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Proximate and Metal Composition of Smoked Fish Samples in Umuahia, Nigeria

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Abstract

Proximate and heavy metal compositions of fish muscles in four smoked fish species procured from three local markets in Umuahia, Nigeria were determined. Proximate analysis was done with Food and Agriculture Organization methods while Flame Atomic Absorption Spectrophotometry was used for heavy metal (cadmium, Cd; chromium, Cr; iron, Fe; lead, Pb and nickel, Ni) analysis. Mean crude protein contents of the fish species were high (>15%) and were significantly higher ($P < 0.05$) in *Oreochromis niloticus* samples. While the mean concentrations of other metals in the fish species from the three markets were below FAO/WHO limits, mean Pb concentrations in all the smoked species from Ubani Modern market and *Clarias gariepinus* from Gate 6 market were either above or equal to the limit. The possibility of Pb poisoning from prolonged consumption of smoked fish is inferred.

Keywords

Proximate, Metals, *C. gariepinu*s, *O. niloticus*, *T. trachurus*, *S. scombrus*

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1. Introduction

Fish is a major source of protein for the increasing world population, especially in the developing countries of Africa, Asia and South America [1, 2]. Some fish species contain Omega-3-fatty acids that help to reduce the risk of certain types of cancer and cardiovascular disease [3]. Omega-3-fatty acids include Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA) etc. Fig 1 and 2)

Fish is produced in both culture (aquaculture) and capture fisheries systems. One of the major factors affecting fish production in Nigeria is water pollution and several studies have reported the pollution of water bodies in Nigeria as a result of indiscriminate discharge of effluents and other pollutants into Nigerian waterbodies [4, 5]. Fish grown in polluted waterbodies are at the risk of bioaccumulation of pollutants into their tissues [6]. Fish from polluted waterbodies in Nigeria may sometimes be processed without the necessary public health checks. Fish is traditionally preserved in Nigeria by smoking with fuel wood. This leads to the deposition of different chemicals on smoked fish. Both imported and locally grown fish are smoked in Nigeria. Smoking and handling processes are capable of increasing the levels of metal in fish, in addition to metals which may be accumulated during the production processes from fish feed, water etc. Smoking combines the effects of salting, drying, heating and smoking [7]. Handling processes for fish by local fishermen and fish mongers is fraught with a lot of unhygienic conditions like washing with dirty water, keeping of fish in metal laden containers, transportation in containers that expose them to heavy vehicle exhaust and consequent deposition of chemicals on the fish etc. Heavy metals are implicated in neurological and cardiovascular disorders in man especially in children, which can lead to behavioral changes and impaired performance in intelligent quotient (IQ) test [8]. This study investigated the concentrations of Cd, Cr, Fe, Ni and Pb in imported and local smoked fish obtained from local markets

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within Umuahia. Results were compared to National and International permissible limits of these metals in fish and appropriate recommendations were made.

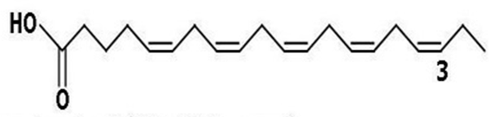

Fig. 1. Eicosapentaenoic acid (EPA, 20 C atoms, 5 double bonds – 20:5n-3).

Fig. 2. Docosahexaenoic acid (DHA, 22 C atoms, 6 double bonds – 22:6n-3).

2. Materials and Methods

2.1. Sampling

Triplicate samples of four smoked fish species (2 local and 2 exotic species); Catfish (*Clarias gariepinus*), Tilapia *(Oreochromis niloticus),* Horse Mackerel *(Trachurus trachurus)* and Mackerel *(Scomber scombrus)* were procured from three local markets in Umuahia, Abia State, Nigeria. The markets included; Ubani Modern Market, Orie-Ugba and Gate 6 Markets. The fish collected were of similar size (315 ± 2.86 g) and were put into polyethene bags and transported in plastic boxes to the laboratory for analysis. Fish muscles were removed with a plastic knife, oven dried at about 80°C overnight before being homogenized with plastic mortar and pestle prior to digestion.

2.2. Sample Digestion and Analysis

The sample was digested with a modification of the method of Coetzee *et al.* [9]. Dried fish (1 g) was weighed into a 100 ml Kjeldahl flask and 20 ml of concentrated nitric acid (HNO_3) and 1 ml of sulphuric acid (H_2SO_4) were added. The mixture was boiled until the atmosphere within the flask began to darken (approximately 15-20 min). The flask was then removed and 0.5 ml of 3:1 HNO_3 – $HClO_4$ solution was added. The mixture was swirled and digested over a burner with intermittent cooling and addition of HNO_3 – $HClO_4$ solution until it became colourless. The digest was then filtered with Whatman no. 40 filter paper into a 50 ml volumetric flask, made up to mark with distilled-deionised water and used for metal analysis with Shimadzu (model AA – 650) double beam digital Atomic Absorption Spectrophotometer (AAS). Proximate composition (moisture, ash, crude fibre, crude fat and crude protein) was determined with the method of FAO [10].

3. Results and Discussion

The results of the proximate composition of the smoked fish species from the three markets are shown in Tables 1-3.

Table 1. Mean (±SD) Proximate Compositions (%) of Fish Samples from Ubani Market.

Sample	Moisture	Ash	Crude Fat	Crude protein	Crude Fibre
A	15.26±1.05	3.60±0.62	10.2±0.16	20.6±1.73	1.02±0.43
B	22.86±1.03	6.90±0.88	16.2±0.08	23.4±2.85	1.15±0.09
C	8.52±0.91	2.71±0.09	18.4±0.59	30.6±3.04	1.05±0.01
D	17.26±2.44	2.50±0.05	5.72±0.70	36.26±2.36	1.26±0.18

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*)

Table 2. Mean (±SD) Proximate Compositions (%) of Fish Samples from Orie Ugba Market.

Sample	Moisture	Ash	Crude Fat	Crude protein	Crude Fibre
A	16.32±1.77	4.45±0.95	12.52±2.59	20.84±3.80	1.11±0.28
B	20.49±3.61	6.27±1.70	17.32±1.04	22.91±3.06	1.54±0.33
C	10.42±2.01	3.55±0.27	19.17±0.83	31.08±2.41	1.70±0.25
D	14.70±1.03	2.89±0.07	7.63±1.11	34.01±4.02	1.16±0.27

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*)

Table 3. Mean (±SD) Proximate Compositions (%) of Fish Samples from Gate 6 Market.

Sample	Moisture	Ash	Crude Fat	Crude protein	Crude Fibre
A	14.90±0.05	3.96±0.84	12.91±1.02	18.96±2.07	2.00±0.71
B	19.83±1.07	5.87±0.92	14.22±0.80	21.46±2.90	1.65±0.30
C	9.26±0.55	2.07±0.68	16.50±1.49	31.08±2.11	1.80±0.07
D	16.80±2.06	2.72±0.85	6.53±1.03	34.33±1.19	2.01±0.54

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*)

Mean moisture content in A (*Scomber scombrus*) from Orie Ugba market was similar (P > 0.05) to that for the same species in Ubani and Gate 6 markets. Mean moisture content for B (*Trachurus trachurus*) samples from Ubani market was significantly higher (P < 0.05) than values obtained for the same species from Orie Ugba and Gate 6 markets. Mean moisture contents for C (*Clarias gariepinus*) in the three markets were similar (P > 0.05) while the value for D (*Oreochromis niloticus*) from Orie Ugba market was significantly lower (P < 0.05) than values for the same species from Ubani and Gate 6 markets. The differences in moisture content can be attributed to different smoking methods adopted and amounts of moisture lost during smoking/drying. There are no negative effects of the drying process on the proximate values in catfish except losses in the energy value [11]. Also, during smoke – drying, the fish flesh loses water in the initial phase that could be compared to cooking and a protective coating is formed due to partial carbonization of tissue and other components by wood smoke [12]. Mean ash content was significantly higher (P < 0.05) in B (*Trachurus trachurus*) than in other species from the three markets while mean crude fat contents were significantly higher (P < 0.05) in C (*Clarias gariepinus*) than in other species. Values for mean crude protein content was significantly higher (P < 0.05) in *Oreochromis niloticus* samples from the three markets than values in the other species. Generally, crude protein content of fish is regarded as high if it is above 15% [13].

The results of heavy metal concentrations in the smoked fish samples from the different markets are shown in Tables 4-6.

Table 4. Heavy Metal Concentrations (mg/kg) in Smoked Fish Samples from Ubani Market.

Samples	Cadmium	Chromium	Iron	Nickel	Lead
A	0.03±0.01	0.05±0.01	12.60±2.09	ND	0.67±0.04
B	ND	0.08±0.02	10.22±2.71	ND	0.50±0.01
C	ND	0.12±0.03	8.05±1.11	ND	0.69±0.18
D	ND	0.09±0.01	8.72±1.52	ND	0.52±0.07

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*); ND = not detected

Table 5. Heavy Metal Concentrations (mg/kg) in Smoked Fish Samples from Orie Ugba Market.

Samples	Cadmium	Chromium	Iron	Nickel	Lead
A	0.07±0.02	0.04±0.01	13.25±2.11	ND	0.39±0.04
B	ND	0.01±0.00	15.40±1.07	ND	0.27±0.01
C	ND	0.03±0.01	10.29±2.08	ND	0.33±0.02
D	ND	0.02±0.01	29.44±5.13	ND	0.18±0.01

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*); ND = not detected

Table 6. Heavy Metal Concentrations (mg/kg) in Smoked Fish Samples from Gate 6 Market.

Samples	Cadmium	Chromium	Iron	Nickel	Lead
A	ND	0.02±0.00	8.14±2.18	ND	0.46±0.03
B	0.04±0.01	0.05±0.01	10.02±1.09	ND	0.29±0.08
C	ND	0.02±0.01	13.90±2.10	ND	0.51±0.06
D	ND	0.01±0.00	11.66±2.43	ND	0.38±0.04

Values are means of three replicates ± SD. Sample A = mackerel (*Scomber scombrus*), Sample B = horse mackerel (*Trachurus trachurus*), Sample C = catfish (*Clarias gariepinus*), Sample D = tilapia (*Oreochromis niloticus*); ND = not detected

Cd was not detected in the fish species from Ubani and Orie Ugba markets except in *Scomber scombrus* which had mean Cd concentrations of 0.03 ± 0.01 mg/kg and 0.07 ± 0.02 mg/kg, respectively in the two markets. Cd was also detected only in *Trachurus trachurus* samples from Gate 6 market. Cd is toxic to human and animal tissues [14] and the limit for Cd in fish muscle is 0.5 mg/kg [15] which is much higher than the values obtained in this study. Mean Cr concentrations was significantly lower (P < 0.05) in *Scomber scombrus* from Ubani market compared to other species, but had similar values (P > 0.05) in samples from other markets. Cr is an essential trace metal and it plays a crucial role in glucose metabolism. Mean Fe concentration in *Oreochromis niloticus* samples from Orie Ugba market was significantly higher (P < 0.05) than the concentrations of metals in all the species from the three markets. Fe is a well-known essential metal in the human body, but like other essential metals, it can be toxic if it accumulates beyond safe limits. Ni was not detected in the fish samples. Mean Pb concentrations were highest in smoked *Clarias gariepinus* compared to other species from both Ubani and Gate 6 markets with values of 0.69 ± 0.18 mg/kg and 0.51 ± 0.06 mg/kg, respectively. However, in the samples from Orie Ugba market, mean Pb concentration was highest in *Scomber scombrus* (0.39 ± 0.04 mg/kg). Pb is a confirmed toxic metal with no known beneficial effect on the human body [16]. Mean Pb concentrations in the samples from Ubani market were either higher or equal to the limit of 0.50 mg/kg [15] in fish muscle while fish samples from Orie Ugba market had mean Pb concentration lower than the limit. However, in Gate 6 market, mean Pb concentration was higher than the recommended limit in *Clarias gariepinus* (0.51 ± 0.06 mg/kg) while the concentration in *Scomber scombrus* (0.46 ± 0.03 mg/kg) was close to the limit.

Heavy metals are divided into essential (e.g. Fe) and non-essential (e.g. Pb and Cd) metals. Essential heavy metals are necessary for the proper functioning of the human body while non-essential heavy metals are toxic to organisms. However, even the essential metals become toxic if safe limits are exceeded. Toxic effects of Cadmium in man include renal damage and dysfunction, proteinuria, bone lesions, prostate and lung cancer. It is also embryotoxic and teratogenic [14]. Chromium is an essential metal in the human body especially in enhancing insulin activity. Above recommended limits however, Cr and its compounds are well known toxins especially Cr(VI) which due to its oxidizing potential, easily permeates biological membranes and causes renal damage, diseases of the central nervous system, cancer etc in man [17]. After absorption of lead by the body, it is carried to soft tissues like the brain, lung, spleen and heart by the blood and finally deposited in the bone where about 90% of total body lead is found. Lead damages the liver, kidneys, brain, central nervous and reproductive systems of man [16]. Intake of toxic doses of iron results to siderosis (deposition of iron in tissue) in liver, pancreas, adrenals, thyroid, pituitary and heart which induces depression, coma, convulsion, respiratory failure and cardiac arrest in animals [18]. Nickel is often associated with allergies and nickel exposures at high concentrations can induce lung and nasal cancers [19]. Knowledge of heavy metal content of food is important for the prevention of diseases related to heavy metal exposure.

4. Conclusion

Proximate analysis showed that the smoking process did not adversely affect crude protein (CP) content and that CP levels in the four fish species were high. However, the study also shows the accumulation of Pb to levels higher than safe limits. Lead is known to induce several diseases in man and adversely affects the cognitive development and intellectual performance of children. It is recommended that further studies on metal composition of smoked fish species be carried out in order to identify the source(s) of high Pb contamination in the fish rearing and smoking processes.

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