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Effect of brining and spice treatment on the quality of hot-smoked catfish (*Clarias gariepinus*)

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ABSTRACT: An experiment was conducted to determine the preservative activity of brine and the effect of pepper and garlic spice mixture at 0%, 1.5%, 2.5%, 3.5% and 4.5% levels (per gram of fish) in retarding lipid oxidation and on the organoleptic quality of hot-smoked Catfish (*Clarias gariepinus*) in Kainji area. The fish samples were frozen, cut, eviscerated, cleaned and dipped in 14.5% brine for 10 minutes, (the control samples were not brined). They were treated with the spices, smoked at 80-86°C for 6 hours, cooled, stored at room temperature (25°C – 31°C) for 21 days and used for physical, chemical, microbial and sensory evaluation studies. Untreated samples served as control. From the results of analysis, samples treated with brine and a mixture of pepper and garlic paste (1:1 ratio) were microbially more stable that the control samples as these had longer shelf-life and were not visibly covered by moulds during a 21-day storage period. The preservative activity of brine and the anti-oxidant activity of pepper and garlic mixture were also evident from lower TBA and peroxide values of treated samples relative to untreated samples. Results of sensory evaluation showed a general preference for treated samples.

Keywords: Brine, spice-treatment, *Clarias gariepinus*, quality.

Introduction

Fish are a major source of food humans providing a significant portion of the protein intake in the diets of a large proportion of the people; particularly so in the developing countries. Fish are a cheap source of animal protein with little or no religious rejection of it, which gives it an advantage over port or beef (Eyo, 2001; Ligia, 2002). Fish has higher levels of essential sulphur-containing amino acids such as cysteine, methionine and lysine which are limiting in some legumes and most cereals-based diets (Borgstrom, 1962). Fish is a major source of animal protein in Nigeria.

Food quality and safety have been concerns of mankind since the dawn of history, and in recent years there has been increasing disquiet on the part of governments, food processors and consumers (WHO, 1995). Fish are a very perishable commodity, more than cattle, sheep and poultry, and get spoiled very quickly after capture, so, unless it is disposed of quickly after capture, it must be preserved in some way. In Nigeria, only a negligible proportion of the fish caught in rivers and lakes is marketed fresh. A greater portion is preserved by smoking and sun-drying (Ikeme and Bhandany, 2001). Fish smoking is mostly done at the artisanal level by women in fishing communities whose main economic activity is fish

processing and marketing. The reasons for fish smoking are varied but, in Nigeria, the process has proved relevant to:

Prolonging shelf life;
Enhancing flavour and increasing utilization in soups and sauces;
Reducing waste at times of bumper catchers;
Storing for lean season
Increasing protein availability to people throughout the year.

Smoking is the process through which volatiles from thermal combustion of wood penetrate meat or fish flesh (Simko, 1991; Ligia, 2002). Food preservatives and anti-oxidants are used to prolong the shelf life of food either by killing micro-organisms or controlling their growth in food. They also preserve by preventing retarding the oxidative deterioration of foods (Ligia, 2002). Sodium chloride controls microbial growth, it enhances the texture, it lowers water activity, strengthens gel structure and enhances colour in processed meats (Ravishankar and Juneja, 2000).

Synthetic anti-oxidants have been prohibited in many countries of the world because of their undesirable effect on the enzymes of the liver and lung (Ikeme and Bhandany, 2001). This has paved way for the extensive use of natural anti-oxidants such as spices in the prevention of rancidity in smoked fish (Watts, 1962). Spices are edible plant materials that possess anti-oxidative, antiseptic and bacteriostatic properties. They are added to foods to delay the onset of deterioration such as rancidity. They also function as seasonings to the foods as well as impart flavour to the foods (Lafont, et al., 1984).

The purpose of this study is to determine the preservative activity of sodium chloride and the effectiveness of pepper and garlic mixture in controlling oxidative rancidity, and on the organoleptic quality of hot smoked *Clarias gariepinus*. The choice of garlic and pepper is because they are often added as ingredients in many Nigeria cooked foods.

Materials and Methods

Samples collection and treatment

Fish samples (*Clarias gariepinus*) were obtained from the Hatchery Complex of the National Institute of Freshwater Fisheries Research, New Bussa. They were frozen, thawed at room temperature (26°C – 31°C) and eviscerated. Muscles of bigger fish were slit using knives according to the method of Roger et al., (1975), while smaller ones were treated directly. The fish were cleaned and dipped in 14.5% sodium chloride for 10 minutes, drained and divided into 5 batches. Fresh garlic (*Allium sativum*) and pepper were bought and the outer coat of garlic scrapped off. They were cleaned, ground properly into fine paste and applied as pepper and garlic (1:1) spice mixture at 0%, 1.5%, 2.5%, 3.5% and 4.5% levels per gram of fish. The control samples were neither treated with brine nor spice. The cleaned, brined and spiced fish samples were transferred to the smoke house, and smoked with hardwood. Initial smoking temperature was lot to prevent surface drying of the fish samples. A temperature of 80°C to 86°C was attained and this was maintained either by withdrawing or adding of wood. Samples were removed after 6 hours of smoking.

Smoked samples were cooled, packaged in bulk and separated by treatment in plastic bags and stored at ambient temperature (26°C – 31°C) for 3 weeks. Samples were subjected to visual observation, chemical and microbiological analysis and sensory evaluations.

Proximate Analysis

The fat, protein, moisture and ash contents of fresh and smoked products were determined according to (AOAC, 1995).

Water Activity Determination

Water activity of smoked catfish samples was determined using water activity meter according to Ligia (2002). The sample was taken from the thickest part of the muscle loin of the fish.

Thiobarbituric Acid Reactive Substance (TBA-RS) Determination

The oxidative stability of smoked catfish was measured by Thiobarbituric Acid-Reactive Substance (TBA-RS) according to (AOACs, 1996).

Peroxide Value

The oxidative stability of smoked catfish was also measured using titrimetric determination of the amount of peroxide and hydroperoxide groups (the initial product of lipid oxidation) according to the method of Lee (1971).

Microbiological Analysis

Mould counts were determined according to standard procedures (Speck, 1976). Visual examination of the products was carried out daily. Products with visibly mouldy mass of mycelium were removed on observation to prevent contamination of products.

Organoleptic Assessment

Subjective evaluation of product quality was carried out in accordance with Post, et al., (1991), by an experienced panel of 10. Coded samples accompanied by questionnaires were presented to the panelists. Quality attributes studied include appearance, saltiness, rancidity (off-flavour), taste, texture and general acceptability. The hedonic scale used was from 1-5, where a score of 5 was "like" extremely and a score of 1 was "dislike" extremely.

Statistical Analysis

Analysis of variance was applied to the treatment values obtained.

Results and Discussion

Shown in Table 1 is the result of proximate analysis of untreated fresh and smoked Catfish (*C. gariepinus*). Tables 2 – 7 show the effects of different concentrations of pepper and garlic spice mixtures on various quality indices of smoked catfish (*C. gariepinus*).

Table 1: Result of proximate analysis of fresh and smoked catfish (*C, gariepinus*).

	Fresh sample	**Smoked sample**
Fat (%)	1.81 ± 1.0	16.50 ± 0.8
Protein (%)	17.54 ± 0.5	58.45 ± 0.6
Ash (%)	1.20 ± 1.5	3.51 ± 0.3
Moisture (%)	79.50 ± 0.5	28.12 ± 1.2

Mean ± standard deviation.

Table 2: Effect of different concentrations of pepper and garlic spice mixture on moisture content of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Storage period	**Moisture Content (%)**				
(days)	**S_o**	**S_1**	**S_2**	**S_3**	**S_4**
1	45.50	42.40	37.30	35.50	30.90
4	40.10	37.20	34.60	33.70	27.50
7	34.50	31.10	30.70	29.60	25.40
10	28.20	25.30	25.40	23.30	21.60
13	22.30	21.30	20.80	18.80	17.80
17	16.10	16.20	15.50	14.40	13.30
21	10.20	9.90	9.10	8.60	7.90

S_o = smoked fish without spice (control); S_1 = smoked fish with 1.5% spice; S_2 = smoked fish with 2.5% spice, S_3 = smoked fish with 3.5% spice; S_4 = smoked fish with 4.5% spice.

Table 3: Effect of different concentrations of pepper and garlic spice mixture on water activity values (a_w) of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Storage period	**Water Activity (%)**				
(days)	**S_o**	**S_1**	**S_2**	**S_3**	**S_4**
1	0.90	0.88	0.88	0.86	0.85
4	0.89	0.87	0.86	0.85	0.83
7	0.87	0.85	0.85	0.85	0.81
10	0.85	0.83	0.84	0.84	0.77
13	0.84	0.81	0.80	0.76	0.74
17	0.80	0.75	0.74	0.72	0.70
21	0.87	0.74	0.72	0.71	0.67

S_o = smoked fish without spice (control); S_1 = smoked fish with 1.5% spice; S_2 = smoked fish with 2.5% spice; S_3 = smoked fish with 3.5% spice; S_4 = smoked fish with 4.5% spice.

Table 4: Effect of different concentrations of pepper and garlic spice mixture on TBA values of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Storage period (days)	TBA values (mg malonaldehyde/Kg dry wt)				
	S_o	S_1	S_2	S_3	S_4
1	0.38	0.22	0.15	0.11	0.08
3	0.41	0.35	0.29	0.25	0.19
5	0.44	0.42	0.36	0.30	0.25
7	0.47	0.49	0.39	0.37	0.29
9	0.52	0.51	0.50	0.49	0.35
11	0.57	0.58	0.56	0.52	0.38
13	0.66	0.62	0.60	0.58	0.41
15	0.72	0.68	0.65	0.61	0.46
17	0.86	0.85	0.79	0.74	0.51
19	0.95	0.90	0.85	0.82	0.59
21	1.15	1.00	0.89	0.86	0.60

S_O = smoked fish without (control); S_1 = smoked fish with 1.5% spice; S_2 = smoked fish with 2.5% spice; S_3 = smoked fish with 3.5% spice; S_4 = smoked fish with 4.5% spice.

Table 5: Effect of different concentrations of pepper and garlic spice mixture on peroxide values of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Storage period (days)	Peroxide Values				
	S_o	S_1	S_2	S_3	S_4
1	8.90	8.10	7.50	6.40	5.80
3	11.10	10.50	9.60	7.90	7.20
5	13.50	13.10	12.50	11.40	10.50
7	16.20	15.80	14.40	13.20	11.60
9	19.80	18.70	17.90	15.80	14.60
11	23.60	23.20	22.50	19.30	17.20
13	26.50	25.90	25.10	23.60	21.40
15	29.80	28.10	27.60	25.10	24.60
17	29.10	27.50	25.50	23.20	25.80
19	29.70	26.20	25.70	24.50	25.50
21	34.50	28.60	26.10	23.40	16.70

S_o = smoked fish without spice (control); S_1 = smoked fish with 1.5% spice; $S_{2\,=}$ smoked fish with 2.5% spice; S_3 = smoked fish with 3.5% spice; S_4 = smoked fish with 4.5% spice.

Table 6: Effect of different concentrations of pepper and garlic spice mixture on mould counts of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Storage period (days)	Mould count (colonies/g)				
	S_o	S_1	S_2	S_3	S_4
1	3.1×10^4	1.6×10	1.4×10^4	1.2×10^4	1.1×10^4
4	5.6×10^4	2.3×10^4	2.2×10^4	2.1×10^4	2.2×10^4
8	7.5×10^4	3.9×10^4	3.6×10^4	2.8×10^4	2.6×10^4
12	12.6×10^4	6.5×10^4	6.6×10^4	4.3×10^4	3.8×10^4
16	15.7×10^4	7.4×10^4	7.1×10^4	4.1×10^4	4.1×10^4
21	16.5×10^4	8.7×10^4	8.1×10^4	5.2×10^4	5.3×10^4

S_0 = smoked fish without spice (control); S_1 = smoked fish with 1.5% spice; S_2 = smoked fish with 2.5% spice; S_3 = smoked fish with 3.5% spice; S_4 = smoked fish with 4.5% spice.

Table 7: Taste panel rating of smoked catfish (*C. gariepinus*) during a 21-day storage period.

Treatment	Appearance	Rancidity	Saltiness	Taste	Texture	General acceptability
S_o	3.05 ± 0.5	3.03 ± 0.1	2.65 ± 0.4	3.55 ± 0.2	3.70 ± 0.3	3.01 ± 0.5
S_1	3.99 ± 0.2	40.6 ± 0.3	3.35 ± 0.2	4.10 ± 0.5	4.03 ± 0.4	4.36 ± 0.9
S_2	4.25 ± 0.4	4.05 ± 0.6	3.20 ± 0.4	4.32 ± 0.3	3.95 ± 0.1	4.65 ± 0.3
S_3	4.52 ± 0.1	4.45 ± 0.8	3.40 ± 0.3	4.48 ± 0.3	4.50 ± 0.2	4.60 ± 0.5
S_4	4.55 ± 0.1	4.54 ± 0.1	3.32 ± 0.1	4.49 ± 0.1	4.35 ± 0.3	4.85 ± 0.2

Mean ± standard deviation.

Proximate composition and water activity

The fat content of fresh sample was 1.81%. After the smoking process, the percentage of fat increased significantly due to loss of moisture and an increase in the dry matter content per unit of weight following sample dehydration. The fat content after smoking was 16.50%. The protein content of the fresh sample was 17.5%, while that of the smoked sample was 58.45%. The sharp increase in protein content from fresh to dry sample is also due to increase in dry matter content per unit of weight. This is similar to a report by Forrester (1999) who reported that the protein content of farm-raised catfish ranges from 15-20% for fresh samples and 56.19 – 67.53% after smoking. The ash content followed the same trend in which the fresh sample had a value of 1.20% and smoked sample 3.51%.

Contrary to protein, fat and ash contents, the moisture content decreased sharply after smoking from 79.50% to 28.12%. This decrease was due to loss of water during smoking (Asiedu et al., 1991).

During the 21-day storage period, a consistent decrease in moisture content and water activity was observed in all treatments (Tables 2 and 3). The untreated samples (control) recorded the lowest rate of decrease. 4.5% spiced samples recorded the highest rate of decreased followed by 3.5% spiced samples. The reduction in moisture content can be attributed to protein denaturation and consequent loss of water

holding capacity of the proteins of the fish samples. Another factor could be due to protein cross-linkage which occurs during prolonged storage which must have led to further moisture loss eventually resulting in the extended shelf-life of the smoked fish samples (Ikeme and Bhandary, 2001).

Thiobarbituric Acid (TBA) and Peroxide Value

The oxidative stability of smoked catfish was measured using TBA-RS and peroxide value during a 21-day storage period. In both cases, the samples were affected by treatment and storage period. The TBA and peroxide values of untreated samples were higher than the treated samples. All sampled showed increased TBA and peroxide values with time. It was also observed that higher concentrations of spice-treatment were more effective in retarding rancidity. Lower TBA and peroxide values were obtained in 3.5% and 4.5% spice-treated samples when compared to the control.
Similar results were obtained by Ligia, (2002), Ikeme and Bhandary, (2001) in which ginger and garlic pastes were very effective in retarding the development of rancidity in catfish. They also reported that the effectiveness of spices as antioxidants is directly related to their concentration.

Microbiological Analysis

There was a steady increase in mould count with storage period in all cases. However, brined and spice-treated samples shoed lower counts. Untreated samples were covered by mouldy mass of mycelium as from the 8^{th} day of storage. 1.5% and 2.5% spice-treated samples were equally covered by mould after 2 weeks. On the other hand, 3.5% and 4.5% spice treated samples showed no sign of mould growth throughout the 3-week storage period. The observation of visibly mouldy mass of mycelium as from the 8^{th} day of storage under ambient condition observed in the control sample indicated the effectiveness of spices as anti-fungal agents, which resulted in the extended shelf life of spice-treated samples. 3.5% and 4.5% spice treatment gave the highest extended shelf life.

Evaluation of sensory panel rating

From the result of taste panel rating of smoked catfish (*C. gariepinus*) during a 21-day storage period, the control samples received lower panel scores than the spice treated samples with regards to appearance, rancidity saltiness, taste, texture and general acceptability. The detection of rancidity in the control sample can be attributed to lipid oxidation rate, which affected general acceptability.

The taste panel ratings during a 21-day storage period showed that treated samples were rater better than untreated in all parameters studied. Samples treated with 3.5% and 4.5% spice mixture recorded highest acceptability. This is similar to the report by Ikeme and Bhandary (2001) in which 3% and 4% spice mixture were generally preferred over others. Analysis of variance showed that treatments significantly ($P<0.05$) influence appearance, rancidity, taste and general acceptability.

Conclusion

From the results of analysis, samples treated with brine and a mixture of pepper and garlic paste were microbially more table than the control samples as these had longer shelf life and were not covered by moulds during a 21-day storage period. The preservative activity of brine and the antioxidant activity of pepper and garlic mixture were evident from lower TBA and peroxide values of treated samples. Results of sensory evaluation showed a general preference for spice-treated samples.

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