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Effect of Smoking and Storage Conditions on the Quality and Acceptability of Smoked Catfish (*Clarias gariepinus*)

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ABSTRACT

Background: This study was carried out to investigate the effect of smoking conditions on the quality attributes and consumer acceptability of the smoked catfish (*Clarias gariepinus*).

Methods: The samples were divided into four equal portions and smoked. Sample FAD: smoked with charcoal for 2 hrs at 89°C; Sample SPA: smoked with charcoal for 2 hrs 15 min at 85°C; Sample ADF: smoked with wood for 1 hr and 30 min at 120°C; Sample PAS: smoked with wood for 1 hr 45 min at 105°C. Smoked samples were analyzed for free fatty acid (FFA), thiobarbituric acid (TBA), trimethylamine (TMA), total volatile base-Nitrogen (TVB-N) and sensory scores using standard methods.

Result: The results showed that the FFA values increased as the storage day increases from 2.67-5.40, 2.47-5.90, 2.83-5.23 and 2.7 -5.33 for ADF, FAD, PAS and SPA respectively from 0-day to 15 day. TBA values in this study were within the range of 0.01-0.19, 0.01-0.20, 0.02-0.19 and 0.01-0.19 for ADF, FAD, PAS and SPA respectively from 0-day to 15 day. TVB-N values in this study showed sample ADF reduced from 0.63-2.37, 0.67-2.23, 0.70-2.57 and 0.67-2.33 for ADF, FAD, PAS and SPA respectively from 0-day to 15 day. The sensory evaluation results also showed high sensory scores for colour, aroma, texture and overall acceptability. There was significant difference ($p>0.05$) between the samples for colour but there was no significant difference ($p<0.05$) between the samples for aroma, texture and overall acceptability. However, sample PAS was more preferred to other samples.

Key words: Acceptability, Catfish, Quality, Smoking, Storage.

INTRODUCTION

Fish is a highly nutritious food and it is particularly valued for its protein which is of high quality compared to those of meat and egg (Ojutiku *et al.,* 2009). It contains high quality protein, amino acids and absorbable dietary minerals (Bruhiyan *et al.,* 1993, Adeyeye et al., 2015b). Fish is rich in omega-3-fatty acid that is heart friendly as well as protein and minerals to reduce anemia and protein energy malnutrition (Ojutiku *et al.,* 2009, Adeyeye *et al*., 2015b). However, fish is highly perishable because it provides favourable medium for the growth of microorganisms after death (Adeyeye *et al*., 2015a; Aliya *et al.,* 2012; Oparaku and Mgbenka, 2012).

The shelf-life of smoked fish product is usually extended primarily due to the reduced water activity (Eyo, 2001). Eyo, (2001) carried out a study to ensure short time storage of dry fish that is safe from molds and bacteria infestation and found that the moisture content of the dried fish must be less than 30%. Smoked seafood products vary widely in microbial stability, but this depends on the nature and degree of severity of smoking. Heavily salted, hard smoked products have water content that is too low to support microbial growth and present little or no public health hazards (Eyo, 2001). However, the application of heat to dehydrate fish does not only remove water but excess of such heat can affect the nutritional content of the dried fish (Eyo, 2001). Studies have shown that smoking causes loss of lysine which is proportional to the temperature and duration of smoking (Eyo, 2001).

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Akinola *et al.* (2006) reported that smoking prolongs shelf life, enhances flavor and increases utilization of smoked fish in soups and sauces. According to Stone and Sidel, (2004), sensory evaluation is used in measuring those responses to product that are perceived by the sense of sight, smell, touch, taste and hearing. Researchers reported that phenol and carbonyl compounds play an important role in taste of smoked fish, such as guaiacol and syringol as phenolic compounds gave a specific organoleptic characteristic (Kjallstrand and Petersson, 2001; Oduor-Odote *et al.,* 2010; Jónsdóttir *et al.,* 2008; Martinez *et al.,* 2007 and Cardinal *et al.,* 2006). It is therefore important to ascertain effects of smoking conditions on the quality and acceptability of smoked catfish.

This study was carried out to investigate the effects of smoking and storage conditions on the quality of smoked catfish (*Clarias gariepinus*) and to determine its sensory parameters by consumer acceptability.

MATERIALS AND METHODS

Source of materials

Fresh catfish (*Clarias gariepinus*) samples used for this study were purchased from Odogunyan market, Ikorodu. Wood and charcoal as well as other materials like salt, knife, bowl (small and big sizes) were also obtained from the same market.

Methods

Preparation of samples (smoking of fish)

were smoked according to the drum smoking method described by Ahmed *et al.,* 2013 and Adeyeye, *et al.,* 2015b. The fishes were slaughtered and then gutted, washed and salted and was left for some minutes. The samples were divided into four portions. The first and second portions were smoked with charcoal for 2 h at 89°C (FAD) and 2 h 15 min at 85°C (SPA) respectively. The third and fourth portions were smoked with wood for 1 h and 30 m at 120°C (ADF) and 1 h 45 min at 105°C (PAS) respectively. The hot smoking temperature is between 80°C to 120°C (Adeyeye *et al.,* 2015b). This was done to determine the effects of smoking methods, fuel and time on the quality of smoked fish. The smoked fish samples were kept in a desiccator to cool, packaged in Ziploc bags and kept at ambient temperature for laboratory analyses.

Quality assessment analysis

The pH, FFA, TMA, TBA and TVB-N were determined by using AOAC (2000) method.

Sensory evaluation of the samples

The samples were assessed by a test panel of 20 judges. The smoked catfish samples were evaluated for taste, colour, aroma, texture and overall acceptability (Hough *et al*., 2006). Each panelist was given the smoked fish sample to taste and compare. Nine (9) point hedonic scale was used where 9 represented “like extremely”, 5 represented neither like nor dislike and 1 represented dislike extremely.

Statistical analysis

Data were analyzed using SPSS Version 21.0 for windows (IBM Corporation, New York, USA). Variability within the means was separated by Duncan’s multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$).

RESULTS AND DISCUSSION

The results of the pH, free fatty acid, thiobarbituric acid, trimethylamine, total volatile base and nitrogen are shown Table 1-Table 6. The results of the pH values are presented in Table 1. From the results, it was observed that the values of the pH value of the samples reduced as the number of day increased. pH is the most critical factors affecting microbial growth and spoilage of foods. In this study, the pH value (6.40) decreases for samples ADF, FAD, PAS and SPA from 0-day to 15 day. Similar findings were reported by Yanar, (2007), who worked on hot smoked catfish. In contrast, Kolodziejska *et al.* (2002) found that the pH levels of hot smoked mackerel slightly changed from 6.13-6.22 after 21 days of storage. The reduction in the pH after 3 days could be due to the decarboxylation of protein and the fact that carbohydrate of the fish was fermented to acids (Eyo, 1993). The values obtained in this study are indications that fish is a low acid food as documented by Adedeji and Ibrahim (2013).

The results of the free fatty acid content of the samples are shown in Table 2. The values of the free fatty acid increased as the number of days increased. Yoshida *et al.* (1992) documented that free fatty acid enhance lipid oxidation. Free fatty acid (FFA) value is the number of milligrams of potassium hydroxide required to neutralize the free acid in one gram of the sample. It was observed from the study that the values obtained at day 0 did not changed at day 3 for all the samples but increased steadily after day 3. The values in this study increase as the day increases. Similar results have been reported by Ozogul and Balikci (2013) for smoked mackerel from 2.46-7.33 after a storage period of 9 months. FFA values of 1.02 to 1.26% were reported for smoked bonga shad by Adeyeye *et al.* (2015a) which is lower when compared to the values obtained in this study.

The thiobarbituric acid (TBA) values are commonly used to measure the level of rancidity. It was found that storage affected thiobarbituric value due to oxidation of fish fat during storage (Table 3). The increased in TBA values in the smoked catfish was probably originated from the breakdown of oxidation products, mainly malonaldehyde, during smoking due to the high temperature and fat oxidation during storage period (Adeyeye 2015a, 2015b; Goktepe and Moody, 1998). The increase in thiobarbituric acid after day 3 may reduce the shelf life of the fish samples. Studies by Beltran and Moral (1991) showed that high TBA values are correlated with the degree of oxidation of fats in hot smoked sardines. The results in this study were lower when compared to the value (6.50 mgMol/100 g) reported by Adeyeye, 2016 in smoked silver catfish and Nigerian tongue sole. The values of trimethylamine are shown in (Table 4). TMA is a reduction product of trimethylamine oxide (TMAO) during spoilage and ammonia is mainly formed as a product of protein break-down. Trimethylamine (TMA) is one of the volatile amines plus ammonia which can be used as an index of spoilage (Da Silva, 2002). The values obtained in this study were within the range of 0.21-0.47 from day 0-day to 15 day. The values in this study were lower while compared to the value 5.00 mgN/100 g for doubtful quality specified U.S.F.D.A (Da Silva, *et al.,* 2008). Trimethylamine is associated with fatty substance and is responsible for the fishy smell of spoiled fish. The lower level of trimethylamine in the samples

Table 1: pH values of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	6.40±0.00^{a}	6.40±0.00^{a}	5.50±0.00^{a}	5.50±0.00^{a}	5.00±0.00^{a}	4.90±0.00^{a}
FAD	6.40±0.00^{a}	6.40±0.00^{a}	5.70±0.00^{a}	5.70±0.00^{a}	5.10±0.00^{a}	5.00±0.00 ^{a}
PAS	6.60±0.00^{a}	6.60±0.00^{a}	5.80±0.00^{a}	5.80±0.00^{a}	5.30±0.00^{a}	5.10±0.00 ^{a}
SPA	6.50±0.00^{a}	6.50±0.00^{a}	5.80±0.00^{a}	5.80±0.00^{a}	5.20±0.00^{a}	5.00±0.00 ^{a}

Mean±standard deviation with the same superscript along the column is not significantly different at (p≤0.05).

Table 2: Free fatty acid contents (%) of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	2.67±0.15^{ab}	2.67±0.15^{ab}	4.03±0.15^{a}	4.03±0.15^{a}	4.90±0.20^{a}	5.40±0.10 ^{a}
FAD	2.47±0.15^{b}	2.47±0.15^{b}	3.83±0.15^{ab}	3.83±0.15^{ab}	5.03±0.15^{a}	5.90±0.70 ^{a}
PAS	2.83±0.21^{a}	2.83±0.21^{a}	3.70±0.20^{b}	3.70±0.20^{b}	4.80±0.10^{a}	5.23±0.15 ^{a}
SPA	2.70±0.10^{ab}	2.70±0.10^{ab}	3.97±0.15^{ab}	3.97±0.15^{ab}	4.87±0.15^{a}	5.33±0.15 ^{a}

Mean±standard deviation with the same superscript along the column is not significantly different at (p≤0.05).

Table 3: Thiobarbituric acid contents (mgMol/100 g) of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	0.01±0.00^{ab}	0.01±0.00^{ab}	0.11±0.00^{c}	0.11±0.00^{c}	0.16±0.00^{b}	0.19±0.00^{ab}
FAD	0.01±0.00^{b}	0.01±0.00^{b}	0.09±0.00^{a}	0.09±0.00^{a}	0.17±0.00^{a}	0.20±0.00 ^{a}
PAS	0.02±0.00^{a}	0.02±0.00^{a}	0.10±0.00^{b}	0.10±0.00^{b}	0.17±0.00^{a}	0.19±0.00^{b}
SPA	0.01±0.00^{a}	0.01±0.00^{ab}	0.11±0.00^{c}	0.11±0.00^{c}	0.17±0.00^{a}	0.19±0.00 ^{c}

Mean±standard deviation with the same superscript along the column is not significantly different at (p≤0.05).

Table 4: Trimethylamine contents (mgN/100 g) of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	0.21±0.02^{b}	0.21±0.02^{b}	0.31±0.01^{a}	0.31±0.01^{a}	0.42±0.02^{a}	0.45±0.02^{a}
FAD	0.23±0.01^{ab}	0.23±0.01^{ab}	0.33±0.01^{a}	0.33±0.01^{a}	0.43±0.02^{a}	0.47±0.01 ^{a}
PAS	0.25±0.01^{a}	0.25±0.01^{a}	0.39±0.02^{c}	0.39±0.02^{c}	0.45±0.02^{a}	0.46±0.01^{a}
SPA	0.24±0.02^{a}	0.24±0.02^{a}	0.36±0.02^{b}	0.36±0.02^{b}	0.44±0.02^{a}	0.46±0.02^{a}

Mean±standard deviation with the same superscript along the column is not significantly different at (p≤0.05).

indicates that there was low rate of decomposition of fish protein and the fish samples are of good quality.

The values of total volatile bases-Nitrogen are shown in (Table 5). The total volatile base (TVB-N) values of all the smoked fish samples have not reached the limit of 30mg/100g (Daramola *et al.,* 2007) after 15 days of storage period and this further confirms the quality of the fishes smoked with charcoal and wood. The TVB-N values found in this study are lower than the values reported by Magawata and Musa (2015) for smoked *Clarias gariepinus*. The results of TVB-N from this study showed that the values of nitrogen contents of the catfish samples steadily reduced after 3 days of storage. Samples ADF and FAD increased from 0.63-2.37 and 0.67-2.23 while sample PAS increased from 0.70-2.57 and for sample SPA from 0.67-2.33 on the 15th day (Table 6).

The results of the sensory evaluation of smoked catfish are shown in Table 7. The taste of the smoked catfish samples showed a very good quality as far as the assessment was concerned. Highest taste mean score of 7.58 was recorded for sample PAS while the lowest score of 6.10 was obtained in sample SPA. This showed that sample PAS was more acceptable the panelists. The results of this study were higher when compared to the values of 3.68-4.88 for smoked skipjack tuna reported by Isamu *et al.* (2012). The sensory mean scores of colour of smoked catfish ranged from 5.47-6.79 with sample PAS having highest mean score while sample SPA obtained the lowest mean score. There was significant difference (p>0.05) between the samples. Similar observation was also reported by Krasemann (2006) that smoking of white fish with soft wood materials added appreciable colour to the smoked product. There was no significant difference (p<0.05) between the samples for aroma. From this study, the mean scores for aroma ranged from 6.26-6.68 which were higher than the values of 1.77-2.45 reported by Usman (2017) who worked on assessment of the nutritional quality of smoked catfish (*Clarias gariepinus*). There was significant difference in texture (p>0.05) between samples SPA and ADF but there was significant difference in texture (p<0.05) between samples SPA and PAS. The mean scores for texture in this study ranged from 5.60-6.95 and were higher when compared to

Table 5: Total volatile base-Nitrogen (mg/100g) contents of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	0.63±0.06^{a}	0.63±0.06^{a}	1.30±0.10^{a}	1.30±0.10^{a}	1.90±0.10^{b}	2.37±0.15^{ab}
FAD	0.67±0.06^{a}	0.67±0.06^{a}	1.27±0.06^{a}	1.27±0.06^{a}	1.93±0.15^{b}	2.23±0.15^{b}
PAS	0.70±0.10^{a}	0.70±0.10^{a}	1.33±0.06^{a}	1.33±0.06^{a}	2.20±0.10^{a}	2.57±0.15 ^{a}
SPA	0.67±0.12^{a}	0.67±0.12^{a}	1.37±0.15^{a}	1.37±0.15^{a}	1.93±0.15^{b}	2.33±0.15^{ab}

Mean±standard deviation with the same superscript along the column is not significantly different at ($p \leq 0.05$).

Table 6: Nitrogen contents (mg) of smoked fish over a period of 15 days.

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	6.52±0.02^{b}	6.52±0.02^{b}	6.47±0.02^{a}	6.47±0.02^{a}	6.44±0.02^{a}	6.41±0.02^{b}
FAD	6.56±0.02^{a}	6.56±0.02^{a}	6.48±0.02^{a}	6.48±0.02^{a}	6.44±0.02^{a}	6.43±0.02^{ab}
PAS	6.58±0.03^{a}	6.58±0.03^{a}	6.51±0.02^{b}	6.51±0.02^{b}	6.47±0.02^{a}	6.45±0.02^{a}
SPA	6.55±0.02^{ab}	6.55±0.02^{ab}	6.46±0.01^{a}	6.46±0.01^{a}	6.44±0.02^{a}	6.45±0.01^{a}

Mean±standard deviation with the same superscript along the column is not significantly different at ($p \leq 0.05$).

Table 7: Mean scores of sensory evaluations of smoked fish.

Sample	Taste	Colour	Aroma	Texture	Overall acceptability
ADF	6.35±1.46^{ab}	6.45±1.47^{ab}	6.45±1.54^{ab}	5.60±1.31^{bc}	7.19±1.23^{a}
FAD	6.55±1.3^{a}	5.90±1.33^{bc}	6.35±1.66^{ab}	6.00±1.49^{ab}	6.35±1.60^{ab}
PAS	7.58±1.17^{a}	6.79±1.00^{a}	6.26±1.28^{ab}	6.95±1.58^{a}	7.21±1.23^{a}
SPA	6.10±1.29^{b}	5.47±1.22^{c}	6.68±1.00^{ab}	5.89±1.52^{bc}	6.21±1.27^{b}

Mean±standard deviation with the same superscript along the column is not significantly different at ($p \leq 0.05$).

the values of 3.65-3.76 reported by Ibrahim *et al.* (2015) for smoked Nile tilapia (*Oreochromis niloticus*). Also, highest overall acceptability score of 7.21 was recorded for sample PAS while the least rating of 6.21 was recorded for sample SPA. The panelists preferred the sample PAS to the other samples. The highest score observed in sample PAS maybe due to the use of wood for smoking at high temperature at shorter time.

CONCLUSION

From the research study, it can be shown that the FFA, TBA, TMA, TVB, the nitrogen and pH contents of samples increased during the storage period. This decrease could be attributed to fat oxidation and decarboxylation of amino acid in the samples. The organoleptic test scores showed that sample PAS had highest mean scores for sensory attributes and overall acceptability except for aroma and it was the most prefer and acceptable. The initial (day 0) results of the study showed that the samples are of good and wholesome quality for human consumption, however, the quality of the samples during storage progressively declined until day 15 but smoking with charcoal for 2 hrs at 89°C produced smoked fish of better quality parameters and high consumer acceptance than other smoking methods used.

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Declaration of interest

The author declares no conflict of interest.

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