Comparative study on the Proximate, Amino, and Fatty acid Compositions of Three Species of Stock Fish Sold in Markets within Yenagoa Local Government Area of Bayelsa State, Nigeria.

Abstract

Fishes are consumed for their taste, high protein content, amino acids, and saturated fatty acids. However, nutritional information on stock ~~fishes~~ fish consumed in Yenagoa, Bayelsa State is limited. In this study, proximate, amino acid, and fatty acid compositions of three stock fish species (cod, apama, and ramsi black cod) from three different markets within Yenagoa LGA of Bayelsa State were determined using standard methods. The proximate composition revealed that fibre was high (8.87%) in Apama when compared to Cod (3.85%) and Ramsi black cod (6.73%). Protein content was ~~observed to be~~ higher in Cod (13.30%) compared to Apama and Ramsi black cod with values of 11.20% and 10.50 % respectively. The carbohydrate content was ~~seen to be~~ 60.85% for Ramsi black cod, 60.83% for cod, and 46.86% for Apama. Eighteen amino acids were screened in the ~~stock fish~~stockfish samples and glutamate was seen to be higher in all the ~~stock fish~~stockfish samples (14.70, 15.23, and 14.67 g/100g of Protein) followed by aspartate (12.20, 12.09 and 12.07 g/100g of Protein) for cod, apama, and ramsi black cod respectively when compared with the other amino acids. The result of the fatty acids revealed that twelve fatty acids were seen in the ~~stock fish~~stockfish samples analysed. For cod, Hexadecanoic acid was seen to be higher (21.84 µg/ml), apama, omega 3 fatty acid, and Linoleic acid (34.15 µg/ml) while ramsi black cod had oleic acid (41.05 µg/ml) to be higher. The results showed that the fish species are nutritious as they had high protein content, essential and non-essential amino acids, and saturated, monounsaturated, and polyunsaturated fatty acids.

Keywords: ~~Stock fish~~Stockfish, proximate, amino acids, fatty acids, proteins.

Introduction

Fish are aquatic animals that habit, survive, and carry out their daily activities in water. There are several species of ~~fishes~~ fish distributed all over the world, they belong to the kingdom Animalia, phylum chordata, and subphylum vertebrata. All the species of fish found in the world are classified into Agnatha (jawless fish), Chrondrichyes (cartilaginous fish), Osteirchthyes (bony fish), ~~Ray finned~~Ray-finned and Lobe finned fish. Fish is a good source of protein, ~~lipid~~lipids, fat, essential fatty acids, minerals, and vitamins (Paul *et al*., 2018).

~~Stock fish~~Stockfish is made from different species of white fish but cod is the most frequently used fish, cod fish belong to a group of fish called Osteirchthyes meaning bony fish. There are several species of cod, they are named according to their habitats and other ~~characters~~ characteristics (such

as colour, structure, and swimming pattern) they include; *Gradus morhua* (Atlanta cod), *Molva molva* (lingcod), Green cod, Pacific cod, *Pollachius vireus* (saith), Tusk (*Brosme brosme*), *Pollachius pollachius*, Haddock (*Melaogrammus aeglefinus*), Vicenza cod, Bacalhau cod, Norwegian cod, Murray cod and Alaska Pollock (Akin and Grace 2015).

The cod used in ~~stock fish~~stockfish production ~~are~~is usually harvested in fresh water so they are usually salted two weeks before drying. According to ~~Abiodum~~ Abiodun *and Blessing* (2016) ~~stock fish~~stockfish is one of the foreign fish which are distributed to many countries mostly in Nigeria, this is because the fish is not found in any part of the country, the fish is locally known as Okporoko among the Igbos, Bazabaza among the Benins and kpanla among the western part of the country. Fish generally are an important source of protein and vitamins needed by ~~human~~ humans and animals to maintain tissues and cells, and ~~it's~~ it is mostly consumed more than meat ~~claimed~~ (Akinwumi and Kehinde, 2015).

Table 1: Common species of stockfish (Kurlansky, 2014)

S/No.	Stockfish	Scientific Name	English Name	Local Name
1.	Cod	*Gadus morhua*	Cod	Okporoko
2.	Apama	*Sepia species*	Apama	Okporoko
3.	Haddock	*Melaogrammus aeglefinus*	Haddock	Okporoko
4.	Tusk	*Brosme brosme*	Tusk	Okporoko
5.	Ling	*Molva molva*	Ling	Okporoko

Atlantic cod (***Gadus morhua***)

The Atlantic cod (*Gadus morhua*) is a benthopelagic fish of the family Gadidae, widely consumed by humans. It is also commercially known as cod or codling. Dry cod may be prepared as unsalted stockfish~~,~~ and as cured salt cod or clipfish.

In the western Atlantic Ocean, cod has a distribution north of ~~Cape Hatteras~~Cape Hatteras, ~~North Carolina~~North Carolina, and around both coasts of ~~Greenland~~Greenland and the ~~Labrador Sea~~Labrador Sea; in the eastern Atlantic, it is found from the Bay of Biscay north to the ~~Arctic Ocean~~Arctic Ocean, including the ~~Baltic Sea~~Baltic Sea, the ~~North Sea~~North Sea, ~~Sea of the Hebrides~~Sea of the Hebrides, areas around ~~Iceland~~Iceland and the ~~Barents Sea~~Barents Sea.

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Atlantic cod can live for up to 25 years and typically grow up to 100–140 cm (39.4-55.1 in), but individuals ~~in excess of~~over 180 cm (70.9 in) and 50 kg (110.2 lbs) have been caught. They will attain sexual maturity between ages two and eight with this varying between populations and has varied over time.

~~Colouring~~ The colouring is brown or green, with spots on the dorsal side, shading to silver ventrally. A stripe along its lateral line (used to detect vibrations) is ~~clearly~~ visible. Its habitat ranges from the coastal shoreline ~~down~~ to 300 m (1,000 ft) along the continental shelf. Atlantic cod is one of the most heavily fished species. Atlantic cod was fished for a thousand years by north European fishers who followed it across the North Atlantic Ocean to North America. It supported the US and ~~Canada~~ Canada's fishing economy until 1992~~,~~ when there was a ban on fishing cod. Several cod stocks collapsed in the 1990s (a decline of more than 95% of maximum historical biomass) and have failed to fully recover even with the cessation of fishing. This absence of the apex predator has led to a trophic cascade in many areas. Many other cod stocks remain at risk.

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Plate 1a. Fresh *Gadus morhua* stockfish

Plate 1b: Dried *Gadus morhua* stockfish (Cod)

The sablefish (*Anoplopoma fimbria*) is one of two members of the fish family Anoplopomatidae and the only species in the genus *Anoplopoma*. In English, common names for it include sable (US), butterfish (US), black cod (US, UK, Canada), blue cod (UK), bluefish (UK), candlefish (UK), coal cod (UK), ~~snowfish~~ snowfish coalfish (Canada), beshow, and skil (Canada), although many of these names also refer to other, unrelated, species.

The sablefish is a species of deep-sea fish common to the North Pacific Ocean. Adult sablefish are opportunistic piscivores, preying on Alaskan pollock, eulachon, capelin, herring, ~~sandlance~~sand lance, and Pacific cod, as well as squid, euphausiids, and jellyfish. Sablefish are long-lived, with a maximum recorded age of 94 years although the majority of the commercial catch in many areas is less than 20 years old.

Sablefish growth varies regionally, with larger maximum sizes in Alaska, where total lengths up to 114 cm (45 in) and weights up to 25 kg (55 lb) have been recorded. However, average lengths are typically below 70 cm (28 in) and 4 kg (8.8 lb).

Tagging studies have indicated that sablefish have been observed to move as much as 2,000 km (1,200 mi) before recapture with one study estimating an average distance between release and recapture of 602 km (374 mi), with an average annual movement of 191 km.

Plate 2a: Fresh Sablefish (black cod)

Plate 2b. Dried black cod

Fish has been considered ~~as~~ one of the cheapest and most available sources of animal protein and other required essential nutrients in human diets (Sadiku and Oladimeji, 1991). It has been reported that fish provides about 22% of the total protein intake in sub-Saharan Africa (FAO, 2003). Pamploner-Roger (2006) reported that available fats in ~~fishes~~ fish contain unsaturated fatty acids which are ~~heart friendly~~heart-friendly as they help reduce blood triglycerides. ~~Variation~~ Variations in the type, quality, and nature of nutrients in fishes could be due to species, type of food, and feeding habits of the fishes. In addition to the general acceptability of fish as a veritable source of

vitamins, it also contains polyunsaturated fatty acids and minerals required for healthy growth (Andrew, 2001).

Stockfish is very rich in protein, B vitamins, iron, and calcium with a mild flavour and a dense white flesh that flakes easily (Kurlansky, 1997).

It is a popular source of digestible protein, vitamins, and minerals. Studies have recommended the consumption of stockfish as the source of omega-3 fatty acids which have some health benefits (Brawn, 2011). The most commonly sold species is cod (*Gardus morhua*) but others such as Ling (*Molva molva*), Haddock (*Melaogrammus aeglefinus*), and Tusk (*Brosme brosme*) are also found. Assessment of potential health ~~hazard~~ hazards in food is vital ~~in order to~~to evaluate the consequences of human actions and their impact on public health (Ukoha *et al.*, 2014).

Materials and Methods

Materials

Equipment/Apparatus

Standard and calibrated equipment and apparatus were used in this study

Reagents and Chemicals

All reagents and chemicals used in this study are of analytical grade.

Collection of samples

a. Purchase of ~~Stock fish~~Stockfish Samples

Specimens of three popular species of imported stockfish namely Cod, Apama, and black cod stockfish samples were purchased from retailers in three popular markets (Swali ultra-modern market, Tombia junction market, and Kaiama market) in Yenagoa L.G.A of Bayelsa state, Nigeria. These species were imported from Norway into Nigeria and are highly cherished as sources of protein, especially by their consumers. From each species, a set of stockfish ~~were~~ was randomly collected and transported in sterile ~~polyethene~~ polyethylene bags to the laboratory for analysis.

Methods

Sample preparation

The samples were separately dried in a laboratory oven at 65^{O}C for 12 ~~hr~~hrs. to obtain a constant dry weight of 0.5g from each sample. Then dried samples were each ground to powder, using laboratory ceramic mortar and pestle, and sieved with a 2mm sieve.

Determination of Proximate Composition

Proximate analysis to determine the moisture, crude protein, fat, ash, fiber, and total carbohydrate contents of the samples ~~were~~ was carried out according to the standard methods (AOAC, 2006).

Determination of Moisture Content

Procedure

An empty silica dish was allowed to cool in the desiccator, after which its weight was taken. Then 1.0g of the sample was weighed into the silica dish and placed in the oven at about 105^{o}C for 24 hours. It was cooled in a desiccator to ~~the~~ room temperature. The silica dish and contents ~~was~~ were weighed and later placed back in the oven for another 24 hours to ensure complete drying. The cooling process in the desiccator was repeated until a constant weight was obtained.

Determination of Ash Content

Procedure

To a pre-weighed, clean, empty ~~petri dish~~petri dish, 1.0g of the sample was added and placed in the muffle furnace at 550^{o}C for 4 hours. The sample was allowed to cool in the desiccator. This was repeated until a constant weight was obtained. The weight of the ~~petri dish~~petri dish and residue ~~was~~ were taken.

Determination of the Protein Content

Procedure

Digestion

To 1.0g of the sample in a 100 ml Kjeldahl digestion flask, was added 3g of Kjeldahl digestion catalyst, ~~20ml~~ 20 ml of the 1.25% concentrated sulphuric acid, and a few anti-bumping agents. The flask was fitted to a reflux condenser and gently heated until foaming had ceased, and the contents became completely liquefied. Then the content of the flask was heated intensely, with occasional rotation of the flask, until the colour of the digest changed from ash to blue-green or pale green colour. The flask was allowed to cool and its contents were quantitatively transferred into a 100ml volumetric flask and made up to the 100ml mark with distilled water.

Distillation

Twenty ml of this diluted digest was transferred into a ~~150ml~~ 150 ml distillation flask. The flask into which some anti-bumping chips have been added was connected to a condenser whose receiver was attached to a Buchner funnel immersed in a 400ml beaker containing 10ml of 2% boric acid solution masked with 2 drops of double (methyl red-methylene blue) indicator. Then,

~~20ml~~ 20 ml of 40% NaOH solution was added to the flask using a syringe. Distillation was stopped when the volume in the beaker was about the same ~~in~~ as the original volume, and the colour of the boric acid in the receiver flask changed from purple to pale green. The ammonia was liberated into the boric acid solution. The distillation unit was dismantled and rinsed with distilled water.

Titration

The distillate (boric acid-ammonia solution) was titrated with 0.1M hydrochloric acid~~,~~ until the colour changed to pink, which marked the end of the titration. The titre value was recorded and this was used to determine the nitrogen content from which the protein value was calculated by multiplying with the Nitrogen factor, 6.25.

Determination of the Crude fat content

Procedure

Extracting flasks (250ml) capacity ~~was~~ were dried in the oven at 105^{o}C, transferred to the desiccator to cool to the laboratory temperature, and their weights were measured. Petroleum ether (250ml) was measured into the dried flasks while 0.25g of the sample was weighed into labelled porous thimbles and placed in the condenser of the ~~soxhlet~~Soxhlet extractor, and the sample was extracted for 4 hours. The thimbles were removed with care and the petroleum ether in the top container (tube) was collected for reuse. The extraction flask was removed from the heating mantle arrangement when it was almost free of petroleum ether. The extraction flask with the oil was ~~oven dried~~oven-dried at 105^{o}C for ~~the period of~~ 1 hour. The flask containing the dried oil was cooled in the desiccator and the weight of the cooled flask with the dried oil was measured.

Determination of the Fiber Content

Procedure

Two grams of the pulverized sample ~~was~~ were weighed into ~~1 litre~~1-litre conical flask and 200ml of 1.25% sulphuric acid was added and allowed to boil gently for ~~30minutes~~ 30 minutes and the contents were filtered through the Buckner funnel and rinsed well with hot ~~deionised~~ deionized water. To the filtrate 200ml of the boiling 1.25% of sodium hydroxide was added, allowed to boil gently for ~~30minutes~~ 30 minutes, and later filtered through the Buckner funnel. The residue was washed with hot ~~demonized~~ deionized water, with 10% hydrochloric acid, and then followed by dimethyl ether, and then dried in an oven overnight at 110^{o}C. The residue was then transferred into the desiccator to cool before weighing. After weighing, it was ashed in the muffle furnace at 550^{o}C for 90 minutes. After ashing, it was transferred to the desiccator to cool and then weighed.

Determination of Total Carbohydrate

The total carbohydrate was determined by getting the percentage difference between the summations of values of crude protein, crude fat, crude fibre, ash, and moisture content of the sample.

Energy value: The energy value was calculated using the Atwater factors 4, 9, and 4 for protein, fat, and carbohydrate respectively.

Determination of Amino Acid Content

Preparation of samples and standards

~~Prior to~~Before derivatization, sample proteins were hydrolyzed as follows. A 0.1-g lyophilized sample was weighed into a 16- × 125-mm screw-cap Pyrex (Barcelona, Spain) tube, 15 mL of 6N hydrochloric acid was added, and the tube was thoroughly flushed with N 2-, quickly capped, and placed in an oven at 110°C for 24 h (17). After hydrolysis, the tube contents were vacuum filtered (Whatman #541, Maidstone, England) to remove solids, the filtrate was made up to 25 mL with water, and an aliquot of this solution was further filtered through a 0.50-µm pore-size membrane (Millipore, Madrid, Spain). A standard solution containing 1.25 µmol/mL of each amino acid in 0.1N hydrochloric acid was created.

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Derivatization procedure

The procedure used was a modification of the method of Elkin *et al.*, (1985). A standard solution (5, 10, 15, or 20 µL) or 50 µL of sample solution was pipetted into a 10- × 5-mm tube and dried in vacuo at 65°C. To the residue, 30 µL of methanol-water-Phenylisothiocianate (2:2:1 [v/v]) was added and then removed in vacuo at 65°C. Next, 30 µL of the derivatizing reagent methanol-water-Phenylisothiocianate (7:1:1:1 [v/v]) was added, and the tube was agitated and left to stand at room temperature for 20 min. Finally, the solvents were removed under a nitrogen stream, and the tube was sealed and stored at 4°C, pending analysis. ~~Prior to~~Before injection, 150 µL of diluent consisting of 5mM sodium phosphate with 5% acetonitrile was added to each tube.

Chromatographic procedure

Chromatography was carried out at a constant temperature of 30°C using a gradient eluent ion as follows. Eluent A was an aqueous buffer prepared by adding 0.5 mL/L Triethylamine to 0.14M

sodium acetate and titrating it to pH 6.20 with glacial acetic acid; eluent B was acetonitrile-water (60:40 [v/v]).

Determination of Fatty ~~acid~~ Acid Composition.

Procedure

Fifty milligrams of the extracted fat content of the sample ~~was~~were saponified (esterified) for five minutes at 95^{o}C with 3.4ml of the 0.5M KOH in dry methanol. The mixture was neutralized by using 0.7M HCL. Three millilitres (3ml) of the 14% boron ~~triflouride~~ trifluoride in methanol was added. The mixture was heated for 5 minutes at ~~the~~ a temperature of 90^{o}C to achieve a complete methylation process. The Fatty acid methyl esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1ml for gas chromatographic analysis.

Chromatographic Analysis

Chromatographic analyses were carried out on an HP 6890 (Hewlett Packard, Wilmington, DE, USA), GC apparatus, fitted with a flame ionization detector (FID), and powered with HP Chemstation Rev A 09.01 (1206) software. The capillary column was an AC-5 Column (30m × 0.32mm × 0.25µm film thickness).

Nature/Sources of Data

Data ~~of~~ from this study were obtained from primary ~~source~~ sources mainly through laboratory work and ~~through~~ other ~~literatures~~literature.

Results and Discussion

Results

Table 2: Proximate composition (%) of the analyzed samples of cod, apama, and Ramsi black cod purchased from three popular markets in Yenagoa LGA, Bayelsa State.

Parameters	Cod	Apama	Ramsi black cod
Fibre Content	3.85	8.87	6.73
Fat Content	2.63	12.12	1.44
Ash Content	8.52	7.42	6.59
Moisture Content	10.83	13.50	13.87

Protein	13.30	11.20	10.50
Carbohydrate	60.83	46.86	60.85

The results of the investigation of the proximate composition (%) of the ~~stock fish~~stockfish samples are presented in ~~table~~ Table 2 above.

The fibre and fat contents were seen to be higher in Apama (8.87 and 12.12 % respectively) when compared with cod (3.85 and 2.63 %) and ramsi black cod (6.73 and 1.44 %). The ash and moisture contents were observed to be higher in cod (8.52) and ramsi black cod (13.87 %) respectively when with apama. Protein was higher in cod (13.30 %) while carbohydrates were seen to be higher in ramsi black cod.

Table 3: Amino acid Profile of Cod, Apama, and Ramsi black cod purchased from three popular markets in Yenagoa LGA, Bayelsa State.

Amino Acids (g/100g of Protein)	Cod	Apama	Ramsi black cod
Glycine	3.88	4.04	3.54
Alanine	4.07	4.22	3.98
Serine	4.83	5.47	4.83
Proline	3.90	4.03	4.33
Valine	4.74	5.26	4.83
Threonine	4.28	4.37	3.69
Isoleucine	4.49	4.83	4.13
Leucine	7.43	7.78	7.20
Aspartate	12.20	12.09	12.07
Lysine	6.28	6.31	6.11
Methionine	1.54	1.59	1.30
Glutamate	14.70	15.23	14.67
Phenylalanine	5.13	5.34	5.08
Histidine	2.87	2.96	2.31
Arginine	5.66	6.24	5.37
Tyrosine	2.97	2.98	3.39
Tryptophan	1.23	1.18	1.15
Cystine	1.43	1.22	1.30

The ~~result~~ results of the amino acid profile of Cod, Apama, and Ramsi black cod are shown in ~~table~~ Table 3 above. Eighteen amino acids were screened in the ~~stock fish~~stockfish samples and glutamate was seen to be higher in all the ~~stock fish~~stockfish samples (14.70, 15.23, and 14.67

g/100g of Protein) followed by aspartate (12.20, 12.09, and 12.07 g/100g of Protein) for cod, apama and ramsi black cod respectively when compared with the other amino acids.

Table 4: Fatty acid composition (µg/ml) of Cod, Apama, and Ramsi black cod purchased from three popular markets in Yenagoa LGA, Bayelsa State.

Fatty acids (µg/ml)	Number of carbon atom	Type of fatty acids	Cod	Apama	Ramsi black cod
Lauric acid	C12:0	SFA	6.63	2.74	ND
Myristic acid	C14:0	MUFA	13.08	6.47	12.36
Hexadecanoic acid	C16:0	SFA	21.84	7.08	26.67
Stearic acid	C18:0	SFA	ND	0.01	6.67
Oleic acid	C18:1	MUFA	14.46	4.99	41.05
Linoleic acid	C18:2	PUFA	1.97	10.42	39.64
Linoleic acid (Omega 3)	C18:3	PUFA	17.30	34.15	12.15
Eicosadienoic acid	C20:2	PUFA	7.20	2.39	3.12
Eicosatrienoic acid (Omega 3)	C20:3	PUFA	9.33	3.69	2.35
Cetoleic acid	C20:4	PUFA	4.65	0.37	5.67
Eicosapentaenoic acid	C20:5	PUFA	0.01	3.10	3.68
Docosahexaenoic acid	C22:6	PUFA	ND	ND	3.04

ND = Not Detected; SFA=Saturated Fatty Acid; MUFA=Monounsaturated Fatty Acid
PUFA=Polyunsaturated Fatty Acid

The result of the fatty acid composition (µg/ml) of Cod, Apama, and Ramsi black cod is shown in ~~table~~ Table 4 above. The result shows that twelve fatty acids were seen in the ~~stock fish~~stockfish samples analysed. For cod, Hexadecanoic acid was seen to be higher (21.84 µg/ml), apama, omega 3 fatty acid, and Linoleic acid (34.15 µg/ml) while ramsi black cod had oleic acid (41.05 µg/ml) to be higher. Other saturated, monounsaturated, and polyunsaturated fatty acids were also observed in the ~~stock fish~~stockfish samples analysed.

Discussion

Fish is a highly proteinous food consumed by the populace. A larger percentage of consumers do eat fish because of its availability, flavors, and palatability while ~~fewer~~ a smaller percentage do so because of its nutritional value. Therefore, studies on the proximate composition and elemental composition of the fishes have not ~~really~~ caught the attention of ~~researches~~ researchers in fisheries; hence the consumer and fishery workers are left with limited or paucity of information on the importance of particular fish species in their daily diets (Adewoye *et al.*, 2003).

The results of the investigation of the proximate composition (%) of the ~~stock fish~~stockfish samples purchased from three popular markets in Yenagoa LGA of Bayelsa state are presented in ~~table~~ Table 2 above.

The crude fibre and fat contents were seen to be higher in Apama (8.87 and 12.12 % respectively) when compared with cod (3.85 and 2.63 %) and ramsi black cod (6.73 and 1.44 %). The ash contents were observed to be higher in cod (8.52%) with apama having ~~the~~ a value of 7.42% and ramsi black cod, 6.59%. For moisture content, 13.87 %, 13.50%, and 10.83% values were seen for ramsi black cod, apama and cod respectively. Crude protein level was higher in cod (13.30 %), apama (11.20%) and ramsi black cod (10.50) while carbohydrates were seen to be higher in ramsi black cod (60.85%) followed by cod (60.83%) and apama (46.86%).

The crude fat content of the stockfish samples reported by Adeyeye and Olaleye, 2022 ~~were~~ was relatively low in the range of 2.55 – 3.85g/100g with a mean value of 3.80±0.492. These values were lower than 5.35g/100g and 6.26g/100g in adult bee and maize weevil respectively (Adeyeye and Olaleye, 2016), 14.2g/100g in beef jerky meat (Adeyeye *et al.*, 2020) and 18.4g/100g in Nigerian local cheese (Adeyeye *et al*., 2021). Crude ~~fat~~ fats in this study are cod (2.63%), apama (12.12%), and ramsi black cod (1.44%). This is not surprising as stockfish is one of the lean ~~fishes~~ fish expected to have ~~low fat~~low-fat content. The values recorded in this research agree with Adeyeye and Ayejuyo (2007) who reported the following for organs in turkey (g/100g): muscle (2.12) and skin (12.1). However, crude fat in this study was higher than 1.16-1.91g/100g in the muscle of different fish species from Muthupettal mangroves (Suganthi *et al*., 2015).

The levels of moisture content in the samples; 13.87 %, 13.50%, and 10.83% for ramsi black cod, apama, and cod respectively were comparatively higher than the following literature values (g/100g): mean values of organs of duck (2.88 ± 1.40) (Adeyeye, 2020), pouch rat (3.23 ± 2.02) (Adeyeye and Adesina, 2018) and *Numidia meleagris* (2.99 ± 1.75) (Adeyeye and Adesina, 2014). High levels of moisture content in the stockfish samples would affect the preservation quality of

the samples as high moisture content promotes microbial activities in the samples during storage thereby exposing the samples to microbial attack.

Total ash content could be used to roughly estimate the mineral content of any given sample; the higher the total ash, the higher the mineral content. High levels of ash in the samples could therefore predict the samples to be good sources of mineral elements.

The crude protein contents of the ~~stock fish~~stockfish samples ~~analysed~~ analyzed were very high, confirming the literature reports that fish is a very good source of protein. The results of the of protein content recorded in this research were within the range of variations reported by Zelibe (1989). The stock fish species may therefore be an ideal source of animal protein for use in controlling diets. The high tissue protein content of the fish species in this study may be related to the high protein contents of their common diets as they fed mostly on fish items, crustaceans, molluscs, algae, and diatoms (Osibona, 2005).

The carbohydrate content recorded in the ~~analysed~~ analyzed fish samples ~~were~~ was observed to be 60.85% in ramsi black cod followed by cod (60.83%) and apama (46.86%). These values suggest that these stock fish samples could be a good source of carbohydrates and could be used the diet therapy.

The physiological role of proteins is to provide substrates for the ~~syntheses~~ synthesis of body proteins and other important nitrogen-containing compounds, and the building, repair, and maintenance of the body. Amino acids are associated with health problems and their deficiencies lead to many diseases, hence, knowledge of the amino acid composition of foods might be the basis for the establishment of their potential nutritive values. The results for the essential and non-essential amino acid profiles of cod, apama, and ramsi black cod purchased from three popular markets in Yenagoa LGA of Bayelsa state are shown in ~~table~~ Table 3 above. Results from this study showed the presence of eighteen amino acids in the ~~stock fish~~stockfish samples and glutamate was seen to be higher in all the ~~stock fish~~stockfish samples (14.70, 15.23, and 14.67 g/100g of Protein) followed by aspartate (12.20, 12.09 and 12.07 g/100g of Protein) for cod, apama and ramsi black cod respectively when compared with the other amino acids. Among these 18 amino acids are 10 nutritionally functional amino acids (FAAs) including arginine, cysteine, leucine, methionine, tryptophan, tyrosine, aspartic acid, glutamic acid, glycine, and proline, which are involved in the regulation of key metabolic pathways to improve health, growth, and development, and reproduction in organisms (Wu, 2010 and Wu, 2013) and seven conditionally

essential amino acids (CEAAs), which are non-essential amino acids that become conditionally indispensable in times of illness, extreme trauma, surgery, thermal injury, sepsis, ~~etc~~etc. (Postnauer, 2010) and they include arginine, lysine, glutamic acid, tyrosine, glycine, proline, and serine. The nutritionally essential amino acids in food proteins are the primary determinants of the nutritional quality of proteins (Young and Pellet, 1984). There were observed high values in the protein content of the three stockfishes studied, which might be due to factors like the season of the year, availability of food, migration, feeding habit and rate of feeding, habitat, age, size, reproductive cycle, and genetic trait (Abdullahi,2001). The quantity and quality of amino acids in the stockfishes studied showed that they are good sources of protein. The functions of these amino acids in the body have been reported (Ibegbulem *et al.,* 2012 and Wu *et al.,* 2013), and the results of this research showed that proteins from the meats of the species of stock fishes studied have amino acids with biological values that can meet human demand for essential amino acids. The nutritive value of meat from any animal is determined by the presence of more essential amino acid in its protein (Abdel-Salam, 2014).

Fatty acid analysis of the three stock fish samples indicated the presence of different categories of fatty acids, saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). The result of the fatty acid composition (µg/ml) of Cod, Apama and Ramsi black cod is shown in table 4 above. The result shows that twelve fatty acids were detected in the stock fish samples analysed. For cod, hexadecanoic acid was seen to be higher (21.84 µg/ml), apama, omega 3 fatty acid, and Linoleic acid (34.15 µg/ml) while ramsi black cod had oleic acid (41.05 µg/ml) to be higher. Other saturated, monounsaturated, and polyunsaturated fatty acids were also observed in the ~~stock fish~~stockfish samples analysed. The predominant fatty acid in the saturated fatty acid family was hexadecanoic ~~acid~~ (C16:0; cod: 21.84, apama: 7.08 and ramsi black cod: 26.67), however, stearic acid (C18:0; cod: ND, apama: 0.01 and ramsi black cod: 6.67) exhibited the lowest proportion. Myristic acid and Oleic acid were the only MUFAs identified. The PUFAs family was abundant in the three stock fishes analysed. The highest observed ~~PUFAs~~ PUFA levels are linked to the high content of n-3 Fatty acid series, mainly represented by eicosapentanoic acid (EPA) and Linoleic acid. The result is in agreement with Ben *et al.* (2014). Fishes are generally rich in n-3 fatty acids and low in the n-6 family (Rioux and Legrand, 2001). These groups of fatty acids are known to have beneficial effects ~~for~~ on human health (FAO, 2013). The fatty ~~acids~~ acid composition of the three stock fishes used in this study was in agreement with the data available

on the fatty acid composition of the fish species reported by Ackman (1980). Several authors have concluded that fatty acid profiles in fish reflect the diets of the animals (Turner *et al.*, 1990). In addition to diet composition, the spawning activity of these fish could drain their fat reserves, thereby contributing to the variability of the fatty acids and low tissue lipids.

Conclusion

Conclusively, the result obtained in this study has provided scientific information and detailed knowledge of the proximate, amino acid, and fatty acid composition of these three important stock fish species. The results showed that the fish species had ~~high quality~~high-quality protein, essential and non-essential amino acids, and saturated, monounsaturated, and polyunsaturated fatty acids. The three stock fishes are excellent sources of fatty acids and amino acids and are a good supplement for polyunsaturated omega-3 in the diet. The fishes contain essential fatty acids particularly docosahexaenoic acids and eicosapentaenoic acids and essential amino acids for promoting improved health, prevention, and healing of wounds and diseases in humans.

Overall, cod appears to be the best ~~as~~ diet for humans due to its relatively high nutrient components and the ratio of polyunsaturated: saturated fatty acid followed by Apama and ramsi black cod.

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