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Proximate and Mineral Composition in the Flesh of Five Commercial Fish Species in Nigeria

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Abstract

The proximate and mineral composition in the flesh of five commercially important fish species in Nigerian market, Scomber scombrus, Trachurtus trachurus, Micropogonias furnieri, Sardinella aurita and Clarias gariepinus were studied to assess their nutritional values in order to gain the knowledge of the risk and benefits associated with the indiscriminate consumption of these fish species in Nigeria. The fish samples were classified into two groups using hierarchical cluster analysis techniques; S. aurita and S. scombrus belong to high lipid high protein fish species while M. furnieri, C. gariepinus and T. trachurus belong to average lipid high protein fish species. The mean protein contents were 20.81%, 16.72%, 20.73%, 19.97%, and 20.80% for T. trachurus, S. aurita, M. furnieri, S. scombrus and C. gariepinus respectively. Mean values for fat contents were 5.42%, 20.94%, 3.09%, 19.19% and 3.24% for T. trachurus, S. aurita, M. furnieri, S. scombrus and C. gariepinus respectively. The moisture content was inversely related to lipid content. The fish species are rich in calcium and magnesium. The iron content was not statistically different (p<0.05) between the fish species.

Key words: Proximate composition, mineral content, cluster analysis, T. trachurus, S. aurita, M. furnieri, S. scombrus, C. gariepinus.

Introduction

The nutritional characteristics of fish and fishery products are of vital interest to consumers. Fishery products are highly nutritious and an excellent means of obtaining dietary essentials, like protein, minerals and vitamins. Fish fat contains a high proportion of polyunsaturated fatty acids, which may help to decrease the incidence of atherosclerosis, and heart related diseases. The flesh of a fish in good condition is made up of five main chemical components namely protein, lipid, water, minerals and vitamins.
Fisheries reduce vulnerability to hunger by providing a complementary food source as part of diversified livelihood strategies. Fisheries especially provide food when other food sources such as agriculture are at a seasonal low.

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Foran et. al., (2005) submitted that, fish is a highly proteinous food consumed by a larger percentage of populace because of its availability and palatability.
The study of mineral elements present in living organisms is of biological importance. Many of such elements take part in some metabolic processes and are known to be indispensable to all living things (Shul'man, 1974).
The body usually contains small amount of these minerals, some of which are essential nutrients, being components of many enzymes system and metabolic mechanisms, and as such contribute to the growth of the fish. The most important mineral salts are that of calcium, sodium, potassium, phosphorous, iron, chlorine while many others are also needed in trace amounts. The deficiency in these principal nutritional mineral elements induces a lot of malfunctioning including reduced productivity, inability of blood to clot, osteoporosis, anemia e.t.c. (Shul'man, 1974 and Mills, 1980). The measurement of some proximate

profiles such as protein contents, carbohydrates, lipids, moisture contents and ash percentage is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000).

In this study, samples of five important commercially available fish species in Nigerian market were evaluated for their proximate and mineral compositions. We studied the ability of hierarchical cluster analysis statistical protocols to identify the similarities and differences in the nutrient contents that could be used to classify the fish species.

Material and Methods

Sample collection. The fish samples used for this study include Scomber scombrus, Trachurtus trachurus, Micropogonias furnieri, Sardinella aurita and Clarias gariepinus. They were purchased from a fish market in Sandgross, Lagos, Nigeria. The fishes collected were virtually of the same size as variability in size stands to affect the proximate composition and the mineral elements concentration. All the samples were collected fresh and refrigerated below 40C prior use.

Chemical analysis. The percentage proximate composition of collected fish samples was determined according to the AOAC (1994) methods. The moisture content was determined by drying samples overnight at 1050C until constant weight was achieved (Gallenkamp, UK). Crude protein was determined using the Kjeldahl method (Kjeltec System 2100, Sweden). Crude fat content was determined using the Soxhlet method (SoxtecTM 2050, Sweden) and the ash content was by ashing the samples for 6 hrs at 5000C (Carbolite Sheffield® muffle furnace, England). Carbohydrate content was calculated by difference; (i.e., the sum total percentage of moisture, crude protein, crude fat and ash contents were subtracted from 100%). The concentration of mineral elements was determined using Atomic Absorption Spectrophotometer (AAS) and calculated in ppm (μg/g dry weight).

Statistical data analysis. Data were analyzed by descriptive analysis and one-way analysis of variance (ANOVA) to explore the general trend of the experimental data. Tukey's honestly significant difference (HSD) test and Ducan's Multiple Range Test of difference between means (DMRT) were also performed. Cluster Analysis (CA) was done for the purpose of classifying the fish samples based on the chemical composition. SPSS (version 16.0) statistical software package (SPSS, Chicago, USA) was employed in the analysis. Differences were considered significant at an alpha level of 0.05. All means were given with ± standard deviation.

Results

The result of the proximate composition of the fish samples is shown in Table 1. The values represent the mean of triplicate determinations and standard deviation. Mean values of duplicate determination and standard deviation were reported for protein while the values for carbohydrate were obtained by difference. Mean values followed by different letters in the same column were significantly different (P<0.05). The ash content range between 0.46g/100g for *C. gariepinus* to 5.42g/100g for *S. scombrus*, there was no significant difference (p<0.05) between the values for all the fish species. The protein content showed highest value (20.81g/100g) for T. trachurus and

Table 1: Proximate composition of five fish samples (*Scomber scombrus, Trachurtus trachurus, Micropogonias furnieri, Sardinella aurita* and *Clarias gariepinus*)

Fish sample	Ash* (g/100g)	Protein† (g/100g)	Fat* (g/100g)	Moisture* (g/100g)	Carbohydrate** (g/100g)
T. trachurus	1.13±0.01a	20.81±0.01d	5.42±0.02 c	71.16±1.25 c	1.48±1.27 a
S. aurita	0.98±0.01 a	16.72±0.01 a	20.94±0.09 e	57.36±0.00 a	4.01±0.10 b
M. furnieri	1.07±0.01 a	20.73±0.01 c	3.09±0.02 a	71.53±1.06 c	3.59±1.02 b
S. scombrus	5.42±0.01 a	19.97±0.01 b	19.19±0.01 d	59.12±0.00 b	1.63±0.01 a
C. gariepinus	0.46±0.01 a	20.80±0.01 d	3.24±0.01 b	70.98±0.33 c	4.54±0.33 b

*Mean values of triplicate determinations and standard deviation.
† Mean values of duplicate determinations and standard deviation
**Values obtained by difference
Mean values followed by different letters in the same column were significantly different (P < 0.05)

least value (16.72g/100g) for *S. aurita*. The protein content values of 20.8g/100g, 20.73g/100g and 19.97g/100g were obtained for *C. gariepinus*, *M. furnieri*, and *S. scombrus* respectively. The protein content for all the fish species followed a decreasing order *T. trachurus* > *C. gariepinus* > *M. furnieri* > *S. scombrus* > *S. aurita*. The fat content values showed significant difference (p<0.05) among the fish species with *S. aurita* having the highest value (20.94g/100g) and *M. furnieri* having the least (3.09g/100g). The fat contents of *T. trachurus*, *S. scombrus* and *C. gariepinus* are 5.42g/100g, 19.19g/100g and 3.24g/100g respectively. The fat content for the fish species followed a decreasing order *S. aurita* > *S. scombrus* > *T. trachurus* > *C. gariepinus* > *M. furnieri*.

Table 2 shows the mean values and standard deviation of duplicate determinations for the mineral content of the fish samples. Mean values followed by the same letters in the same column were not significantly different (p<0.05). The iron content of the fish species ranged between 0.0035ppm and 0.006ppm. There was no significant difference (p<0.05) between the values of the iron contents. The Calcium content varies significantly (p<0.05) for the fish species with the least value (0.44ppm) and the highest value (0.97ppm) obtained for *S. scombrus* and *C. gariepinus* respectively. The calcium content for the fish species followed an increasing order *S. scombrus* < *M. furnieri* < *T. trachurus* < *S. aurita* < *C. gariepinus*.

The dendrograms (Fig.1a and 1b) show two hierarchical clusters of the fish species based on the chemical properties examined using two different methods. Fig.1a employed average linkage (between group) using squared Euclidean distance as measure of dissimilarity (default method used by SPSS®) while Fig.1b used Ward's method.

Table 2: Mineral composition of five fish samples (*Scomber scombrus, Trachurtus trachurus, Micropogonias furnieri, Sardinella aurita* and *Clarias gariepinus*)

Fish samples	Calcium (ppm) †	Iron (ppm) †	Phosphorus (ppm) †	Magnesium (ppm) †
T. trachurus	0.67±0.00 c	0.0048±0.0006 a	0.03±0.00 a	0.64±0.01 c
S. aurita	0.90±0.01 d	0.0039±0.000 a	0.20±0.00 c	0.70±0.00 e
M. furnieri	0.58±0.00 b	0.0044±0.0046 a	0.20±0.00 c	0.60±0.01 b
S. scombrus	0.44±0.01 a	0.006±0.000 a	0.22±0.00 d	0.50±0.01 a
C. gariepinus	0.97±0.00 e	0.0035±0.000 a	0.15±0.00 b	0.68±0.00 d

† Mean values of duplicate determinations and standard deviation. Mean values followed by different letters in the same column were significantly different (P < 0.05)

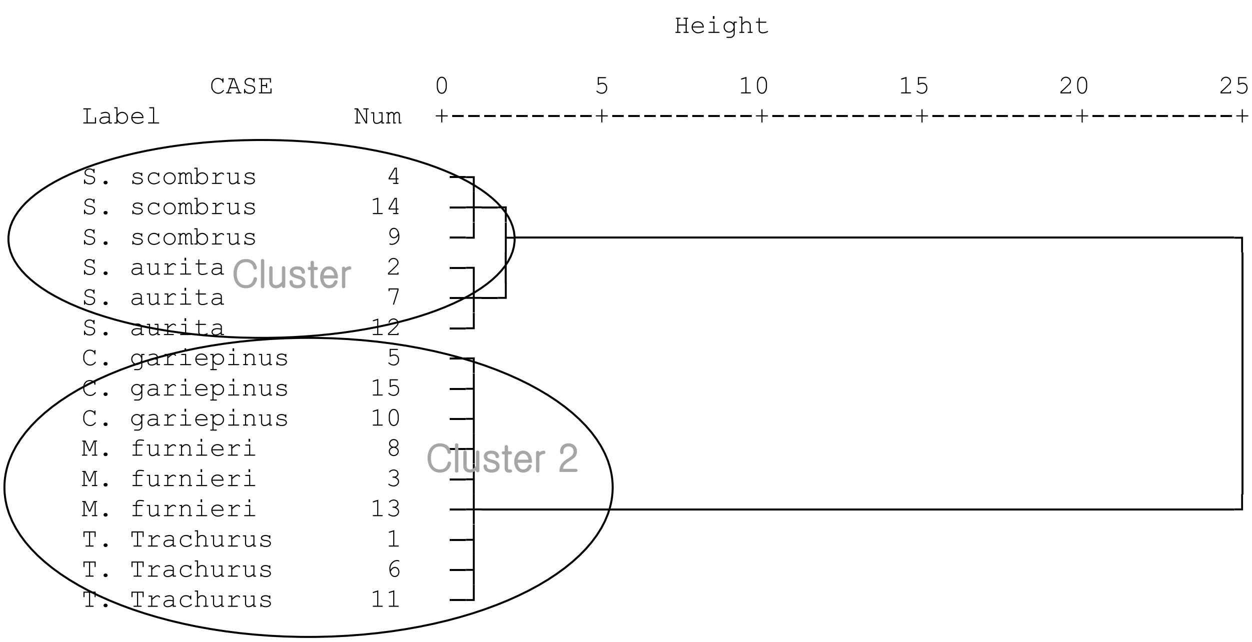

Figure1a. Dendrogram showing two hierarchical clusters of fish species based on all the chemical properties examined. Clustering method: average linkage (between group) using squared Euclidean distance as measure of dissimilarity.

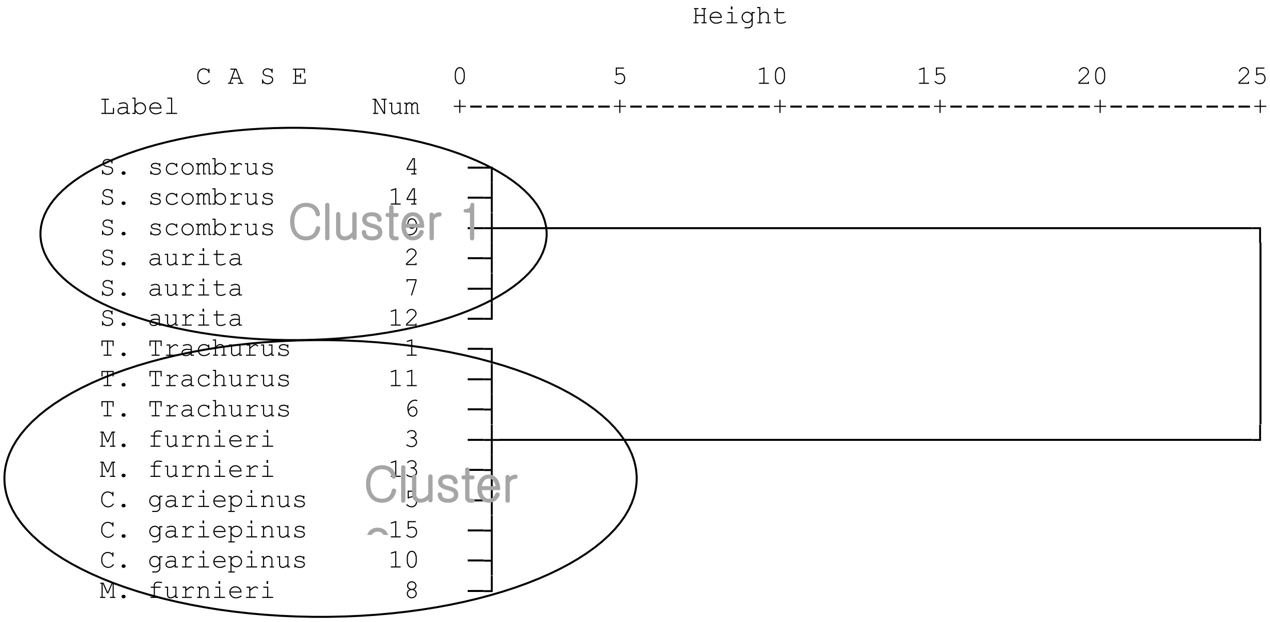

Figure1b. Dendrogram showing two hierarchical clusters of fish species based on all the chemical properties examined using Ward's method.

Discussion

General trend of properties. The univariate statistical analysis showed that all the properties examined, except for the ash and iron contents, vary significantly ($p<0.05$) among the fish species (Tables 1 and 2). The calcium and magnesium contents showed higher variability among the species. The two different methods of hierarchical cluster analysis performed on the fish species based on the chemical properties studied resulted into classifying the fish samples into two groups (Figures1a and 1b). First group comprising S. aurita and S. scombrus, and the second group comprises C. gariepinus, M. furnieri and T. trachurus. We observed from Table 1 that the fish species in the first group had higher values of fat content (20.94g/100g and 19.19g/100g respectively) compared with the fish species in the second group having values of fat content below 6g/100g (i.e. 3.24g/100g, 3.09g/100g and 5.42g/100g respectively). Also, the moisture content for the fish species in the first group were below 60% while the fish species in the second group had higher moisture content (above 70%).

Proximate composition. Fishery products satisfy the appetite and taste, and are cheaper than other sources of animal protein. Fish is nutritionally very important; it provides a source of easily digestible high quality protein containing essential amino acids, (particularly lysine in high concentration). The fat is high in polyunsaturated fatty acids e.g. Omega-3 fatty acids, and these are highly beneficial to the health of the consumers (FAO, 1998). Fish is lower in total fat and saturated fat than red meats (Land, 1986). The proximate composition of a species helps to assess its nutritional and edible value compared to other species. The proximate data assist the nutritionist, dieticians and consumers to estimate the intake of the principal nutrient in the human diet, to calculate energy values of diet and to have the knowledge of the content of the diet.

The chemical composition of marine organisms comes quite close to that of land animals. The principal constituents are water (66 – 84 %), protein (15 – 24 %), lipids (0.1 – 22 %), minerals (0.8 – 2 %) and sugar in very minute quantity (0.3%) at maximum value in fishes (Jacquot, 1961). In this investigation, the protein contents of the fish samples show that the fish are high in protein since the protein content fall in the range 15-20 % in accordance with (Stansby, 1962).

Depending upon the level of lipids in the fish muscles, fishes are classified into three categories e.g. fat fish with more than 8 % average fat content, average fat fish with fat content vary between 1 % and 8 % and lean fish with fat content less than 1 % (Srivastava, 1999). Accordingly, S. aurita and S. scombrus having fat contents of 20.94% and 19.19% respectively fall into the category of fatty fish while M. furnieri, C. gariepinus and T. trachurus having fat contents of 3.09% , 3.24% and 5.42% fall into the category of average fat fish. The fish samples analyzed belong to high lipid, high protein fish species (i. e. S. aurita and S. scombrus) and average lipid high protein fish species (i. e. M. furnieri, C. gariepinus and T. trachurus). This further explains the cluster analysis classification (Figures 1a and 1b).

The moisture was inversely related to lipid content in the present study. The inverse relationship has also been reported in marine fishes such as Mugil cephalus (Das, 1978); Sarda sarda (Zaboukas et. al., 2006) and freshwater fishes Wallago attu (Bloch) (Jafri, 1969) and Ophicephalus punctatus (Jafri and Khawaja, 1968).

Carbohydrates formed a minor percentage of the total composition of the muscle. The low values of carbohydrates recorded in the present study could be because glycogen in many marine animals does not contribute much to the reserves in the body (Jayasree et al., 1994). Ramaiyan et al. (1976) reported similar findings in 11 species of Clupeids. Phillips et al. (1967) reported that carbohydrates are utilized for energy in trout, thus sparing protein for building of the body.

The percentage ash content in the fishes analyzed is an indication of ample mineral content in fish. The mean values of the ash content for the flesh of the fish samples (Table 1) follow an increasing order C. gariepinus < S. aurita < T. trachurus < M. furnieri. < S. scombrus .The ash content of C. gariepinus was the least (0.46%) and could be traced to the fact that it is a fresh water species compared to others which are of relatively higher salinity environment. The ash contents for all samples examined were not above the World Health standard and the values were not significantly different ($p<0.05$) between the samples.

Mineral contents. The concentration of the microelement, iron, analyzed for the fish samples, were not statistically different at $p<0.05$ between the fish species. Iron is an essential component of the respiratory pigments, haemoglobin and myoglobin. It is an essential component of various enzyme systems including the cytochromes, catalases, peroxidases, and the enzymes xanthine and aldehyde oxidase, and succinic dehydrogenase. As a component of the respiratory pigments and enzymes concerned in tissue oxidation, it is essential for oxygen and electron transport within the body. The iron contents for the fish samples are within the World Health standard.

Calcium is an essential component of bone and cartilage. It is essential for the normal clotting of blood, by stimulating the release of thromboplastin from the blood platelets. It is also an activator for several key enzymes, including pancreatic lipase, acid phosphatase, cholinesterase, ATPases, and succinic dehydrogenase. Through its role in enzyme activation, calcium stimulates muscle contraction (i.e. promotes muscle tone and normal heart beat) and regulates the transmission of nerve impulses from one cell to another through its control over acetylcholine production. In conjunction with phospholipids, calcium plays a key role in the regulation of the permeability of cell membranes and consequently over the uptake of nutrients by the cell. It is believed to be essential for the absorption of vitamin B12 from the gastro-intestinal tract. Both C. gariepinus and S. aurita recorded higher level of calcium, the relative preference of these species for consumption of hard structure could be a contributing factor as observed by Adewoye et al., (2003). The low calcium content recorded in M. furnieri could probably be due to preferential accumulation and calcification of scales which make the element less available in its flesh.

Phosphorus plays a central role in energy and cell metabolism. Inorganic phosphates serve as important buffers to regulate the normal acid-base balance (i.e. pH) of animal body fluids. The lower concentration of phosphorus in the flesh of the fish species compared to calcium can be attributed to the fact that the body phosphorus requirements are usually met from dietary sources. Within plant foods, including cereals and oilseeds, 50–80% of the phosphorus occurs in the form of the calcium or magnesium salt of phytic acid; phytic acid being the hexaphosphate ester of inositol. This organic form of phosphorus must first be hydrolyzed within the gastro-intestinal tract by the enzyme phytase to inositol and phosphoric acid before it can be utilized and absorbed by the animal. The result obtained in this investigation testifies the specific differences of functioning of the systems that take part in support of acid-base balance of organisms.

All the elements with the exception of iron significantly varied ($p<0.05$) in their concentrations between the selected species sampled. This observation was supported by the findings of Windom et al., (1987) which showed that such variations in concentrations of these mineral elements from one species of fish to another was due to the chemical forms of the elements and their concentrations in the local environment. However, the microelement (iron) recorded very low values; this may be due to the fact that the body needs it in trace amounts.

Conclusion

Fish are good sources of protein, micro-nutrients and essential fatty acids, providing an important complement to the predominantly carbohydrate-based diet of many people in Nigeria. The study of the proximate composition of *Scomber scombrus, Trachurtus trachurus, Micropogonias furnieri, Sardinella aurita* and *Clarias gariepinus* revealed that they are rich in protein and have average to high lipid contents. The present study showed that these fish species are good sources of minerals. It could also be inferred that the mineral elemental levels of each species is a function of the availability and preferential accumulation. Cluster analysis was successfully used to classify the fish samples into two major groups of high lipid high protein fish and medium lipid high protein fish based on the combinations of compositional properties which maximized the similarity of cases within each cluster while maximizing the dissimilarity between groups that were initially unknown.

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