenoate | 2.57±0.01 ^a | 3.77±0.00 ^b | NIL | 5.71±0.01 ^c |
| Arachidic Acid, Methyl Ester | 1.13±0.00 ^a | 5.29±0.00 ^b | 0.16±0.00 ^c | 3.36±0.01 ^d |
| Heneicosanoic Acid, Methyl Ester | 0.18±0.00 ^a | 0.54±0.00 ^b | 0.11±0.00 ^c | 1.60±0.01 ^d |
| 4,7,10,13,16,19-Docosahexanoic Acid, Methyl Ester | 0.36±0.01 ^a | 2.03±0.00 ^b | NIL | 3.63±0.01 ^c |
| 13-Docosenoic Acid, Methyl Ester | 0.07±0.00 ^a | 1.78±0.00 ^b | 0.11±0.00 ^a | 4.69±0.01 ^c |
| Docosanoic Acid, Methyl Ester | 0.50±0.02 ^a | 3.02±0.00 ^b | 0.04±0.00 ^c | 4.68±0.01 ^d |
| Tricosanoic Acid, Methyl Ester | 0.66±0.00 ^a | 2.32±0.00 ^b | NIL | 5.52±0.01 ^c |
| Methyl-13,16-Docosadienoate | 1.05±0.00 ^a | 8.80±0.01 ^b | 0.51±0.00 ^c | 7.37±0.01 ^d |
| Tetracosanoic Acid, Methyl Ester | 0.23±0.00 ^a | 6.39±0.00 ^b | 0.10±0.00 ^c | 1.13±0.01 ^d |

Mean values with different superscripts in the same row are significantly different ($P = 0.05$)

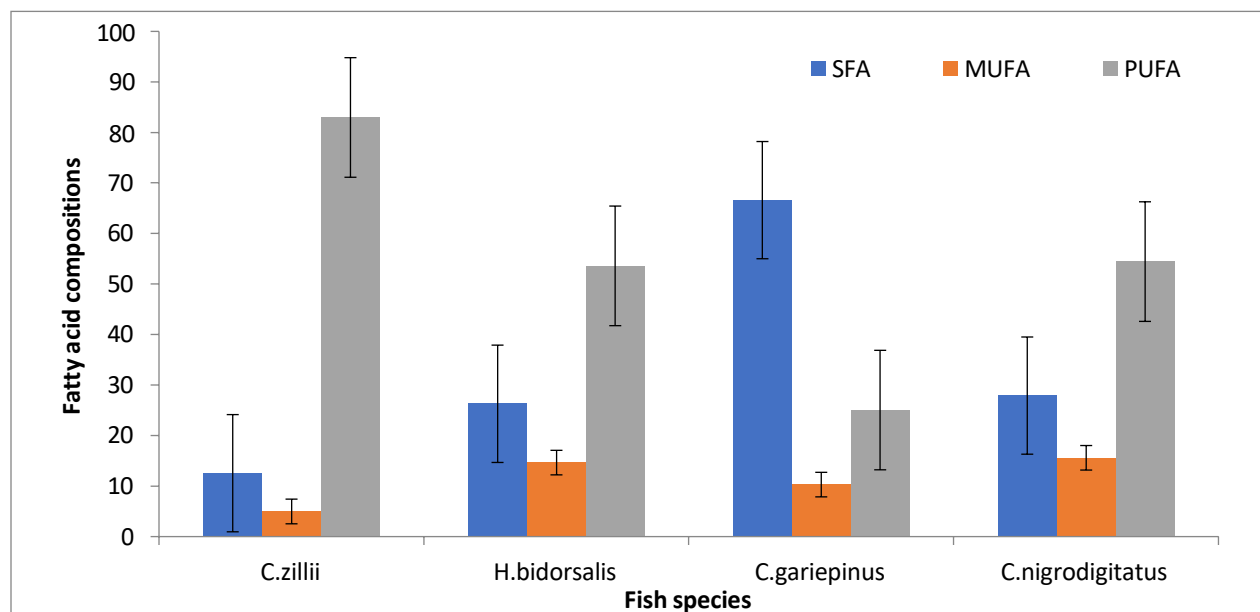


Fig. 1: Quality of fatty acid profile in *C. zillii*, *H. bidorsalis*, *C. nigrodigitatus* and *C. gariepinus*.

There was a significant difference ($P=0.05$) (four treatments and three replicates) in the PUFA of *C. zillii* compared with those of *H. bidorsalis*, *C. nigrodigitatus* and *C. gariepinus* respectively. No significant difference ($P=0.05$) was observed in the PUFA of *H. bidorsalis* and *C. nigrodigitatus*. *C. gariepinus* was low in PUFA. There was also a significant difference ($P < 0.05$) in the SFA of *C. gariepinus* compares with those of *C. zillii*, *H. bidorsalis* and *C. nigrodigitatus* respectively. *C. zillii* had the lowest MUFA concentration compared with *H. bidorsalis*, *C. nigrodigitatus*, and *C. gariepinus*.

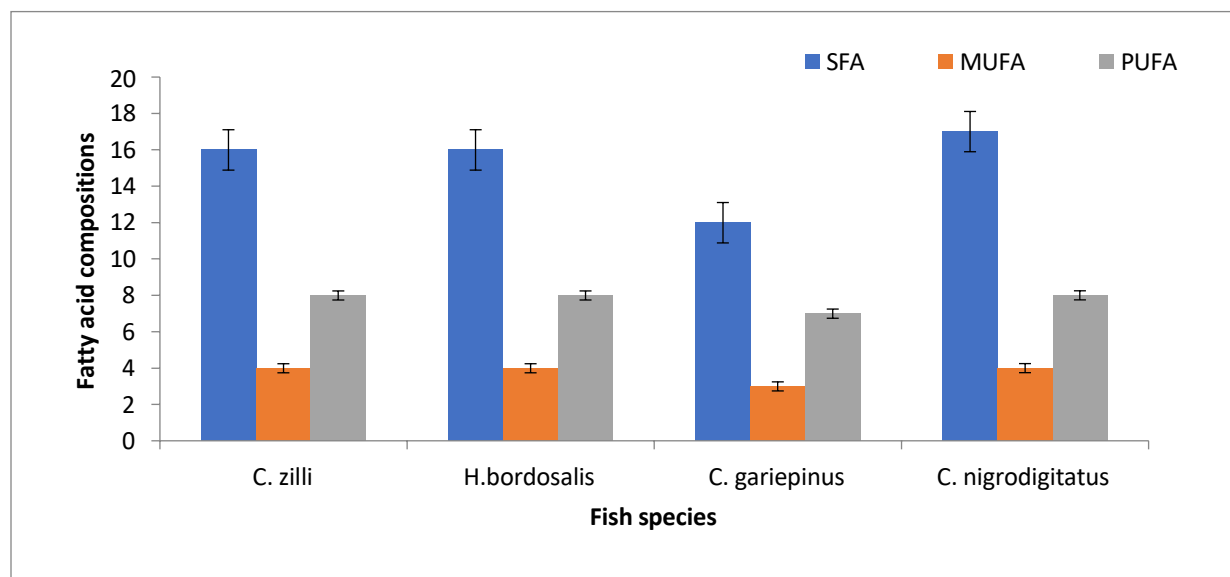


Fig. 2: Quantity of fatty acid in *C. zillii*, *H. bidorsalis*, *C. nigrodigitatus* and *C. gariepinus*.

The SFA was significantly ($P=0.05$) higher than MUFA and PUFA in all samples respectively. No significant difference ($P=0.05$) was observed in the PUFA of all four fish species while a slight difference was noticed in the MUFA of *C. gariepinus* compared to other species.

The fatty acid composition of the studied fish species increases in the order saturated < monounsaturated < polyunsaturated fatty acids. The major SFA revealed in this study were pentadecanoic acid in *C. zillii*, Tetracosanoic acid in *H. bidorsalis*, Methyl myristate in *C. gariepinus*, and Tricosanoic acid in *C. nigrodigitatus*. Stearic acid was not determined in any of the studied species, but palmitic acid was present in all with no significant difference. Studies have shown that palmitic and stearic acid are the major and dominant SFA in freshwater fishes [31, 2, 32, 33]. With its anti-inflammatory properties and capacity to support metabolic health, palmitic acid promotes skin health. Nevertheless, when it is consumed in excess compared to other healthy fats, it may raise the risk of cardiovascular disease. For the greatest benefits, it should be eaten in a ratio of monounsaturated to polyunsaturated fats [34]. Generally, it is believed that the consumption of SFA is associated with a high risk of coronary heart disease [35]. The WHO 2003 advised that the dietary intake of SFA should not exceed 10% of total energy consumption, to reduce the risk of cardiovascular disease and other heart-related diseases.

The result gathered from this study shows that *C. zillii* has an SFA composition of 12.58%, 26.31% in *H. bidorsalis*, 66.6% in *C. gariepinus* and 27.9% in *C. nigrodigitatus*. Özogul *et al.*, [36] noted that the percentage of SFA in fish ranges from 30.10% to 46.88%, which implies that these species are of low SFA composition, and this aligns with the provision of WHO, except for *C. gariepinus* with a relatively higher composition among the four species studied, and this also agrees with the result presented by [37, 38] Heptadecanoic acid, which is an odd chain fatty acids (OCFA's) associated with lower risk of adiposity, chronic inflammation, cardiovascular disease, pancreatic cancer and other conditions [39] was discovered in higher quantity in *C. gariepinus*, which makes it non discardable, but controllable in terms of SFA.

Monounsaturated fatty acids (MUFAs) have a significant impact on human health by lowering the body's level of low-density lipoprotein (LDL), which lowers the risk of coronary heart disease [40, 41]. In the present study, a total of 4 MUFAs (Palmitoleic acid, oleic acid, 13-Docosenoic Acid and Methyl-11-eicosanoids were detected in all, except for *C. gariepinus* which has 3 MUFAs (Palmitoleic acid, oleic acid and 13-Docosenoic Acid). Osibona [2] had earlier reported a similar number of MUFAs in four commercially important fishes in Lagos. Oleic acid was the most abundant MUFA recorded in *H. bidorsalis* followed by *C. zillii* and *C. nigrodigitatus* respectively. This agrees with the findings of [42, 43] on freshwater fishes. Oleic acid reduces blood pressure, lowers cholesterol, promotes fat burning by controlling the insulin, prevents type 2 diabetes, promotes skin repair, and prevents ulcerative colitis [44, 45, 46]. Palmitoleic acid is said to boost insulin sensitivity by reducing inflammation and preventing the degeneration of pancreatic beta-cells, which are known to release insulin [47]. MUFAs are good storage lipids preferentially used as energy sources and substrates for β -oxidation in fish [48, 49].

Polyunsaturated Fatty Acids (PUFAs) are well-known as crucial chemical elements in human diets that can offer many health benefits [31]. The PUFA contents in the studied species are higher than the MUFAs and were in line with the observations of [50]. However, other researchers have also shown that freshwater fish have lower contents of PUFA compared to MUFA [51]. Quantitatively, the number of PUFAs recorded in this study for *C. zillii* (82.99%), *H. bidorsalis* (53.61%), *C. gariepinus* (25.04%), and *C. nigrodigitatus* [54,45] was relatively higher than that of *C. gariepinus* (24.01%) [31]; *C. nigrodigitatus* (26.30%) and (11.62%) [37] and *C. zillii* (12.1%) [2]. Osman *et al.*, and Vleg [52, 53] have earlier reported higher values PUFAs ranging from 29.03 – 41.34% in fish species of Nigerian inland waters. A total of 4 (8, 11, 14- Eicosatrienoate, Arachidonic acid, Eicosapentanoic acid and 4, 7, 13, 16, 19-Docosahexanoic acid) omega3 fatty acids and 4 (Linoleic acid LA, Gamma-linolenic, 11, 14- Eicosadienoate and Docosadienoate) omega 6 fatty acids were recorded in this study. The major PUFA were linoleic acid, Eicosadienoate, Docosahexanoate (DHA) and Eicosapentanoate (EPA). Several other authors reported that linoleic, docosahexanoic acid, and eicosapentanoic acid as principal fatty acids in fishes [54, 55, 56, 42].

The omega-3 PUFAs such as EPA and DHA are essential biomolecules that when consumed improve the quality of life and reduce the risk of premature death of human beings. DHA is necessary for newborn brain development and growth as well as for adults' brains to function normally, while EPA has an impact on mood and behavior [57, 58]. The risk of coronary heart disease, high blood pressure, cancer, atherosclerosis, rheumatoid arthritis, lung diseases, and old age disorders like Alzheimer's disease, dementia, and age-related macular degeneration can be reduced with the use of EPA and DHA [59]. Regular consumption of omega-3 PUFAs can prevent the neurobehavioral disorder, attention deficit hyperactivity disorder, which is primarily caused by EPA and DHA deficiency and most frequently affects children and adolescents [60]. In addition to preventing asthma, hypertension, diabetes, cancer, and kidney

dialysis, PUFAs, according to [61], can help lower one's risk of developing an irregular heartbeat that can cause heart problems and sudden death. They also have the potential to inhibit the development or metabolism of these diseases in the body.

All the studied species contain an appreciable amount of important PUFAs. Arachidonic acid is a precursor for the manufacture of prostaglandin and thromboxane [62]. Moreover, it attaches to endothelial cells during wound healing and disrupts blood coagulation [63]. All biological cell membranes include a substance called arachidonic acid, which gives them fluidity and flexibility. This is notably true of the immunological, skeletal, and neurological systems [64].

One of the two naturally occurring essential fatty acids that humans need to get through diet is linoleic acid [65]. It is present in large amounts in all species except for *C. gariepinus*, which contains a few and according to [66], linoleic acid helps to promote reproductive, skin, heart, and bone health. The high proportions of essential omega-3 fatty acids such as EPA and DHA acid make them to be a better source of essential fatty acids which are of greater pharmaceutical importance since they are linked to reduced risk of cancer [67].

The European Food Safety Authority [68], recommended that EPA and DHA intake should range between 250 and 500 mg per day for primary cardiovascular protection. Several studies have shown that a low intake of omega-3 polyunsaturated fatty acids is associated with an increased risk of coronary heart disease and that eating fish and fish oils helps lower that risk [69, 70]. Moreover, these omega-3 fatty acids are crucial for the prevention of cancer, diabetes, hypertension, depression, allergies, and other diseases [71].

The PUFA/SFA ratio reveals the fats' quality according to [72]. The ratio of PUFA/SFA should be more than 0.4 for the fish species to be considered favourable. In the current study, the ratio of PUFA to SFA ranged from 0.4 in *C. gariepinus* to 1.95 in *C. nigrodigitatus*, 2.04 in *H. bidorsalis*, and 6.59 in *C. zillii*, showing that the species are good sources of PUFA, especially EPA, DHA, and LA. Thus, they were determined to be appropriate for inclusion in highly unsaturated low-fat diets and to favorably offer the amount of dietary essential fatty acids needed for effective human growth and development.

4. CONCLUSION

The major distribution of fatty acid content found in these species was discovered to be in line with findings in fish species from the majority of freshwater fishes around the world. Health-beneficial PUFAs such as EPA, DHA, and LA, were recorded in larger quantity across all species. The PUFA/SFA ratio which gives the fat quality of the fish was in good range, with *C. zillii* having the highest ratio and *C. gariepinus* having the least. All studied species have appreciable amounts of PUFAs, which make them healthy for consumption.

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COMPETING INTERESTS

Authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

AMH participated in the experimental design, collation, and interpretation of data; OOF participated in conducting the laboratory analysis, AOA and OOB participated in the interpretation of data and manuscript preparation; and overseeing execution of experimentation; MAS, MRA, GCS, and AOI participated in samples collection, experimentation and data collation. All authors read and approved the final manuscript.

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