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Compositional Analysis of Nutritional Characterization, Chemical and Microbial Composition of Some Fish Species

Albert O. Amosu[1]*, Ayofe M. Hammed[2], Lucas O. Dalmeida[1], Olufemi O. Joseph[1], Theophilus F. Sunnuvu[3], & Taofeek T. Adebayo[2]

[1]Department of Agricultural Science, Lagos State University of Education, Oto/Ijanikin, P.M.B 007 Festac Town, Lagos, Nigeria
[2]Department of Fisheries, Faculty of Science, Lagos State University, P.O. Box 0001, LASU Post office, Ojo, Lagos, Nigeria
[3]Department of Aquaculture and Fisheries Management, College of Agriculture, Lagos State University of Science and Technology, Sagamu Road, Ikorodu, Lagos, Nigeria

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Abstract: The study was conducted to evaluate to nutritional charateristics, microbial and chemical composition of *Cynoglossus browni* (Nigeria tonguesole), *Pentanemus quinquarus* (Royal threadfin), *Clupea harengus* (Atlantic herring) and *Trichiurus lepturus* (Largehead hairtail). The proximate composition was determined using the Association of Official Analytical Chemists, the mineral contents were measured using Atomic Absorption Spectrophotometer (AAS). This study showed that proximate, mineral, amino acid and chemical composition varied significantly ($p<0.05$) among the selected species.Protein levels were indicated as *C. harengus* > *P. quinquarius*. Also the second highest level of crude fat was recorded in *P. quinquarius* (5.69±0.46), following *T. lepturus* (6.23±0.32). In addition, higher levels of mineral compositions (except for potassium), and glutamic acid was recorded in *P. quinquarius*. However, it can be concluded that the nutritional body composition of the selected fish species, are considerably within the nutritional ranges required by humans, though they are not high protein sources. *Pentanemus quinquarius* was observed to have quite an ideal level of the compositions.
Keywords: Amino Acid, Chemical and Microbial Composition, Fish Species.

INTRODUCTION

Fishes are highly favoured by many over other animals in terms of its availability and palatability by considerable number of people as a source of animal protein (Foran *et al*., 2005), coupled with the low level of cholesterol and good flavour (Eyo, 2001). Fishes are sources of balanced animal protein found in many low income homes even in metropolitan areas (Bene and Heck, 2005). Nigeria generates just around 40% of the projected 2.66 million metric tons of domestic consumption demand, importing the remaining 60% to meet demand (Iwegbue *et al*., 2015; & Amosu *et al*., 2017). The high demand for fish is not only because of its taste but also largely due to its nutritional values which is a function of its vital role as it accounts for 50% of total animal protein consumed by larger percentage of the populace (Elaigwu, 2019). Fish has been recognized as a very significant supply of animal protein and most of the necessary nutrients in human food (Fawole *et al*., 2007) that contain reasonable quantity of amino acids, especially lysine which is known to be in low quantity in cereals (Shirmohammadli & Mohammad, 2022). Fish is a significant source of the most cost-effective protein and other vital elements in human diets the only accessible and economical animal protein for low-income families in urban and semi-urban settings in sub sahara Africa for a variety of health reasons (Bene & Heck, 2005; Ali & Kiumars, 2010; & Adewunmi *et al*., 2014).

Most aquatic animals' nutritional nature and quality are determined by the type of food they eat. The feeding habits of a particular fish species also have a significant impact on the makeup of its body nutrients and minerals (Hammed *et al*., 2013; Hammed & Amosu, 2020; & Hammed *et al*., 2020a; 2020b). The body typically contains a limited number of these minerals, some of which are necessary nutrients and, components of various enzyme systems and metabolic pathways, and hence contribute to fish growth. Calcium, sodium, potassium, phosphorous, iron, and chlorine are the most significant mineral salts, but many others are also required in minute amounts (Kasozi *et al*., 2014). Furthermore, heavy metal contamination is a major form of pollution that poses a serious health risk and environmental problem. All living organisms require these mineral elements and some of these biochemical attributes at moderate levels; however, when they exceed metabolic demand or requirement, they tend to accumulate in tissues of organisms such as fish, which

***Corresponding Author:** Albert O. Amosu

can only metabolize them to a limited extent because the majority of these heavy metals are non-biodegradable (Fawole *et al.*, 2009). However, growing industry, urbanization, population growth, agricultural, and other human activities have resulted in significant heavy metal contamination worldwide, particularly in developing countries (Hossain & Majumder, 2018). Fishes are regarded one of the most prevalent bio-indicators for contaminants due to their higher trophic level in the food chain (Ali & Khan, 2018). Heavy metal build up in fish organs may also be influenced by physiochemical and biological factors like pH, temperature, hardness, exposure length, species eating patterns, and habitat complexity (Zeitoun *et al.*, 2014; & Hammed *et al*, 2020b). For example, an excess of Hg, As, Pb, and Cd elements may be harmful to living cells, and continuous exposure to the body can result in several disease, mental retardation, skeletal hematopoietic function disorders or death (Hossain & Dutta, 2017; & Zhong *et al*., 2018).

The hunt for a relatively potent and inexpensive source of food with high nutritional contents and value has become vital since the world as a whole is grappling with a serious malnutrition and undernutrition problem, particularly in emerging and developing countries. The goal of this study was to examine and determine the mineral composition, as well as the proximate analysis, amino acid profiles, microbial &chemical in a number of different species under study.

MATERIALS AND METHODS

Study Area

Epe is a town and Local Government Area (LGA) in Lagos State, Nigeria located on the north side of the Lekki Lagoon and about 90 km from Ibadan. Epe local government area has a total land area of 121 km^2 (Olujide, 2008). Epe have a tropical water body with a surface area of 243 km^2. Epe lagoon is fresh, lotic, non-tidal and sandwiched between Lagos and Lekki lagoons (Nwankwo, 1998; & Uwadiae, 2010). It is connected to the Atlantic Ocean via the Lagos lagoon year round. Epe lagoon is influenced by freshwater input from creek and river inflow (Nwankwo, 1998).

Collection of Fish Samples

Samples were obtained from Epe market, Lagos, Nigeria. Fresh samples of experimental species (*Cynoglossus browni*, *Pentanemus quinquarus*, *Clupea harengus* and *Trichiurus lepturus)*, were purchased, stored in a cooler and conveyed to Biolife Consults Chemistry Lab. Lagos, Nigeria for all the analysis.

PROXIMATE COMPOSITION ANALYSIS

Moisture content

AOAC (1994) outlined the procedure that was used. The approach is based on water removal from the sample and calculating its weight loss. A clean crucible was weighed and dried in the oven (W_1), and 1.0 g of each sample was weighed into the crucible (W_2) and dried for 24 hours at 105°C. Thereafter, the crucible was moved from the oven to the desicator, cooled, and reweighed (W_3). The percentage moisture content was estimated using the formula:

$$\% \text{ Moisture content} = 100 - \frac{W3 - W1}{W2 - W1} \times 100$$

Ash content

The method described by AOAC (1994) was adopted. The porcelain crucible was dried in an oven at 100°C for 10 min, cooled in a desicator and Weighed (W_1). Two grams of the sample was placed into the previously weighed porcelain crucible and reweighed (W_2) and then placed in the furnace for fazour hours at 600°C to ensure proper ashing. The crucible containing the ash was removed cooled in the desicator and weighed (W_3).

The % ash content was calculated as:

$$\% \text{ Ash content} = \frac{W2 - W1}{W3 - W1} \text{ x } 100$$

Crude Protein Determination

The micro Kjeldahl model was adopted, as specified by AOAC (1994). In a heating tube, two grams of each sample were mixed with 10ml of concentrated H_2SO_4. One selenium catalyst tablet was added to the tube, and the mixture was heated in a fume closet. The digest was then poured into distilled water for further processing. Ten millimeter portion of the digest mixed with equal volume of 45% NaOH solution and poured into a Kjeldahl distillation apparatus. The mixture was distilled, and the resulting distillate was immersed in a 4% boric acid solution with 3 drops of methyl red indicator. A total of 50 ml of distillate were collected and titrated. The sample was duplicated, and the average value was recorded. The nitrogen content was calculated and multiplied by 6.25 to determine the crude protein content.

This is given as percentage Nitrogen $= \frac{(100 \times N \times 14 \times VF) \times T}{100 \times Va}$

Where; N= Normality of the titrate (0.1N)
VF= Total volume of the digest= 100ml
T= Titre Value
Va= Aliquot Volume distilled

Extraction and Measurement of Total Lipids (Bligh & Dyer Method)

The lipid extractions were carried out according to the Bligh and Dyer technique, as specified by the AOAC (1994). In a pre-weighed 100 ml conical flask, 10g of wet material was weighed, followed by 20 ml methanol (MeOH) and 10 ml chloroform. An Ultra-Turrax mixer was used to homogenize the sample for 2 minutes. A second addition of 10 ml was made. However, the mixture was thoroughly shaken for 1 minute. A total of 18 mL of distilled water was added to the mix (including the

***Corresponding Author:** Albert O. Amosu

water already in the sample). For 1 minute, the mixture was vortexed again. In a thermostatic centrifugation at 20°C, the two layers were separated by centrifuged for 10 minutes at 450 g. A Pasteur pipette was used to transfer the bottom layer to a pear-shaped flask. A second extraction was performed using 20 ml of 10% (v/v) MeOH in a vortex for 2 minutes. The lower layer was added to the initial extract after centrifugation. The sample was evaporated to dryness using a rota-vapor. The residue was then dried for 1 hour at 104°C. The extracted weight was recorded, and the lipid content was estimated as a result.

Determination of Total Carbohydrate by Anthrone Method

This method was described by Dreywood (1946). 100 mg of each sample was weighed into a boiling tube. It was then hydrolyzed for three hours in a boiling water bath with 5 ml of 2.5 N HCl before being cooled to room temperature. The sample was neutralized with solid sodium carbonate until the exuberance stopped. 100 ml of the sample, however, was centrifuged. For analysis, the supernatant was collected (adding 1 ml of aliquots). The sample was filled to a volume of 1 ml with distilled water and 4 ml of anthrone reagent. It was then heated in a boiling water bath for eight minutes. Before the green to dark green color was measured at 620 nm, the material was allowed to cool quickly. A standard graph was plotted, with the standard concentration on the X-axis and absorbance on the Y-axis. The quantity of carbohydrate in the sample tube was determined using the graph.

$$\text{Total carb. (Glu \%)} = \frac{(a-b) \times Slope\ Reciprocal \times Extractant\ Vol.}{Sample\ Weight\ (g) \times 10{,}000}$$

DETERMINATION OF MINERAL CONTENTS

Copper, zinc, calcium, magnesium, potassium, sodium, phosphorus, and iron were measured using Atomic Absorption Spectrophotometer (AAS) based on the Association of Official Analytical Chemists (AOAC, 2000). 2 g of the sample was weighed into a small porcelain crucible and ashed for three hours in the furnace at 650°C. The ash was extracted by half filling the crucible with 2 ml HCl, boiled gently and the solution was transferred to a 50 ml beaker using Pasteur pipette. The precipitates were washed with distilled water, filtered into the filtrate and solution made up to 50 ml mark distilled water. Blanks were prepared using only distilled water. K was determined using flame photometer (model: Jenway PFP 7) with standard solutions while Fe was determined by Atomic Absorption Spectrophotometer (AAS) Bulk Scientific model 210/211 VGP with standard solutions. To determine the phosphorus content, 5 g of samples solution (from dry digestion) was pipetted into a 50 ml volumetric flask and 30ml of distilled water was added. Within 5 minutes, 10ml of vanado-molybdate reagent was added, contents were mixed and allowed to stand for 10 minutes before the transmittance percent was determined at 400 mm.

DETERMINATION OF MICROBIAL AND CHEMICAL COMPOSITION

Microbial determination

Media preparation: The SDA was prepared according to the manufacturer's direction that is 65 g per litre of distilled water and was sterilized at 121ºC for 15 min in the autoclave which was later cooled in the water bath at 45ºC (ICMSF, 2002). Sample preparation: The fish was blended 10 g of each sample was weighed on analytical balance. It was transferred into 90 mL sterile distilled water, to make 10-1 dilution. After adequate shaking, 10 mL was transferred into another 90 mL sterile water to make 10-2 dilution. All sterile water has been previously sterilized at 120ºC for 15 min in the autoclave (ICMSF, 2002). Sample dispensing: 1 mL of 10-1 and 10-2 dilutions of each sample after thorough shaking was measured and dispensed separately into pre-labelled sterile Petri dish using 1 mL pipette previously sterilized at 180ºC for 1 hour using hot air oven and cooled. 20 mL of dissolved Sabouraud Dextrose Agar (SDA) was poured into the Petri dish containing 15 g of each sample. They were gently mixed and allowed to set. The sample preparation and dispensing were done in the ultraviolet safety cabinet. The ultraviolet safety and all materials used were swabbed with 70% absolute ethanol.

- Plate incubation: The SDA plates were incubated at 25ºC for 5 days.
- Plate reading: The total mould count of each Petri dish was recorded (ICMSF, 2002).

BIOCHEMICAL PROPERTIES AND LIPID OXIDATION ANALYSES

The Total Volatile Base- Nitrogen (TVB-N)

The total volatile base-nitrogen of the fish samples was determined by AOAC (2000) method. Sample (5 g) of finely comminuted and thoroughly mixed sample was weighed into a food blender. Exactly 100 ml water was added and then homogenized for 1 minute. The content was washed into the distillation flask with further 200 ml of water. Magnesium oxide (5g) and a drop or two of antifoam solution were added. The content was raised to boil in exactly 10 minutes and distilled for exactly 25 minutes using the same rate of heating with 25 ml of 2% boric acid solution when added in a 500 ml conical flask. The tube at the end of condenser was dipped below the boric acid solution. The splash head was disconnected and heating stopped. The condenser was washed down with distilled water and the contents of the conical flask were titrated with 0.1 N NH_2SO_4. A blank determination was carried out. TVB-N value is reported as mg N/100 g flesh of fish sample (mgN/100g).

Trimethylamine Value (TMA)

The trimethylamine Value (TMA) of the fish samples were determined by AOAC (1995) method. 100 g of minced fresh fish sample were weighed into blender

***Corresponding Author:** Albert O. Amosu

and 200 mL of 7.5% trichloroacetic acid solution added and blended. The homogenous solution was centrifuged at 2000 – 3000 x g until supernatant was clear and then decanted. 4 mL aliquot of supernatant was pipetted into a test tube. A blank and standards were prepared. For the blank, 4mL distilled water was used and for the standard, 1.0, 2.0 and 3.0 mL of working standard solution (0.01 M TMA/mL) each, diluted to 4 mL with distilled water was used. To each tube (blank, standard, samples) was added 1 mL $HClO_4$ (20%), 10 mL anhydrous toluene and 4 mL K_2CO_3 solution (10%). The content of the test tube was well shaken with 0.1 g anhydrous Na_2SO_4 to dry the toluene. 5 mL picric acid working solution (0.02%) added. This was properly mixed and transferred to a spectrophotometric cell, and the absorbance recorded at 410 nm against the blank. The levels of TMA (mg/100g sample) were computed as below:

Where A = absorbance of sample, A1 = absorbance of standard nearest to absorbance of sample, Vx = mg TMA standard solution, Vt = volume (mL) of solution used, and Vs = volume (mL) of aliquot of sample used.

$$TMA = \frac{A/A1(Vx)(Vt)(300)}{Vs}$$

Thio-Barbituric Acid Value

The thiobarbituric acid value of each samples were determined by AOAC (2000) method. Samples (10 g) were weighed and macerated with 50 ml of distilled water for 2 minutes then washed into a distillation flask with 47.5 ml distilled water and 2.5 ml of 4 M hydrochloric acid was added to bring the pH to 1.5 and followed by antifoam preparation and a few glass beads. The samples were heated in the flask by means of an electric mantle so that 50 ml distillate was collected in 10 minutes from the time boiling commences. The distillate (5 ml) was pipette into a glass-stoppered tube and TBA reagent (0.2883 g/100 ml of 90% glacial acetic acid) was added. The distillate was shaken and heated in boiling water for 35 minutes. A blank was prepared using 5 ml of distilled water. Then the tubes were cooled in water for 10 minutes and the absorbance (D) was measured against the blank at 538 nm using 1 cm cells. The thio-barbituric acid value was reported as mg malonaldehyde per kilogram of sample (mgMol/kg).

Peroxide Value

The peroxide value was determined by AOAC (1994) method. Samples (5g) were weighed into dry boiling tube and 1g powdered potassium iodide and 20 ml of solvent mixture (2 vol glacial acetic acid + 1 vol chloroform). The samples were allowed to boils for 30 minutes in tube within boiling water and then allowed to boil vigorously for more than 30 seconds. The contents were quickly poured into a flask containing 20 ml of potassium iodide solution (5%) and the tube washed out twice with 25 ml of distilled water and then titrated with 0.002 M sodium thiosulphate solution using starch as indicator. The peroxide value was reported as milliequvalents of peroxide oxygen per kilogram of sample (meq peroxide/kg).

Statistical Analysis

All the data were presented inform of mean ± SD, with alpha level ($p < 0.05$) analysis of variance (ANOVA) using Graph Pad Prism V analytical software. A further study to determine the species showing significant disparities was done using Least Significant Difference (LSD) and the DNMR test.

RESULTS

Table 1 shows the difference in the proximate composition of the sample species. The levels of moisture and CHO were higher in *Cynoglossus browni* (69.23 ± 0.67% and 9.21 ± 0.42%) respectively. *Clupea harengus* appeared to have the highest protein, crude fibre and ash content, 17.67 ± 0.47%, 1.73 ± 0.44% and 1.39 ± 0.21%, respectively. However, the highest and lowest crude fat content was found in *Trichiurus lepturus* and *Cynoglossus browni*, 6.23 ± 0.32 and 4.23 ± 0.70, respectively. *T. lepturus* had the lowest protein content (15.05 ± 0.25), while the highest protein content was recorded in C. *harengus* (17.67 ± 0.47).

Table 1. Proximate Analysis of fish samples.

	C. browni	***P. quinquarius***	***C. harengus***	***T. lepturus***
%Moisture	69.23 ± 0.67^a	66.34 ± 0.34^b	67.01 ± 0.62^b	68.05 ± 1.00^a
% Carbohydrate	9.21 ± 0.42^a	7.45 ± 0.65^b	7.03 ± 0.54^c	7.82 ± 0.43^b
%Protein	15.21 ± 0.35^a	17.45 ± 0.55^b	17.67 ± 0.47^b	15.05 ± 0.25^a
%Crude Fiber	1.10 ± 0.50^a	1.02 ± 0.37^a	1.73 ± 0.44^b	1.70 ± 0.25^b
%Crude Fat	4.23 ± 0.70^a	5.69 ± 0.46^b	5.17 ± 0.33^c	6.23 ± 0.32^b
%Ash	1.02 ± 0.30^a	1.05 ± 0.11^a	1.39 ± 0.21^b	1.15 ± 0.12^a

Values with the same superscript in the same row are not significantly different at $p>0.05$.

Table 2 illustrates the mineral contents in the fish samples. Higher levels of the analyzed minerals were found in *Pentanemus quinquarus*, except for Potassium which was higher in *Cynoglossus browni*, 22.14 ± 0.52. Among the analyzed minerals, it was observed that the most abundant is Calcium, 123.42 ± 2.5.

***Corresponding Author:** Albert O. Amosu

Table 2. Mineral Contents of fish samples.

MINERALS	*C. browni*	*P. quinquarius*	*C. harengus*	*T. lepturus*
Calcium	67.09 ± 0.43[a]	123.42 ± 2.5[b]	47.34 ± 1.03[c]	16.09 ± 0.85[d]
Sodium	37.32 ± 0.97[a]	82.09 ± 1.04[b]	51.12 ± 1.10[c]	25.90 ± 0.58[d]
Potassium	22.14 ± 0.52[a]	17.09 ± 0.33[b]	12.21 ± 0.85[c]	2.89 ± 0.63[d]
Magnesium	15.56 ± 0.80[a]	27.50 ± 1.01[b]	5.60 ± 0.5[c]	4.91 ± 0.34[d]
Iron	12.78 ± 0.41[a]	15.36 ± 0.23[b]	12.03 ± 1.02[a]	8.45 ± 1.22[c]
Zinc	2.65 ± 0.35[a]	5.28 ± 0.82[b]	3.19 ± 0.85[c]	1.05 ± 0.33[d]

Values with the same superscript, in the same row, are not significantly different. (p>0.05)

The amino acid compositions of the fish samples are illustrated in Table 3 below. From this table, it appears the fish samples possess 20 amino acids, with glutamic acid being the dominant amino acid in all the fish samples. Its content ranges from 4.52 ± 1.01 to 7.19±1.07. Highest level of glutamic acid was observed in *Pentanemus quinquarus* (7.19±1.07) and the lowest in *Trichiurus lepturus* (4.52±1.01). Glutamine, which is synthesized from glutamic acid is another predominant amino acid present in the fish samples, ranging from 3.06±0.11 to 4.35±1.12. *Cynoglossus browni* appeared to have the highest glutamine content (4.35±1.12), while *Trichiurus lepturus* had the lowest (3.06 ± 0.11).

Table 3. Amino Acid Contents of Fish Samples

AMINO ACIDS	*C. browni*	*P. quinquarius*	*C. harengus*	*T. lepturus*
Cystine	0.57 ± 0.06[a]	1.09 ± 0.12[b]	0.35 ± 0.07[c]	0.90 ± 0.10[b]
Histidine	1.35 ± 0.12[a]	1.78 ± 0.29[b]	2.16 ± 0.21[c]	0.30 ± 0.04[d]
Aspartic acid	1.67 ± 0.14[a]	2.05 ± 0.09[b]	2.20 ± 0.33[b]	2.11 ± 0.21[b]
Methionine	0.81 ± 0.03[a]	1.62 ± 0.07[b]	1.57 ± 0.13[b]	1.45 ± 0.27[b]
Asparagine	1.73 ± 0.16[a]	2.09 ± 0.11[b]	2.84 ± 0.91[c]	1.39 ± 0.14[d]
Threonine	0.84 ± 0.07[a]	1.05 ± 0.07[b]	1.00 ± 0.07[b]	0.78 ± 0.09[a]
Serine	1.94 ± 0.27[a]	1.12 ± 0.14[b]	0.80 ± 0.05[c]	0.89 ± 0.10[c]
Glutamic acid	5.70 ± 1.31[a]	7.19 ± 1.07[b]	4.83 ± 0.54[c]	4.52 ± 1.01[d]
Glycine	1.59 ± 0.34[a]	3.18 ± 0.21[b]	2.07 ± 0.11[c]	1.22 ± 0.17[a]
Alanine	1.06 ± 0.21[a]	1.67 ± 0.24[b]	1.18 ± 0.21[c]	1.05 ± 0.11[a]
Valine	0.80 ± 0.07[a]	2.87 ± 0.54[b]	1.50 ± 0.29[c]	0.83 ± 0.05[a]
Leucine	1.90 ± 0.82[a]	1.75 ± 0.49[a]	2.10 ± 0.31[a]	1.86 ± 0.12[a]
Tyrosine	0.65 ± 0.12[a]	0.88 ± 0.13[a]	0.54 ± 0.12[a]	0.35 ± 0.02[b]
Isoleucine	1.05 ± 0.19[a]	1.55 ± 0.23[a]	0.89 ± 0.14[b]	0.58 ± 0.02[c]
Glutamine	4.35 ± 1.12[a]	4.01 ± 0.43[a]	3.89 ± 0.78[a]	3.06 ± 0.11[b]
Lysine	1.45 ± 0.39[a]	2.80 ± 0.95[b]	1.09 ± 0.23[a]	1.27 ± 0.18[a]
Arginine	1.11 ± 0.20[a]	1.09 ± 0.13[a]	1.48 ± 0.50[b]	1.50 ± 0.10[b]
Proline	0.84 ± 0.07[a]	0.97 ± 0.08[b]	1.02 ± 0.07[b]	0.85 ± 0.11[a]
Phenylalanine	0.98 ± 0.19[a]	1.03 ± 0.22[a]	1.05 ± 0.12[a]	0.67 ± 0.08[b]
Taurine	0.19 ± 0.02[a]	0.30 ± 0.07[a]	0.28 ± 0.09[b]	0.17 ± 0.02[a]

Values with the same superscript, in the same row, are not significantly different. (p>0.05).

Table 4 shows the microbial and chemical composition of the fish samples. Mould load and total volatile nitrogen were statistically different among the four selected species. The concentration of mould, thiobarbituric acids, peroxide and total volatile nitrogen appeared to be higher in *Pentanemus quinquarus*, with the values 7.32±0.91, 8.58±0.76, 9.85±0.23 and 19.78±1.62 respectively. However, *Clupea harengus* had higher concentration of trimethylamine, 7.23±1.36. The lowest levels of thiobarbituric acids were recorded in *T. lepturus*, while the lowest levels of total volatile nitrogen and trimethylamine were recorded in *C. browni*. Also the lowest levels of mould load and peroxide were recorded in *C. harengus*.

Table 4. Microbial and Chemical Content of Fish Samples

	C. browni	*P. quinquarius*	*C. harengus*	*T. lepturus*
Mould load of Fish	4.74 ± 0.59[a]	7.32 ± 0.91[b]	2.05 ± 0.32[c]	2.84 ± 0.32[d]
Thiobarbituric Acids	5.56 ± 0.23[a]	8.58 ± 0.76[b]	6.70 ± 0.72[c]	5.00 ± 0.57[a]
Peroxide value	9.14 ± 0.21[a]	9.85 ± 0.23[a]	8.15 ± 0.99[b]	8.53 ± 1.02[b]
Total volatile nitrogen	11.45 ± 1.52[a]	19.78 ± 1.62[b]	13.56 ± 1.51[c]	15.60 ± 1.48[d]
Trimethylamine value	2.35 ± 0.47[a]	5.58 ± 0.63[b]	7.23 ± 1.36[c]	2.70 ± 0.52[a]

Values with the same superscript, in the same row, are not significantly different. (p>0.05)

***Corresponding Author:** Albert O. Amosu

DISCUSSION

The proximate analysis, which include moisture, carbohydrate, protein, crude fiber, crude fat and ash content, of the fish samples revealed the protein contents of the experimental fishes were less than 20%, hence are not considered as high protein sources. Carbohydrate also varied among the species studied as observed by Daniel (2015). Fat compositions in the experimental fishes were above 5% below 10%, except for *C. browni*. Hence, fishes are often classified on the basis of their fat content into fatty fish, and medium fat fish (Osman *et al.*, 2007). Based on this classification, the experimental species in the study can be classified as medium fat fish. The low fat content value in *C. browni* might be as a result of the nature of food availability in the fish environment. The most dominant amino acid recorded in this study, was the glutamic acid. The dominance of glutamic acid as a major amino acid reported in this study is similar to a study on amino acids composition of *C. gariepinus*, *T.zilli*, *P.quinquarius* and *P.typus* carried out by Adesola (2011). However, the level of glutamic acid recorded in *P. quinquarius*, in this study, was lesser than that recorded by Adesola (2011). Nine essential amino acids namely, Lysine, Histidine, Arginine, Threonine, Valine, Methionine, Isoleucine, Leucine and Phynylalanine. Which are very important for human body were present in the four species examined, therefore these species would be good source of these amino acids in human diet. The microbial loads observed in this study ranged is between 2.05±0.32 and 7.32±0.41 was consistent with previous studies has reported (Udochukwu *et al.*, 2016; Yusuf *et al.*, 2017; & Borodi *et al.*, 2020). Also the values of thiobarbituric acid (TBA), which was used to assess the degree of fish spoilage especially in fatty fish, in fresh fish are higher. This could be attributed to handling of fish at the landing site and during transportation (Adeyeye *et al.*, 2015). On the other hand, the levels of Total Volatile Nitrogen recorded in this study were below the maximum recommended level, which ranges from 20 to 30 mg N/100g (Pearson, 1976). Kirk & Sawyer (1991) also suggested a value of 30 to 40 mg N/100g as the upper limit.

CONCLUSION

It can be deduced that the nutritional body composition of the selected fish species, are considerably within the nutritional ranges required by humans, though they are not high in protein sources.

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