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Analysis of the Fatty Acid Profile, Heavy Metal Concentration, and Overall Nutritional Value of Five Cameroonian Marine Fish Species

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Abstract

The nutritional content, heavy metal levels, and fatty acid characteristics of 5 Cameroon coastal aquatic organisms were examined. The Tiko port served as the collection point for a sample of several species, including Ilisha Africana (N1), Sardinella maderensis (N2), Cyprinus carpio (N3), Arius parkii (N4), Ethmalosa fimbriata (N5), which were then transported to the testing, rinsed with filtered water, and analyzed. Analysis of proximate structure, elements, lipids value, and heavy metals was carried out utilizing the Association of Official Agricultural Chemists (AOAC) protocol. The outcomes indicate the amount of protein and lipids content in N1 is greater than average. Ash concentration was highest in N3. This study indicated that the abundance of various minerals and metals increased as follows: phosphorus > magnesium > potassium > calcium > sodium > iron > zinc > copper > manganese > cadmium > arsenic. When compared to the oils obtained from N1 and N2, the oils obtained from N3, N4, and N5 were semi-siccative. Therefore, these kinds of fish can be utilized to treat protein and minerals difficulties in both people and animals.

Keywords: Heavy metals, minerals, proteins, fatty acids.

Introduction

Fish has a significant amount of nutrition because of its availability of important minerals and bioactive components. The aquatic varieties of fish caught in Cameroon, a nation with a substantial coastal region, are extremely important to the residents (1). To ensure food quality and assess the possible health advantages, it is essential to recognize the lipid composition, heavy metal content, and entire nutritional significance of certain varieties of fish (2). Polyunsaturated fatty acids (PUFAs) especially have been demonstrated to perform an important function in health maintenance. The beneficial effects of vital fatty acids like omega-3 and omega-6 for heart health, the immune system, and the brain are considerable (3). Lipid profiles in fishes can differ according to a number of factors, including organisms, nutrition, and environment (4). The fatty acid composition of varieties of fish found in the Cameroonian coastal environment can shed light on their intended health advantages and help people make more well-rounded food decisions (5). While fish has numerous health advantages, the fact that seafood often contains dangerous levels of heavy metals is an important disadvantage. Harmful heavy metals, including mercury, lead, cadmium, and arsenic, can build up in water supplies (6). Human behaviours such as manufacturing methods, contamination, and waste disposal all contribute to the introduction of such

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elements into the food web of the marine environment. Considering the dangers of consuming certain types of fish requires knowledge of the heavy metal levels in those species (7).

Oreochromis niloticus, Malapterurus electricus, Parachanna obscura, and Chrysichthys nigrodigitatus were collected from the Ogun River in Nigeria to ascertain the closest relationship and quantity of different metals. Manganese (Mn), Lead (Pb), Nickel (Ni), Cadmium (Cd), and Zinc (Zn) concentrations were determined in fish samples taken from the river's Abeokuta branch using atomic-level absorption analysis (8). The biological accumulation of metallic components in Down Beach and Isobe tissues from fish and crabs is examined. Following iron, copper, manganese, lead, and cadmium are the next most prevalent. Prospective danger factor for kids found in Down Beach fish types to be more polluted than Isobe's Variety due to the presence of zinc component in crab, which has a danger factor proved to be larger than one (9). The study (10) evaluated the negative health effects related to eating crabs and shrimps that are commonly consumed in Mansoura town, Egypt, and determined how being cooked affects the remaining amount of harmful heavy metals. The research (11) determined how much of a concern harmful elements found in the muscles of fish in the group Gadidae provide and evaluated the mineral content of cod. They looked at the Atlantic cod (Gadus morhua morhua L.), Baltic cod (Gadus morhua callarias L.), and saithe (Pollachius virens) among three different cod varieties. The research (12) identified and assessed the levels of As, Cd, Cr, Cu, Ni, and Pb in four western Mediterranean varieties of fish used for human consumption. Almera Bay (Spain) fish species Mullus surmuletus, Merluccius merluccius, Auxis rochei, and Scomber japonicus were tested using Graphite Furnace Atomic Absorption Spectrophotometry (GF-AAS) to identify harmful components in their livers and muscles. Biometrics, trophic status, and the percentage of muscle tissue in the body were also calculated. The research (13) involved purchasing and sterilized transport to a laboratory of smoked-dried fish specimens involving three various kinds Catfish (Clarias gariepinus), Bonga fish (Ethmalosa fimbriata), and Atlantic bumper (Chloroscombrus chrysurus) from four various markets in Ogun State, which involves Arepo, Ibafo, Magboro, and Mowe. They looked into the fish's microbial quality, fundamental evaluations, and metallic traces. The study (14) examined the amounts of harmful pollutants like arsenic, cadmium, mercury, and lead in five varieties of commercially available aquatic fish caught in Angola by the research vessel Dr. Fridtjof Nansen. Recommended nutritional intakes (RNI) for women and children were calculated, and the organism's contributions were evaluated in relation to that of food items derived from animals on land. The study (15) performed an occasional investigation of the level of fatty acids and dietary characteristics of mullet varieties captured in the Köyceiz lagoon on the coastline of northwest Turkey in the Mediterranean Sea. Their research demonstrated that mullet lipids concentrations and levels of fatty acids change during their lifespan and depending on their age of maturation.

The purpose of the study is to learn more about the lipid composition, mineral content, and total nutritional significance of five different marine fish species found in the coastal regions of Cameroon. These varieties of fish are widely available and perform a significant part in the

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regional food system. Essential fats have been related to a variety of health advantages, and this research intends to shed light on their existence by analyzing their lipid appearance.

Materials and Methods

Materials

Straight away, when the ships reached the port of Tiko, Cameroon, in August 2022, they were filled with 60 freshly caught fish of five different species N1, N2, N3, N4, and N5. Cameroonian officials from the Ministry of Farm Animals, Fishing, and Veterinary Organisations used FAO fish recognition forms to name the kind of fish they caught. In order to transfer the collections of fish to the Laboratories of Food Sciences and Nutrition in the Faculty of Sciences at Dschang University, iceboxes were filled with ice at a fish/ice proportion of 1:3. The sizes and weights of every fish were determined with the help of a cytometer and an accurate harmony, correspondingly. The fishes utilized in the examination had mean values of weights and size, 86.56 ± 20.84 g and 22.32 ± 2.40 cm; 110.60 ± 30.79 g and 32.2 ± 3.41 cm; 407.38 ± 91.43 g and 29.53 ± 5.10 cm; 784 ± 323.31 g and 51.58 ± 8.71 cm; 324 ± 42.21 g and 34.41 ± 4.32 cm for N5, N3, N4, N1, and N2.

Collection of Samples

The fish was cut up with a sterilized surgical knife following morphometric evaluation. The guts and the heads were thrown away. Portions of the consumable meat, skin, and additional portions were chopped up for the locals to eat. The removal of the middle vertebrae was surgical. Lipids were measured using the newly harvested consumable portion. The specimens (edible section or cleaned middle vertebrae) were then dried in an oven at 53 °C for 52 hours and then extensively homogenized in a food mixer fitted with metallic blades for proteins, ashes, and minerals evaluation.

Comparative evaluation

Specific humidity

The relative humidity was measured with a hot air oven. The specimens then dry at 110 ºC ± 3 ºC until their weights remain consistent. The proportion of the variance between the dry weights and the original weights was determined by dividing the dry weights by the original weights.

Fat quantity

Calculate the overall fat concentration in a solution of formyl trichloride/methanol/water 3:3:2.9. Using a mixer, we blended 102 ± 0.62 g of raw fish with 110 milliliters of formyl trichloride and 210 milliliters of methanol for 3 minutes. After adding another 110 milliliters of formyl trichloride and another 105 milliliters of deionized water, the mixture was stirred for 45 seconds. A hoover is used for filtering the mixture. To achieve complete the extraction process, formyl trichloride is added to the remaining while maintaining a last solvents proportion of 3:3:2.9. In order to separate the components of the combination, it is poured through a hollow tube. Anhydrous sodium sulfate is added to the lowest organic layer in a weighted container to remove any remains of moisture. After that, a rotating evaporator was

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used to evaporate the solution. The amount of fat waste is measured and then converted to a percentage of the original amount.

Amount of raw protein

Kjeldahl's approach, which measures nitrogen and applies a conversion ratio of 7.36 to estimate the number of proteins, was used to calculate the raw protein level. A total of 0.3 g of Merk catalysts, 8 milliliters of a concentrated H_2SO_4 and ortho-hydroxybenzoic acid combination, and 0.2 g of samples were added to test containers. The solution was produced by heating both substances for four hours on a digestion plate in a hooded incubator. The mineralized items were transferred to the entry of an automated micro Kjeldahl kind still, and 30 milliliter of 50% NaOH was included to neutralize acid levels due to H_2SO_4 and, more importantly, to raise the pH over 8 in order to promote vaporization of ammonia. To collect the condensed ammoniac, a conical flask consisting of 30 milliliters of hydrogen borate and some droplets of colored markers was put at the point of exit of the extractor. When the distilled product attained 250 milliliters in the Meyer Erlen, the process terminated. The extract was titrated by adding 0.12 N HCl and measuring the resulting change in color from pale green to deep pink. Simultaneously, an empty test was conducted over identical situations, and the burette descending quantity was recorded to identify any remaining nitrogen from the chemicals.

Amount of ash

The percentage of ash was determined after the organic matter was burned off for 6 hours at 480 ºC. In order to generate controllable particles, the individual specimens were heated in an oven at 120 ºC and then crushed in a mixer. Every prepared specimen was then sealed in metallic capsules and given a unique identification number. To stop the specimens from getting wet again, they were chilled in a dehydrator for 40 minutes. 3.60 g of samples and the Pyrex vessels placed in were measured using an accurate balancer. They were calcined for 6 hours at 480 degrees Celsius in a muffle furnace. Ashes, which appeared like a greyish powder form, were collected at the end of this stage, dried in a desiccator, and then weighed to assess their ash composition.

Total lipids, protein, ashes, and hydration were subtracted from 100 in equation 1 to yield the sugar amount.

$$Percentage\ Carbohydrates = 100 - Percent\ humidity - Percent\ Proteins - Percent\ lipids - Percent\ Ash \quad (1)$$

Equation 2 was used to determine an approximate mean energy level. Energy levels for carbohydrates, proteins, and lipids in the Atwater basic component method are 4, 4, and 9 kcal/g, respectively. Here SE denotes Standard Energy.

$$SE = (4\ x\ amount\ of\ carbohydrates) + (9\ x\ amount\ of\ lipids) + (4\ x\ amount\ of\ Protein) \quad (2)$$

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Minerals evaluation

3 g of material was measured, as were the Pyrex vessels into which it was placed. They were calcined in a muffle oven for 6 hours at 480 degrees Celsius. Following the burning of the fish meals, the ashes were put into 110-milliliter vessels, and 15 milliliters of strong HNO_3 were added to break down the remaining natural products. For maximum absorption, the various containers were heated in a bath of water at boiling temperature for 45 minutes. A 110-milliliter volumetric container was used to hold the filtering solution before being filled to the gauge point. Standard solutions were used in the calibrating process. Calcium was measured at 534 nm, potassium at 523.6 nm, magnesium at 342.3 nm, sodium at 324.8 nm, iron at 327.2 nm, zinc at 314.8 nm, copper at 433.6 nm, and manganese at 368.4 nm using atomic absorption spectrum analysis. Spectrophotometry at 910 nm was utilized to ascertain phosphorus quantity. After plotting the amounts opposed to the absorbing capacity of the norms in a gradual manner, we may determine the amount present in the sample. The quantities are determined in Excell, with the curve for calibration created and the amounts calculated in milligrams/110 g of dry material.

Examination of heavy metals

The amount of heavy metals was calculated using the filtrates produced during ash absorption. Existing solutions of 1000 ppm of Cd, Pb, Hg, and As were used to create the specifications. Atomic absorption spectrophotometer readings were taken to establish the Cd, Pb, Hg, and As concentrations in the absorbed specimen mixtures. Linear estimation of quantities over absorption of norms yields a number of samples. Excell is used to creating a curve for calibration and determine quantities in terms of milligrams/Kg of dry material. Triangulated data from each analysis was used to ensure accuracy.

Evaluations of the chemical composition of fish oils

The acidity value was measured using the AS formula. To a 270-milliliter beaker, 2 g of oil and 110 milliliters of ethanol heated to 98 degrees Celsius were added. The materials of the container are regulated with 0.2 N potassium hydroxide mixture after a couple of drops of 2% phenolphthalein solution are included. The amount of KOH employed in this dilution and the results of the empty testing are recorded. The acidity level of the oil was reported in milligrams of potassium hydroxide/g of oil.

The Degree of hydrolysis (DH) was calculated. A solution of C_2H_5KO (0.6 N) in ethyl alcohol was used for dissolving 3 g of oil, and the mixture was then added to a ground-joint beaker. The vessel is heated up for 50 minutes with a reflux condenser attached and mixed every 20 minutes. Hydrochloric acid solution (0.6 N) was used to regulate the surplus KOH while phenolphthalein was present. A similar approach was used to make an empty test. The value was calculated as per milligram Potassium hydroxide/g of oil used in the process.

The 20 milliliters of tetrachloromethane mixture and 30 milliliters of Wijs' reagents, 0.3 g of oil was added, and the mixture was measured. After slightly shaking the tightly closed container and letting it remain in a dark container for 2 hours, 25 milliliters of a 15% potassium iodide aqueous solution, 20 milliliters of filtered water, and seven drops of 2%

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starch are introduced. Using 0.2 N sodium thiosulfate solution, the flask's contents were adjusted to determine how much sodium thiosulfate was required to enable the mixture to transform. Empty testing was also used in this titration. The IC was given as a value in g 15/110 g of material.

Add 8.7 milliliters of a formyl trichloride-methanol combination to a glass test tube holding 60 milligrams of the oil samples and spin for 3 to 5 seconds. After adding 60 µl of a water-soluble ammonium thiocyanate solution (at 40% concentration) and spinning the combination for 3-5 seconds, 60 µl of a water-soluble iron chloride IC solution was introduced. The product is then whirling for another 3-5 seconds. After 7 minutes at atmospheric temperature, the absorption value of the resulting solution is measured at 600 nm using a spectrophotometer in comparison to a blank comprising every ingredient excluding the oil. The milliequivalent of oxygen/kg of oil was used to describe the peroxide level.

AOCS's approach was used to calculate the amount of ranitidine (AA). 2 g is dispersed in isooctane and mixed to the correct level in a 30-milliliter volumetric container. After the mixture has been thoroughly mixed, its absorbing power is calculated at 370 nm against an empty of isooctane using a spectrophotometer. The resulting mixture was pipetted into a test tube at a concentration of 10 milliliters. Isooctane is introduced in equal quantity to another tube. Then, 2 milliliters of a 0.35% p-anisidine mixture in anhydrous acetic acid was inserted into each tube, and the contents were whirled around for some moments. The absorption (As) of the mixture from the initial tube was examined at 370 nm after 15 minutes of incubating at atmospheric temperature, with the mixture from another tube serving as empty.

The Thiobarbituric acid molecular size was determined. After weighing 2 g of oil into a 15-milliliter test container, a 0.2% trichloroacetic acid water-soluble solution was included, and the combination was whirled violently. The components of the tube were then shaken once more before being placed in a bath of water at 89 °C for 40 minutes; the following solutions were inserted in rapid succession: 2 milliliters of 0.463% thiobarbituric acid solution, 2 milliliters of 20% trichloroacetic acid mixture, and 2 milliliters of 0.30 N hydrochloric acid mixture. Once the tubes had cooled to atmospheric temperature, a specimen of the aqueous phase was taken, and the optical density was determined at 621 nm employing a spectrophotometer over a white background. Malondialdehyde (MDA) levels per kg of oil were used to quantify the TBA.

Total oxidation (TOX) results were calculated from oil samples employing the equation (3) below:

$$TOX = 2MPL + AA \quad (3)$$

Where TOX = Total oxidation number, MPL = Measurement of peroxide levels, AA = Amount of ranitidine.

Statistical Examination

There were three separate evaluations for each variable. The mean was used to demonstrate data distribution. The variation among organisms was analyzed using a one-way analysis of variance. The level of relevance was set at $P < 0.06$. When the p-value from an ANOVA was statistically important, comparisons among the categories were made using Fisher's

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PLSD (Protected Least Significant Difference). The Windows version of SPSS 29 was used for the statistical analysis.

Results and discussion

Approximate construction

Through The macronutrient composition of various foods is shown in Table 1. There is a statistically relevant difference ($P < 0.06$) between the water contents of N1 and N5 and that of N4 and N2. There is a statistically relevant difference ($P < 0.06$) in the protein contents among various types of fish. The maximum number is 19.53 for N1, and the lowest value is 14.57 for N3. N1 has the greatest total lipid level at 4.78. However, its variation is 2.86-4.78. Carbohydrate levels are between 0.30 - 2.58 percent. Species differed greatly ($P < 0.06$) in their carbohydrate level, most likely because of the differing amounts of glycogen deposited in their muscles.

Table (1): Approximate percentages of consumable fish sections for various species

Species	Macronutrients					
	Humidity	Proteins	Lipids	Ash	Carbohydrate	Energy
N1	76.72 ± 0.80^{a}	19.48 ± 0.19^{e}	3.75 ± 0.21^{d}	2.05 ± 0.11^{a}	0.25 ± 0.02^{b}	109.82 ± 0.86^{d}
N2	77.70 ± 0.42^{b}	16.80 ± 0.10^{b}	2.78 ± 0.17^{bc}	2.42 ± 0.19^{b}	0.35 ± 0.11^{c}	87.51 ± 1.31^{b}
N3	76.92 ± 3.76^{ab}	15.62 ± 0.41^{a}	1.82 ± 0.25^{a}	4.64 ± 0.13^{d}	0.92 ± 0.20^{d}	77.73 ± 1.32^{a}
N4	75.86 ± 2.20^{b}	17.47 ± 0.13^{c}	2.61 ± 0.14^{b}	2.17 ± 0.07^{a}	0.13 ± 0.04a	87.34 ± 0.13^{b}
N5	78.83 ± 1.27^{a}	18.58 ± 0.38^{d}	2.82 ± 0.02^{c}	3.41 ± 0.32^{c}	1.54 ± 0.12^{e}	98.35 ± 0.87^{c}

Composition of minerals

N2 has the greatest calcium concentration of any fish type. When comparison with N4, N2, and N3, this concentration changes considerably ($P < 0.06$) in N1 and N5. Calcium's suggested daily consumption for adults is around 900 milligrams. N2 diet of 110 g could provide 45.82%. Phosphorus consumption should be around 900 milligrams per day. Approximately 88.63 g of N3 and 110 g of N1 may cover 86.64% of the required daily needs, correspondingly. N4 had the highest potassium content. The quantity differs significantly ($P < 0.06$) among several species. The daily consumption of potassium is around 3000 milligrams. N4 has 14.64% in 110 g. Manganese is necessary for the formation of pyruvate carboxylase and the fixing of minerals; it additionally assists in the prevention of protein-energy deficiency. Table 2 shows the mineral components of consumable portions in fish.

Table (2): Mineral components of consumable portions in fishes

Micronutrients	N1	N2	N3	N4	N5
Sodium	166.65 ± 6.25^{e}	117.88 ± 5.61^{d}	44.40 ± 1.30^{b}	73.46 ± 0.53^{c}	36.20 ± 1.60^{a}
Manganese	0.88 ± 0.07^{b}	0.78 ± 0.08^{a}	1.87 ± 0.16^{c}	2.19 ± 0.12^{d}	3.24 ± 0.20^{e}
Zinc	1.34 ± 0.27^{a}	2.29 ± 0.20^{b}	12.45 ± 0.56^{d}	10.33 ± 0.60^{c}	12.48 ± 1.91^{cd}
Copper	4.41 ± 0.37^{e}	3.87 ± 0.19^{d}	2.47 ± 0.42^{b}	1.88 ± 0.18^{a}	3.17 ± 0.27^{c}

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Calcium	471.72 ± 37.76^{b}	1432.52 ± 39.27^{d}	1312.87 ± 35.57^{c}	224.26 ± 21.12^{a}	484.10 ± 38.23^{b}
Sodium/ Potassium	0.20 ± 0.01^{c}	0.11 ± 0.01^{b}	0.08 ± 0.01^{a}	0.06 ± 0.01^{a}	0.07 ± 0.01^{a}
Calcium/ Phosphorus	0.20 ± 0.02^{b}	0.74 ± 0.02^{d}	0.32 ± 0.01^{c}	0.10 ± 0.01^{a}	0.31 ± 0.03^{c}
Potassium	987.23 ± 4.82^{c}	1078.57 ± 42.26^{d}	660 ± 18.06^{b}	1356.70 ± 38.91^{e}	619.75 ± 7.89^{a}
Phosphorus	2554.37 ± 56.89^{c}	2176.12 ± 16.32^{b}	4771.55 ± 48.10^{e}	2328.32 ± 79.67^{d}	1575.46 ± 87.61^{a}
Magnesium	845.36 ± 51.42^{a}	2125.86 ± 14.69^{c}	4684.59 ± 38.37^{d}	2123.41 ± 35.39^{c}	1590.19 ± 40.23^{b}
Iron	6.61 ± 0.48^{a}	10.71 ± 0.54^{d}	7.72 ± 0.52^{bc}	8.42 ± 0.60^{c}	7.40 ± 0.26^{b}

Quantity of heavy metals

The percentage of cadmium in N4 is the highest among the recognized species. There is a statistically relevant difference ($P < 0.06$) in the cadmium levels among N4 and N5. It is possible that variations in diet and lifestyle account for these distinctions. The hemogenesis, neurological, reproductive, and urinary functions have been negatively impacted by lead exposure. The amount of mercury ranges from 0.239% to 0.272%. The mercury levels in N1 are the highest of any recognized species. When comparing N1, N3, and N5, there is no apparent distinction in arsenic concentration ($p > 0.06$). The mean and standard deviation values of heavy metals in fish species are shown in Figures 1 and 2 respectively. The varieties of N4 and N2 were not tested for arsenic because the concentrations were too low to measure. Table 3 displays the variations in heavy metal levels in fishes with consumable portions.

Table (3): Variations in heavy metal levels in fishes with consumable portions

Species	Heavy metals			
	Lead	Arsenic	Cadmium	Mercury
N1	0.152 ± 0.065^{a}	0.034 ± 0.012^{a}	-	0.173 ± 0.011^{b}
N2	0.183 ± 0.034^{ab}	-	0.072 ± 0.020^{ab}	0.171 ± 0.011^{b}
N3	-	0.032 ± 0.004^{a}	0.074 ± 0.011^{ab}	0.161 ± 0.009^{b}
N4	0.183 ± 0.012^{b}	-	0.094 ± 0.030^{b}	0.145 ± 0.02^{a}
N5	0.192 ± 0.022^{b}	0.035 ± 0.003^{a}	0.060 ± 0.023^{a}	0.137 ± 0.015^{a}

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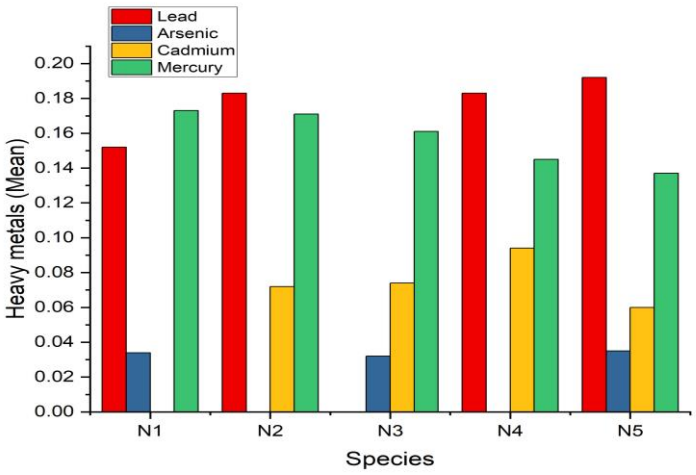

Figure (1): Mean values of heavy metals in fish species

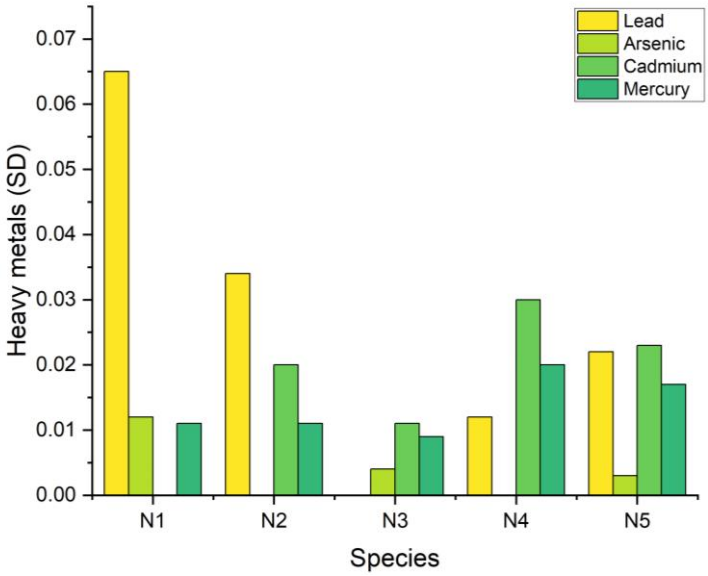

Figure (2): Standard deviation of heavy metals in fish species

The chemical composition of fish oils obtained from fresh fishes

Oils from the researched fish species have certain chemical indices that can be used to identify them. Species varied greatly from one another in their iodine content (IC) ($P < 0.06$). The iodine index is maximum in N1 and lower in N3. Initial oxidation results (measured by MPL) and secondary oxidation results (measured by AA) are calculated by factoring in the oil's non-volatile aldehyde components. There is a statistically considerable difference ($P < 0.06$) in the total oxidation value (TOX) among N3 and the remaining species. Figures 3 and 4 displays the mean and standard deviation values of chemical indicators of the examined species. Using this value, which takes consideration of the various forms in which fatty acids might be oxidized, the oxidation of fats can be more accurately evaluated. Table 4 shows the chemical values of the oils extracted examined species.

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Table (4): Chemical indices of the oils of the examined species

Chemical indicators	N1	N2	N3	N4	N5
DH	192.90 ± 8.82^{c}	198.12 ± 16.62^{c}	131.15 ± 14.79^{b}	110.92 ± 7.23^{ab}	99.10 ± 7.51^{a}
AA	0.72 ± 0.09^{a}	0.72 ± 0.11^{a}	0.71 ± 0.12^{a}	0.79 ± 0.20^{a}	0.82 ± 0.21^{a}
AS	1.07 ± 0.20^{a}	1.42 ± 0.41^{a}	1.53 ± 0.75^{a}	1.19 ± 0.62^{a}	1.09 ± 0.23^{a}
TBA	0.72 ± 0.28^{a}	0.91 ± 0.07^{a}	0.94 ± 0.25^{a}	1.32 ± 0.92^{a}	1.26 ± 0.37^{a}
IC	161.06 ± 16.65^{d}	154.32 ± 6.81^{d}	106.45 ± 5.53^{a}	123.16 ± 4.39^{b}	136.72 ± 7.59^{c}
MPL	1.54 ± 0.35^{a}	1.72 ± 0.43^{a}	2.12 ± 0.87^{a}	1.21 ± 0.33^{a}	1.32 ± 0.63^{a}
TOX	3.89 ± 0.82^{a}	4.61 ± 0.59^{a}	5.96 ± 0.32^{b}	3.64 ± 0.66^{a}	3.75 ± 0.65^{a}

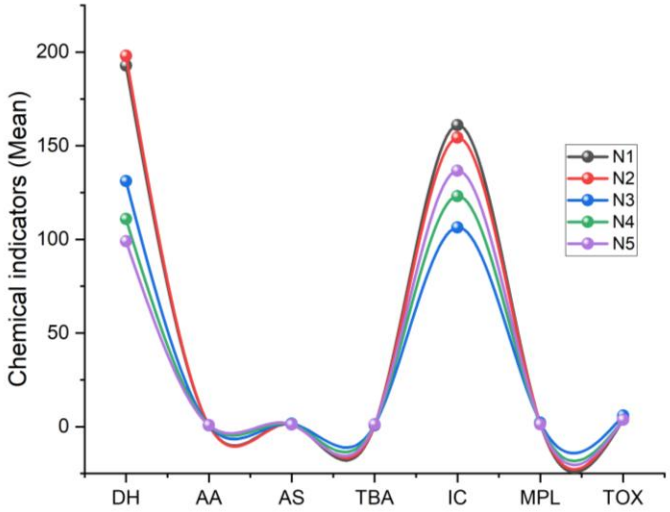

Figure (3): Mean values of chemical indicators of oils in fish species

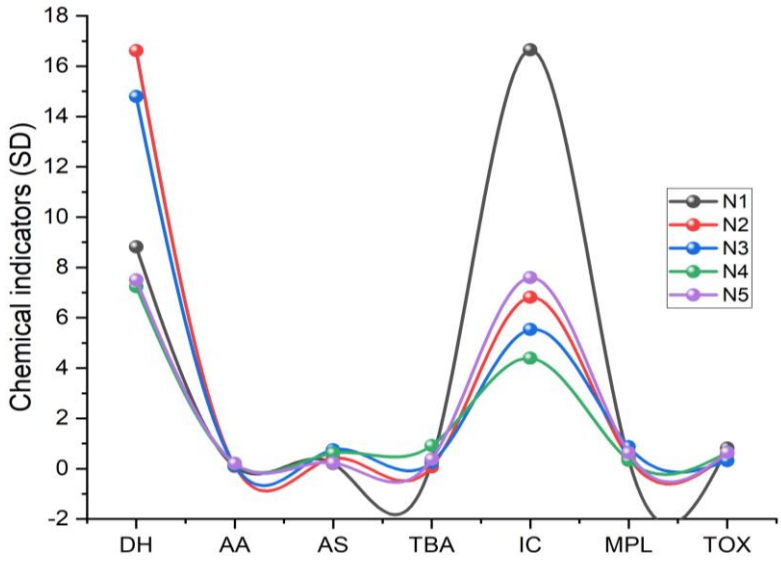

Figure (4): Standard deviation of chemical indicators of oils in fish species

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Conclusion

This research demonstrated that different species of fish have different nutritional profiles. The fats that may be derived from them are high quality, and they are excellent suppliers of minerals and proteins. The levels of heavy metals found in these fish were below the global standards for contamination. These findings highlight the need to educate individuals on the potential adverse effects associated with excessive intake of these species. The nutritional and shortages of minerals can be tackled with the help of these fish, as demonstrated by their nutritious content and the high quality of their lipids. Subsequent research will look at the impact of periodic fluctuation on macronutrient, lipid, and protein identities, as well as the impact of diverse regional cooking practices on the basic structure.

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