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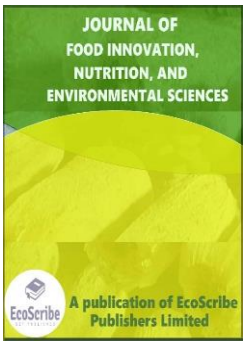

ORIGINAL RESEARCH ARTICLE

Comparison of Fatty Acid Profile and Lipid Quality Indices of Local Brackish Water Fish, and Imported Marine Fish Consumed in Benin

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ABSTRACT

In Benin, there is limited data on the nutritional composition of commonly consumed fish, particularly their fatty acid profiles. This study aimed to compare the fatty acid composition and nutritional lipid indices of brackish water fish (*Coptodon guineensis* and *Sarotherodon melanotheron*) harvested from acadjas with those of imported, frozen seawater fish (*Scomber scombrus* and *Trachurus trachurus*) consumed in Benin. Fatty acids were extracted from fish flesh (n=20) and analyzed using gas chromatography-mass spectrometry (GC-MS). Palmitic and oleic acids were the most abundant saturated (SFA) and monounsaturated fatty acids (MUFA), respectively. Marine fish contained significantly higher levels of oleic acid ($p<0.05$), while brackish fish had higher levels of arachidonic and linoleic acids (n-6 PUFA). Alpha-linolenic acid (ALA) was only detectable in brackish fish, whereas marine fish had significantly higher eicosapentaenoic acid (EPA) and similar docosahexaenoic acid (DHA) levels. The atherogenic index (AI) was highest in *S. scombrus* ($p<0.05$), suggesting possible cardiovascular risks with frequent consumption. These findings underscore the nutritional distinctions between locally sourced and imported fish and provide insight for dietary planning and food policy in Benin.

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1. INTRODUCTION

Fatty acids, particularly essential polyunsaturated fatty acids (PUFAs), play a crucial role in human health. Fish are one of the richest dietary sources of these fatty acids and also provide high-quality protein for a large proportion of the global population (FAO, 2014 and 2019; Çagiltay et *al*., 2015; Mesías et *al*., 2015). In Benin, fish consumption is met through a combination of locally harvested freshwater and brackish water species such as *Sarotherodon melanotheron*, *Coptodon guineensis*, and *Oreochromis niloticus* as well as imported frozen marine fish including Atlantic mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) (El Ayoubi and Failler, 2013; Achoh et *al*., 2018).

The nutritional value of fish is largely influenced by their fatty acid composition, especially the balance of omega-3 (n-3) and omega-6 (n-6) PUFAs, which have been associated with reduced risk of cardiovascular diseases and other chronic conditions (Weintraub, 2013; Lovegrove & Griffin, 2013; Al-Reza and *al*., 2015). Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), both n-3 PUFAs, are known for their protective roles in cardiovascular health, neurodevelopment, and inflammatory disorders (Schneedorferová et *al*., 2015; Nurjanah et *al*., 2016). Cardiovascular diseases are a growing public health concern in Benin. They are the leading cause of cardiology consultations, with an estimated prevalence of 27.5% and an absolute cardiovascular risk of nearly 35% at national referral centers (WHO, 2016; Sonou et *al*., 2017). Given this context, increasing the intake of n-3-rich fish could serve as a preventive nutritional intervention. However, data on the fatty acid composition and nutritional quality indices of fish commonly consumed in Benin especially a comparison between local and imported species remain limited.

Globally, several studies have examined the lipid and fatty acid profiles of both freshwater and marine fish species (Osman et *al*., 2001; Farhat and Abdul, 2011; Homayooni et *al*., 2014; Schneedorferová *et al*., 2015; Tenyang et *al*., 2016), often with the aim of evaluating nutritional benefits through PUFA ratios or lipid health indices. While food safety and nutrition regulations have been taken from similar assessments in other countries, Benin currently lacks such standards or data-driven guidelines regarding essential fatty acids in fish.

Although previous research in Benin has explored the microbiological safety and sensory properties of fish (Wabi, 2010; Degnon *et al*., 2013; Chabi *et al*., 2014; Kpodekon et *al*., 2014; Assogba et *al*., 2018a; b; c; d), there is a clear knowledge gap concerning their fatty acid composition and lipid quality indices. Therefore, this study aims to assess and compare the fatty acid profiles and nutritional lipid indices of selected brackish water fish (*C. guineensis*, *S. melanotheron*) and imported marine fish (*S. scombrus*, *T. trachurus*) commonly consumed in the southern Benin.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out in Abomey Calavi (Kpota and Akassato) and Cotonou (Wlacodji). The data collection area of Wlacodji is located at 8 meters of altitude between 6° 2' North latitude and 2° 26' East longitude. It is in the Littoral Department, part of the 5th district of the Township of Cotonou and covers about 10 hectares in a sandy angle formed by the sea and the Cotonou lagoon channel. This area holds one of the major smoking sites of Littoral.

As for the Township of Abomey-Calavi, it is located at 12 meters of altitude between 6° 26' North latitude and 2° 21' East longitude. This Township is in the Atlantic Department, South of Benin and bounded to the North by the Township of Zè, to the South by the Atlantic Ocean, to the East by the Township of Sô-Ava and Cotonou, and to the West by the Townships of Tori-Bossito and Ouidah. Abomey-Calavi has two bodies of water (Nokoué Lake and Cotonou Lagoon), a sea front juxtaposed to Cotonou Lagoon, marshes, streams and swamps. These bodies of water offer the Township a very lively artisanal fishing activity. The township has also several local markets (Kpota, Glodjigbé, Akassato, Zinvié and Zè). Near Kpota and Akassato markets there is the embankment of Nokoué Lake. In these markets, fish are sold whole, processed, fried and smoked. Fish processing is of artisanal type. The climate of the two study Township is of subequatorial type characterized by two rainy seasons and two dry seasons.

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2.2 Sampling and laboratory analysis

Analyses of total lipid and fatty acid profile were performed on the flesh of four fish species (*S. melanotheron*; *C. guineensis*; *T. trachurus*; *S. scombrus*). A total of 20 fish samples, 5 per species, were collected from the sites. Fresh *S. melanotheron* (143.74g±23.22) and *C. guineensis* (109.97g±16.96) caught in the acadjas, without being previously preserved were collected at Kpota market. Acadjas systems are dense masses of woody branches installed in shallow water, traditionally used in lagoon fisheries in Benin. *T. trachurus* (178,38g±45.5) and *S. scombrus* (405,99 g±104.37) frozen, imported were sampled at the Wlacodji smoking site in Cotonou. *T. trachurus and S. scombrus* were previously frozen, imported fish (not freshly caught). They are initially frozen and come from several countries such as France, Spain, Mauritania, Ghana, Angola and Morocco. The processor, who buys the fish from economic operators who are wholesalers, is unaware of the origin of the imported fish.
The samples were put in a cooler at +4° C temperature according to ISO 7218: 2007 requirements and transported to the laboratory. The sampled fish were treated at the Laboratory of

Animal Biotechnology and Meat Technology of the Department of Animal Production and Health of the Polytechnic School of Abomey-Calavi of the University of Abomey-Calavi (Benin). Then, the samples were sent to Fundamental and Applied Research Laboratory for Animal and Health (FARAH) at the Foodstuffs Analysis Service of the Department of Sciences of the University of Liège for fatty acid analyses.

2.3 Lipid analysis

2.3.1. Fat extraction

A total of 50 g of flesh from each fish was taken for fatty acid analysis. Samples were weighed, homogenized or minced and lyophilized. The dry matter was weighed and the water content was then calculated. Then, the total lipids were extracted from 2 g of dry sample using the Folch method (chloroform/methanol 2/1 v/v) (Folch, 1957).

2.3.2. Preparation of fatty acids methyl esters

The fatty acids profile was determined by analyzing the fatty acids methyl esters by GC-MS according to Douny et *al*. (2015) modified method. Fifty milligrams of fat extracted following Folch method was mixed with 5 mL of hexane and 10 µL was used for fatty acids saponification/ methylation. 75 µL nonadecanoic acid (C19:0) of 0.05 mg/mL of concentration used as an internal standard, was then added and the hexane was evaporated to dryness under nitrogen stream. One milliliter toluene and 5 mL sulfuric acid 2% (v/v, in methanol) were added to the fat and the capped tube was heated in a water bath at 100 °C for 2 h, with vigorous agitation thanks to a magnetic stirrer. Then, 3 mL NaCl 5% were added and the methyl esters were extracted twice with 2 mL hexane. The extract was washed with 4 mL K_2CO_3 2% (w/v) and Na_2SO_4 was added to a part of the extract. The final extract was evaporated to dryness to completely eliminate the toluene. Finally, four hundred microliters of hexane were added and the tube was vortexed. The sample was transferred into an injection vial.

2.3.3. Separation, detection and quantification of fatty acids

The FAME were separated on a Focus GC gas chromatographer (Thermo Fisher Scientific) using a CP-Sil88 column (100 m × 0.25 mm, 0.2 µm) (Varian, Agilent Technologies, Santa Clara, California, USA) and analyzed using a mass spectrometer of PolarisQ ion trap type (Thermo Fisher Scientific). The GC conditions were: injector: 250°C; splitless injection; helium as gas carrier at 1.0 ml min^{-1}; temperature program: 55°C for 1 min, followed by an increase of 5°C min^{-1} up to 180°C, then 10°C min^{-1} up to 200°C for 15 min, then an increase of 10°C min^{-1} up to 225°C for 14 min; the total analysis time was 59.50 minutes. The injection volume was 1 µl. The peaks were identified by comparing their mass spectrum and their retention time with those of the corresponding standards.

The Mass Spectometer conditions were: transfer line: 250°C; ion source: 220°C; collision energy: 35 eV; positive ionization mode. The FAME were detected using the "selected ion monitoring" (SIM) mode with 5 intervals of time. At each analysis, different ions were followed for each fatty acid analyzed, which allow to perform detection and their quantitative analysis: m/z 74 + 143 for saturated fatty acids, 79 + 91 for mono and polyunsaturated fatty acids. For quantification, a 6-point calibration curve performed using standard solutions and an internal standard was performed for each of the 23 analyzed fatty acids. The response (ratio between each FAME and internal standard chromatographic peak areas) was plotted as well as the standard solutions concentration. Linear regression was used.
After determination of the fatty acid content of each sample and of the sum of saturated, monounsaturated and polyunsaturated fatty acids, n-6/n-3 and PUFA/SFA ratios were calculated.

2.4. Nutritional quality index of lipids

The nutritional quality of lipids of the flesh of the four fresh fish species was evaluated through several quality indices, namely: the Thrombogenicity Index (Ulbricht and Southgate, 1991), the Arterogenicity Index (Ulbricht and Southgate, 1991), the Hypocholesterolaemia and Hypercholesterolaemia ratio (Santos et *al*., 2002) and the Peroxidation Index (Arakawa and Sagai, 1987). The following formulas were used to determine these indices:

$$\text{Atherogenicity Index (AI)} = \frac{[(C12{:}0 + 4xC14{:}0 + C16{:}0)]}{[(\Sigma MUFA + \Sigma n{-}6 + \Sigma n{-}3)]}$$

$$\text{Thrombogenicity Index (TI)} = \frac{[(C14{:}0 + C16{:}0 + C18{:}0)]}{[(0.5x\,\Sigma MUFA) + (0.5x\Sigma n{-}6) + (3x\Sigma n{-}3) + (\Sigma n{-}3 / \Sigma n{-}6)]}$$

Hypocholesterolaemic / Hypercholesterolaemic ratio (H/H) = [(C18: 1n-9 + C18: 2n-6 + C20: 4n-6 + C18: 3n-3 + C20: 5n-3 + C22: 5n-3 + C22: 6n-3 / (C14: 0 + C16: 0)].

Peroxidability Index (PI) = [(0.025 x ΣMUFA) + (C18: 2n-6 + C20: 2n-6) x1 + (C18: 3n-6 + C18: 3n-3) x 2 + (C18: 4n-3 + C20: 4n-6) x 4 + (C20: 5n-3 + C22: 5n-3) x 6 + (C22: 6n-3 x 8)].

2.5. Statistical analysis

Statistical analyses were performed using the Statistical Analysis System (SAS) software, version 9.4 (SAS Institute Inc., Cary, NC, USA). The differences in fatty acid composition among the four fish species were assessed using a one-way Analysis of Variance (ANOVA) via the Generalized Linear Models (GLM) procedure, with fish species as the fixed factor.
Prior to analysis, the assumptions of normality and homogeneity of variances were tested using the Shapiro–Wilk test and Levene's test, respectively. Where assumptions were violated,

data were log-transformed to meet the model requirements. Following a significant ANOVA result ($p < 0.05$), post-hoc pairwise comparisons were performed using Tukey's Honestly Significant Difference (HSD) test to adjust for multiple comparisons and control the Type I error rate.
All results are reported as mean ± standard deviation (SD). A significance level of $\alpha = 0.05$ was used throughout the analysis. Confidence intervals (95%) were also calculated for key comparisons. Outliers were assessed using boxplots and retained if biologically justifiable.

3. RESULTS

3.1 Lipid content and saturated fatty acid composition

The total lipid (TL) content and saturated fatty acid (SFA) composition of the four fish species are shown in **Table 1**. The TL content was significantly higher ($p < 0.05$) in the marine species (*T. trachurus* and *S. scombrus*) compared to the brackish water species (*C. guineensis* and *S. melanotheron*). However, no significant difference ($p > 0.05$) was observed between the two brackish water species or between the two marine species. The total SFA content did not differ significantly among all four species.
Several SFAs including capric (C10:0), lauric (C12:0), tridecylic (C13:0), arachidic (C20:0), docosanoic (C22:0), and lignoceric acid (C24:0) were below the limit of quantification (<LOQ) in all samples. Palmitic acid (C16:0) and stearic acid (C18:0) were the predominant SFAs. Stearic acid content was significantly higher ($p < 0.001$) in *C. guineensis* compared to the other species, while palmitic acid content showed no significant variation. Myristic acid (C14:0) content varied without significance, with the highest proportion observed in *S. scombrus* and the lowest in *C. guineensis*. Heptadecanoic acid (C17:0) was detected in all species except *T. trachurus*, but its content did not significantly differ among species.

3.2 Monounsaturated Fatty Acids (MUFA)

Table 2 summarizes the MUFA composition. The total MUFA content ranged from 13.57% in *C. guineensis* to 21.65% in *S. scombrus*, but this variation was not statistically significant ($p > 0.05$). Among the MUFAs, oleic acid (C18:1) was the most abundant, with significantly higher content ($p < 0.001$) in *S. scombrus* compared to *S. melanotheron*, while *C. guineensis* and *T. trachurus* had intermediate values. Palmitoleic acid (C16:1) content differed significantly across species ($p < 0.05$), with *S. melanotheron* showing the highest level and *T. trachurus* the lowest. Heptadecenoic acid (C17:1) was quantified only in *C. guineensis* and *S. melanotheron*, with a significantly higher level in the latter ($p < 0.001$). It was below the quantification limit in both marine species.

3.3 n-6 Polyunsaturated Fatty Acids (PUFA n-6)

The n-6 PUFA profiles are presented in **Table 3**. Brackish water species (*C. guineensis* and *S. melanotheron*) exhibited higher levels of n-6 PUFAs compared to marine species (*T. trachurus* and *S. scombrus*), although the difference between the two brackish species or between the two marine species was not statistically significant. Linoleic acid (C18:2 n-6) was significantly higher ($p < 0.001$) in both brackish species, with *T. trachurus* showing undetectable levels. Gamma-linolenic acid (C18:3 n-6) was the highest in *S. melanotheron* and the lowest in *C. guineensis*, but below quantifiable levels in marine fish. Arachidonic acid (C20:4 n-6), the dominant n-6 PUFA, followed a similar trend significantly higher in brackish species than in marine ones ($p < 0.001$). Eicosadienoic acid (C20:2 n-6) was only detected in *C. guineensis* at a low level. Despite large numerical differences in ∑PUFA n-6 content (e.g., ~8.65% in *C. guineensis vs*. 0.29% in *T. trachurus*), the overall difference across species was not statistically significant, likely due to small sample size.

3.4 n-3 Polyunsaturated Fatty Acids (PUFA n-3)

The content of n-3 PUFAs is presented in **Table 4.** Although no statistically significant differences ($p > 0.05$) were observed in the total n-3 PUFA content among species, there were considerable numerical variations. *T. trachurus* had the highest trend of ∑PUFA n-3 content (44.35 ± 14.97%), while *S. scombrus* had the lowest (31.83 ± 19.91%). Alpha-linolenic acid (ALA, C18:3 n-3) was detected only in the brackish water species, with *S. melanotheron* showing a significantly higher content ($p < 0.001$) than *C. guineensis*. Octadecatetraenoic acid (C18:4 n-3) was present in *S. melanotheron*, *T. trachurus*, and *S. scombrus*, but not in *C. guineensis*. However, differences were not significant. Di-homo-γ-linolenic acid (C20:3 n-3) was highest in *C. guineensis*, followed by *S. melanotheron* and *S. scombrus*, and was undetectable in *T. trachurus*. Eicosapentaenoic acid (EPA, C20:5 n-3) content was significantly higher ($p < 0.001$) in the marine fish, with *T. trachurus* recording the highest level (17.7%), followed by *S. scombrus* (13.22%), and substantially lower values in the brackish species. In contrast, docosapentaenoic acid (DPA, C22:5 n-3) was significantly more abundant in brackish water fish, especially *S. melanotheron* (18.93%) and *C. guineensis* (15.45%), compared to marine species. Docosahexaenoic acid (DHA, C22:6 n-3) levels were similar among *C. guineensis*, *T. trachurus*, and *S. scombrus*, but significantly lower in *S. melanotheron*.

3.5 PUFA/SFA and n-6/n-3 ratios

The PUFA/SFA and n-6/n-3 ratios of the species are presented in **Table 5.** The PUFA/SFA ratios were similar ($p > 0.05$) across all four fish species, despite numerical differences ranging from 0.93 in *S. scombrus* to 1.19 in *T. trachurus*.

In contrast, the n-6/n-3 ratio was significantly higher ($p < 0.05$) in the brackish water species (*C. guineensis* and *S. melanotheron*) compared to the marine species. *C. guineensis* had the highest ratio (0.22), while *T. trachurus* had the lowest (0.02), indicating a greater predominance of n-3 PUFAs in the marine species.

3.6 Nutritional quality indices

The nutritional lipid indices, including the atherogenicity index (AI), thrombogenicity index (TI), hypocholesterolaemic/hypercholesterolaemic ratio (H/H), and peroxidability index (PI), are presented in **Table 6**.

The AI differed significantly among species ($p < 0.05$). *S. scombrus* had the highest AI (1.19), while *C. guineensis* had the lowest (0.56). The AI values of *T. trachurus* and *S. melanotheron* were intermediate and not significantly different from each other. The TI and H/H ratio did not vary significantly among the species ($p > 0.05$). TI values ranged from 0.30 to 0.37, and H/H ratios ranged from 1.60 to 1.99.

The peroxidability index (PI), which reflects the degree of unsaturation and susceptibility to oxidation, showed significant differences ($p < 0.001$). The highest PI was observed in *T. trachurus* (303.24), followed by *C. guineensis* (274.57), while *S. scombrus* had the lowest value (228.76). These differences align with the variation in total PUFA content.

Table 1. Total lipid content and saturated fatty acid composition (% of total fatty acid) of *S. melanotheron*, *C. guineensis*, *T. trachurus* and *S. scombrus* (Mean ± Standard Deviation)

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
TL	1.86b	1.45	1.50b	0.28	11.43a	5.01	11.08a	4.64	*
C10 :0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
C12: 0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
C13 :0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
C14:0	1.56a	1.00	4.8a	1.94	5.57a	1.92	7.70a	2.98	NS
C16:0	26.15a	4.58	24.74a	3.47	27.54a	6.17	28.17a	8.24	NS
C17:0	0.62a	0.61	0.66a	0.47	<LOQ	-	0.72a	0.44	NS
C18:0	12.18a	1.75	9.07b	1.58	8.02b	1.70	8.51b	1.87	***
C20 :0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
C22 :0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
C24 :0	<LOQ	-	<LOQ	-	<LOQ	-	<LOQ	-	-
∑SFA	40.52a	5.08	39.28a	5.53	41.15a	9.32	45.11a	13.36	NS

NS: $p>0.05$; *: $p<0.05$; ***:$p<0.001$; TL : Total Lipids; Capric acid (C10: 0), Lauric acid (C12: 0), Tridecylic acid (C13: 0), Myristic acid (C14: 0), palmitic acid (C16: 0), heptadecanoic acid (C17: 0), stearic acid (C18: 0), Arachidic acid (C20: 0), Docosanoic acid (C22: 0), Lignoceric acid (C24: 0), Sum of Saturated fatty acids (∑SFA), <LOQ: proportion lower than quantification limit (corresponds to approximately 0.1% of total fatty acids); The means of the same row followed by different letters, differ significantly at the threshold of 5%.

Table 2. Content of monounsaturated fatty acids (% of total fatty acids) of *S. melanotheron*, *C. guineensis*, *T. trachurus* and *S. scombrus* (Mean ± Standard Deviation)

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
C16:1	3,99bc	2,96	8,2a	2,78	1,74c	2,78	6,55ab	2,59	*
C17:1	0,91b	0,50	2,29a	0,93	<LOQ	-	<LOQ	-	***
C18:1	8,67ab	3,13	7,57b	0,65	12,45ab	8,05	15,1a	5,34	***
∑MUFA	13,57a	6,11	18,07a	4,15	14,19a	7,19	21,65a	7,67	NS

NS: $p>0.05$; *: $p<0.05$; ***: $p<0.001$; Palmitoleic acid (C16: 1), heptadecenoic acid (C17: 1), oleic acid (C18: 1); Sum of Monounsaturated Fatty Acids (∑MUFA); <LOQ: proportion below quantification limit (corresponds to approximately 0.1% of total fatty acids); The means of the same row followed by different letters, differ significantly at the threshold of 5%.

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4. DISCUSSION

The present study assessed and compared the fatty acid composition and nutritional lipid indices of brackish water fish (*Coptodon guineensis*, *Sarotherodon melanotheron*) and imported marine fish (*Scomber scombrus*, *Trachurus trachurus*) commonly consumed in the southern Benin. The findings provide important insights into the nutritional quality of these fish species, particularly regarding their contribution to essential fatty acid intake and potential implications for cardiovascular health.

4.1. Total lipid and fatty acid composition

Marine fish exhibited significantly higher total lipid content than brackish water fish, consistent with previous studies indicating that pelagic marine species often store more lipids as energy reserves for migration and colder environments (Osman et *al*., 2001; Tenyang et *al*., 2016). However, among the saturated fatty acids (SFA), no consistent differences were observed between species. Palmitic and stearic acids were the dominant SFAs across all species, aligning with literature that identifies these as the primary saturated fats in fish (Nazemroaya et *al*., 2011). Notably, stearic acid was significantly higher in *C. guineensis*, while *S. scombrus* had elevated myristic acid both of which may influence the atherogenic potential of the fish's lipid profile.

4.2 Monounsaturated and Polyunsaturated Fatty Acids

Oleic acid (C18:1), the dominant monounsaturated fatty acid (MUFA), was particularly abundant in *S. scombrus*, which could contribute positively to cardiovascular health, given its cholesterol-lowering effects (Weintraub, 2013). However, MUFA content varied considerably, and differences were not statistically significant overall due to high inter-sample variability.

Polyunsaturated fatty acids (PUFAs), especially those in the n-3 series, are of particular nutritional interest. Marine fish had significantly higher levels of eicosapentaenoic acid (EPA), a potent anti-inflammatory omega-3 fatty acid, while brackish species contained more docosapentaenoic acid (DPA) and alpha-linolenic acid (ALA). The exclusive presence of ALA in brackish fish highlights their potential contribution to dietary omega-3 diversity, although ALA must be converted in the body to longer-chain n-3 PUFAs (e.g., EPA and DHA), a process that is often inefficient in humans (Lovegrove & Griffin, 2013). DHA, a key component for brain function and neurodevelopment, was present in all species, with *S. melanotheron* showing the lowest content. The relatively similar DHA levels in *C. guineensis*, *T. trachurus*, and *S. scombrus* suggest that both brackish and marine fish can serve as valuable DHA sources.

Interestingly, brackish water fish had significantly higher levels of n-6 PUFAs, particularly linoleic and arachidonic acids. While n-6 fatty acids are essential, an imbalance with n-3 fatty acids reflected in the higher n-6/n-3 ratio in brackish species could counteract some health benefits if consumed excessively (Bashir et *al*., 2012).

Table 3. Content of polyunsaturated fatty acids (% of total fatty acid) of *S. melanotheron*, *C. guineensis*, *T. trachurus* and *S. scombrus* (Mean ± Standard Deviation)

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
C18:2 (n-6)	1.94a	1.10	2.11a	0.87	<LOQ	-	0.44b	0.61	***
C18:3 (n-6)	0.15b	0.21	0.68a	0.24	<LOQ	-	<LOQ	-	***
C20:2 (n-6)	0.31a	0.20	<LOQ	-	<LOQ	-	<LOQ	-	-
C20:4 (n-6)	6.23a	3.37	4.63a	1.01	0.29b	0.40	0.95b	0.64	***
∑AGPIw6	8.65a	3.48	7.43a	1.42	0.29a	0.40	1.39a	1.15	NS

NS: p>0.05; ***-p<0.001; Linoleic acid C18: 2 (n-6), gamma linolenic acid C18: 3 (n-6), eicosadienoic acid C20: 2 (n-6), arachidonic acid C20: 4 (n-6); Sum of Polyunsaturated Fatty Acids of the n-6 series (∑PUFA w6); <LOQ: proportion below quantification limit (corresponds to approximately 0.1% of total fatty acids); The means of the same row followed by different letters, differ significantly at the threshold of 5%.

Table 4. Content of n-3 series polyunsaturated fatty acids (% total fatty acid) of *S. melanotheron*, *C. guineensis*, *T. trachurus* and *S. scombrus* (Mean ± Standard Deviation)

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
C18:3 (n-3)	0.53b	0.50	1.32a	0.47	<LOQ	-	<LOQ	0.00	***
C18:4 (n-3)	<LOQ	-	0.058a	0.13	0.17a	0.24	0.08a	0.18	NS
C20:3 (n-3)	1.61a	0.33	1.29b	0.31	<LOQ	-	0.05c	0.11	***
C20:5 (n-3)	2.45c	0.88	2.91c	0.53	17.7a	3.34	13.22b	5.53	***
C22:5 (n-3)	15.45a	1.43	18.93a	2.85	8.87b	3.18	2.05c	3.16	***
C22:6 (n-3)	17.19a	8.82	10.67b	4.80	17.61a	10.64	16.42a	12.85	NS
∑PUFAw3	37.24a	7.99	35.20a	7.03	44.35a	14.97	31.83a	19.91	NS
∑PUFA	45.9a	10.50	42.63a	6.82	44.65a	14.75	33.23a	20.99	NS

NS: p>0.05; ***:p<0.001; Alpha (α) linolenic acid C18: 3 (n-3), octadecatetraenoic acid C18: 4 (n-3), di-homo-γ-linolenic acid C20: 3 (n-3), eicosapentaenoic acid (EPA) C20: 5 (n-3), docosapentaenoic acid (DPA) C22: 5 (n-3), docosahexaenoic acid (DHA) C22: 6 (n-3); Sum of Polyunsaturated Fatty Acids of the n-3 series (∑PUFA w3); Sum of Polyunsaturated Fatty Acids (∑PUFA); <LOQ: proportion below quantification limit (corresponds to approximately 0.1% of total fatty acids); The means of the same row followed by different letters, differ significantly at the threshold of 5%

Table 5. PUFA / SFA and n-6 / n-3 ratios

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
PUFA/SFA	1.17a	0.40	1.11a	0.31	1.19a	0.63	0.93a	0.83	NS
n-6/n-3	0.22a	0.07	0.21a	0.06	0.02b	0.01	0.04b	0.01	*

NS: p>0.05; *: p <0.05; Sum of Polyunsaturated Fatty Acids (∑PUFA); Saturated fatty acids (SFA); Polyunsaturated Fatty Acids of n-3 series (n-3); Polyunsaturated fatty acids of n-6 series (n-6); The means of the same row followed by different letters, differ significantly at the threshold of 5%.

Table 6. Nutritional quality indices of fish

Variables	*C. guineensis* (n=5)		*S. melanotheron* (n=5)		*T. Trachurus* (n=5)		*S. scombrus* (n=5)		Significance test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
H/H	1.99a	0.67	1.68a	0.46	1.84a	0.66	1.60a	1.04	NS
AI	0.56b	0.18	0.73ab	0.21	0.89ab	0.36	1.19a	0.61	*
TI	0.32a	0.09	0.32a	0.10	0.30a	0.12	0.37a	0.26	NS
PI	274.57a	73.79	242.40b	53.99	303.24a	109.45	228.76b	146.01	***

NS: p>0.05; ***: p<0.001; *: p <0.05; AI: Atherogenicity index; TI: Thrombogenicity index; HH: Hypocholesterolaemic / Hypercholesterolaemic Ratio; The means of the same row followed by different letters, differ significantly at the threshold of 5%.

4.3. Lipid quality indices and health implications

The calculated nutritional indices provide further insight into the health value of these fish species. The atherogenicity index (AI) was highest in *S. scombrus*, suggesting a greater potential to contribute to arterial plaque formation, whereas *C. guineensis* had the lowest AI, reflecting a more favorable lipid profile. Thrombogenicity indices (TI) and hypocholesterolaemic/hypercholesterolaemic (H/H) ratios were not significantly different among species, suggesting comparable influence on blood cholesterol modulation. The peroxidability index (PI), an indicator of susceptibility to lipid oxidation, was highest in *T. trachurus* and *C. guineensis*, consistent with their high PUFA content. While higher PI can imply nutritional value, it also points to a need for proper storage and handling to avoid lipid peroxidation and rancidity, particularly in tropical climates.

4.4. Public health relevance and recommendations

Cardiovascular diseases remain a leading health concern in Benin, with an estimated prevalence of 27.5% (WHO, 2020; Houehanou and *al*., 2022). This study confirms that both local and imported fish provide significant quantities of health-promoting omega-3 fatty acids, especially EPA and DHA, which have been shown to reduce cardiovascular risk. The findings support dietary recommendations encouraging fish consumption as part of a heart-healthy diet. Given the higher EPA levels in imported marine fish, but higher DPA and ALA levels in brackish fish, both sources offer unique nutritional contributions. Policymakers and nutritionists may consider promoting a balanced intake of both fish types to optimize n-3 PUFA diversity and reduce the n-6/n-3 imbalance in the general population's diet.

4.4. Study limitations

This study is not without limitations. The sample size was relatively small (n=5 per species), and high variability in some fatty acid measurements reduced the statistical power to detect differences. Additionally, while the imported marine fish were labeled “fresh,” they were sourced from a smoking site and are often frozen before being used for consumption. This could have influenced their lipid composition, especially PUFA stability. Future studies should include larger sample sizes, control for fish size, sex, and maturity, and distinguish clearly between fresh and frozen product sources.

CONCLUSION

This study provides comparative data on the fatty acid composition and nutritional lipid quality indices of two brackish water fish species (*Coptodon guineensis* and *Sarotherodon melanotheron*) and two imported marine species (*Trachurus trachurus* and *Scomber scombrus*) commonly consumed in Benin. The results show that all species are valuable sources of essential fatty acids, including omega-3 and omega-6 PUFAs, though their specific profiles vary considerably. Marine species, particularly *T. trachurus* and *S. scombrus*, had higher total lipid content and significantly greater levels of EPA and DHA key long-chain omega-3 fatty acids known for their cardioprotective effects. In contrast, brackish water fish contained higher levels of ALA, DPA, and n-6 PUFAs, suggesting they also contribute to essential fatty acid intake but with a different profile. Nutritional quality indices such as the atherogenicity and peroxidability indices varied among species, indicating differences in potential health benefits and oxidative stability. These findings underline the nutritional importance of both local and imported fish and support promoting their consumption as part of a diversified, heart-healthy diet in Benin. However, due to the study’s small sample size and variability in lipid content, these findings should be interpreted with caution. Future studies should involve larger, more representative samples and controlled comparisons of fresh versus frozen or processed fish. Such data are essential to guide public health recommendations and inform fish consumption policies aimed at improving cardiovascular health and food security.

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DATA AVAILABILITY STATEMENT

The data used in this study is available upon request from the author

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS’ CONTRIBUTIONS

M.H.M.A carried out the methodology of this work, the experiments, did the statistical analyses and wrote the article; G.A.B and C.F.A.S participated in the literature review and reading the article; D.O.A participated in the collection of data for chemical analyses; M.D., A.C. and S.F corrected the article; C.D and M-L S helped in the analysis of fatty acids in fish flesh, I. Y.A.K monitored the statistical analysis of the data.

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