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Storage Stability of Hot Smoked Spiced African Catfish (*Clarias gariepinus*)

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Abstract

Hot Smoked Spiced Catfish (HSSC) samples prepared under optimal conditions (garlic, 7.29 g/100 ml; ginger, 7.50 g/100 ml; turmeric, 2.5 g/100 ml; soaking temperature, 38.68 °C and soaking time, 7.51 min) were stored at ambient temperature (30±2 °C) for a period of 20 days to evaluate storage stability; un-spiced hot smoked catfish served as control. Moisture Content (MC), Thiobarbutric Acid (TBA), Peroxide Value (PV), Free Fatty Acid (FFA), Total Viable Counts (TVC) and Mould Counts (MoC) were monitored at two-day intervals as a measure of the storage stability indices. Sensory attributes of the Optimized Hot Smoked Spiced Catfish (OHSSC), control (unspiced) and commercial hot-smoked catfish were determined using a preference test. The storage stability indices values for HSSC were in the range of 6.64 - 7.01% (MC), 4.50 - 13.77 mg MDA/kg (TBA), 0.20 - 2.84 mEq/kg (PV), 0.72 - 9.64% (FFA), 9.50 - 57.00 cfu/g (TVC), 8.00 - 34.50 cfu/g (MoC). The control sample values were in the range of 6.97 - 7.30% (MC), 5.51 - 14.92 mg MDA/kg (TBA), 0.23 to 2.86 mEq/kg (PV), 2.24 - 11.88% (FFA), 13.50 - 113.00 cfu/g (TVC), and 10.00 - 49.00 cfu/g(MoC). The sensory evaluation indicated that OHSSC was most preferred in all the evaluated sensory parameters. This study established the synergistic effects of garlic and turmeric on the keeping quality and sensory attributes of hot-smoked catfish with the prospect of reducing post harvest losses.

Keywords: Ambient temperature; Shelf-life; Spices; Chemical parameters; Microbial load; Sensory attributes

1 Introduction

Fish, like all food products, is composed of biological raw materials which inherently spoil and deteriorate overtime (Ahmad et al., 2021). Consequently, preservation is required unless it is consumed soon after capture; because of its susceptibility to spoilage. Various food products have different spoilage times that are referred to as shelf-life (Humaid & Jamal, 2014). Catfish is a very important freshwater fish in Nigeria. It has enjoyed wide acceptability across the country, because of its unique taste, nutrients, flavour and good texture (Adebowale et al., 2008). Catfish commonly sold in Nigeria comes in various sizes and weight ranging from small (average weight, 250- 330 g) to large (> 1.0 kg) that depend on several factors, such as feeds, age and others (Usman, 2017). In Nigeria, the shelf life of caught fish is estimated to be between 16 and 20 h in the southern part and between 20 and 36 h in the northern part at ambient temperature (Eyabi, 1996). The rate with which fish spoils depends on hygienic conditions, storage temperature, acidity and the structure of the muscular tissue (Clucas, 2006). It is estimated that post-harvest losses of

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fish accounts for more than 50% of the total fish caught in Nigeria (Tyokumbur, 2014). Hence, to ensure the availability of fish throughout the year, especially during the lean season, it is essential to process the fish to preserve it in appreciable quantities in good condition until its use is required (FAO, 2001). There are different methods of prolonging the shelf-life of fish which commonly include use of chemical preservatives, chilling, freezing, canning, drying, salting and smoking.

Smoking has long been employed for preservation and is still widely used for extending the shelf life of fish among several communities in developing countries (Adeyeye, 2016; Ward, 1995). More than 50% of fish caught in Nigerian inland waters are preserved by smoke curing (Daramola et al., 2007). Smoking favours lengthy preservation by removing moisture, which contributes to bacteriological and enzymatic spoilage. Several factors such as raw material preparation, use of additives, type and time of smoking, relative humidity, air velocity, temperature, and others have been identified as factors that affect the quality and shelf life of the smoked product (Hilderbrand, 2001; Osibona & Ezekiel, 2014). Several authors have reported various levels of success with the use of spices (garlic, ginger, turmeric, and others) on shelf-life or organoleptic properties enhancement of fish (Tiamiyu et al., 2005). In a recent study the optimum conditions (garlic, 7.29 g/100 ml, ginger, 7.50 g/100 ml, turmeric, 2.5 g/100 ml, soaking temperature, 38.68 ^{o}C and soaking time, 7.51 min) for producing hot smoked spiced catfish with improved organoleptic and nutritional status were reported (Akinbisoye et al., 2019). This present study evaluated the storage stability of the catfish produced under these optimum conditions.

2 Materials and Methods

2.1 Materials

Twenty mature catfish with weight range of 250 to 350 g were procured live from Owena market in Ondo State, Nigeria. The fish were immediately transported to the laboratory for further processing. The fish were slaughtered, beheaded and gutted, washed and kept in the freezer (-18 ^{o}C) overnight unsalted and without packaging material prior to the experiment. Smoked commercial catfish, ginger, garlic and turmeric were purchased from a local market in Ado-Ekiti, Ekiti State, Nigeria.

2.2 Methods

Preparation of the optimized hot smoked spiced catfish

The unsalted, cleaned and eviscerated whole fish were soaked in the optimized solution and optimized conditions (garlic;7.29 g/100 ml, ginger;7.50 g/100 ml, turmeric;2.5 g/100 ml, soaking temperature, 38.68 ^{o}C and soaking time, 7.51 min) as described and established in a previous publication (Akinbisoye et al., 2019). After draining of the spiced fish samples for about 5 min, both spiced and unspiced (control) fish samples were smoked in a smoking kiln. Smoking was performed at a temperature of 80 ^{o}C for 7 h (Abdel-Hamied et al., 2009). The spiced and unspiced (control) smoked fish samples were cooled before subjection to storage studies.

2.3 Storage stability studies

The unspiced (control) and optimized smoked spiced catfish were stored at ambient temperature (30 ± 2 ^{o}C) and monitored at two-day intervals for a period of 20 days to evaluate its stability. The monitored storage indices were moisture, thiobabituric acid (TBA), peroxide value and free fatty acid (FFA) content of the fish samples using the standard method of AOAC (2005). Also, total viable and mould counts in the catfish samples were determined as described by Downes and Ito (2001) and Okechalu et al. (2011), and Montville and Matthews (2005) respectively.

2.4 Sensory evaluation

The sensory evaluation was carried out on Optimised Hot Smoked Spiced Catfish, unspiced (control) smoked catfish and smoked commercial catfish samples. Sensory attributes (taste,

texture, appearance, after-taste, aroma and general acceptability) were evaluated separately according to the method of Stone and Sidel (2004). A panel of 75 semi-trained people (50% male) comprised of staff and undergraduate students of the Department of Food Science and Technology, Federal Polytechnic Ado Ekiti, Nigeria, was constituted. The assessors fell within the age group of 25-55 years. The evaluation was carried-out in a well illuminated room with cross ventilation at ambient temperature. A 9-point hedonic scale, with 9 for extremely liked down to 1 for extremely disliked, was adopted. Consumer ethical conduct was followed by explaining the whole experimental process to the panellists before the organoleptic testing. Assessors were briefed about the type of fish species, which they would taste and the sources of the fish including the mode of processing e.g. the fish samples were smoked. Each panelist therefore participated in the study with full knowledge of the process. Approval from Ethics Committee is optional for common food sensory analysis hence, approval was not sought for this exercise being a commonly consumed food in the country. Nevertheless, these analyses were carried out following international tenets and informed consents were obtained from the panellists.

2.5 Statistical analysis

All the data obtained from the experiments were analysed with the statistical programme SPSS for Windows version 20 with analysis of variance (ANOVA) for the normalized data. Means that were statistically different were separated using Duncan´s Multiple range test. The statistical significance for all the parameters was identified at 95% confidence level ($p < 0.05$). In the case of two samples comparison, t- test: paired two samples for means was used.

3 Results and Discussion

3.1 Moisture content of the stored catfish samples

The moisture content (Table 1) of the Optimised Hot Smoked Spiced Catfish (OHSSC) decreased as storage period progressed and was consistently lower than the control sample. The moisture content of OHSSC decreased from 7.01 to 6.65% while that of the control sample decreased from 7.30 to 6.98%. Significant differences ($p < 0.05$) based on the t-test analysis existed in the moisture content of the OHSSC and control sample before and during storage. The storage period was also observed to have a significant effect on the moisture content in both the spiced and unspiced (control) fish samples. The difference in the initial moisture content of the OHSSC and the control sample might be attributed to the impact of the spices in the fish (Tagoe et al., 2011). The observed moisture content is close and falls within the range of moisture content (7-9%) for smoked Clarias gariepinus as reported by Usman (2017). However, the decreasing trend observed in both the OHSSC and control sample during storage might be attributed to loss of moisture into the atmosphere. The loss of moisture into the surrounding air may be dependent on the air's humidity. It was reported that the moisture content of fish subjected to different treatments decreased after smoking from 6.95 to 4.93% (Oyelese, 2006). The moisture content (which is of great importance in storage) of both the spiced and unspiced smoked *Clarias gariepinus* was between 6 and 7% which is within the moisture content reported for dried fish (6% to 8%) (Yanar, 2007). This observation indicates that the spiced smoked fish could be preserved successfully for 20 days and beyond without spoilage thus reducing postharvest losses of the fish.

3.2 Thiobabituric acid content of the stored catfish samples

Thiobabituric acid (TBA) content is a widely used indicator for the assessment of degree of secondary lipid oxidation. It evaluates the second stage of autoxidation, during which the peroxides are oxidised to aldehydes and ketones, which impart the disagreeable fishy or rancid odours and flavour (Romero et al., 2008). The TBA values (Table 1) increased consistently in both the spiced and unspiced samples as storage days increased, however the OHSSC had

Table 1: Effect of Storage Days on the Control and Optimised Hot Smoked Catfish

Storage Period (Days)	MC (%)		PV (mEq/kg)		FFA (%)		TBA (mg MDA/kg)	
S/N	Optimised (A)	Control (B)	Optimised (A)	Control (B)	Optimised (A)	Control (B)	Optimised (A)	Control (B)
0	7.010 ± 0.000^{j}	7.300 ± 0.00^{j}	0.209 ± 0.001^{a}	0.230 ± 0.003^{a}	0.724 ± 0.000^{a}	2.248 ± 0.397^{a}	4.503 ± 0.022^{b}	5.516 ± 0.028^{a}
2	6.937 ± 0.002^{i}	7.267 ± 0.02^{i}	0.471 ± 0.004^{b}	0.489 ± 0.004^{b}	2.976 ± 0.01^{b}	5.220 ± 0.012^{b}	4.685 ± 0.017^{a}	5.682 ± 0.017^{b}
4	6.905 ± 0.002^{h}	7.235 ± 0.02^{h}	0.735 ± 0.004^{c}	0.753 ± 0.004^{c}	3.716 ± 0.012^{c}	5.961 ± 0.012^{c}	5.534 ± 0.017^{c}	6.712 ± 0.017^{c}
6	6.905 ± 0.002^{h}	7.203 ± 0.00^{g}	0.999 ± 0.004^{d}	1.017 ± 0.004^{d}	4.457 ± 0.01^{d}	6.701 ± 0.012^{d}	6.564 ± 0.017^{d}	7.742 ± 0.017^{d}
8	6.873 ± 0.002^{g}	7.171 ± 0.002^{f}	1.263 ± 0.004^{e}	1.281 ± 0.004^{e}	5.198 ± 0.012^{e}	7.442 ± 0.012^{e}	7.593 ± 0.017^{e}	8.771 ± 0.017^{e}
10	6.841 ± 0.002^{f}	7.139 ± 0.002^{e}	1.527 ± 0.004^{f}	1.545 ± 0.004^{f}	5.938 ± 0.012^{f}	8.182 ± 0.012^{f}	8.623 ± 0.017^{f}	9.801 ± 0.017^{f}
12	6.709 ± 0.002^{e}	7.107 ± 0.002^{d}	1.791 ± 0.004^{g}	1.809 ± 0.004^{g}	6.679 ± 0.01^{g}	8.923 ± 0.012^{g}	9.653 ± 0.017^{g}	10.830 ± 0.01^{g}
14	6.747 ± 0.002^{d}	7.075 ± 0.002^{c}	2.055 ± 0.004^{h}	2.073 ± 0.004^{h}	7.419 ± 0.01^{h}	9.663 ± 0.012^{h}	10.682 ± 0.01^{h}	11.860 ± 0.01^{h}
16	6.704 ± 0.002^{c}	7.035 ± 0.002^{c}	2.483 ± 0.004^{h}	2.501 ± 0.004^{h}	7.419 ± 0.01^{h}	9.663 ± 0.012^{h}	10.702 ± 0.01^{h}	11.960 ± 0.01^{h}
18	6.681 ± 0.002^{b}	7.011 ± 0.002^{b}	2.583 ± 0.004^{i}	2.601 ± 0.004^{i}	8.900 ± 0.012^{i}	11.144 ± 0.01^{i}	12.741 ± 0.017^{i}	13.919 ± 0.017^{i}
20	6.649 ± 0.002^{a}	6.979 ± 0.002^{a}	2.847 ± 0.004^{j}	2.865 ± 0.004^{j}	9.641 ± 0.012^{j}	11.885 ± 0.01^{j}	13.771 ± 0.017^{j}	14.949 ± 0.017^{j}

The t-tests conducted for the optimised and control samples for each day along each row are all significantly different ($p = 0.05$). Means with different letters along each column were significantly different at $p<0.05$. (Mean ± Std. deviation). MC: Moisture Content, PV: Peroxide Value, FFA: Free Fatty Acid, TBA: Thiobarbutric Acid

lower values of TBA compared to the control samples. The TBA values ranged from 5.51 to 14.92 mg MDA/kg in the control sample while for OHSSC, the values ranged from 4.50 to 13.77 mg MDA/kg. This observation showed that spiced and unspiced samples had the rancidity tendencies but the level was more in control samples than the spiced fish samples. The differences between the spiced and unspiced samples were significant throughout the storage period indicating the impact of the spices to minimise rancidity tendency in the catfish. These results are in line with TBA result documented for *Scomber japonicus* (Goulas & Kontominas, 2005) and *Argyrosomus regius* (Hernández et al., 2009). This observation also agrees with the findings of Famurewa et al. (2017) on storage of African catfish in freezer over a period of six weeks where increasing TBA was recorded with storage. The result indicates that spices are effective in retarding lipid oxidation. A previous report had also demonstrated that spices possess antioxidant and antimicrobial properties (Srinivasan, 2014).

3.3 Peroxide value of the stored catfish samples

The peroxide value as presented in Table 1 ranged from 0.23 to 2.87 mEq/kg for the control sample and 0.21 to 2.85 mEq/kg for the OHSSC. Similar trends as recorded for TBA were also observed for the peroxide values in both the stored spiced and unspiced samples. The values increased as the storage period increased but the values for OHSSC were generally lower than that of the control sample. The differences ($p\leq0.05$) within the spiced sample or control sample, and between the spiced and unspiced samples were significant during the storage period. The spices and storage period had impact on the peroxide value as also noted in TBA. The peroxide value is an initial evidence of rancidity development in oils and fats, it is therefore inferential that the OHSSC would have reduced rate of primary peroxidation, compared to the control sample. This result is in agreement with report by Silva et al. (2008) which showed that ginger is effective in retarding rancidity in hot smoked catfish. It also agrees with the studies of Pakawatchai et al. (2009), that spices' activities as antioxidants are directly related to their concentration.

3.4 Free fatty acid of the stored catfish samples

The free fatty acid (FFA) values (Table 1) in Optimised Hot Smoked Spiced Catfish (OHSSC) ranged from 0.72 to 9.64% and from 2.25 to 11.88% in the control sample. The notable differences within each sample (OHSSC and control)

and between the control sample and OHSSC were significant during the storage period. The control sample had higher FFA values than OHSSC. This suggests that the addition of the local spices might have inhibited FFA production. Similar increasing trend in FFA was reported for smoked catfish stored in the freezer for six weeks (Famurewa et al., 2017). FFA content in a product can be an indicator of spoilage and sensory quality of the product (Clucas, 2006). It is used also to measure the rancidity of foods. The observed trend was similar to the other indices (TBA and PV) used to evaluate the rancidity tendencies in the stored catfish. The results further established the effectiveness of garlic, ginger and turmeric as antioxidants which are able to inhibit the synthesis of free fatty acid in the OHSSC stored for 20 days under ambient temperature.

3.5 Microbiological Characteristics

The microbial status of Optimised Hot Smoked Spiced Catfish (OHSSC) during storage is presented in Table 2. The TVC values ranged from 9.50 (after two days) to 57.0 x 10^2 cfu/g (after twenty days) and from 13.50 (after two days) to 113.00 x 10^2 cfu/g (after twenty days) for OHSSC and control, respectively. The relatively lower TVC values of OHSSC may be attributed to the antibacterial activities of the spices. Kumolu-Johnson and Ndimele (2011) had earlier reported lower microbial load of Clarias gariepinus treated with ginger paste. The microbial load is within the safe limit ($<10^5$ $<10^7$ cfu/g) as reported by Frazier and Westhoff (1998) and FAO and WHO (2013). For mould count, the values were between 8.00 and 10.00 x 10^6 cfu/g (day 2); and 35.00 and 49.00 x10^6 cfu/g (day 20) for OHSSC and control, respectively. There was an increasing trend in both TVC and MoC within the two samples and between the spiced and unspiced samples with increased storage period. However, the extent of increase of TVC between spiced and the control samples was more than 7-fold. For instance, between the 2^{nd} and 4^{th} day of storage there was about 95% increase in the OHSSC while the percentage increase in the control was about 737%. Gupta and Ravishankar (2005) demonstrated the antibacterial activity of ginger, garlic and turmeric on Escherichia coli and the findings from this study also support this claim. Another study on the antibacterial activity of Allium plants including garlic has been documented (Benkeblia, 2004).

3.6 Sensory attributes of the OHSSC, Control and Commercial Smoked Catfish

The sensory attributes of the optimised smoked spiced catfish, control and commercial smoked catfish are presented in Table 3. Significant differences ($p<0.05$) existed among the three samples in almost all the parameters evaluated. From the table, it was clear that OHSSC product was the most preferred among the three samples based on their sensory scores. The mean sensory scores for aroma (7.44), texture (7.31), taste (7.51) and overall acceptability (7.47) of OHSSC were consistently higher than that of the control and commercial smoked catfish. The sensory evaluation showed over 80% preference for the optimised hot smoked spiced catfish. The higher preference for the spiced fish might be attributed to the inclusion of spices which have been demonstrated to enhance organoleptic quality of foods (Ade-Omowaye et al., 2015). This observation agrees with the findings of Kumolu-Johnson and Ndimele (2011) where panelists rated *Clarias gariepinus* treated with ginger paste better than untreated sample.

4 Conclusions

The anti-oxidative and antimicrobial properties of the garlic, ginger and turmeric spices were demonstrated on hot smoked spiced catfish with significant reduction in rancidity tendencies and total viable and mould growths during storage under ambient temperature for a period of 20 days. The low TBA and peroxide value, as well as reduced total viable and mould counts in the spiced catfish samples as compared to the unspiced sample are good indicators of the potentials of local spices in extending shelf life of catfish. Organoleptically, the general pattern of consumer preference of the products indicated that

Table 2: Microbial Load of the Control and Optimised Hot Spiced Smoked Catfish

Storage Period (Days)	TVC (× 103)		MoC (× 106)	
	Optimised (A)	Control (B)	Optimised (A)	Control (B)
0	-	-	-	-
2	0.950 ± 353.553^{a}	1.350 ± 212.132^{a}	8.000^{ab}	10.000^{a}
4	41.850 ± 70.711^{b}	11.300 ± 141.421^{b}	5.500^{a}	13.000^{a}
6	2.250 ± 212.132^{bc}	11.600 ± 144.214^{bc}	9.000^{ab}	15.500^{a}
8	2.550 ± 212.132^{cd}	12.950 ± 353.553^{bcd}	12.500^{b}	17.000^{a}
10	2.800 ± 282.843^{d}	13.200 ± 339.113^{bcd}	18.500^{c}	$18.5.000^{ab}$
12	2.950 ± 212.132^{d}	15.800 ± 565.685^{cde}	23.000^{cd}	$19.5.000^{ab}$
14	3.450 ± 353.553^{e}	16.850 ± 3323.402^{def}	25.000^{d}	28.000^{bc}
16	4.250 ± 70.711^{f}	18.250 ± 919.239^{ef}	31.000^{e}	35.000^{cd}
18	5.250 ± 353.553^{g}	19.250 ± 3464.823^{ef}	30.500^{e}	40.000^{de}
20	5.700 ± 141.421^{g}	20.350 ± 353.553^{f}	34.500^{e}	49.000^{e}

The t-tests conducted for the optimised and control samples for each day along each row are all significantly different ($p = 0.05$). Means with different letters along each column were significantly different at $p<0.05$. (Mean ± Std. deviation). TVC: Total Viable Counts and MoC: Mould Counts

Table 3: Mean Sensory Attributes of the Control and Optimised Hot Smoked Spiced Catfish

Categories	Appearance	Aroma	Texture	Taste	After taste	Overall acceptability
OHSSC	7.48 ± 0.20^{a}	7.44 ± 0.18^{a}	7.31 ± 0.21^{a}	7.51 ± 0.13^{a}	7.53 ± 0.14^{a}	7.47 ± 0.30^{a}
CSC	7.52 ± 0.13^{a}	7.35 ± 0.11^{b}	6.61 ± 0.14^{c}	5.19 ± 0.11^{c}	6.67 ± 0.23^{c}	6.97 ± 0.23^{c}
CC	7.25 ± 0.24^{b}	6.12 ± 0.13^{c}	$7.25\pm0.07\mathrm{b}^{b}$	7.25 ± 0.07^{b}	7.19 ± 0.11^{b}	7.31 ± 0.31^{b}

Means without a common superscript in a column are significantly different ($p<0.05$). (Mean ± Std. deviation). (OHSSC) - Optimised Hot Smoked Spiced Catfish; (CSC) - Control smoked catfish; (CC) Commercial smoked catfish

the optimised spiced samples were most acceptable compared to the control and commercial catfish samples.

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