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Assessment of different drying techniques on the quality attributes of *Scylla serrata* (Mud crab) in Makurdi, Benue State

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Abstract

This study evaluated the influence of different drying methods on the nutritional composition, mineral content, and sensory quality of Scylla serrata (mud crab) to determine the most suitable preservation method. Ten crabs, each weighing approximately 500 g, were collected from the University of Agriculture fish farm, humanely euthanized, eviscerated, and thoroughly washed. The samples were divided into two groups with replicates, processed by smoking and oven-drying at a controlled temperature of 60 ± 5 °C for 24 hours. Processed samples were examined for proximate composition, mineral elements, and sensory characteristics using standard analytical techniques. The results showed significant differences between the two drying methods. Smoked samples had higher protein and lipid contents, while oven-dried samples recorded greater moisture, ash, and energy values of 72.76%, 3.12%, and 124.91%, respectively. Calcium levels showed no significant difference between treatments. However, smoked samples contained higher amounts of potassium, sodium, magnesium, iron, zinc, copper, selenium, and cobalt. Phosphorus was significantly higher in oven-dried samples than smoked samples. Sensory evaluation indicated smoked samples were most preferred in flavor, aroma, texture, and overall acceptability. Overall, smoking proved more effective in preserving nutrients, enhancing mineral retention, and improving consumer preference and overall product quality retention.

Keywords: Nutritional quality, Oven dried, Smoked dried *Scylla Serrata* (Mud crab), Sensory, Smoke dry.

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Contents

Contribution of this paper to the literature

This study provides a comprehensive comparison of oven and smoke-drying methods for Scylla serrata under standardized processing conditions in Makurdi, Nigeria, by integrating proximate composition, mineral content, and sensory evaluation, thereby generating location specific evidence to identify the most effective preservation technique and the method most preferred by consumers.

1. Introduction

The human body needs minerals as essential micronutrients for processes like bone development, enzyme activation, and neural function. The nutritional value and health benefits of foods, including aquatic foods, are significantly influenced by their mineral content [1]. Among crustaceans, specifically prawn and crabs are a great source of nutrition due to their high digestible proteins, essential amino acids, mineral and bioactive peptides content [2]. Mud crabs are highly sought after because of their rich flavor and substantial meat yield, making them economically important to the global freshwater fisheries sector. They belong to the family Portunidae and are euryhaline species classified into four main types: Scylla paramamosain, Scylla serrata, Scylla transquebarica, and Scylla olivacea. Nutritionally, mud crabs are valuable sources of protein, minerals, and polyunsaturated fatty acids. In addition to their nutritional significance, several studies have examined their biological functions, particularly their antioxidant potential and antimicrobial peptides [3, 4], other nutrients that provide a range of health benefits to the consumer fishing. In certain nations and regions, they are an important part of small scale inland fishing [5]. The lack of comprehensive research hinders informed dietary choices, as essential mineral intake can be unknowingly impacted as the influence of minerals on aquatic food taste and texture is well-established [6]. Shelf life are also linked to its mineral profile [7]. Certain minerals can influence enzymatic activity and oxidation, which contribute to spoilage. Research shows that species, habitat, seasonality, and processing techniques affect the mineral composition of aquatic foods. A common preservation technique that increases shelf life and reduces waste is drying, however, the mineral profile of the mud crab meat may change depending on the preservative method [8]. This ignorance of the precise alterations brought about by each technique is problematic for a number of reasons, even though the nutritional makeup of different fisheries products has been studied [6]. Understanding how preservation methods affect the mineral profile of mud crab is crucial for consumer health, product quality, and longevity. Since minerals are vital dietary components, it is important to know the effects of smoking and oven drying on these levels to ensure adequate nutrition (e.g., calcium for bone health) [7]. Furthermore, the mineral composition can influence the flavor and texture [9]. Some minerals affect enzymatic activity and oxidation, contributing to spoilage. Understanding these interactions can help develop drying techniques that maximize shelf life and maintain the quality of dried mud crab meat [10].

Smoking aquatic food which is exposure to smoke and heat. Similarly, oven drying involves the application of heat, potentially leading to loss or retention of nutritional quality and minerals depending on the duration and temperature of the process [8]. The quality attributes of dried food preservation, such as moisture level, protein content, fat content, color, texture, and sensory properties, are affected by the drying technique used [11]. This study aimed to evaluate the proximate and mineral composition of freshwater Mud crab (*Scylla serrata*) processed using different heat-based preservation methods (smoking and oven-drying), in order to determine the method that most effectively preserves nutritional quality and ensures optimal suitability for human consumption

2. Materials and Methods

2.1. Location of Study

This study was carried out at Fisheries Unit of the Experimental farm, under the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi.

2.2. Collection and Preparation of Mud Crab

Mud Crab (*Scylla serrata)* was collected from the Department of Fisheries experimental farm of Joseph Sarwuan Tarka University Makurdi using handpicking techniques with priority was given to areas encompassing various habitat types across different reaches of the Fish Farm.

2.3. Experimental Design

Collected samples of 10 Mud Crabs divided in to two sets with a replicate, each sample weighing 500g were cleaned, degutted. It was the subjected to two drying methods, smoke dry in smoking kiln (Drum Smoker 2M) and Oven drying (Model-Binder 53#06-97573) at uniform temperature of 60 ± 5^0 C for 24 hours. Drying conditions were closely controlled and modified as needed to attain the target moisture level and texture in the dried mud crab, with regular sampling and analysis conducted to monitor drying progress and evaluate quality characteristics. The dried sample were taken to Hydrobiology and Fisheries Research laboratory, University of Jos, Plateau State, Nigeria for further laboratory analyses of proximate and minerals.

2.4. Proximate Composition

The nutritional composition of the dried fish samples was analyzed using the standard procedures of the Association of Official Analytical Chemists (AOAC), as describe by Ullah, et al. [12].

2.5. Mineral Analysis

The mineral content of the dried mud crab samples was quantified using the spectrophotometric technique as described by Şimşek, et al. [13] with measurements obtained using a Jenway digital spectrophotometer. Mineral concentrations were determined by measuring absorbance or emission intensity and comparing results with calibration curves, reporting values on a dry weight basis using a specific formula [14].

$$\text{Mineral concentration } mg \therefore kg = \left(\frac{\text{concentration from calibrated curve } (mg \therefore kg) \times \text{Final Volume } (L)}{\text{weight of sample } (kg)}\right)$$

2.6. Sensory Evaluation

Sensory evaluation was performed by trained panelists to determine the quality of the dried fish samples based on flavor, texture, aroma, and overall acceptability. Standard sensory scoring scales and descriptive analytical methods were applied to quantitatively assess these attributes following Chan, et al. [15]. The results offered important information on the sensory characteristics and consumer preference of the dried fish products.

2.7. Statistical Analysis

The data obtained was subjected to T-test of independent variable to determine the proximate and mineral composition of mud crab. The software to be used for statistical analysis is SPSS

3. Result

The proximate analysis (Table 1) indicated that smoked samples had significantly higher protein (22.3%) and lipid (3.81%) contents, as denoted by superscript ("a"). In contrast, oven-dried samples showed the highest moisture (72.76%), ash (3.12%), and energy (124%) values, while smoke-dried samples recorded the lowest levels for these parameters.

Table 1. Proximate composition of freshwater smoked and oven dried freshwater *S. serrata* (Mud Crab).

Component (%)	Smoked Crab	Oven dry crab
Protein	22.3 ± 1.3^{a}	19.81 ± 0.43^{b}
Lipid	3.81 ± 0.37^{a}	2.64 ± 0.12^{b}
Moisture	70.7 ± 0.2^{b}	72.76 ± 0.04^{a}
Ash	1.20 ± 0.09^{b}	3.12 ± 009^{a}
Energy	107^{b}	124.91^{a}

Note: Means in the same row with different superscript differs significantly.

Table 2. Sensory evaluation of freshwater smoked and oven dried freshwater *S. serrata* (Mud Crab).

Drying Method	Flavor (Mean ± SD)	Texture (Mean ± SD)	Aroma (Mean ± SD)	Overall Acceptability (Mean ± SD)
Oven Dried	8.8 ± 0.3^{b}	7.9 ± 0.7^{b}	8.7 ± 0.4^{b}	8.5 ± 0.3^{b}
Smoked Dried	9.5 ± 0.2^{a}	8.7 ± 0.2^{a}	9.0 ± 0.2^{a}	9.1 ± 0.2^{a}

Note: Means in the same row with different superscript differs significantly.

Smoke drying produced the highest scores for flavor (9.5), texture (8.7), and aroma (9.0), as indicated by superscript ("a"), whereas oven drying recorded the lowest scores for flavor (8.8), texture (7.9), and aroma (8.7). Overall acceptability was also greatest in smoke-dried samples (9.1) compared to oven dried samples (8.5) (Table 2).

In this study, Table 3; presents the mineral content of smoked and oven dried freshwater mud crab (*S. serrata*). The result shows that calcium content was similar in smoked (39.54 ± 0.01 mg/100 g) and oven-dried (39.55 ± 0.06 mg/100 g) crabs. Smoked crabs showed higher levels of sodium (21.62 ± 0.15 mg/100 g), magnesium (18.77 ± 0.13 mg/100 g), iron (5.45 ± 0.02 mg/100 g), zinc (9.72 ± 0.07 mg/100 g), potassium (34.38 ± 0.08 mg/100 g), copper (0.84 ± 0.01 mg/100 g), selenium (0.45 ± 0.02 mg/100 g), and cobalt (0.14 ± 0.01 mg/100 g) compared to oven-dried samples. In contrast, phosphorus was higher in oven-dried crabs (20.40 ± 0.05 mg/100 g) than in smoked ones (19.54 ± 0.10 mg/100 g). The superscript notation "a" for significant higher to that of "b".

Table 3. Mineral content of smoked and oven dried freshwater Mud Crab (*S. serrata*).

Minerals	Smoked Sample (mg/100g)	Oven dried Sample (mg/100g)	P-Value
Calcium (Ca)	39.54 ± 0.01^{a}	39.55 ± 0.06^{a}	0.87
Potassium (K)	34.38 ± 0.08^{a}	32.56 ± 0.10^{b}	0.00
Sodium (Na)	21.62 ± 0.15^{a}	20.21 ± 0.06^{b}	0.00
Magnesium (Mg)	18.77 ± 0.13^{a}	17.60 ± 0.17^{b}	0.01
Phosphorus (P)	19.54 ± 0.10^{b}	20.40 ± 0.05^{a}	0.00
Iron (Fe)	5.45 ± 0.02^{a}	5.18 ± 0.03^{b}	0.00
Zinc (Zn)	9.72 ± 0.07^{a}	9.44 ± 0.02^{b}	0.02
Copper (Cu)	0.84 ± 0.01^{a}	0.76 ± 0.01^{b}	0.02
Selenium (Se)	0.45 ± 0.02^{a}	0.27 ± 0.01^{b}	0.00
Cobalt (Co)	0.14 ± 0.01^{a}	0.08 ± 0.01^{b}	0.02

Note: Means in the same row with different superscript differs significantly.

4. Discussions

The proximate analyses show maximum moisture content for both samples, but more in oven dried method. It also indicates that the oven dried method has higher ash and energy content. The protein was the same for both drying methods, but the lipid (3.81 %) was higher for smoked samples. The stable protein stability in mud crab shows regulated heat while drying, which prevented protein denaturation. Protein loss can be due to high heat related denaturation and heat regulation enhances protein structure [16, 17]. The decreases in fat levels observed in the oven-dried sample may be attributed to exposure to heat and rapid oxidation of fats during the drying processes. This findings agrees with Akinneye, et al. [18] and Rangasamy, et al. [2] stating that the decreased fat in different heat source methods of samples preservation may give rise to lipid oxidation. Proximate analysis of

mud crabs is essential for understanding their nutritional and biochemical characteristics. However, detailed information on specific nutrients such as carbohydrates, fats, proteins, fatty acids, amino acids, and minerals, particularly in relation to sex and body parts is been researched [19]. The proximate composition of mud crabs differs and is influenced by factors including the species, season, temperature, size, and developmental stages of an individual crab, as well as the availability of food or nutritional sources, have all been demonstrated to affect the proximate components of crabs, [8] and the results further identifies the differences in the proximate content between the processing methods, providing insights into their impact on nutritional value.

Sensory assessment of crab products provides valuable information on consumer preference and acceptability, which are essential for identifying the most suitable processing techniques. This study examines the sensory characteristics which are flavor, texture, aroma, and overall acceptability of smoked and oven-dried *S. serrata* (mud crab) using the available data. The findings reveal notable differences among the three drying methods, with each method imparting unique effects on the sensory qualities of the mud crab. Smoke-dried method crab recorded the highest flavor, texture, aroma and the overall acceptability rate (9.5, 8.7, 9.0 and 9.1, respectively) to that of oven dried method. The enhanced flavor observed in crab is attributed to the Kostyra and Baryłko-Pikielna [20] reactions of the uptake of smoke giving volatile composition, such as phenols and carbonyl compounds, which improve flavor profile identity of smoked flavoring. The strong and chewy texture of smoked crab is caused by structural modifications in proteins due to heat exposure. This agrees with Puke and Galoburda [21] who said smoked improves texture when pre-treatment and controlled drying during drying processing, which can prevent over drying which will improve texture and sensorial changes in the final product. Volatile compounds produced during smoking contribute to the improved aroma of smoked products [22]. Smoked crab had higher overall acceptability (9.1). However, improvements in product quality must be guided by consumer preferences. Sensory characteristics such as smoky aroma and spiced flavor, among others, play an important role in consumer perception, with different consumer groups showing similar patterns in their evaluation of smoked fish. The enhanced sensory qualities of smoked fish, particularly its flavor and aroma, correspond closely with consumer preferences [23].

The major minerals calcium (Ca) Sodium (Na), Potassium (K), and Magnesium (Mg) varied in significance across the different preservation methods. They play vital roles in numerous physiological and biochemical processes in the human body therefore, adequate dietary intake is essential. Crustaceans are rich sources of both macro- and micro-minerals, and key elements such as calcium (39.52 mg/100 g), copper (0.84 mg/100 g), manganese (18.77 mg/100 g), zinc (9.72 mg/100 g), and selenium (0.45 mg/100 g) are present in appreciable amounts in crab meat. In this study Calcium content was comparable in smoked (39.54 mg/100 g) and oven-dried (39.55 ± 0.06 mg/100 g) samples, a trend also observed for magnesium and sodium, although slightly higher values were recorded in smoked crabs with no significant difference. The indication that calcium remained relatively stable and it is resilient to processing conditions, with only minor variations between the processing methods. This aligns with the study by Vrdoljak, et al. [24], who found that calcium content in various aquatic food remains largely unchanged regardless of drying method. Sodium levels were higher in the smoked sample (21.62 mg/100g) and oven-dried sample having lower (20.21 mg/100g). This corroborates with the research by Bover Cid, et al. [25] indicating that smoking can lead to higher sodium retention, potentially due concentration effects as moisture evaporates. Polak-Juszczak [26] also stated that elevated sodium (NaCl) levels contributed to the extended shelf life of the products. Magnesium content was significantly higher in smoked crabs (18.77 mg/100g) compared to oven-dried crabs (17.60 mg/100g). This result is similar to study by Fitri, et al. [27] who found that smoking preserves magnesium better than drying methods due to less mineral leaching.

In respect to trace elements, iron, zinc, copper, selenium, and cobalt were higher in smoked samples, whereas phosphorus was more concentrated in oven-dried sample. Phosphorus and zinc exhibited the highest levels among the trace elements analyzed. Iron was significantly higher in smoked samples (5.45 mg/100g) compared to oven-dried samples (5.18 mg/100g), which is similar to report by Moruf, et al. [28], which indicate that smoking can preserve iron levels better than drying due to the protective effects of smoke and reduced exposure to high temperatures. Zinc levels were significantly higher in smoked crabs (9.72 mg/100g) compared to oven-dried crabs (9.44 mg/100g). This finding aligns with research by Schroeder [29] which suggests that smoking may help retain zinc content due to reduced oxidation and mineral loss. Akinneye, et al. [18] also reporting zinc as the most abundant trace element in the effect of drying methods on the chemical composition of three species of fish. Phosphorus content was higher in oven-dried samples (20.40 mg/100g) compared to smoked samples (19.54 mg/100g). Ekwere, et al. [30], which suggests that phosphorus is more efficiently retained through oven drying due to the controlled heating process which minimizes phosphorus loss compared to smoking. Potassium content was significantly higher in smoked crabs (34.38 mg/100g) compared to oven-dried crabs (32.56 mg/100g). Ibraheem, et al. [31] in his similar findings express that smoking can enhance potassium retention compared to other drying methods due to reduced moisture and preservation of cellular structures that hold potassium. Copper content was also higher in smoked samples (0.84 mg/100g) compared to oven-dried samples (0.76 mg/100g), which is a similar case observation in a study by Akinneye, et al. [18] who observed that copper levels are better preserved in smoked fish compared to dried counterparts. Selenium and cobalt levels were higher in smoked crabs (selenium: 0.45 mg/100g; cobalt: 0.14 mg/100g) compared to oven-dried crabs (selenium: 0.27 mg/100g; cobalt: 0.08 mg/100g) respectively. These results agree with the reports of Sengar, et al. [32], who observed that smoking more effectively preserves trace minerals such as selenium and cobalt by minimizing mineral loss during processing. The same observation was ascertained by Polak-Juszczak [26], who noted that, after accounting for moisture reduction, smoked fish experience significantly lower microelement losses than those subjected to other processing methods. Nevertheless, the nutritional composition of muscle tissues depending on season and biological variations (such as species, size, age, sex, and reproductive stage) [33, 34]. Similarly, Barrento, et al. [35] and Zotti, et al. [36] attribute variations in the nutritional and elemental composition of crabs to be linked to differences in the chemical forms of the elements, as well as to nutritional and environmental factors such as water chemistry, salinity, temperature, and contaminant levels.

5. Conclusion

The nutritional data obtained from this study shows that smoking retains higher levels of proximate and mineral components in freshwater mud crabs when compared with oven drying, possibly due to reduced moisture loss and the protective effect of smoke. In contrast, oven drying preserves a significantly higher level of phosphorus. This demonstrates that processing techniques influence the nutritional quality of freshwater aquatic foods, with smoking being more effective for maintaining most nutrients, while oven drying is more suitable for phosphorus retention. Crab meat is a rich source of essential and non-essential nutrients, particularly protein and minerals, making it a valuable alternative dietary resource with quality attributes. The present study indicates that Scylla serrata contains higher protein levels than many other crab species, providing an excellent source of both essential and non-essential amino acids. The nutrient profile obtained can support the commercialization of this species through appropriate nutritional labeling, offering consumers detailed information on its quality attributes. Further research is recommended to assess the effects of seasonal changes on the nutritional composition of edible crab species

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