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RESEARCH PAPER

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Proximate Composition and Sensory Evaluation of Catfish (*Clarias gariepinus*) Smoked with Different Materials

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Abstract

This study determined the proximate and organoleptic properties of smoked *Clarias gariepinus* using plantain leaves (PL) and foil paper (FP). Twelve catfish samples (570±25g) were euthanized, eviscerated, washed and divided into Control, plantain leaf (PL), and foil paper (FP) before being smoked. The proximate analyses of the initial and smoked samples were done according to standard methods. Organoleptic assessment was done by trained panelists. The result indicated that control sample was preferred in all the organoleptic parameters followed by plantain leaf and foil paper samples. Proximate analyses of the catfish showed that the control sample had the lowest moisture content (19.87±0.59), followed by PL (38.35±0.39), FP (40.46±1.98), and the initial samples (59.78±1.52). Crude protein was 17.45±1.70, 59.03±0.89, 38.28±1.70, and 40.31±0.49 for initial, Control, FP and PL respectively. Crude lipid was 10.32±0.26 (initial), 12.06±0.62 (control), 10.66±0.33 (FP) and 10.51±0.37 (PL). Lipid content of the control sample was significantly different from the other samples. Ash was in the order of Initial (11.65±0.45)>PL (7.55±1.03)>FP (9.88±0.09)>Control (9.40±0.40) while NFE was Initial (1.96±0.95)> Control (0.90±0.18)>FP (0.61±0.35)>PL (0.37±0.18). This study established no significant difference between FP and PL samples while the control was more acceptable and more nutritious in comparison to Plantain leaves and foil paper.

Introduction

Fish smoking originated naturally along the coastal fishing communities, with the aim of preserving the catch for a long period (Adesulu, 2007). It is a very popular processing method in Africa and other continents where smoked fish is a delicacy (Ayofemi and Adeyeye, 2018). In Nigeria, fish smoking which is one of the oldest methods of fish preservation usually leave the processor with two end products; fresh smoked fish and smoked-dried fish which has a longer shelf-life than fresh smoked fish. Fish smoking combines the effects of drying, salting and heating. It has received great attention because of its acceptance among consumers. The acceptance of a smoked fish is based primarily on the sensory characteristics and its impact on the fish (Ghaly *et al.,* 2010). Fishermen recently subject their fish to smoking rather than selling it fresh because it generates more income (Magawata and Musa, 2015).

Fish smoking plays a pivotal role in terms of reducing post-harvest losses, employment creation, poverty alleviation, food security, income generation, and foreign exchange earnings as well as improving the fisheries sector of a country's economy (Olagbemide,

2015; Asiedu *et. al.,*2018). Asiedu *et. al.,* (2018) opined that proximate analyses reveal the various substances that are present in fish. Apart from identifying the key nutritional components of the fish, it helps an individual ascertain the quality of the fish product. The proximate composition of fish is crucial for minimizing post-harvest losses; therefore, smoking is frequently employed to address this concern. Smoking improves organoleptic characteristics, induces water loss, and reduces the microbial load of food (fish) due to heat and the presence of bactericidal and aromatic substances (Chakroborty and Chakraborty, 2017).

Various researchers (Sengor *et al*., 2004; Fagbenro *et al.,* 2005; Olokor *et al*., 2007; Abolagba and Melle, 2008; Ojutiku *et al.,* 2009, Olagbemide, 2015) have demonstrated that, smoking of fish do not only give the fish the needed taste and flavour but provide a longer shelf-life due to its antibacterial and its oxidative effects imparting coloration of the fish, decreasing pH as well as augmenting the drying process, and acting as an adversary to spoilage agents (Sengor *et al*., 2004; Olokor *et al*., 2007; Abolagba and Melle, 2008) and chemical degenerative alterations (Sowumi, 2007). Smoking helps fish to remain fresh for a long time with slight or no loss of taste, flavour, digestibility and nutritive value of the flesh. Smoked fish also provide highly nutritious protein and amino acid composition that can complement the daily human dietary requirement (Fagbenro *et al.,* 2005; Ojutiku *et al.,* 2009, Olagbemide, 2015).

Foil paper helps to evenly spread the heat, seals in moisture, and keeps the fish intact. Additionally, it enables aromatics and seasonings to enhance the flavor of grilled fish fillets. Given that foil is not permeable, it tends to retain all of the fish's fluids and fat, which are subsequently reabsorbed to seal in the flavor (Usman, 2017). Wrapping cooked meals with leaves is a very common practice in Africa and especially in Nigeria. Foods such as moi-moi, rice, porridges and many more are often cooked with leaves wrapped around it. However, it is not a common practice to smoke fish wrapped with leaves in Nigeria compared to the Caribbean where fish is smoked wrapped in leaves. Plantain and Banana leaves are often used to prepare meals from fish sources. According to the Chakroborty and Chakraborty (2017), banana leaves were used to prepare grilled fish in coconut chutney (Patrea NI Machhi). Moreover, nutritionists often use plantain leaves to preserve fish. It is also believed that leaves obtained from *Musca spp* often add flavor to the food and also impact antibacterial effects to the food (Chakroborty and Chakraborty, 2017).

African catfish (*C. gariepinus*) is one of the most important species that are cultured both in and outside its natural environments (Adewolu *et al.,* 2008). It is highly favored by fish farmers due to its rapid growth, robust resistance to diseases, and adaptability to a broad range of environmental conditions, including extreme temperatures and low oxygen levels. Catfish is mostly served in different forms such as barbeque, roasted fish, fish sauce, fish pepper soup, smoked fish, among other forms of preparation (Olaniyi *et al*., 2016). Catfish was used for this study because of its wide acceptability and availability in Nigeria as well as its high flesh quality. Hence, this study assessed the nutritional benefits and sensory characters associated with the consumption of *C. gariepinus* smoked with plantain leaf and foil paper.

Materials and Method

Collection and Preparation of Fish Sample

Twelve (12) Catfish samples (*Clarias gariepinus)*, with an average weight of 570±25g, were collected from the teaching and research Farm of Wesley University Ondo, Nigeria. The fish were weighed using a 50kg (Camry) scale. Salt was employed in ratio 1:10 (salt:fish ratio) for about one hour to kill the fish and also used to reduce the bacterial load on the skin of the fish. The fish was eviscerated, washed and covered with a muslin cloth to prevent flies from perching on it prior to smoking process, as described by Akinwumi (2014).

Experimental Smoking Materials

Plantain (*Musca domestica)* leaves used for this study were collected from the Ethnobotanical Garden of Wesley University Ondo. The plant was identified by a Botanist in the University while foil paper was purchased from a supermarket in Ondo city. The plantain leaves and foil paper were heated in a laboratory oven (Fan Azma Gostar, BM 55 Model) at 100^{o}C for 2 minutes to sterilize it before it was used to wrap the fish samples (Abolagba and Melle, 2008). The fish were packaged in triplicates and labeled as Control (CL) for the unwrapped fish, Foil paper (FP) for the fish wrapped in Foil paper, and Plantain Leaf (PL) for the fish wrapped with Plantain leaf. Threads were used to tie the plantain leaf samples so that they will not lose while in the oven. The prepared fish samples were smoked with charcoal at a temperature of 140^{o}C using a locally fabricated smoking kiln (Figure 1), following the method outlined by Magawata and Musa (2015).

Organoleptic Characteristics Method

Organoleptic characteristics analysis, as outlined by Olaniyi *et al*. (2016), employed a subjective analysis approach. Thirty members of the staff from Wesley University were recruited for the tests after screening for primary tastes, including sweet, sour, bitter, and salty. Members of the panel were selected and trained for each parameter like odour, texture, flavour, palatability and appearance aspects of organoleptic characteristics and how to allocate mark for each parameter (Adebowale *et al.,* 2008). Both genders were equally represented to avoid errors due to gender (Adebowale *et al.,* 2008). Fish products samples were

Figure 1. Frontal and External View of the Smoking kiln.

unwrapped served in clean petri-dishes alongside questionnaires to the panelists. Panelists were instructed to assess the fish by feeling and tasting it, assigning scores based on appearance, texture, aroma/flavor, taste, and acceptability/palatability. The Organoleptic characteristics were assigned numeric values on the hedonic scale of 1-5. Where 1=Poor, 2=Fairly good, 3=Averagely good, 4=Good, 5=Excellent. The questionnaires were returned and analysed for each parameter.

Proximate Analysis

The proximate analyses of the initial and smoked samples were determined as described by Association of Analytical Chemist Method, (AOAC, 2005).

Statistical Analysis

Analysis of variance (ANOVA) was used to determine significant differences among the samples at P=0.05 using Statistical Package for Social Scientists (version 20.0). Means and standard deviations were presented in table and figure.

Results

The results presented in Figure 2 demonstrate the outcomes of the organoleptic evaluation conducted on *C. gariepinus* subjected to different smoking materials. The control fish sample exhibited a statistically significant enhancement (P<0.05) in key sensory attributes, including appearance, texture, aroma/flavor, taste, and overall acceptability, compared to samples wrapped with either plantain leaf or foil paper. This heightened sensory appeal in the control group suggests the effectiveness of traditional smoking methods in preserving and enhancing the fish's organoleptic qualities.

The figure also highlights a lack of significant disparity between the organoleptic properties of fish processed with foil paper and those wrapped with plantain leaves. This observation implies a potential similarity in the impact of these two materials on the sensory characteristics of the smoked fish. The comparable organoleptic profiles of foil paper and plantain leaf-wrapped samples may be indicative of certain shared influences during the smoking process.

Additionally, it is noteworthy that the aroma/flavor of the control sample did not exhibit a statistically significant difference from that of the samples wrapped with plantain leaf. This intriguing result suggests that, despite the overall superiority of the control in various sensory aspects, there may be nuanced similarities in the aroma/flavor profile between the traditionally smoked control and plantain leaf-wrapped samples. Understanding these subtle variations in sensory attributes is crucial for discerning the nuanced impacts of different smoking materials on the final product's sensory quality.

The proximate composition of the processed fish samples is shown in Table 1. The result showed that the initial sample had the highest moisture content (59.78±1.52) followed by the foil paper (40.46±1.98) and Plantain leaf (38.35±0.39) samples respectively, while the control (smoked dried) sample had a moisture content of 19.87±0.59. Significantly (P<0.05), there was a difference observed between the moisture content of the initial and control samples. However, no significant difference was noted between the foil paper and

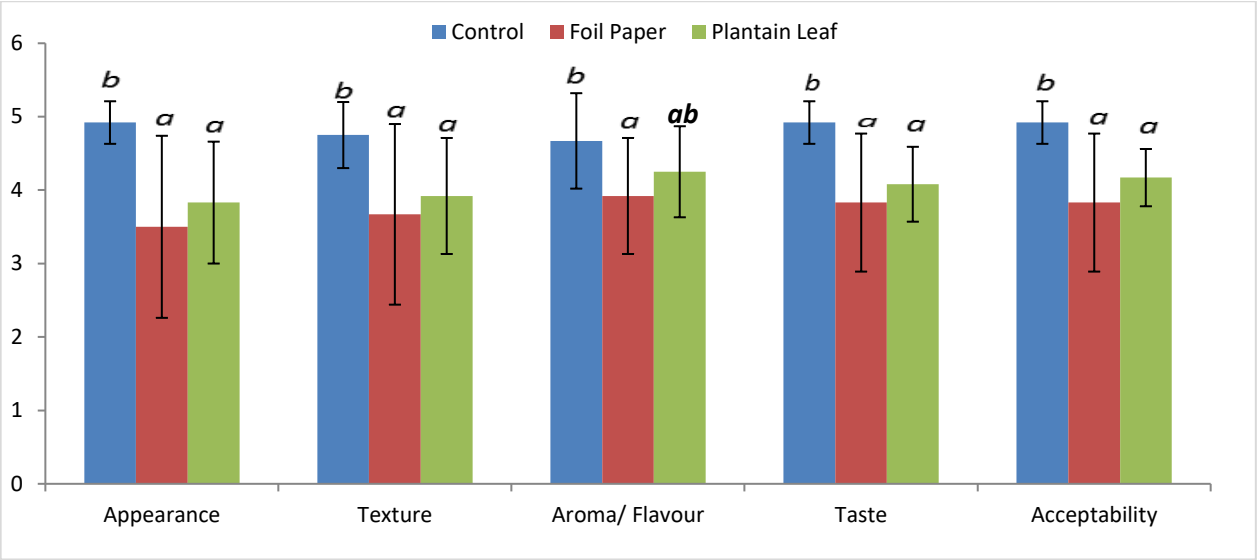

Figure 2. Organoleptic properties of *C. gariepinus* smoked with different smoking materials.

Table 1. Proximate Composition of catfish smoked with different smoking materials

Parameter	Initial (%)	Control (%)	Foil Paper (%)	Plantain Leaf (%)
Moisture	59.78±1.52^{c}	19.87±0.59^{a}	40.46±1.98^{b}	38.35±0.39^{b}
Crude Protein	17.45±1.70^{a}	59.03±0.89^{c}	38.28±1.70^{b}	40.31±0.49^{b}
Crude Lipid	10.32±0.26^{a}	12.06±0.62^{b}	10.66±0.33^{a}	10.51±0.37^{a}
Ash	11.65±0.45^{c}	7.55±1.03^{a}	9.40±0.40^{b}	9.88±0.09^{b}
Nitrogen Free Extract	1.96±0.95^{b}	0.90±0.18^{ab}	0.61±0.35^{ab}	0.37±0.18^{a}

plantain leaf samples. The highest crude protein (59.03±0.89) was observed in the control sample while the lowest crude protein was recorded for the initial sample. The table showed significant difference between the proximate composition of the initial and control samples. The result of the crude lipid recorded the highest in the control sample (12.06±0.62) and was significantly different between the other samples which ranged between 10.32-10.66. Ash content was highest in the initial sample (11.65±0.45) while the lowest was found in the control sample (7.55±1.03). There was no significant difference between the ash content of the foil paper and plantain leaf samples. Nitrogen Free Extract (NFE) showed significant difference between the initial and plantain leaf samples. The highest NFE value (1.96±0.95) was observed in the initial sample while the lowest value (0.37±0.18) for NFE was observed in the plantain leaf sam ple.

Discussion

Sensory evaluation is a crucial part in food development because it determines how consumers will react towards a product (Bouzgarrou and Sadok, 2017). It is generally assumed that consumers' primary consideration when selecting and consuming a new food commodity is the product's palatability and quality, with nutritional attributes taking a secondary role (Olaniyi *et al.,* 2016). The organoleptic properties of the control sample showed significant difference when compared with experimental fish samples. The appearance, texture, aroma/flavor, taste and acceptability of the control fish were most preferred. The texture probably may be due to relatively low water-holding capacity and low resistance to mechanical stress (compression, extrusion) when smoked, thus contributing to the tenderness, juiciness and better taste of the flesh. This was similar to the observation of Olaniyi *et al.,* (2016) when comparing the proximate composition and sensory attributes of different *Clariid* catfish species.

Taste and aroma/flavour play a significant role in food choices, appetite and nutrient intake because chemosensory signals prepare the body to digest food by triggering salivary, pancreatic, intestinal and gastric secretions (cephalic phase responses) which enable the detection and discrimination of foods in the face of fluctuating nutritional requirements. There is an association between a food's taste and aroma/flavour and its postingestive effects because taste enables the consumer to modulate food intake in anticipation of its nutritional consequences. Thus, Olaniyi *et al.,* (2016) concluded that taste and aroma/flavour indicates the nutritional value of food while they (taste and aroma) both initiate, sustain and terminate ingestion, therefore playing a major role in the volume of consumed food.

It has also been reported that aroma/flavour and appearance may be affected by the composition of fatty

acid and resultant effects of lipid oxidation (Heinz and Hautzinger 2007) while the overall palatability or acceptability is a reflection of the cognitive and qualitative sensory attributes. The result showed that the control was statistically different ($P<0.05$) from both plantain leaf and foil paper samples in the overall acceptability, with the control being widely accepted more than the experimental samples. However, the organoleptic properties of the experimental fish samples (i.e. PL and FP) were also good. This indicates that there were no deficiencies in the sensory attributes of the experimental samples.

The proximate composition of the control fish was similar to the findings of Afulenu *et al*., (2004), Osibona *et al.,* (2006), Adebowale *et al.,* (2008) and Ayofemi and Adeyeye, (2018). The moisture content of catfish is important in preserving the fish. It is a precursor of the relative content of protein, lipid and energy (Msuku and Kapute, (2018). The contrast in moisture content between the initial and control samples indicates that *Clarias gariepinus* is composed mostly of water, rendering it highly perishable. The reduction in the moisture content of the smoked samples in comparison to the initial sample is as a result of the water loss during the smoking process. The moisture content values of the initial and control samples were consistent with the findings of Magawata and Musa (2015)

However, it was higher than the findings of Olayemi *et al.* (2011) who opined that the recommended safe moisture content of smoked dried fish is between 6 – 8%. This disparity could be as a result of the extent of dryness as well as the smoking duration and type of smoking kiln used. The degree of dryness, represented by differences in moisture content, may also be attributed to factors such as genetic profile, size, feed intake, metabolic efficiency, and sex of the fish used. Smoked dried catfish is more nutritious and may have a longer shelf life or better storage qualities (than the fresh smoked fish produced in this study) due to its relatively low moisture (Ayofemi and Adeyeye, 2018).

The result showed that the crude protein increased as the moisture reduces. Also, the range of the values recorded for protein in this study agreed with the observation (33.66 – 66.04) of Adebowale *et al.,* (2008). This study also reveals that the crude protein for the initial sample was within the range of crude protein reported by Osibona *et al.,* (2006), Onyia *et al.,* (2007), Adetuyi *et al.,* (2012) and Oyedokun (2020) in their independent studies on *C. gariepinus*. The value of the crude protein content also shows the inverse relationship between the protein and moisture contents. Usman (2017) opined that the protein content of fish may be influenced by size, sexual maturation, water quality as well as feeding ration and frequency. The significantly high crude protein in the control sample makes it a better dietary protein source for human consumption than the experimental samples.

The high lipid content of the samples is an indication that there was so much fat reserve in the muscle of the fish. Onyia *et al.,* (2007) also reported that the lipid level in the fish could have been due to the impact of the feed. The result of the lipid content of catfish obtained from this study was slightly different from the report of Usman (2017) who recorded a range of 14.47 – 15.53 for smoked *C. gariepinus* in Lapai, Niger state, Nigeria. Also, there was no significant difference in the crude lipid content of all the samples except in the control because the lipid content of the samples increased as the fish dried. These similar values of the fat content in the fish samples may be because they were obtained from the same source and were subjected to the same conditions. This implied that smoking must have had an impact on the fat content of the fish as obtained in the control sample with significant difference. The ash content of the fish in this study showed a good percentage. The range of the ash content was an indication that the fish samples may be good sources of minerals such as calcium, potassium, zinc, iron and magnesium (Andrew, 2011).

Conclusion

This study has established that fresh smoked *Clarias gariepinus* is more nutritious than the fresh unsmoked ones. The study also revealed that the unwrapped (control) fish samples possessed better proximate and organoleptic properties than those wrapped with plantain leaf and foil paper even though the experimental fish samples were also of good nutritional and sensory quality. This study also revealed that smoking of fish helps to reduce the moisture content thereby increasing the shelf life as well as the nutritional values. It is therefore recommended that *C. gariepinus* should be smoked/processed unwrapped in order to achieve better sensory and nutritive properties.

Ethical Statement

No any ethical issues.

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Author Contribution

All authors are equally responsible for the general design, sample collection and writing the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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