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Quality and Microbial Safety Analysis of Smoked Catfish Sold in Wadata Market, Benue State, Nigeria

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ABSTRACT

Background and Objective: Smoked catfish sold in Wadata Market, Benue State, may pose health risks due to potential microbial contamination and insufficient quality control measures, necessitating an assessment of its safety and quality standards. This study, therefore, examined the quality and microbial content of smoke-dried African catfish (*Clarias gariepinus*) sold at Wadata Market in Makurdi, Benue State. **Materials and Methods:** Twelve, 500 g samples were purchased from different vendors, wrapped in sterile bags and sent for analysis at the Nigerian Institute of Leather and Science Technology. Skin, gills and tissue samples were collected and then microwaved for varying durations (2, 4, 6 and 8 min) with one sample as a control (unheated). A statistically significant difference was observed ($p<0.05$). **Results:** It showed the presence of pathogenic bacteria, including *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp., along with fungi like *Kutha* spp., *Bacillus* spp., *Arthrobacter* spp. and *Shigella* spp. The highest bacterial count was observed in samples microwaved for 2 min, showing a significant microbial presence. **Conclusion:** The study concludes that microbial contamination in smoke-dried catfish varies with heating duration, highlighting a need for better dehydration methods to reduce moisture-related contamination. Recommendations include the adoption of mechanized smoking systems and monitoring by regulatory bodies to ensure sanitary conditions in production and distribution environments.

KEYWORDS

Smoked, catfish, sanitary conditions, pathogenic bacteria, fungi, microbial contamination

INTRODUCTION

Catfish (*Clarias gariepinus*), known for their distinctive whisker-like barbels, are freshwater fish commonly found in diverse aquatic habitats worldwide. They adapt to varied environments, from shallow, muddy waters with low oxygen levels to fast-flowing rivers and deep lakes[1]. Smoked catfish is a popular and convenient food, valued for its enhanced flavor, extended shelf life and ease of storage[2,3]. However, the quality and safety of smoked catfish are often compromised by microbial contamination, which can arise from poor handling and inadequate processing[4].

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Smoking, an ancient preservation technique, reduces moisture in fish, inhibiting the growth of spoilage microbes[5,6]. Yet, issues with sanitation and handling can lead to high microbial loads, including harmful bacteria and toxins, in smoked fish products[7]. This poses health risks for consumers, especially in Nigeria, where smoking is a preferred preservation method among rural fish farmers due to limited resources[8]. Ensuring safe and high-quality smoked catfish is essential, as microbial contamination can quickly turn nutrient-rich fish into a health hazard. This study aimed to enhance consumer safety and quality perception of smoked catfish products.

MATERIALS AND METHODS

Study area: This study was conducted between November and December, 2023 in Benue State, Nigeria, located at GPS coordinates 7°4'3.7472"N and 8°32'20.9184"E. The region's economy is primarily agricultural, with activities including crop cultivation, animal husbandry and fishing. Benue has urban settlements featuring various markets where food items such as smoked fish, meat and frozen fish are sold under diverse conditions, environments and packaging standards, often with varying levels of quality control. One prominent fish market in the state, Wadata Market, served as the sampling site for this study.

Sample collection and preparation: Twelve smoke-dried catfish were randomly purchased from Wadata Market, Makurdi, during three sampling occasions. The samples were aseptically wrapped in sterile polythene bags and transported to the Fishery and Aquaculture Laboratory at Joseph Sarwuan Tarka University, Makurdi. The fish samples were manually crushed using gloves and 20 g of each crushed sample was placed into five airtight containers. Four of these samples were microwaved for varying durations (2, 4, 6 and 8 min), while the fifth sample served as an unmicrowaved control.

Proximate composition: The proximate composition of the samples, including moisture content, crude protein, ash, fat and fiber, was analyzed at the Environmental Analysis Laboratory (Soil and Wastewater Study) of the Nigerian Institute of Leather and Science Technology, Zaria. The analysis were carried out following the standard methods by the Association of Official Analytical Chemists[9].

Mineral assessment: The mineral content of the samples was analyzed using a computer-controlled 969 spectrometer. Commercial BDH stock standards were used to prepare working standards through appropriate dilution for automatic absorption analysis. Sodium and potassium levels were measured using a flame photometer, while calcium was determined using flame atomic absorption with a nitrous-oxide flame. Zinc and magnesium concentrations were assessed using an atomic absorption spectrometer with an air-acetylene flame.

Microbial analysis: A 1 g representative sample was aseptically obtained from the muscle of each smoked catfish sample. The samples were ground and subjected to serial dilutions (10^{-1} to 10^{-4}) using sterile distilled water. Each analysis was performed. A statistically significant difference was observed ($p<0.05$) and microbial analysis were conducted[10].

RESULTS

Table 1 presents the proximate composition of fish samples heated in a microwave oven for varying durations. Moisture content showed no significant difference ($p>0.05$), with the control sample at 7% and the sample heated for 4 min at 6.3%. Ash content showed a significant difference ($p<0.05$), with the highest value recorded at 4 min (14.7%) and the lowest at 8 min. Crude protein content also exhibited a significant difference ($p<0.05$), with the sample heated for 6 min having the highest protein content (70%) and the control sample the lowest (60.5%). Fat content remained uniform across samples at 8.8%, while fiber content showed significant variation ($p<0.05$).

Table 1: Mean proximate composition of smoke-dried *Clarias gariepinus* subjected to the microwave oven

Treatment	Moisture	Ash	Protein	Fat	Fiber
2 min	6.8±0.02	14.9±0.00^{ab}	61.5±0.15^{b}	8.8±0.00	4.39±0.00
4 min	6.3±0.01	15.1±0.00^{a}	64.5±0.25^{ab}	8.8±0.00	4.38±0.01
6 min	6.6±0.01	15.0±0.00^{ab}	70.0±0.10^{a}	8.8±0.01	4.39±0.00
8 min	6.8±0.01	14.7±0.01^{b}	63.5±0.05^{ab}	8.8±0.00	4.38±0.01
Control	7.0±0.01	14.0±0.00^{b}	60.5±0.05^{b}	8.8±0.01	4.38±0.00
p-value	0.093	0.015	0.029	0.898	0.468

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

Table 2: Mineral content of smoke-dried *Clarias gariepinus* subjected to microwave oven

Treatment	Zn	Ca	Fe	K	Mg
2 min	12.54±0.06^{b}	980.05±8.42^{b}	25.5±0.66^{d}	1196.8±6.90^{b}	61.7±4.57^{b}
4 min	7.53±0.29^{c}	60.66±0.44^{d}	6.89±0.82^{e}	1047.16±39.60^{c}	69.03±0.36^{ab}
6 min	12.39±0.18^{b}	3179.1±67.90^{a}	42.31±0.33^{b}	1359.06±9.70^{a}	62.37±3.27^{b}
8 min	17.13±0.08^{a}	3124.58±18.5^{a}	35.8±0.24^{c}	1314.04±13.1^{ab}	61.27±2.41^{b}
Control	12.95±0.18^{b}	390.24±1.75^{c}	179.8±0.40^{a}	877.22±18.90^{d}	79.2±0.22^{a}
p-value	0.000	0.000	0.000	0.000	0.022

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

Table 3: Mean microbial count in samples of smoke-dried *Clarias gariepinus* subjected to the microwave oven

Treatment	Mean	Bacterial present	Bacterial load
2 min	430000±10000^{a}	*Escherichia coli* and *Bacillus* spp.	High
4 min	260000±10000^{d}	*Escherichia coli* spp., *Kurtha* spp., *Bacillus* spp. and *Shigella* spp.	Low compared to 2 min sample
6 min	155000±5000^{c}	*Pseudomonas* spp., *Strepto bacillus* spp., *Bacillus* spp. and *Escherichia coli*	Moderate
8 min	100000±10000^{b}	*Bacillus* spp., *Escherichia coli*, *Kutha* spp. and *Bacillus* spp.	Lowest
Control	700000±10000^{d}	*Kurthia* spp., *Arthro bacter* spp., *Bacillus* spp. and *Escherichia coli*	Highest
p-value	0.000		

Table 2 highlights the mineral content of the fish samples, revealing significant differences ($p<0.05$) across treatments. Zinc (Zn) levels ranged from a high of 17.13 mg/kg at 8 min to a low of 7.53 mg/kg at 4 min. Calcium (Ca) was highest at 317.1 mg/kg and lowest at 60.66 mg/kg at 4 min. Iron (Fe) levels were significantly higher in the control sample compared to treated samples. Potassium (K) reached its peak at 1359.06 mg/kg at 6 min, while magnesium (Mg) showed the lowest level in the treatment at 8 min.

Table 3 presents the main microbial counts in the fish samples, showing a significant difference in the counts. The fish subjected to 2 min in the oven exhibited the highest microbial count of 43×10^4 CFU, while the control sample had the lowest count at 7×10^4 CFU.

DISCUSSION

The proximate composition analysis of smoked *Clarias gariepinus* subjected to varying durations in a microwave oven revealed significant differences in certain nutrient contents, with implications for both nutritional value and potential microbial contamination. The study highlights that while moisture content did not vary significantly ($p>0.05$), ash content, crude protein and fiber content were significantly influenced by the microwave heating time.

The moisture content of the fish samples showed no significant variation. This indicates that the microwave drying process did not significantly affect the water retention in the fish, suggesting a stable moisture retention capacity across the treatments.

Ash content was highest in the 4 min heating sample and lowest in the 8 min sample. This variation in ash content could be attributed to the changes in the mineral concentration during the different heating durations. It has been noted that the microwave drying process can alter the bioavailability of certain minerals in fish, potentially increasing or decreasing their concentrations depending on the heat applied[11].

Crude protein content showed a significant difference across the treatments. The increase in protein content with prolonged heating could be explained by the concentration effect as water evaporates during the microwave drying process. This result aligns with previous studies which suggest that heat treatment can influence protein denaturation and concentration, potentially making protein more bioavailable to consumers[12].

Fat content, however, remained consistent across all samples, which suggests that microwave heating did not significantly affect the lipid content of the fish. Minimal changes in fat content following the microwave drying of fish. Fiber content showed significant variation, across treatments which may be related to the nature of the fish muscle structure and the effect of drying time on the fish's connective tissue[13].

Mineral content analysis revealed significant differences in zinc (Zn), calcium (Ca), iron (Fe), potassium (K) and magnesium (Mg) across the treatments. Zinc, calcium and potassium levels were highest in the 8 min treatment. These findings suggest that extended microwave heating may enhance the availability of certain minerals, likely due to the breakdown of fish tissue and the release of bound minerals into the surrounding matrix. Conversely, iron levels were highest in the control sample, which may indicate that longer microwave heating reduced the bioavailability of iron due to its potential degradation under heat stress[12]. Magnesium levels were lowest at 8 min, which could be attributed to the volatilization or degradation of magnesium under extended heating conditions.

Microbial contamination results from the heating process showed significant differences across the samples, with the 2 min treatment exhibiting the highest bacterial load (43×10^4 CFU). This could be attributed to incomplete drying in the microwave, which may have provided a suitable environment for bacterial growth, as residual moisture supports microbial proliferation[14]. In contrast, the control sample had the second-highest bacterial load (7×10^4 CFU), suggesting that the fish was exposed to environmental contaminants during transportation and handling.

The lower bacterial counts in samples subjected to longer heating times (6 and 8 min) may be attributed to the longer exposure to heat, which likely inactivated or inhibited microbial growth. The 8 min treatment recorded the lowest bacterial load[15] that extended heating can help reduce microbial contamination by drying out the fish and impairing the growth of spoilage organisms.

Escherichia coli, Bacillus spp. and other bacteria such as *Kurthia* and *Shigella* were commonly found in the samples. The presence of *E. coli* indicates fecal contamination, which could have occurred during post-processing handling, transportation or exposure to unsanitary environments[16]. The presence of *Bacillus* spp. and *Pseudomonas* spp. suggests that the fish could be at risk of spoilage and potential foodborne illness if not properly handled or stored. These microorganisms are commonly found in open-market fish and can cause foodborne infections if consumed without adequate cooking.

CONCLUSION

The study demonstrated that different microwave heating durations affect the proximate composition, mineral content and microbial contamination of smoked *Clarias gariepinus*. While heating improved the nutritional profile in terms of protein and mineral availability, it also influenced the bacterial load, with shorter heating times leading to higher microbial counts. These findings underline the importance of optimizing processing methods, such as heat treatment, to improve the nutritional value and safety of smoked fish products. Furthermore, proper hygiene and handling during post-processing remain crucial to minimizing microbial contamination and ensuring consumer health.

SIGNIFICANCE STATEMENT

This study highlights the impact of varying microwave heating durations on the proximate composition, mineral content and microbial load of smoked *Clarias gariepinus*. Optimized heating enhanced protein and mineral availability but also influenced microbial contamination, with shorter durations resulting in higher bacterial counts. These results emphasize the need to refine processing methods to maximize nutritional benefits while ensuring food safety. Additionally, maintaining proper hygiene and handling practices during post-processing is essential for minimizing microbial risks and safeguarding consumer health.

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