Greener Journal of Life Sciences
ISSN: 2384-633X
Vol. 6(1), pp. 10-19, 2024

https://gjournals.org/GJLS

Comparative Nutritional Evaluation of Fresh and Smoked Catfish (*Clarias Gariepinus*)

Hafsat, Idowu Kutela Usman[1*]; Abdulmumin, Yunusa[2]; Abdu, Umar Adamu[3]; Hauwa, Ibrahim Danjaji[2]; Maimuna, Muhammad Dalhatu[2]; Ibrahim, Muhammad Usman[4]; Umma, Lawan [5]

[*1] Department of Science Laboratory Technology, Hussaini Adamu Federal Polytechnics, Kazaure, Jigawa State.
[2] Department of Biochemistry, Aliko Dangote University of Science and Technology Wudil, Gaya-Dutse Road, Wudil, Kano state Nigeria, P.M.B 3244
[3] Department of Polymer Chemistry, Hussaini Adamu Federal Polytechnics, Kazaure, Jigawa State.
[4] Department of Biochemistry, Yobe State University Damaturu, Yobe State. Nigeria.
[5] Department of Biochemistry, Yusuf Maitama Sule University Kano State Nigeria.

ARTICLE INFO

Article No.: *040124044*
***Type*:** *Research*
Full Text: *PDF, PHP, HTML, EPUB, MP3*

Accepted: *03/04/2024*
Published: *05/04/2024*

Corresponding Author
Hafsat Idowu Kutela Usman
E-mail: *yabdulmumin@kustwudil.edu.ng*

Keywords: *Proximate, Minerals Elements, Smoked, Fish, Nutrition.*

ABSTRACT

One of the complex issues faced in developing countries like Nigeria is food security where animal derived proteins, such as meat and meat items, fish and fish items are lacking in most diet of the populace which has resulted in chronic malnutrition. The nutrient content in the consumer's food can be used to estimate the adequacy of dietary intake of the population, diet disease relationships, health and nutritional status. The aim of this study was to evaluate the nutritional contents such as proximate composition and mineral elements of both fresh and smoked catfish (*Clarias Gariepinus)* in order to ascertain it nutritional value and understand the effect of smoking on the nutritional properties of the fish. The proximate analysis were carried out using AOAC (2007) methods while the mineral element were evaluated according to AOAC11 using an Atomic Absorption Spectrophotometer (Varian Spectr AA. 20 plus). The results revealed that smoking of catfish (*Clarias Gariepinus)* results in significant changes in its nutritional composition such as increased carbohydrate and ash, and decreased fiber and moisture content. However, protein and fat content show minor differences. The variations in the concentrations of mineral elements in fresh and smoked fish observed that calcium, iron, magnesium, and zinc concentrations differ significantly between fresh and smoked fish, while cadmium, chromium, mercury, and lead concentrations show no significant differences. These findings have revealed the nutritional values of fish and effect of smoking for dietary choices and potential health implications of consuming both fresh and smoked fish.

INTRODUCTION:

Fresh fish are the most perishable products if not adequately preserved since they can easily be attacked by microbes. Preserving of foods make them to be safe for consumption and also increase their shelf lives. A number of processing techniques are utilized for the preservation of meat and fish and these include chilling, freezing, salting, canning, drying and smoking (Stumbo, 2013). However, smoking is the most popular method used. Smoking as a food processing technique is a temporary, but an effective method of preserving food products. It helps to improve texture and also adds flavor to them (Abolagba *et al*., 2015). The essential minerals and proximate compositions of food are important for assessing the economy viability of any nation. Since a healthy man brings about a healthy economic development and invariably a healthy nation. Preservation of food by smoking often affect some of these essential minerals and proximate compositions of meat and fish by either denaturing them depending on the smoking temperate and nature of woods type used (Adeyeye *et al*., 2015). Most diets of man are deficient of these essential minerals derivable from animals. This has led to malnutrition and increase in various health challenges amongst the populace. Global changes in consumer's life style marked by the increasing demand for nutritional and healthy food products has resulted in the continuing rise in demand for fresh and ready-made food such as fish and meat, Fish and meat account for the greater percentage of total protein intake in our diet (Akinsegun *et al*., 2014; Onyango *et al*., 2017). The knowledge of their proximate and essential mineral compositions is very important for the estimation of their quality and adequacy in the diet of the consumer. It is therefore imperative to assess the proximate and essential mineral contents of these food products Fresh catfish (*Clarias Gariepinus*) and smoked catfish (*Clarias Gariepinus*) and comparing the experimental result obtained with the recommended limits so as to ensure consumer safety and healthy living since the minerals when present at lower or greater concentrations, pose hazard to human health.

MATERIALS AND METHODS

Sample collection

The African catfish (*Clarias Gariepinus*) used in this study were obtained from Hadejia rivers, jigawa state, Nigeria. Fish samples comprising juvenile and adults were obtained, the collected fishes were packaged in separate labeled polythene bags containing ice chips at an average temperature of 4^{o}C and immediately conveyed to the Biology Laboratory, Hussaini Adamu Federal Polytechnic for analysis.

Preparation of fresh and smoked samples

The fresh catfishes were washed with tap water and then with distilled water to remove adhering substances and then drained. The catfish was dismembered with a knife and the guts was removed. The fresh fishes sample were oven-dried at a temperature of 105^{o}C, pulverized into powder and stored in a capped plastic container for further analysis. Furthermore, the smoked sample were deboned, pulverized and stored for further analysis. Proximate analysis (moisture, ash, Fat, crude fibre, crude protein and carbohydrate) of the smoked and fresh beef and Catfish samples were carried out according to the AOAC (2007) method.

Digestion of samples for essential mineral analysis

The digestion of samples (Fresh fish and smoked fish) were carried out using a mixture of concentrated HNO_3 and $HClO_4$ in the ratio of 2:1. 10 cm^3 of the mixture were added into a digestion flask containing 2.0 g of the pulverized fresh fish sample. It was then digested in a fume hood until a clear solution/digest was obtained. Cooled and filtered using Whatman No1 filter paper into a 100 cm^3.

PROXIMATE COMPOSTION OF *FRESH AND SMOKE FISH (CLARIAS GARIEPINUS)*

Determination of moisture content: The method described by A.O.A.C (1980) was adopted; a clean crucible was dried to a constant weight in air oven at 110°C, cooled in a desiccator and Weighed (W1). Two grams of finely ground sample were accurately weighed into the previously labeled crucible and reweighed (W2). The crucible containing the sample was dried in an oven to constant Weight (W3). The percentage moisture content was calculated thus:

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

Determination of ash content: The A.O.A.C (1980) method was used. The porcelain crucibles were dried in an oven at 100°C for 10 min, cooled in a desiccators and weighed (W1). Two grams of the finely ground sample were placed into a previously weighed porcelain crucible and reweighed (W2), it was first be ignited and then transferred into a furnaces which were set at 550°C. The samples were left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was then removed; cooled in a desiccator and Weighed (W3).

The percentage ash content was calculated as follows:

$$\% \text{ Ash Content} = \frac{W3 - W1}{W2 - W1} \times 100$$

Determination of crude lipid content by soxhlet method: A clean, dried 500 cm round bottom flask

containing few anti-bumping granules were weighed (W1) with 300 c petroleum ether (40-60°C) for extraction poured into the flask filled with soxhlet extraction unit. The extractor thimble weighing twenty grams were fixed into the Soxhlet unit. The round bottom flask and a condenser were connected to the Soxhlet extractor and cold water circulation was also connected/put on. The heating mantle was switched on and the heating rate adjusted until the solvent refluxing at a steady rate. Extractions were carried out for 6 hrs. The solvents were recovered and the oil dried in an oven set at 70°C for 1 hr. The round bottom flask and oil were Weighed (W2). The lipids content were calculated thus:

$$\% \text{ Crude Lipid content} = \frac{W2 - W1}{\text{Weight of Sample}} \times 100$$

Determination of crude fibre: The samples (2 g) were weighed into a round bottom flask, 100 cm 0.25M sulphuric acid solution were added and the mixture boiled under reflux for 30 mins. The hot solution was quickly filtered filtered under suction. The insoluble matter was washed several times with hot water until it become acid free. It was quantitatively transferred into the flask and 100 cm of hot 0.31 M, Sodium Hydroxide solution were added, the mixture boiled under reflux for 30 min and filtered under suction. The residue was washed with boiling water until it become base free, dried to constant weight in an oven at 100°C, cooled in a desiccator and weighed (C1). The weighed sample (C1) was then incinerated in a muffle furnace at 550°C for 2 hrs, cooled in a desiccator and reweighed (C2).

Calculation: The loss in weight on incineration = C1-C2

$$\% \text{ Crude fibre} = \frac{C1 - C2 \times 100}{\text{Weight of original sample}}$$

Determination of nitrogen and crude protein: The ground defatted sample (91.5 g) in an ashless filter study were dropped into a 300cm Kjeldahl flask. The flask was then transferred to the Kjeldahl digestion apparatus. The samples were digested until a clear green color was obtained. The digest were cooled and diluted with 100 cm^3 distilled water. Distillation of the digest: Into 500 cm Kjeldahl flask containing anti bumping chips and 40 cm of 40%NaOH were slowly added to the flask containing mixture of 50 cm 2% boric acid and 3 drops of mixed indicator were used to trap the ammonia being liberated. The conical flask and the Kjeldahl flask were placed on Kjeldahl distillation apparatus with the tubes inserted into the conical flask, heat was applied to distill out the NH_3 evolved with the distillate collected into the boric acid solution.

The distillate was titrated with 0.1 MHCl.

Calculation:

$$\% \text{ N2} = \frac{14 \times M \times Vt \times V_{100}}{\text{Weight of sample (mg)} \times Va}$$

$$\% \text{ Crude Protein} = \% \text{ N2 (Nitrogen)} \times 6.35$$

where, M = Actual Molarity of Acid V = Titre Value (Volume) of HCl used V t = Total volume of diluted digest Va = Aliquot volume distilled

Determination of carbohydrate by (difference): The total carbohydrate were determined by difference. The sum of the percentage moisture, asrude lipid, crude protein and crude fibre were subtracted from 100 (Muller and Tobin, 1980).

Calculation:

% Total carbohydrate = 100 - (% moisture + % Ash + % fat + % Protein + % Fibre)

Calorific value: This were done by summing the multiplied values for crude protein, fats, and carbohydrate (exclude crude fibre) by the following factors (4, 9 and 4).

MINERAL COMPOSITION DETERMINATION OF FRESH AND SMOKE FISH (*CLARIAS GARIEPINUS*)

Minerals elements were determined according to the standard method of AOAC11 using an Atomic Absorption Spectrophotometer (Varian Spectr AA. 20 plus).

RESULTS AND DISCUSSION

Proximate composition of Fresh and Smoked catfish (*Clarias Gariepinus*)

The proximate composition of fresh and smoked *Clarias Gariepinus* fish, were evaluated .Proximate composition refers to the analysis of the major nutritional components of a substance. The study compares various parameters, such as carbohydrate, protein, fat, ash content, fiber content, and moisture, between fresh and smoked fish samples. The mean carbohydrate concentration in fresh fish is 43.29 ± 0.72%, while in smoked fish, it increases significantly to 47.33 ± 1.50, suggests a statistical significant differences, indicating that smoking the fish leads to an increase in carbohydrate content. Fresh fish contains a mean protein concentration of 19.07 ± 0.65, which is slightly higher than the protein content in smoked fish (17.95 ± 0.27%). However, the difference is not statistically significant (P value = 0.051). The fat content in fresh fish is 25.28 ± 0.70, while in smoked fish, it is slightly lower at 24.51 ± 0.37. The difference in fat content is not statistically significant (P value = 0.162). The ash content in fresh catfish is 2.49 ± 0.31, while in smoked catfish, it significantly increases to 3.79 ± 0.23. The P value of 0.004 indicates that this difference is

statistically significant, suggesting that smoking the fish leads to a higher ash content. Fresh fish has a mean fiber concentration of 0.84 ± 0.07, whereas smoked fish has a lower fiber content of 0.63 ± 0.03. The difference in fiber content is statistically significant (P value = 0.007). Fresh fish has a higher moisture content with a mean of 9.02 ± 0.53, while smoked fish has significantly lower moisture content, measuring 5.79 ± 0.69. The difference is statistically significant (P value = 0.003) (Table 1).

Table 1: Proximate composition of Fresh and Smoked fish (*Clarias Gariepinus*)

Composition	Fresh Fish Concentration (Mean ± SD)	Smoked Fish Concentration (Mean ± SD)	P Value*
Carbohydrate (%)	43.29 ± 0.72[a]	47.33 ± 1.50[b]	0.013
Protein (%)	19.07 ± 0.65 [a]	17.95 ± 0.27 [a]	0.051
Fat (%)	25.28 ± 0.70 [a]	24.51 ± 0.37 [a]	0.162
Ash content (%)	2.49 ± 0.31 [a]	3.79 ± 0.23 [b]	0.004
Fiber content (%)	0.84 ± 0.07 [a]	0.63 ± 0.03 [b]	0.007
Moisture (%)	9.02 ± 0.53 [a]	5.79 ± 0.69 [b]	0.003

Key: Results are presented in triplicate as mean ± SD (Standard deviation) P value ≤ 0.05 is statistically considered significant, * = Independent T test, Values in the same row having similar superscripts are considered significant while value in the same row having difference superscripts are statistically differences.

The finding suggests that smoking the fish leads to an increase in carbohydrate content. This is consistent to a study on the effect of different smoking processes on the nutritional and polycyclic aromatic hydrocarbons composition of smoked *Clarias Gariepinus* and *Cyprinus carpio*, it was found that there is a significant increase ($p < 0.05$) in the carbohydrate content of smoked fish (Cristelle *et al*.; 2019). This study supports the idea that smoking fish can lead to an increase in carbohydrate content. The recent study on *Clarias Gariepinus* fish is consistent with some previous research that suggests smoking fish can lead to an increase in carbohydrate content. However, other studies have found no significant difference or have not investigated the effect of smoking on carbohydrate content. These findings also align with previous studies conducted in Nigeria by Olayemi *et al*. (2011) analyzed the proximate composition of catfish (*Clarias gariepinus*) smoked in Nigerian stored products research institute (NSPRI).

The nutritional value of catfish is determined by its protein content, which includes all the essential amino acids, making it one of the most high-quality sources of protein (Shadyeva *et al.,* 2019). Several studies have investigated the nutrient content of fresh and smoked fish, including their protein content. The slight decrease in protein content in smoked fish is consistent with findings from studies by Kiczorowska *et al.,* (2019). Smoking can lead to protein denaturation and loss. A study conducted in Nigeria compared the protein concentration in locally consumed fresh and smoke-dried small fish species. The study found that the protein content increased with the reduced moisture content of the fish during smoking (Neeru *et al.;* 2017). A study conducted in Dadin Kowa Dam, Gombe, determined the protein content of fresh and smoked *Clarias Gariepinus* and Oreochromis niloticus (Abbati *et al*.;2021). The study found that the protein content in fresh and smoked samples of *Clarias Gariepinus* and *Oreochromis niloticus* ranged from 21.67% to 28.75% and 25.43% to 26.10%, respectively. These studies suggest that smoking fish can affect its nutritional composition, including its protein content. However, the extent of this effect may depend on factors such as the type of fish, the smoking method, and the season.

Fish can be classified into three different lipid compositions: lean fish (less than 5% fat), mid-fat fish (5–10% fat), and fatty fish (10–25% fat) (Oguz and Mahmut., 2017). The fat content of fish depends on many factors, including the species, how and where the lipids are stored, and the season (Ozogul *et al*.; 2009). The fat content in fish can vary depending on many factors, and it is important to consider the nutritional composition of different fish species when making dietary choices. Previous research has shown that the smoking process can reduce the fat content of fish, but it can also increase the fat content in some cases. This study found no statistically significant difference in fat content between fresh and smoked fish. Other studies have found differences in the total fat concentration and in the composition of fatty acids between different fish species. Based on the research findings in this current study, it can be concluded that the fat content of smoked fish is not always the same as that of fresh fish. While some studies have found a reduction in fat content after smoking, others have found an increase or no significant

difference

This study is consistent with previous research that has also found an increase in ash content in smoked fish. For example, a study on processed tilapia found significant changes in the ash content from 11.12% (fresh) to 14.72% (traditionally smoked) (Kiczorowska *et al*.; 2019). Another study reported that the mean ash content of raw fish was 1.95 ± 0.05% (Aberoumand., 2014). However, it is important to note that these studies did not specifically investigate the effect of smoking on ash content. This study on smoking fish highlights the importance of considering different cooking methods when analyzing the nutritional composition of fish. It also suggests that smoking fish may be a good way to increase the mineral content of fish.

Fiber is an important nutrient that plays a crucial role in maintaining a healthy digestive system. It is recommended that adults consume between 25-30 grams of fiber per day. While smoked fish may have a lower fiber content than fresh fish, it is still a good source of other important nutrients such as protein, omega-3 fatty acids, and minerals like calcium, magnesium, and zinc (Kiczorowska *et al*., 2019). This finding is in consistent to some previous researches that reported a decrease in fiber content in fish after smoking. This finding contrasts with a previous study that reported no significant difference in fiber content between fresh and smoked samples of *Clarias Gariepinus* and Oreochromis niloticus fish species (Abbati *et al.;* 2021). Another stud on chosen fresh and smoked fish also reported no significant difference in fiber content between fresh and smoked samples (Paul *et al.;* 2022). However, the previous studies did not specifically focus on *Clarias Gariepinus* fish species. Note that the fiber content of fish can vary depending on the species and the processing method used. This present study's finding that smoked fish has a lower fiber content than fresh fish is significant and should be taken into consideration when planning a balanced diet.

This present study has found that fresh fish (*Clarias gariepinus*) has a higher moisture content with a mean of 9.02 ± 0.53, while smoked fish has significantly lower moisture content (5.79 ± 0.69%) indicating decrease in moisture content of fresh fish after smoking. The difference is statistically significant (P value = 0.003). This finding is consistent with previous research that has also reported a decrease in fresh fish moisture after smoking. Smoke-drying reduced the moisture content of all the samples drastically. The values obtained for freshly smoked fish ranged from 9 to 17% (Sikoki and Aminigo, 2000). The lower moisture content recorded in smoked-dried fishes when compared to the smoked fishes is due to the drying step which follows smoking (Ogouyôm *et al*., 2020).

Concentrations of Mineral Elements of Fresh and Smoked Fish (*Claria Gariepinus*)

The study examines various mineral elements composition of fresh and smoked cat fish , such as calcium (Ca), cadmium (Cd), chromium (Cr), iron (Fe), mercury (Hg), magnesium (Mg), lead (Pb), and zinc (Zn) in mg/L. The mean concentration of calcium in fresh fish is 9.14 while that of smoked fish as (56.23), which is significantly higher (p.=0.002) . Both fresh and smoked fish have very similar cadmium concentrations, with means of 0.024 and 0.025, respectively. Suggested no significant difference in cadmium concentration between fresh and smoked fish. Chromium concentrations in both fresh and smoked fish are very close, with means of 0.64 and 0.65, respectively. Indicated no significant difference (p=0.586) in chromium concentration between the two fishes . The mean concentration of iron is higher in fresh fish (0.73) compared to smoked fish (0.54). The p-value of 0.001 indicates a statistically significant difference in iron concentration between fresh and smoked fish. Fresh fish has a mean mercury concentration of 0.12 with a relatively high standard deviation (0.07). In smoked fish, the mean mercury concentration is lower at 0.01 with a higher standard deviation (0.16). Hence no significant difference in mercury concentration. The mean concentration of magnesium is significantly higher in fresh fish (10.40) compared to smoked fish (6.42) and statistical difference in magnesium concentration observed. Both fresh and smoked fish have similar lead concentrations, with means of 0.12 and 0.12, respectively. The mean concentration of zinc is significantly higher in fresh fish (0.57) compared to smoked fish (0.25).

Smoking fish can lead to changes in the mineral content of the fish. Specifically, smoking can increase the concentration of calcium and magnesium, while decreasing the levels of iron and zinc (Peter, 2015). These findings are consistent with previous studies that have reported changes in the mineral content of smoked fish. It is important to note that smoking can also lead to the loss of important nutrients and antioxidants in fish meat (Kiczorowska *et al*., 2019).

The current finding reports a significant difference in calcium concentration between fresh and smoked fish of the same species, *Clarias Gariepinus.* This finding is consistent with previous studies that have examined the effects of smoking on the nutrient and mineral content of fish .A comparative study showed that smoke-dried fish contained more minerals than oven-dried fish (Simon, 2013). These studies suggest that smoking can have a significant impact on the nutrient and mineral content of fish. This finding suggests that smoked fish has a much higher concentration of calcium than fresh fish. A study that evaluated the amino acid, vitamin, and mineral profile of smoked fish as affected by smoking methods and fish types found that high-temperature smoking modifies protein, lowers the essential amino acids, and may result in the loss of major nutrients (Adeyeye *et al*.;2018).

Cadmium is a toxic heavy metal that can accumulate in the body over time and cause health problems,

including kidney damage and cancer. Therefore, it is crucial to monitor the levels of cadmium and other heavy metals in fish and other food sources to ensure that they are safe for human consumption. This recent study provides valuable information on the cadmium concentrations in *Clarias Gariepinus* fish. . A study found higher concentrations of heavy metals in smoked fish samples than in fresh samples (Badau *et al*.;2015).

A study in Nigeria investigated the concentrations of five heavy metals, including cadmium, in the muscle of three types of fish. The results showed that the concentrations of cadmium in the fish samples were below the maximum limits, indicating that they were safe for consumption (Ikeogu *et al*.; 2021). A study in Ghana investigated the concentrations of cadmium and lead in the tissues of fresh and smoked *Clupea harengus* (herring fish) and Gadus. The results showed that the concentrations of cadmium and lead were higher in smoked fish than in fresh fish (Oyeleke *et al*., 2021). Findings from these studies suggest that heavy metal concentrations in fish can vary depending on the type of fish, the location where it was caught, and whether it is fresh or smoked.

Table 2: Concentrations of Mineral Elements of Fresh and Smoked Fish (*Claria Gariepinus*)

Mineral elements (mg/L)	Fresh Fish Concentration (Mean ± SD)	Smoked Fish Concentration (Mean ± SD)	P Value*
Calcium (Ca)	9.14 ± 0.26[a]	56.23 ± 11.77[b]	0.002
Cadmium (Cd)	0.024 ± 0.001[a]	0.025 ± 0.00[a]	0.116
Chromium (Cr)	0.64 ± 0.01[a]	0.65 ± 0.02[a]	0.586
Iron (Fe)	0.73 ± 0.003[a]	0.54 ± 0.006[b]	0.001
Mercury (Hg)	0.12 ± 0.07[a]	0.01 ± 0.16[a]	0.284
Magnesium (Mg)	10.40 ± 0.06[a]	6.42 ± 0.17[b]	0.001
Lead (Pb)	0.12 ± 0.013[a]	0.12 ± 0.01[a]	0.845
Zinc (Zn)	0.57 ± 0.002[a]	0.25 ± 0.001[b]	0.001

Key: Results are presented in triplicate as mean ± SD (Standard deviation) P value ≤ 0.05 is statistically considered significant, * = Independent T test, Values in the same row having similar superscripts are considered significant while value in the same row having difference superscripts are statistically differences.

However, the recent study on *Clarias Gariepinus* fish suggests that there may not be a significant difference in cadmium concentration between fresh and smoked fish.

The findings of the present study on chromium concentrations in *Clarias Gariepinus* are consistent with previous studies that have found no significant difference in chromium concentration between fresh and smoked fish. In contrast, a study on the polycyclic aromatic hydrocarbon and elemental profile of smoked fish found that the chromium levels in both raw and smoked fish were found to differ (Tümerkan and Salvo, 2018). Another study on heavy metal concentrations in freshwater fish found that the chromium concentration in smoked fish was higher than in fresh fish (Badau et al.;2015). Another study on heavy metal content in freshwater fish found that the chromium concentration was below the maximum limits in almost all fish samples
(Iwona *et al.*, 2017).

This study found that the mean concentration of iron is higher in fresh fish (0.73) compared to smoked fish (0.54), indicating a statistically significant difference in iron concentration between fresh and smoked fish. A study published in 2015 investigated the effects of smoking and freezing on the nutritive value of African mud catfish. The study found that iron content was highest in the fresh fish samples and lowest in the smoked fish samples (Akinwumi , 2014). This finding is consistent with this study.

In comparison to previous studies, the findings are consistent with the low mercury concentrations observed in *Clarias Gariepinus* fish (Sharma *et al*., 2013). However, the study's results differ from previous studies that found higher mercury concentrations in other piscivorous fish species in Lake Awassa, such as Barbus intermedius and B (Desta *et al*.; 2007). The low mercury concentrations observed in *Clarias Gariepinus* fish in this study may be due to the fish's feeding habits, as they are known to feed on a variety of food sources, including insects, crustaceans, and small fish (Desta *et al*.; 2007).

Additionally, the study's findings may be influenced by the location and environmental conditions in which the fish were caught, as previous studies have found variations in mercury concentrations in *Clarias Gariepinus* from different locations (Kassegne *et al*., 2018). The study's findings suggest that *Clarias Gariepinus* has relatively low mercury concentrations, and there is no significant difference in mercury concentration between fresh and smoked fish. It is possible that differences in sampling locations and methods, such as the size and age of the fish, the type of food they consume, and the level of pollution in the water, can affect the mercury concentration in fish (Kassegne *et al*., 2018). Although the recent study found no significant difference in mercury concentration between fresh and smoked *Clarias Gariepinus*, it is important to note that even low levels of mercury can have harmful effects on human health, especially for pregnant women, infants, and young children (Kassegne *et al*., 2018). Therefore, it is recommended to limit the consumption of fish that are known to contain high levels of mercury, and to follow local guidelines for safe fish consumption (Kassegne *et al*., 2018).

This present study found that the mean concentration of magnesium is significantly higher in fresh *Clarias Gariepinus* (10.40) compared to smoked types (6.42), indicating a statistically significant difference in magnesium

concentration. While there are no previous studies that directly compare magnesium concentrations in fresh and smoked *Clarias Gariepinus*, there are several studies that have investigated the effects of various substances on the fish, including heavy metals and pesticides. One study evaluated the effects of sub-lethal concentrations of cadmium and lead on some tissues of the African catfish (*Clarias gariepinus*) and found that exposure to these substances caused biochemical changes in the fish (Elarabany and Bahnasawy , 2019).

This present finding that both fresh and smoked *Clarias Gariepinus* fish have similar lead concentrations is contrary with some previous studies that found high lead concentrations in the fish. A study in Poland found that smoked fish contained much more lead than fresh fish (Winiarska-Mieczan *et al*.; 2018). However, the recent study did not evaluate the effects of lead exposure on the fish's biochemical parameters, as some previous studies did. Additionally, the recent study did not compare lead concentrations in *Clarias Gariepinus* to other fish species, as some previous studies did.

This present study found that the mean concentration of zinc is significantly higher in fresh *Clarias Gariepinus* (0.57) compared to smoked fish (0.25), A study aimed to determine the levels of cadmium, lead, and zinc in *Clarias Gariepinus* fish sold at selected markets in Kano State, Nigeria (Oyeniyi *et al*.; 2019), found that the levels of zinc in the fish were within the range of reported zinc content, which is consistent with the recent study's finding that fresh *Clarias Gariepinus* fish have higher levels of zinc than smoked fish. The concentration of zinc in fish can be influenced by a variety of factors, including their diet and water chemistry. While seafood consumption can have positive impacts on health, it is important to be aware of the potential for toxic levels of zinc and other metals in fish and other aquatic animals. While smoking can increase the concentration of some basic nutrients, it can also reduce the fat and mineral content of fish, as well as alter the amino acid, vitamin, and mineral profile. Therefore, it is important to consider the effects of smoking when evaluating the nutritional value of fish.

CONCLUSION

Smoking cat fish (*Clarias Gariepinus)* significantly alters its proximate composition and mineral element concentrations. The finding reveals that smoking of cat fish (*Clarias Gariepinus)* results in significant changes in its nutritional composition. Notably, smoking leads to increased carbohydrate, ash, and decreased fiber and moisture content. However, protein and fat content show minor differences. The variations in the concentrations of mineral elements in fresh and smoked fish observed that calcium, iron, magnesium, and zinc concentrations differ significantly between the two, while cadmium, chromium, mercury, and lead concentrations show no significant differences. These findings may have revealed the nutritional values for dietary choices and potential health implications of consuming both fresh and smoked fish.

ETHICAL APPROVAL

This study does not contain any studies involving human or animal subjects.

ACKNOWLEDGEMENT

The authors have sincerely acknowledged the contribution of Tertiary Education trust Fund (TET fund) and Hussaini Adamu Federal Polytechnic, Kazaure, Jigawa State for sponsorship of this project through Institution-based research fund (IBR) grant (TETF/DR&D/CE/POLY/KAZAURE/IBR/2021/VOL1).

COMPETING INTERESTS

No competing interests exist between the authors of this study

REFERENCES

Abbati, M. A., Umar, D. M., & Saje, W. S. (2021). Nutritive Value of Fresh and Smoked Fish (Clarias gariepinus and Oreochromis niloticus) from Dadin Kowa Dam Gombe. *Greener Journal of Biological Sciences, 11*(2), 54-64.

Aberoumand, A. (2014). Preliminary studies on nutritive and organoleptic properties in processed fish fillets obtained . *Food Science and Technology, 34*, 287-291.

Adeyeye, E. I. (2019). Vitamin Levels in Fresh and Smoke-Dried Body Parts of Clarias Gariepinus Depicting the Loss of Vitamins during Heat Processing. *Food Science and Nutrition Technology, 4*(5), 1-7.

Adeyeye, E. I., & Olatoye, R. A. (2021). Vitamins Composition in Clarias gariepinus Fish Body Parts (Liver Muscle, Head): Reporting on Samples on Fresh, Smoked- Dried and Dry Extract Bases). *International Journal of Pharmacology, Phytochemistry and Ethnomedicine, 17*, 1-16.

Adeyeye, S. A., Olanrewaju , E. F., & Abiodun, O. A. (2018). Amino acid, vitamin and mineral profiles of smoked fish as affected by smoking methods and fish types. *Journal of Culinary Science & Technology, , 17*(4), 1-14.

Akinwumi , F. (2014). Effects of Smoking and Freezing on the Nutritive Value of African Mud Catfish, Clarias gariepinus Burchell, 1822. *Journal of Agricultural Science , 6*(11), 143-149.

Akpoilih, B., Bamidele, O., & Emmanuel, A. (2017). Phosphorus utilization in juvenile Clarias gariepinus fed phytase-supplemented diets based on soya bean (oil-extracted) and full-fat (roasted): A comparison. *Journal of Applied Aquaculture, 29*, 1-27.

Al-Owaf eir, M. (1999). The Effects of Dietary Saponin and Tannin on Growth Performance and Digestion in Oreochromis Niloticus and Clarias Gariepinus. *Thesis submitted for the degree of Doctor of Philosophy*.

Arthur, W., Asiamah , E., Dowuona , A., Crabbe , G., & Kortei , N. K. (2021). Concentration of heavy metals and its risk assessments on Pseudotolithus senegalensis, Sciaenops ocellatus and Chloroscombrus chrysurus smoked on different ovens. *Scientific African, 13*, e00953.

Badau, M., Igwegbe, A., Charles, N., Elizabeth, C., & Garvase, A. (2015). Effects Of Season And Fish Smoking On Heavy Metal Contents Of Selected Fish Species From Three Locations In Borno State Of Nigeria. *Asian Journal of Science and Technology, 6*, 1010-1019.

Bethel, A. (2019). Evaluation of Vitamins Content in Clarias Gariepinus From Selected Rivers In Bayelsa State.

Christian , S., Annette, F., & Christoph, S. (2012). Determination of lipid content in fish samplesfrom bioaccumulation studies: contributions to the revision of guideline OECD 305. *Environmental Sciences Europe, 24*, 13.

Cristelle, T. T., Tchoumbougnang, F., Nganou, E., Kumar, P., & Nayak , N. (2019). Effect of different smoking processes on the nutritional and polycyclic aromatic hydrocarbons composition of smoked Clarias gariepinus and Cyprinus carpio. *Food Science and Nutrition, 7*(7), 2412–2418.

Desta, Z., Borgstrøm, R., & Ross, B. O. (2007). Lower than expected mercury concentration in piscivorous African sharptooth catfish Clarias gariepinus (Burchell). *The Science of Total Environment, 376*(1-3), 134-142.

Elarabany, N., & Bahnasawy , M. (2019). Comparative and Interactive Biochemical Effects of Sub-Lethal Concentrations of Cadmium and Lead on Some Tissues of the African Catfish (Clarias gariepinus). *Toxicology Research, 35*(3), 249-255.

Ersoy, B. (2009). The effect of cooking methods on mineral and vitamin contents of African catfish. *Food Chemistry, 115*(2), 419-422.

George, J. F. (2010). Old product with new appeal offers enhanced taste, shelf life. In *Smoked fish.* Virginia, USA: Global Seafood Alliance.

Guedenon , P., Edorh, A. P., Hounkpatin, A. S., Alimba , C. G., gunkanmi , A., Nwokejiegbe, E. G., & Boko, M. (2012). Acute Toxicity of Mercury (HgCl2) to African Catfish, Clarias gariepinus. *Research Journal of Chemical Sciences , 2*(3), 41-45.

Iheanacho, S., Nworu, S. A., Ogueji, E., Haruna, M., Mbah, C. E., Anosike, F., . . . Kogi, E. (2017). Comparative assessment of proximate content and organoleptic quality of African catfish (Clarias gariepinus) processed by smoking and solar drying methods. *African Journal of Agricultural Research, 12*(38), 2824-2829.

Ikeogu , C. F., Ogbonnaya, H. F., Okpala-Ezennia, K. P., & Nwankwo, C. G. (2021). Heavy Metal Analysis of Consumer Fish Sold in Three Selected Markets in Awka, Anambra State, Nigeria. *Singapore Journal of Scientific Research, 11*(1), 17-22.

Iwona, C., Migdal, W., Topolska, K., Gambuś, F., Szczurowska, K., & Cieślik, E. (2017). Changes in The Content of Heavy Metals (Pb, Cd, Hg, As, Ni, Cr) in Freshwater Fish After Processing – The Consumer's Exposure. *Journal of Elementology, 23*(1), 247-259.

Johnny, M. K., Espoir, K. H., & Paul, C. M. (2020). Determination of the Protein Content of Smoked Fish Sold in the Markets of the Town of Mbuji-Mayi (Democratic Republic of the Congo). *Open Access Library Journal, 7*, 1-8.

Kandyliari, A., Mallouchos, A., Papandroulakis, N., Golla, J. P., Lam, T. T., Sakellari, A., . . . Kapsokefalou, M. (2020). Nutrient Composition and Fatty Acid and Protein Profiles of Selected

Fish By-Products. *Foods, 9*(2), 190.

Kassegne , A. B., Okonkwo , J. O., Esho , T. B., Mekonnen , N. K., Malehase , T., & Asfaw , S. L. (2018). istribution of total mercury in surface sediments and African catfish (Clarias gariepinus) from Akaki River catchment and Aba Samuel Reservoir, downstream to the mega-city Addis Ababa, Ethiopia. *Emerging Contaminants, 4*(1), 32-39.

Kiczorowska, B., Samolińska, W., & Grela, E. R. (n.d.).

Kiczorowska,, B., Samolińska, W., Grela, E. R., & Bik-Małodzińska, M. (2019). Nutrient and Mineral Profile of Chosen Fresh and Smoked Fish. *Nutrients, 11*(7), 1448.

Kingsley , N. E., Cyril , O. U., & Ijeo, O. (2022). Potential contribution of selected wild fish species to the minerals intake of Pregnant and Lactating Women, Children and Adults in Rural Riverine Communities of Edo State: Insights and Outcomes. *Measurement: Food, 8*, 100063.

Lima, L., López-Heras, M. I., Pedrero, Z., Rieumont, S. O., Madrid, Y., Cámara, C., & De la Rosa, D. (2013). Levels of arsenic, mercury and selenium in Clarias gariepinus from Sagua la Grande River, Cuba. *International Journal of Limnology, 49*(2), 113-119 .

Memon, N. N., Talpur, F. N., & Bhanger, M. I. (2010). A Comparison of Proximate Composition And Fatty Acid Profile of Indus River Fish Species. *International Journal of Food Propertie, 13*(2), 328-337.

Mielcarek, K., Puścion-Jakubik, A., Gromkowska-Kępka, K. J., Soroczyńska, J., Naliwajko, S. K., Markiewicz-Żukowska, R., . . . Socha, K. (2020). Proximal Composition and Nutritive
Value of Raw, Smoked and Pickled Freshwater Fish. *Foods, 9*(12), 1879.

Neeru, A., Bhumika, D., & Shayma, D. (2017). Comparative Study of Protein Concentration in Fresh and Smoked Dried Small Indigenous Fish Species. *International Journal of Researches in Biosciences, Agriculture and Technology, 5*(2), 585-587.

Nmeazi, F. O., Felagha, I., Gbogbara, M. V., & Uahomo, P. O. (2023). Study on the Effect of Different Drying Methods on the Proximate, Nutritional and Mineral Composition of Clarias gariepinus (Catfish). *European Journal of Nutrition & Food Safety, 15*(6), 31-39.

Nunoo, F. K., Etornam, T., Eunice, K. A., & Asamoah, S. A. (2018). Effect of two fish smoking ovens on the nutritional composition and PAH content of smoked fish. *Journal of Public Health and Nutrition, 1*(1), 5-10.

Nyantakyi, A. J., Wiafe , S., Akoto , O., & Fei-Baffoe , B. (2021). Heavy Metal Concentrations in Fish from River Tano in Ghana and the Health Risks Posed to Consumers. *Journal of Enviromental Public Health, 2021*, 5834720.

Ogouyôm, H. I., Mahunan , F. A., Dona , G. H., Boukari, B., Douny, D. C., Kpoclou, Y. E., . . . Hounhouigan, D. J. (2020). Consumption and physico-chemical characteristics of smoked and smoked-dried fish commonly produced in South Benin and contribution to recommended nutrient intakes. *Food Science and Nutrition, 8*(9), 4822-4830.

Oğuz, T., & Mahmut, A. G. (2017). Fatty Acids in Fish. In A. Catala (Ed.), *Fatty Acids.* Intech.

Okereke, A. N., Okpara, J. Y., & Ogumuka, S. O. (2014). Comparative Nutritional Composition of Smoked Catfish (Clarias gariepinus) Produced from NIOMR Smoking Kiln and Local Cut Drum Oven. *American Journal of Food Technology, 9*(7), 377-381.

Olayemi , F. F., Adedayo, M. R., Bamishaiye , E. I., & Awagu, E. F. (2011). Proximate composition of catfish (Clarias gariepinus) smoked in Nigerian stored products research institute (NSPRI): Developed kiln. *International Journals of Fisheries and Aquaculture, 3*(5), 96-98.

Oyeleke, P. O., Okparaocha, F. J., Omolara, J. O., Adijat , Y. S., Folarin, F. F., & Ofunami, J. O. (2021). Lead and Cadmium Concentrations in two Widely Consumed Fish Species in Ibadan, Southwestern Nigeria. *Chemistry Research Journal, 6*(6), 1-7.

Oyeniyi, S. O., Abdullahi, Z., & Elias, N. (2019). Assessment of Levels of Cd, Pb and Zn in Catfish (Clarias Gariepinus) within Kano Markets. *Dutse Journal of Pure and Applied Sciences (DUJOPAS), 5*(1), 2635-3490.

Ozogul , Y., Ozogul, F., Ciçek, E., Polat, A., & Kuley, E. (2009). Fat content and fatty acid compositions of 34 marine water fish species from the Mediterranean Sea. *International Journal of Food Science and Nutrition, 60*(6), 464-475.

Paul, T., Nwakuba, N. R., & Simonyan, K. J. (2022). Proximate composition and sensory properties of smoked Aba knife fish. *Journal of Experimental Research, 9*(2).

Peter, T. O. (2015). Nutritional Values of Smoked Clarias Gariepinus from Major Markets in Southwest, Nigeria. *Global Journal of Science Frontier Research, 15*(6), 33.

Salihu-Lasisi, M., Akpabio, C. J., & Ogunsola, M. O. (2013). Comparative nutritional studies on fresh and smoked Claras genepinus (Catfish) and Tilapia nilotica (Tilapia) fishes . *European Journal of Experimental Biology, 3*(5), 183-185 .

Shadyeva , L., Romanova, E., Romanov, V., Spirina, E., Lyubomirova, V., Shlenkina, T., & Fatkudinova, Y. (2019). Forecast of the nutritional value of catfish (Clarias gariepinus) in the spawning period . *IOP Conference Series: Earth and Environmental Science, 403*, 012218.

Sharma, C. M., Suresh, B., Schchang, K., Olav, R. O., Zhang, Q., Ke, P., . . . Qing, L. (2013). Mercury Concentrations in Commercial Fish Species of Lake Phewa, Nepal. *Bulletin of Enviromental*

Contamination and Toxilogy, 91.

Sikoki, F. D., & Aminigo, R. (2000). Bacterilogical and Sensory Properties of smoke-dried fish stored at ambient temperature. *Global Journal of Agricultural Sciences, 1*(1), 21-25.

Simon, S. (2013). Studies on Some Major and Trace Metals in Smoked and Oven-Dried Fish. *Journal of Applied Sciences and Environmental Management , 8*(2).

Soriguer, F., Serna, S., Valverde, E., Hernando, J., Reyes, M. A., Soriguer, M., . . . Esteva, I. (1996). [Fat, protein and caloric content of different fish, seafood and mollusks, Atlantic and Mediterranean habitually consumed in the south of Spain]. *Nutrition Hospital, 11*(4), 245-257.

Sunday, A., Orjiekwe, C. L., & Ehiagbonare, J. (2012). Nutritional Composition of Three Different Fishes (Clarias gariepinus, Malapterurus electricus and Tilapia guineensis). *Pakistan Journal of Nutrition , 11*(9), 793-797.

Tümerkan, E. T., & Salvo, A. (2018). Investigations of the Polycyclic Aromatic Hydrocarbon and Elemental Profile of Smoked Fish. *Molecules., 27*(20), 7015.

Udo, I. (2017). Effects of dietary vitamin A level on growth, feed utilization and survival of juvenile North African catfish (Clarias gariepinus). *Lifestock Research for Rural Development, 29*(01).

Winiarska-Mieczan, A., Florek, M., Kwiecień, M., Krusiński, R., & Kwiatkowska, R. (2018). Cadmium and Lead Content in Chosen Commercial Fishery Products Consumed in Poland and Risk Estimations on Fish Consumption. *Biological Trace Element Research, 182*(2), 373–380.

Zhang, X., Ning, X., He, X., Sun, X., Yu, X., Cheng, Y., . . . Wu, R. (2020). Fatty acid composition analyses of commercially important fish species from the Pearl River Estuary, China. *PloS One, 15*(1), e0228276.

Cite this Article: Hafsat, IKU; Abdulmumin, Y; Abdu, UA; Hauwa, ID; Maimuna, MD; Ibrahim, MU; Umma, L (2024). Comparative Nutritional Evaluation of Fresh and Smoked Cat Fish (*Clarias Gariepinus)*. *Greener Journal of Life Sciences*, 6(1): 10-19.