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# Comparative Nutritional Analysis of Smoked and Oven-Dried *Clarias gariepinus* Treated with Different Brine Concentrations

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## ABSTRACT

**Background and Objective:** Fish preservation methods and brine concentrations significantly influence nutrient composition and shelf stability. However, limited research has compared the nutritional outcomes of *Clarias gariepinus* under varying brine concentrations using both smoking and oven-drying techniques. This study aimed to evaluate how different brine concentrations (0, 5, and 10 g/L) and preservation methods affect the proximate composition of *C. gariepinus*, with a focus on improving protein retention and product stability. **Materials and Methods:** Twenty fresh *C. gariepinus* specimens (500-2000 g) were obtained from Oracle Fish Farms, Makurdi. Samples were processed and standardized before analysis at Adamawa State University, Mubi, using AOAC (2016) procedures. Fish were treated with varying brine concentrations and preserved through smoking and oven drying. Data were analyzed using Analysis of Variance (ANOVA) to determine significant differences at $p<0.05$. **Results:** In smoked samples, increasing brine concentration reduced moisture (20.5±0.03 to 17.0±0.01%) and carbohydrates (3.9±0.03 to 1.8±0.03%), while protein (55.2±0.02 to 58.6±0.01%), lipid (12.1±0.05 to 13.5±0.01%), and ash (8.3±0.01 to 9.1±0.01%) increased. A similar pattern was observed in oven-dried samples, with decreased moisture (15.2±0.02 to 13.0±0.04%) and carbohydrates (7.5±0.03 to 5.0±0.02%) but increased protein (58.0±0.02 to 60.7±0.01%), lipid (11.3±0.04 to 12.3±0.01%), and ash (8.0±0.01 to 9.0±0.04%). The ANOVA revealed significant differences ($p<0.05$), and oven drying demonstrated better protein retention than smoking. **Conclusion:** Both preservation methods effectively enhanced the nutritional composition of *C. gariepinus*, with higher brine concentrations improving protein content and shelf life. Oven drying proved superior for protein preservation, supporting its use in producing nutrient-rich, stable fish products.

## KEYWORDS

*Clarias gariepinus*, proximate composition, brining, smoking, oven drying, nutritional quality



## INTRODUCTION

Fish is a vital dietary component for many populations, supplying essential nutrients for healthy living. Recognized globally as an affordable source of animal protein, it serves as an outstanding element of human nutrition[1]. Fish protein surpasses other animal-derived proteins and matches the amino acid

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profiles of milk, eggs, and meat. It acts as a primary, cost-effective supplier of dietary animal protein compared to alternative protein sources[2]. In developing nations like Nigeria, where staple foods are predominantly starchy, fish protein is crucial for dietary supplementation[3]. Despite its significance, substantial fish spoilage persists in Nigeria owing to inadequate storage infrastructure, posing a key barrier to the growth of the fishing sector[4].

Various preservation techniques are used to minimize fish spoilage, such as drying, smoking, oven drying, freezing, chilling, and brining[5]. Study by Bellagha *et al*.[6] highlighted that, given fish's perishable quality, longstanding traditional preservation approaches have emerged, including salting, drying, and smoking. Smoking is especially prominent in artisanal fisheries for processing and preservation, as it improves flavour, boosts consumption, curbs waste during abundant harvests, and enhances protein access for rural communities[7]. It was[8] observed that smoke-dried fish is a staple in Nigerian traditional cuisine, prized for its appealing taste and aroma. However, traditionally smoked fish faces several drawbacks, such as inconsistent cooking, scorching or burning from direct heat, bitterness, unappealing appearance, rancidity, short shelf life, and pest infestation[6]. Oven drying, on the other hand, offers controlled drying conditions but may result in higher energy consumption and alterations in flavour and texture[9]. Among these, brining is a pre-treatment technique that involves soaking the fish in a salt solution before smoking or drying. Brine concentration plays a significant role in influencing the proximate composition of fish by affecting moisture content, protein, fat, and ash levels, thereby impacting the nutritional quality of the fish[10]. Therefore, this study aims at determining the nutritional composition of smoked and oven-dried *Clarias gariepinus* treated with different concentrations of brine solution.

## MATERIALS AND METHODS

**Study area:** This research was conducted at the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, Benue State, for a period of three months (July to September 2024).

**Sample collection and preparation:** Twenty fresh *Clarias gariepinus* specimens were obtained from Oracle Fish Farms in Makurdi, Benue State. To maintain their freshness, the specimens were immersed in water in kegs immediately after harvest and transported to the Department of Fisheries and Aquaculture Laboratory at Joseph Sarwuan Tarka University, Makurdi. This process ensured that the fish remained at a low temperature, preserving their sensory and nutritional attributes.

Upon arrival at the laboratory, the fish were washed thoroughly under cold running water to remove any dirt or contaminants[11]. The fish were then gutted to remove the viscera and internal organs. The fish were filleted with care to ensure uniformity in size and thickness, which is crucial for consistency in drying experiments. The fillets were standardized to uniform size and weight using calibrated equipment to maintain consistency across samples.

Different concentrations of brine solutions (0, 5 and 10 g/L) were prepared by dissolving calculated amounts of food-grade salt in distilled water. The fish fillets were soaked in the brine solutions for 10 min to ensure uniform absorption.

Two distinct drying methods were selected for evaluation: Oven drying and Smoke drying. For oven drying, the fish fillets were carefully arranged on trays or racks within the drying oven. The temperature was meticulously regulated at 60°C, which facilitates the removal of moisture while minimizing thermal degradation and preventing flavour loss. The duration of the drying process was closely monitored and adjusted as necessary to achieve the desired moisture content and texture in the dried fish products. For the smoke drying process, fresh fish fillets were placed on racks inside a smoking kiln. The smoking kiln was fueled with charcoal to generate smoke, and the temperature was controlled within a range of 65 to 85°C (149 to 185°F). This controlled temperature allows for even distribution of heat and smoke throughout the kiln.

Table 1: Mean proximate composition of smoked *Clarias gariepinus* under different brine concentrations

| Salt concentration | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Carbohydrate (%) |
|---|---|---|---|---|---|
| 0 g (Control) | 20.5±0.03 | 55.2±0.02 | 12.1±0.05 | 8.3±0.01 | 3.9±0.03 |
| 5 g | 18.3±0.05 | 57.4±0.02 | 13.0±0.03 | 8.7±0.02 | 2.6±0.01 |
| 10 g | 17.0±0.01 | 58.6±0.01 | 13.5±0.01 | 9.1±0.01 | 1.8±0.03 |

Table 2: Mean proximate composition of oven-dried *Clarias gariepinus* under different brine concentrations

| Salt concentration | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Carbohydrate (%) |
|---|---|---|---|---|---|
| 0 g (Control) | 15.2±0.02 | 58.0±0.02 | 11.3±0.04 | 8.0±0.01 | 7.5±0.03 |
| 5 g | 14.1±0.01 | 59.8±0.05 | 11.8±0.03 | 8.5±0.03 | 5.8±0.01 |
| 10 g | 13.0±0.04 | 60.7±0.01 | 12.3±0.01 | 9.0±0.04 | 5.0±0.02 |

**Proximate composition analysis:** The proximate composition of both oven-dried and smoked fish samples was analyzed for moisture, protein, lipid, ash, and fiber content using standard methods of Association of Official Analytical Chemists[12].

**Statistical analysis:** The data obtained were statistically analyzed using Analysis of Variance (ANOVA) to determine the significance of differences between the treatments. Differences were considered significant at $p<0.05$. The results were presented as Mean±Standard Deviation.

## RESULTS

The proximate composition of smoked *Clarias gariepinus* was analyzed under varying salt concentrations during brining, focusing on moisture, protein, fat, ash, and carbohydrate levels across three treatments: Control (0 g salt), 5 g salt, and 10 g salt. Moisture content showed a decreasing trend with increasing salt concentration, dropping from 20.5% in the control to 17.0% at 10 g, which reflects enhanced water loss due to the osmotic effect of salt. As moisture decreased, protein content increased from 55.2% in the control to 58.6% at 10 g, indicating a concentration effect. Fat content rose slightly from 12.1 to 13.5%, suggesting better fat retention during smoking. Ash content also increased from 8.3 to 9.1%, pointing to a higher mineral concentration with salt addition. In contrast, carbohydrate content declined from 3.9 to 1.8%, likely due to its relatively low initial presence being diluted by the rise in other components. These findings underscore the impact of brining on the nutritional profile and water loss of smoked *Clarias gariepinus*, demonstrating how salt concentration can be used to optimize its composition in Table 1.

The mean proximate composition of oven-dried *Clarias gariepinus* treated with varying salt concentrations (0, 5 and 10 g) reveals notable changes in moisture, protein, fat, ash, and carbohydrate levels. Moisture content declined from 15.2% in the control to 13.0% at 10 g, indicating enhanced dehydration during oven drying. As moisture decreased, protein content rose from 58.0 to 60.7%, suggesting a concentration effect. Fat content showed a gradual increase from 11.3 to 12.3%, possibly due to reduced oxidation or improved retention during drying. Ash content increased from 8.0 to 9.0%, reflecting mineral accumulation associated with salt treatment. Meanwhile, carbohydrate content dropped from 7.5 to 5.0%, likely due to the relative increase in other components. These results highlight the influence of salt concentration on the nutritional profile of oven-dried *Clarias gariepinus*, enhancing its protein and mineral content while reducing moisture and carbohydrates in Table 2.

## DISCUSSION

The proximate composition of *Clarias gariepinus*, or African catfish, is shaped by both the processing method and the level of salt used during treatment. A comparison between smoked and oven-dried samples at varying salt concentrations reveals distinct trends in moisture, protein, fat, ash, and carbohydrate contents.

In smoked samples, increasing salt concentration led to a reduction in moisture content from 20.5% in the control to 17.0% at 10 g, consistent with the dehydrating effect of salt. Protein levels rose from 55.2 to 58.6%, attributed to moisture loss concentrating the protein. This finding is in line with previous study[13], who noted that lower moisture content generally correlates with higher protein concentration in smoked fish. Fat content increased slightly from 12.1 to 13.5%, likely due to protein denaturation and fat oxidation during smoking, which aids retention, as suggested by Fanyam *et al*.[14]. Ash content rose from 8.3 to 9.1%, reflecting mineral accumulation from the salt. This agrees with findings by Kiczorowska *et al*.[5], who reported increased ash levels with higher salt concentrations in smoked fish. Carbohydrate content declined from 3.9 to 1.8%, a result of the relative increase in other components overshadowing the carbohydrate fraction.

Oven-dried samples showed similar but more pronounced changes. Moisture content dropped from 15.2 to 13.0%, with oven drying proving more effective at water removal due to higher temperatures, as observed by Zeng *et al*.[15]. Protein content increased from 58.0 to 60.7%, indicating better preservation and concentration than in smoked samples. Fat content rose moderately from 11.3 to 12.3%, suggesting minimal lipid loss during oven drying. Ash content increased from 8.0 to 9.0%, again due to mineral input from salt. This trend aligns with Birie *et al*.[16], who found similar ash increases in salt-treated oven-dried fish. Carbohydrate levels fell from 7.5 to 5.0%, reflecting the concentration effect of drying and the dominance of other macronutrients.

Overall, both salt concentration and drying method significantly affect the nutritional profile of *Clarias gariepinus*. Higher salt levels enhance protein and mineral content while reducing moisture and carbohydrates, with oven drying offering superior protein retention compared to smoking. These insights support the strategic use of salt and drying techniques to improve the quality of processed fish products.

## CONCLUSION

This study shows that increasing salt concentration during the processing of *Clarias gariepinus* significantly reduces moisture content, thereby improving shelf life. Higher salt levels also enhance protein, fat, and ash content, while reducing carbohydrates, indicating improved nutritional quality. Oven drying proved more effective than smoking in preserving protein. Overall, salt treatment optimizes the composition and preservation of processed African catfish.

## SIGNIFICANCE STATEMENT

This study discovered the impact of varying brine concentrations and preservation methods on nutrient retention in *Clarias gariepinus*, which can be beneficial for improving protein quality and shelf stability in processed fish. This study will help researchers uncover the critical areas of fish preservation efficiency that many were not able to explore. Thus, a new theory on brine-enhanced nutrient optimization may be arrived at.

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