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EFFECTS OF PROCESSING ON THE PROXIMATE AND MINERAL COMPOSITION OF CULTURED AND CAPTURED CLARIAS GARIEPPINUS

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ABSTRACT

Fish and fish products serve as vital protein sources in Africa and the world in general. Since fish is typically processed before consumption, this study investigated how different processing methods affect the proximate and mineral composition of both cultured and captured *Clarias gariepinus*. The processing techniques employed in this research included smoking, boiling, and oven drying. Cultured catfish were sourced from Oris Farm in Osogbo, Osun State, Nigeria, while captured catfish were obtained from Asejire Dam in Oyo State. The proximate and mineral compositions of fresh, boiled, smoked, and oven-dried samples of both cultured and captured *Clarias gariepinus* were analyzed in triplicate. The results indicated significant differences ($P<0.05$) in crude protein, dry matter, moisture, ash, fiber, potassium, and phosphorus content among the different processing methods for both cultured and captured catfish samples. Potassium and phosphorus levels also varied significantly ($P<0.05$) across the processing methods. Boiled and oven-dried samples of both cultured and captured catfish exhibited higher crude protein and lipid content, suggesting that these processing methods provide consumers with a rich source of protein and essential nutrients. The study concludes that boiling and oven drying with samples possessing highest percentages of protein are the most effective processing methods for preparing *Clarias gariepinus*, ensuring optimal nutrient retention for consumers.

Keywords: Proximate, Mineral, Processing, *Clarias gariepinus*

INTRODUCTION

Fish remains the most affordable source of protein and micronutrients for millions of people in Africa (Ben & Heck, 2005). Fawole *al et.* 2007 highlighted fish as a key provider of essential animal protein and nutrients in general necessary for a healthy diet in both Africa and globally. The advantages of fish over other protein sources include its amino acid profile, protein digestibility, high palatability, low cholesterol levels, and tender flesh (Louka *et al.,* 2004). Due to these health benefits, fish continues to be a preferred protein source worldwide (Ali & Kumar, 2010).

Despite its numerous benefits, the nutrient composition of fish can vary based on factors such as sex, species, seasonal changes, and feeding habits, all of which significantly impact the nutritional content of individual fish species (Effiong & Fakunle, 2011). Given that fish is a highly perishable food, preservation through processing is crucial, particularly in tropical regions where ambient temperatures promote the rapid growth of microorganisms that cause food spoilage and post-mortem changes (Fakunle *et al.,* 2009).

In other to preserve fish, various processing methods such as boiling, sun drying, salting, smoking, and roasting are commonly employed (Olayemi *et al.,* 2011). Since fish is not consumed raw, it undergoes several processing techniques, including smoking, boiling, roasting, frying, and oven drying, each of which can affect the taste, nutrient content, palatability, and flavor of the fish (Eriksson, 1987).

Saliu (2008) noted that different fish processing methods can either positively or negatively impact the overall nutritional value of fish. According to Watchman (2000), determining the proximate composition including protein, lipid, ash, and other nutrients is essential to ensure that these nutrients meet acceptable dietary standards. This study, therefore, aims to assess how different processing methods affect the proximate and mineral composition of both cultured and captured *Clarias gariepinus.*

MATERIALS AND METHODS

Collection of Fish Sample

The farm-raised cultured catfish were collected from Oris Farm located on Mallam Tope Street, Osogbo, Osun State, Nigeria, while the captured catfish were sourced from Asejire Dam. This dam is a 525-hectare man-made lake, created by impounding the Osun River in 1970, and is situated at a longitude of 3°57'0"E and a latitude of 7°30'0"N. Two catfish each for the cultured and captured fish were used as samples, the cultured fish weighed 800.0g and 850.0g while the capture fish weighed 840.0g and 860.0g making them suitable for the experiment.

Samples Preparation

Each fish was carefully dissected, gutted and the gonads were removed. The fish were then thoroughly washed, cleaned, and filleted before being homogenized in a blender for 15 minutes. The homogenized samples were subsequently used for various chemical analyses.

Boiled Samples

For both captured and cultured samples, the same weight 250g were measured and placed in different labeled white nylon and then boiled at 100°C for 5 minutes (Marimuthu *et al*., 2011) and later placed into foil paper for further analysis.

Fresh samples, 250g of both the cultured and captured fish were weighed and stored in foil paper kept under frozen conditions (−20 °C) until analysis (Marimuthu *et al*., 2011).

The smoked samples involved weighing 250g of both types of fish, which were then smoked for a 3-4hours and

subsequently stored in foil paper for further analysis (Iheanacho et al., 2017).

Oven Dried Samples

The same weight (250g) portions of both cultured and captured catfish were oven dried in a locally constructed oven for 2 hours. After cooling, these samples were also placed in foil paper for subsequent analysis Phillips & Lacroix (2000).

Proximate Composition Analysis

Protein Content Determination

The protein content of the samples was analyzed following the official methods outlined by the Association of Official Analytical Chemists (A.O.A.C., 1990). All analyses were conducted in triplicate. The crude protein content of the samples was determined using the semi-micro Kjeldahl method, which involves three main steps: digestion, distillation, and titration. To begin, 0.5g of each finely ground, dried sample was carefully weighed into Kjeldahl digestion tubes, ensuring that all material reached the bottom of the tubes. A Kjeldahl catalyst tablet and 10ml of concentrated H_2SO_4 were then added to each tube. The tubes were placed in a Digestion Block Heater inside a fume cupboard and heated for 4 hours until a clear, colorless solution remained. The digest was allowed to cool, and then carefully transferred to a 100ml volumetric flask. The digestion tube was rinsed thoroughly with distilled water, and the flask was topped up to the 100ml mark with distilled water.

The distillation was carried out using a Markham Distillation Apparatus, which enables the steam distillation of volatile substances such as ammonia, ensuring complete collection of the distillate. The apparatus was pre-steamed for about ten minutes to remove any condensed water, and then reassembled on the heat source. A 5ml portion of the digest was introduced into the apparatus through a small funnel opening, followed by the addition of 5ml of 40% (W/V) NaOH solution through the same opening. The mixture was steam-distilled for 2 minutes into a 50ml conical flask containing 10ml of 2% boric acid mixed with an indicator solution. The boric acid solution changed from red to green, indicating that all the ammonia released had been captured. The resulting green solution was then titrated against 0.01N HCl from a 50ml burette. At the endpoint, the solution turned from green to wine color, signaling that all the nitrogen trapped as ammonium borate had been converted to ammonium chloride.

The percentage of nitrogen was calculated using the following formula: % N = (Titre value × Atomic mass of Nitrogen × Normality of HCl used × 4) or % N = (Titre value × Normality/Molarity of HCl used × Atomic mass of N × Volume of flask containingthe digest × 100)/ (Weight of sample digested in milligrams × Volume of digest for steam distillation).

The crude protein content was then determined by multiplying the percentage of nitrogen by a constant factor of 6.25, resulting in % CP = % N × 6.25.

Dry Matter and Moisture Determination

To determine dry matter and moisture content, 2g of each sample was weighed into a pre-weighed crucible. The crucible and sample were then placed in an oven set at 100°C and dried to a constant weight over a 24-hour period. After 24 hours, the crucible and sample were removed from the oven, transferred to a desiccator to cool for ten minutes, and then weighed again.

The weight of empty crucible is W_o, weight of crucible plus sample is W_1 and weight of crucible plus oven-dried sample W_3

% Dry Matter = $((W_3-W_1) / (W_1-W_0)) \times 100$

% Moisture = $((W_1-W_3)/(W_1-W_0)) \times 100$

Determination of Ash

Sample (2.0gm) were weighed and placed in a porcelain crucible before being transferred into the muffle furnace set at 5500C then left in it for 4 hours. After it has turned to ash, the crucibles along with the content were cooled to 1000C in air then to room temperature before being weighed.

Ash content = ((weight of ash)/(Original weight of sample)) x 100

Fibre Determination

Samples (2.0gm) were weighed into fiber flask before the addition of 100ml of H_2SO_4. For a period of One hour the mixture were heated under reflux in heating mantle. After filtering the hot mixture through a fiber sieve cloth, filtrate obtained was thrown off and residue returned to the fiber flask, then 100ml of 0.313N NaOH were added and heated under reflux for another 1 hour. Mixtures were thereafter filtered through a fiber sieve cloth and 10ml acetone added to dissolve the organic constituent. 50mls of hot water was used to wash the residue on sieve cloth before transferring it to the crucible. Both crucible and residue were dried in the oven at 105°C overnight to remove moisture. The oven dried crucible and residue were made to cool in a desiccators and the weight taken as W_1. The weighed crucible W_1 was transferred to the muffle furnace for ashing process at 550°C for 4 hours. Dessicator was used to cool the crucible containing white or grey ash (free of carbonaceous) and then weighed as W_2. The difference between the two weight taken resulted in the fiber weight.

% Fiber = $((W_1 – W_2)/$ weight of sample) x 100

Potassium Determination

Two grams of the sample were placed in a small porcelain crucible and ashed in a furnace at 650°C for three hours. The resulting ash was then extracted by adding 2ml of HCl to the crucible, boiling the mixture gently, and transferring the solution to a 50ml beaker using a Pasteur pipette. The precipitates were rinsed with distilled water, filtered, and the filtrate was brought up to a 50ml volume with distilled water. Potassium content was subsequently determined using a flame photometer (model: Jenway PFP 7).

Phosphorus determination

Phosphorus content was routinely measured using the vanado-molybdate colorimetric or spectrophotometric method. The ash obtained from each sample was treated with a 2M HCl solution, following the procedure used for calcium determination. A 10ml aliquot of the filtrate was pipetted into a 50ml standard flask, to which 10ml of vanadate yellow solution was added. The flask was then filled to the mark with distilled water, stoppered, and allowed to sit for 10 minutes to allow for full yellow color development. The concentration of phosphorus was determined by measuring the optical density (OD) or absorbance of the solution using a Spectronic 20 spectrophotometer or colorimeter at a wavelength of 470nm. The percentage of phosphorus was calculated using the appropriate formula.

% Phosphorus = (Absorbance x slope x Dilution factor)/10000

All data collected were subjected to analysis of variance (ANOVA) and significant mean was separated by Duncan's multiple range tests using procedure of SAS (1999).

RESULTS AND DISCUSSION

Result of this studies showed that moisture content is significantly ($p<0.05$) higher (74.83%) in the fresh sample compared to moisture content of other processing methods while oven dried method had the least (1.14%) moisture content (Table 1). The percentage crude fiber sequentially increased from raw (0.9%), oven dry (1.63%), smoked (1.93%) to boiled (3.26%) which is the highest and significant higher than others. Crude protein content (Table 1) differs significant ($p<0.05$) among the different processing methods with oven dried having the highest (67.34%) while fresh sample have the least (20.00%). Crude fat content were not significantly differ ($p<0.05$) between smoke (2.37%) and boiled (2.36%) method whereas both methods differ from other methods significantly (Table 1). Lipid content did not differ between fresh (15.27%) and smoked (14.25%) method while the two differ significantly ($p<0.05$) from the remaining processing methods (Table 1). Boiled method exhibited highest (14.25%) percentage of ash among other methods while fresh sample was the least (2.04%). CHO percentage was highest (4.98%) and significantly ($p<0.05$) different than the other processing method. There is a significant difference (Table 1) in the nitrogen free extract among the four different processing methods, oven dried had the highest (9.74%) NFE while boiled method had the least (0.70%). Percentage Potassium and Phosphorous (Table 1) follow the same trend with oven dried methods having the highest (0.00182%) and (0.00407%) in Potassium and Phosphorous respectively, also the least (0.00012%) and (0.00013%) in Potassium and Phosphorous respectively.

Table 1: Proximate composition of Cultured *Clarias gariepinus*

Parameters	Fresh	Smoked	Boiled	Oven dried
Moisture(%)	74.83 ± 0.20^{a}	3.82 ± 0.12^{c}	39.43 ± 0.10^{b}	1.14 ± 0.00^{d}
Crude Fiber(%)	0.9 ± 0.02^{d}	1.93 ± 0.10^{b}	3.26 ± 1.84^{a}	1.63 ± 0.02^{c}
Crude protein (%)	20.00 ± 0.01^{d}	57.05 ± 0.21^{c}	60.46 ± 2.34^{b}	67.34 ± 4.24^{a}
Crude fat (%)	0.99 ± 0.10^{c}	2.37 ± 1.02^{a}	2.36 ± 1.10^{a}	2.18 ± 1.00^{b}
Lipids (%)	15.27 ± 1.01^{b}	14.25 ± 0.90^{b}	12.85 ± 0.20^{c}	29.57±3.45a
Ash (%)	2.04 ± 0.24^{c}	3.43 ± 0.80^{b}	14.25 ± 0.90^{a}	3.44 ± 0.32^{b}
CHO (%)	4.98 ± 1.02^{a}	2.97 ± 0.55^{c}	3.59 ± 0.89^{b}	3.79 ± 0.90^{b}
NFE (%)	1.77 ± 0.24^{c}	2.14 ± 0.80^{b}	0.70 ± 0.14^{d}	9.74 ± 0.20^{a}
Potassium (%)	0.00012 ± 0.00^{d}	0.00045 ± 0.00^{b}	0.00021 ± 0.00^{c}	0.00182 ± 0.00^{a}
Phosphorous (%)	0.00013 ± 0.00^{d}	0.00026 ± 0.00^{b}	0.00014 ± 0.00^{c}	0.00407 ± 0.00^{a}

^{a,b,c,d}Means within the same row with different superscripts are significantly different ($P<0.05$)

The table 2 below shows the proximate analysis of captured *Clarias gariepinus*, there is a significant ($p<0.05$) difference among the processing methods, in the moisture content, fresh sample had the highest (62.21%) while oven dried had the least (0.88%). Crude fibre content (Table 2) also differ significantly ($p<0.05$) among the processing method with fresh sample having the least (0.70%) and boiled sample having the highest (2.89%). Crude protein content (Table 2) was significantly high in the boiled sample (59.33%) and significantly low in the fresh sample (12.18%). Crude fat content (Table 2) decreased from boiled (1.85%), oven dried (1.28%), smoked (0.99%) to fresh sample (0.25%) while lipid content increased from fresh (4.73%), smoked (20.87%), boiled (21.76%) to oven dried (23.71%). Boiled sample (Table 2) had the highest ash content (4.99%) while oven dried sample had the least (1.17%) amount of ash content and ash content differ significantly among the processing methods.

Table 2: Proximate composition of Captured *Clarias gariepinus*

Parameters	Fresh	Smoked	Boiled	Oven dried
Moisture (%)	62.21 ± 0.22^{a}	3.46 ± 0.20^{c}	47.45 ± 0.38^{b}	0.88 ± 0.01^{d}
Crude Fiber (%)	0.70 ± 0.01^{c}	1.18 ± 0.10^{b}	2.89 ± 0.10^{a}	0.56 ± 0.00^{d}
Crude Protein (%)	12.18 ± 0.02^{d}	46.87 ± 1.28^{c}	59.33 ± 0.03^{a}	49.05 ± 0.01^{b}
Crude Fat (%)	0.25 ± 0.00^{d}	0.99 ± 0.03^{c}	1.85 ± 0.08^{a}	1.28 ± 0.29^{b}
Lipids (%)	4.73 ± 0.21^{d}	20.87 ± 1.58^{c}	21.76 ± 0.98^{b}	23.71 ± 1.74^{a}
Ash (%)	1.42 ± 0.04^{c}	1.86 ± 0.08^{b}	4.99 ± 1.00^{a}	1.17 ± 0.01^{d}
CHO (%)	5.78 ± 1.41^{a}	0.83 ± 0.00^{c}	2.56 ± 0.01^{b}	2.55 ± 0.24^{b}
NFE (%)	1.23 ± 0.10^{c}	1.42 ± 0.18^{a}	0.43 ± 0.00^{d}	1.35 ± 0.20^{b}
Potassium (%)	0.0001 ± 0.00^{b}	0.00067 ± 0.00^{a}	0.00022 ± 0.00^{b}	0.00024 ± 0.00^{b}
Phosphorus (%)	0.0001 ± 0.00^{c}	0.00013 ± 0.00^{b}	0.0001 ± 0.00^{c}	0.00018 ± 0.00^{a}

^{a,b,c,d}Means within the same row with different superscripts are significantly different ($P<0.05$)

Discussion

In the analysis of *Clarias gariepinus* from different processing methods, there is a significant variation in moisture content ($p<0.05$). Specifically, fresh fish exhibits the highest moisture content (74.83±0.20), whereas oven-dried fish shows the lowest (1.14±0.00). This finding aligns with results from Ersoy and Yilmaz (2003), Rosa *et al.* (2007), and Yamar*et al.* (2004). The reduction in moisture content is associated with increases in protein, fat, and ash contents, as noted by Arias *et al.* (2003).

A significant difference ($p<0.05$) is also observed in the fiber content of the cultured fish, with the boiled sample containing the highest fiber (3.26±1.84) and the fresh sample the lowest (0.9±0.02). In terms of crude protein, the oven-dried fish records the highest content (67.34±4.24), while fresh fish has the lowest (20.00±0.01). These results are consistent with findings from Kumolu-Johnson *et al.* (2010) and Okereke *et*

al. (2014). Crude fat, lipid content, and carbohydrates also exhibit significant differences among processing methods, though the highest and lowest values vary. The crude fiber content in smoked (2.37±1.02) and boiled (2.36±1.10) fish samples is not significantly different from each other but is significantly higher ($p<0.05$) compared to other methods, in agreement with Okereke *et al*. (2014). The lipid content is highest in the oven-dried sample (29.57±3.45) and lowest in the boiled sample (12.85±0.20). Additionally, the raw fish sample has the highest carbohydrate content (4.98±1.02), while the smoked sample has the lowest (2.97±0.55).

Significant differences ($p<0.05$) are also noted in potassium content, with the smoked sample containing the highest potassium percentage (0.00045±0.00) and the fresh sample the lowest (0.00012±0.00). Phosphorus content shows a significant difference ($p<0.05$) as well, with oven-dried samples having the highest percentage (0.00047±0.00) and fresh samples the lowest (0.00013±0.00). These results align with those of Kumolu-Johnson *et al.* (2010) and Okereke *et al.* (2014).

For captured fish samples, as shown in Table 2, all parameters exhibit significant differences at $p<0.05$ across processing methods (fresh, smoked, boiled, and oven-dried), though the highest and lowest values differ. Fresh fish has the highest moisture content (62.21±0.22), while oven-dried fish has the lowest (0.88±0.01). The boiled sample has the highest crude fiber content (2.89±0.10), with the oven-dried sample having the lowest (0.56±0.00). Crude protein is highest in the boiled sample (59.33±0.03) and lowest in the fresh sample (12.18±0.02). Oven-dried fish shows the highest lipid content (23.71±1.74), whereas the raw sample has the lowest (4.73±0.21). The boiled sample also has the highest ash content percentage (4.99±1.00), while oven-dried fish has the lowest (1.17±0.01). In nitrogen-free extract content, the smoked sample has the highest (1.42±0.18) and the boiled sample the lowest (0.43±0.00).

Significant differences ($p<0.05$) are found in potassium content, with the smoked sample having the highest (0.00067±0.00) and the fresh sample the lowest (0.0001±0.00). Phosphorus content is also significantly different ($p<0.05$), with oven-dried samples containing the highest (0.00018) and fresh and boiled samples the lowest (0.0001). These findings confirm those reported by Kumolu-Johnson *et al.* (2010) and Okereke *et al.* (2014). Overall, Tables 1 and 2 indicate higher nutritional content in the boiling and oven-drying methods.

CONCLUSION

This study has demonstrated that the nutritional content of both cultured and captured catfish, including moisture, crude fiber, crude protein, crude fat, lipid, ash, carbohydrates, and nitrogen-free extract, varies significantly ($P<0.05$) among different processing methods such as fresh, smoked, boiled, and oven-dried. Specifically, the nutritional content of *Clarias gariepinus* was found to differ depending on the processing technique employed. The findings indicate that fish samples processed by boiling and oven drying retain the highest nutritional content. Therefore, it can be concluded that boiling and oven drying are the most effective processing methods for preserving nutrients in both captured and cultured fish, thereby supporting optimal human development and growth.

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