Original Research Article

Sensory quality and stability of smoked mackerel Fish (*Scrombers combrus*) stored for 20 days as affected by ginger paste application.

ABSTRACT

Background and Objective: This study determined the effect of ginger paste at different concentration of 1-4 % on the stability and sensory quality of hot smoked mackerel (Scromber scombrus) fish stored at 28 ± 2°C for 20 days. **Materials and Methods:** Frozen fish samples were thawed, cut, eviscerated, cleaned and dipped in 75% brine, for 3 minutes. Cleaned and ground Ginger roots paste were applied to the fish at 0%, 1,2,3,4 % per gram of fish sample. The fish samples were then smoked at 80-85^{0}C for 5 hours, cooled and stored at room temperature (28±2^{O}C) for 20 days. Physical, chemical, microbiological and sensory evaluations of fish samples determined using standard methods and data generated were statistically analyzed. Untreated samples served as control. **Results:** The results showed that Samples treated with 4% ginger paste had the lowest TBA (0.301 mg MDA/kg), peroxide (10.4 mEq/kg) and mould count(3.0×10^{2}cfu/g) while the highest TBA (0.548 mg MDA/kg), PV(23.67 mEq/kg) and mould count (8.5×10^{2}cfu/g)occurred in the control. **Conclusion:** Results of this research indicate that samples treated with ginger were microbiologically more stable than the control samples as these had longer shelf-life and no visible mould growth, during the storage period. Lipid oxidation was drastically reduced in ginger treated samples. Sensory evaluation study revealed a general preference for ginger-treated products with samples treated with 4% ginger paste having the best acceptance.

Keywords: Sensory Quality; stability, Thiobarbituric acid. Smoked mackerel fish; Ginger Paste

1. INTRODUCTION

Fish is one of the most important food staples in the world. Fish plays a major role in food supply in West African countries where 15–20 % of all animal proteins consumed are from aquatic sources and plays a unique role in providing a range of micronutrients and essential fatty acids, especially long-chain polyunsaturated fatty acids, which cannot be easily substituted by other food commodities (1). Its flesh is a source of top quality protein especially in the less developed parts of the world such as Nigeria where it represents a

significant proportion of the animal protein in their diet, either in its fresh form or when subjected to various forms of curing (2).

Unfortunately, fish is one of the most perishable of all staple commodities and in the tropical climates of most developing countries, it undergoes spontaneous spoilage within 24 hours unless it is subjected to some form of processing (3,4). The short shelf-life of fish is due to the susceptibility to oxidation of its unsaturated fatty acids resulting in changes in flavor, texture and taste of fish and hence rejection by consumers (5).

In Nigeria the commonest Traditional methods employed in fish preservation is smoking (3,4,6). .The smoking process consist of the direct or indirect action of smoke or heat during incomplete combustion of certain tree species used as fuels (7) and it impacts long shelf life on the fish products due to water loss and reduction of the microbial load of foods due to heat, aromatic and bactericidal substances of smoke (8,9). The simplicity of this method and its relative cheapness has continued to make it the most preferred besides, the nutritional value of smoked fish is not significantly diminished by the smoking process.

Good quality smoked fish have firm texture and are slightly rigid compared with wet soft, flabby products which have not been cured properly poor are of poor quality. The following factors among others affect the quality of smoke fish, the raw materials, the pre-smoking treatments, methods of salting and/or spice application and the smoking techniques adopted (10). Traditional methods and techniques employed in smoking are often inadequate. Very primitive methods and equipment are employed with little or no consideration of maintenance of the intrinsic value of the raw material. The standards of sanitation and hygiene are extremely low.

In order to prevent or retard rancidity in fish products synthetic antioxidants have been used (11). However due to increasing health concern of such synthetic antioxidants, possibly due to their effect on liver enzymes (12), spices serve as the best alternative to synthetic antioxidants for improvement of fish quality. The ability of spice to serve as antioxidant is due to their potential as free radical scavengers which may terminate radical chain reactions and display antibacterial effects against bacterial pathogens (13). Also, spices improve flavor and have been shown to have bactericidal properties (13). Ginger species, (zinger officinale) has been widely used as an antioxidant to retard or reduce rancidity in fish and fish products (4, 14) and is an effective antimicrobial agent (15). A qualitative evaluation of smoke cured fish is essential to determine the effect of processing especially spice application on the quality of the product. It is hoped that the use of ginger spice will improved the quality and acceptability of smoked fish. This will consequently alleviate the protein malnutrition of the Nigerian populace.

Therefore, this study was carried out to investigate the effect of different concentrations (1-4 %) of freshly ground ginger paste on the quality improvement, consumer acceptability and the shelf-life extension of mackerel hot smoked at 80-85 ^{0}C for 5 hours using a smoking kiln by determination of physico-chemical, microbial and sensory quality criteria during the storage period.

2. MATERIALS AND METHOD

2.1 Study Area: The study was carried out in the Department of Food Science and Technology Laboratories. University of Nigeria, Nsukka, Enugu and Madonna University Nigeria, Akpugo Campus, Enugu from January, 2019 to August 2019.

2.2 Materials

Frozen whole mackerel fish (Scromber scombrus) was obtained from a local cold store in Nsukka market and subjected to immediate processing so as to prevent autolysis and bacterial decomposition, while ginger (Zingiber officinalae), sodium chloride (NaCl) were purchased from obtained from Nsukka market. The smoking kiln used was designed by Talabi and Igbinosun (16) at the Nigeria Institute for oceanography and marine Research, Lagos.

2.3 Methods

2.3.1 Sample preparation

Ninety (90) whole mackerel fish with weight ranging from 275 – 280 g were selected for the study. The fish were prepared by cutting it into two equal halves, longitudinally (by cutting through the head to the tail section) eviscerated, washed and brined by dipping in 75% saturated sodium chloride solution for 3 minutes and then rinsed and allowed to drain as suggested by Ikeme and Bhandary (12). After which they were separated into five batches of 36 fish each. To prepare the ginger paste, fresh ginger (Zingiber officinalae) rhizomes were properly cleaned, washed, their skin removed and ground properly into a fine paste and applied at 0 % (control-batch on which no spice was applied), 1 %, 2 %, 3 % and 4 % levels per gram of fish. Finally, the cleaned, brined and spiced fish samples were smoked using smoking kiln, at a temperature of 80 ± 5° C for 5 h, cooled and stored at ambient temperature (28 ± 2° C), for further analysis.. Each concentration level of ginger spice (1.0 % 2.0 % and 3.0 % 4.0 %) represented the treatments in a Completely Randomized Design (CRD) while 0 % served as control replicated three times.

2.3.2 Storage stability and sampling

The smoked fish samples were stored for 20 days at ambient temperature 28±2 ^{O}C and samples were taken at specified days and subjected to visual observation , sensory evaluation, chemical and microbial analysis.

3.3.2 Analysis

2.3.3 Chemical Analysis

Protein, lipid and moisture content of the fish samples were determined according to A.O.A.C. (17) procedure. Thiobarbituric acid (TBA) and peroxide values were determined, according to the method described by Nielsen (18). The water activity of the samples were determined using the water Activity mater (Model 5803) made in West Germany. A reasonable quantity of each of the fish sample were comminuted and placed in the stainless steel container of the water activity measuring instrument in such a way that it takes three quarters of the volume of the container. The container was covered tightly and allowed to stand for three hours. The water activity a_w was then read off from the scale on the upper part of the sensor and recorded. It is important to note that prior to the determination of the water activity a_w values of the fish samples, the measuring instrument was calibrated at 25 ^{0}C.

2.3.4 Microbiological Analysis

Mold counts were determined according to standard procedures of **IS 5403 (19)**. Visual examination of the products was carried out daily. Products with visible moldy mass of mycelium was removed on observation to prevent contamination of other products.

2.4 Sensory Analysis

The sensory analysis on the various fish samples were carried out at various intervals within the 20 days of storage in accordance with Ihuahi *et al*., (20). To achieve this, a ten (10) man semi-trained taste panelist were selected from the students of the Department of Food Science and Technology, University of Nigeria, Nsukka. Quality attributed evaluated include: appearance, juiciness, saltines, rancidity, flavor and general acceptability. Prior to the evaluations of the listed attributes, the fish samples were first rinsed with water for 1 minute, covered with aluminum foil, heated in an oven at 80 ^{O}C for 15 minutes, and allowed to cool at room temperature before presentation to the panelists. The panelists scored all the factors on a 5-point hedonic scale 5 represents extreme acceptability, 3 represents the border line (Neither acceptable nor unacceptable) while 1 represents extreme unacceptability.

2.5 Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) using S.P.S.S. version 16.0 computer packages. Duncan Multiple Range Test (DMRT) was then used to separate treatment means where there is a significant difference at $p \leq 0.05$

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The proximate composition of the fish samples are presented in Table 1. Data obtained revealed that there were significant ($P \leq 0.05$) difference among the samples. The moisture content ranged from 21.5-29.0 % with F_4 (sample with 4 % ginger) having the least value of 21.5 % while the control sample had the highest. The moisture content of the fish samples significantly reduced while the contents of protein, fats and ash were significantly increased with increasing concentrations of ginger treatment. The reduction in moisture content could be attributed to the drying effect of the smoking process and the low moisture content of the samples inferred a higher shelf life stability for the samples. A similar effect has been observed by Crapo *et al.*(21). The highest value of crude protein (43.10 ± 0.06) fat content (20.80 ± 0.01) and ash content (5.3 ± 0.14) were observed in smoked mackerel fish treated with 4 % ginger paste sample F_4. The increases in protein content, fat and ash could be as a result of the effect of smoking and subsequent dehydration of the fish samples during storage (22). The results of this report are similar to the values of proximate composition for smoked mackerel reported by Iheagwara (4). Fish samples used in the research could be classified as fatty fish. Fish samples with more than 5 % fat are generally regarded as fatty (12).

Table 1: Proximate composition of hot smoked mackerel treated with different concentration of ginger paste

Parameters (%)	F_0	F_1	F_2	F_3	F_4

Moisture	29.0±0.01[d]	28.9±0.05[c]	23.50±0.03[b]	23.20±0.11[b]	21.5±0.17[a]
Protein	33.44±0.07 [a]	34.38±0.21[a]	37.83±0.02[b]	42.62±0.13[c]	43.10±0.06[c]
Fat	20.0±0.03[a]	20.10±0.08 [a]	20.40±0.04[ab]	20.80±0.20[b]	20.8±0.01[b]
Ash	3.90±0.31[a]	4.00±0.17 [a]	4.90±0.29[bc]	5.10±0.11[c]	5.30±0.14[cd]

Key: Means along the rows with different superscript are significantly ($p \leq 0.05$) different. F_0=control smoked fish with 0% ginger paste;F_1=Smoked fish with 1% ginger paste per gram of fish;F_2=Smoked fish with 2% ginger paste per gram of fish; F_3 Smoked fish with 3% ginger paste /g of fish;F_4=Smoked fish with 4% ginger paste/g of fish

4.1 Thiobarbituric Acid Values (TBA)

Figure 1 shows the effect of ginger paste application on the TBA values of smoked mackerel during 20 days storage. There was a dung general increase in TBA values in all treatment. The initial TBA values ranged from 0.143 mg MDA/kg in F_4 (the fish sample treated with 4 % ginger paste) to 0.311 mg MDA/kg in F_0 (the control).After 20 days of storage at 28 ± 2° C, the TBA values ranged from 0.301 mg MDA/kg (for sample F_4) to 0.548 mg MDA/kg for F_0 (in the control), thus indicating that the TBA of the fish samples treated with 4 % of ginger paste only increased by 0.158 mg MDA/kg, while the TBA value of the control increased by 0.237 mg MDA/kg after 20 days. It can be inferred that the low initial TBA values obtained for samples treatment with 3 % and 4 % ginger paste resulted from the applications of spices and that the antioxidant effect of ginger is concentration dependent. The occasional upwards and downwards trend in TBA values for all treatments may have resulted from handling during preparation of samples. However, the results obtained are within the acceptable limits of the maximum level of TBA value, indicating good quality of the fish during storage, which is 1-2 mg MDA/kg lipid (23). Thiobarbituric acid value (TBA) evaluates second stage of autoxidation during which the peroxides are oxidized to the aldehydes and ketones which impart the disagreeable fishy or rancid odours and flavours (24).

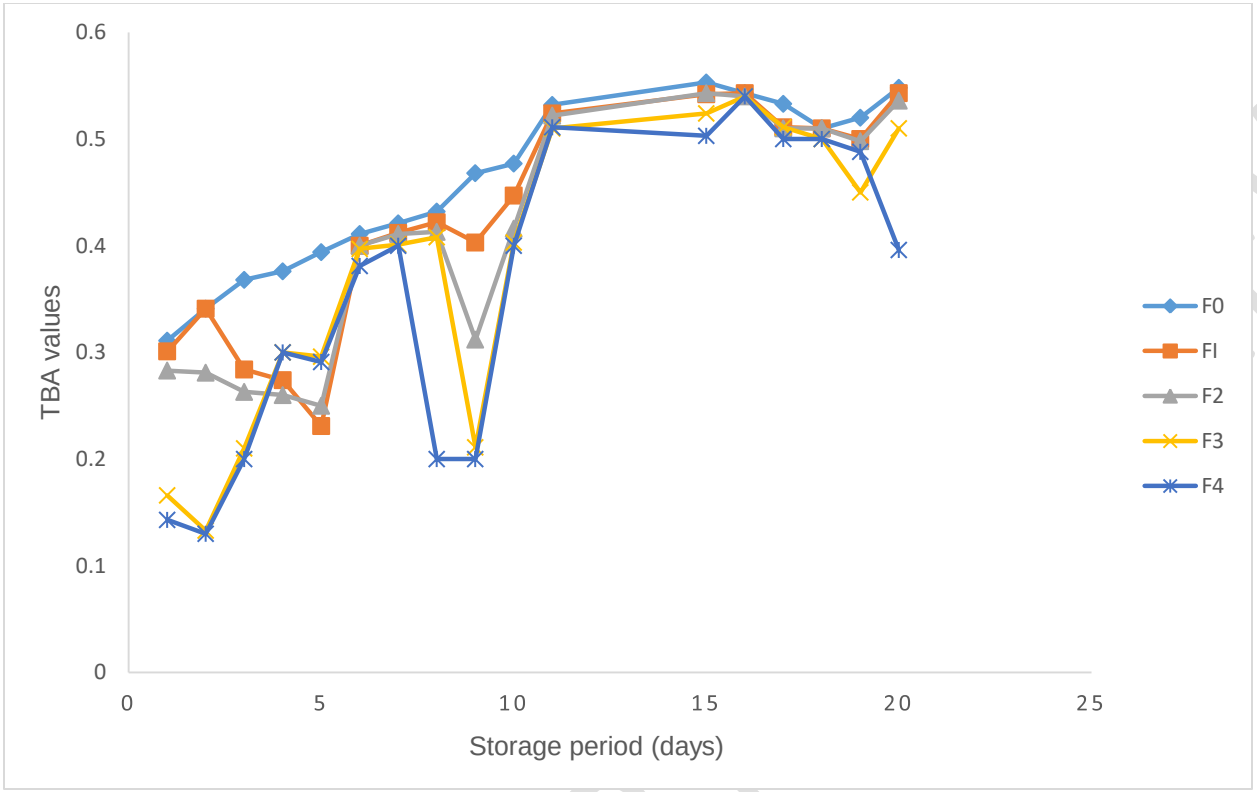

Figure 1: Effect of ginger paste application on the TBA values of smoked mackerel during 20 days storage.
F0 = Smoked fish without ginger paste; F1 = Smoked fish with 1 % ginger paste per gram of fish;
F2 = smoked fish with 2 % ginger paste per gram of fish; F3 = smoked fish with 3 % ginger paste per gram;
F4 = smoked fish with 4 %. Ginger paste per gram of fish.

4.2 Peroxide values (PV)

Peroxide values as primary products of lipid oxidation obtained during the storage period are presented in Figure 2. In all the samples there was an initial increase in PV progressively between day 10 and day 15 later a decline in values. Sample F_0 had the highest (23.67 mEq/kg) peroxide value while sample F_4 had the lowest (10.4 mEq/kg) peroxide values. Also, it was observed that the PV content decreased progressively, as the concentration of the ginger paste increases. Since peroxides are inversely related to development of rancidity, it could be inferred that sample F_4 was the most effective in slowing down primary peroxidation, when compared to other samples. It also agrees with the studies of Siripongvutikorn *et al.*, (25) that spices activities as antioxidant are directly related to their concentration. The peroxide value obtained in this report is similar to PV of 4.50 – 30.07 mEq/kg reported by Iheagwara (4) for smoked mackerel treated with ginger extract and that of Kumolu-Johnson and Ndimele (26) which showed that ginger extract is effective in retarding rancidity in smoked mackerel hot-smoked and catfish respectively.

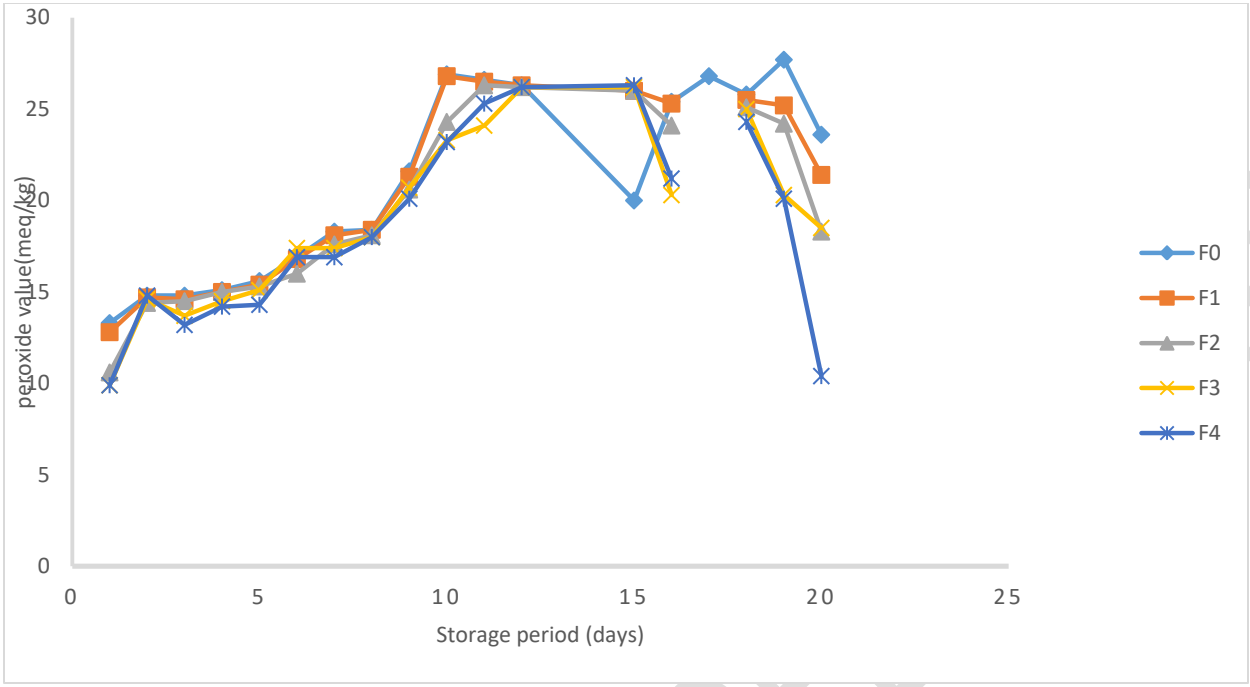

Figure 2: Effect of ginger treatment on the storage stability and peroxide value of smoked fish stored for 20 days. F0 = Smoked fish without ginger treatment; F1 = Smoked fish with 1 % ginger; F2 = smoked fish with 2 % ginger; F3 = smoked fish with 3 %; F4 = smoked fish with 4 %.

4.3 Water activity

The changes in water activity a_w level of smoked mackerel spiced with ginger paste during a 2 weeks storage period is presented in figure 3.There was a steady decrease in a_w in all the treatment samples. Samples treated with 3 % and 4 % ginger paste witnessed a faster decrease in a_w . Samples F_3 and F_4 had initial water activity of 0.87 at the beginning and final a_w of 0.76 and 0.80 respectively after 2 weeks of storage. However there was no significant difference in the water activity levels of the all the samples after 2 weeks of storage except for sample F_3.The data on a_w provides a better criteria for assessing the stability of the smoked product. Water activity is a central factor that affects food composition, stability, safety and nutritive appeal. It also evaluates in qualitative terms how much of the moisture present in food is actually available for chemical reactions, microbial growth and activity[27]. Ikeme[28] reported that moulds grow on products with a_w as low as 0.70. and at a_w of 0.80 to 0.85 spoilage by moulds occurs rapidly. However the intermittent redrying of samples used in this research with the ginger application preserved samples from microbiological spoilage and extended the shelf life for up to 20 days.

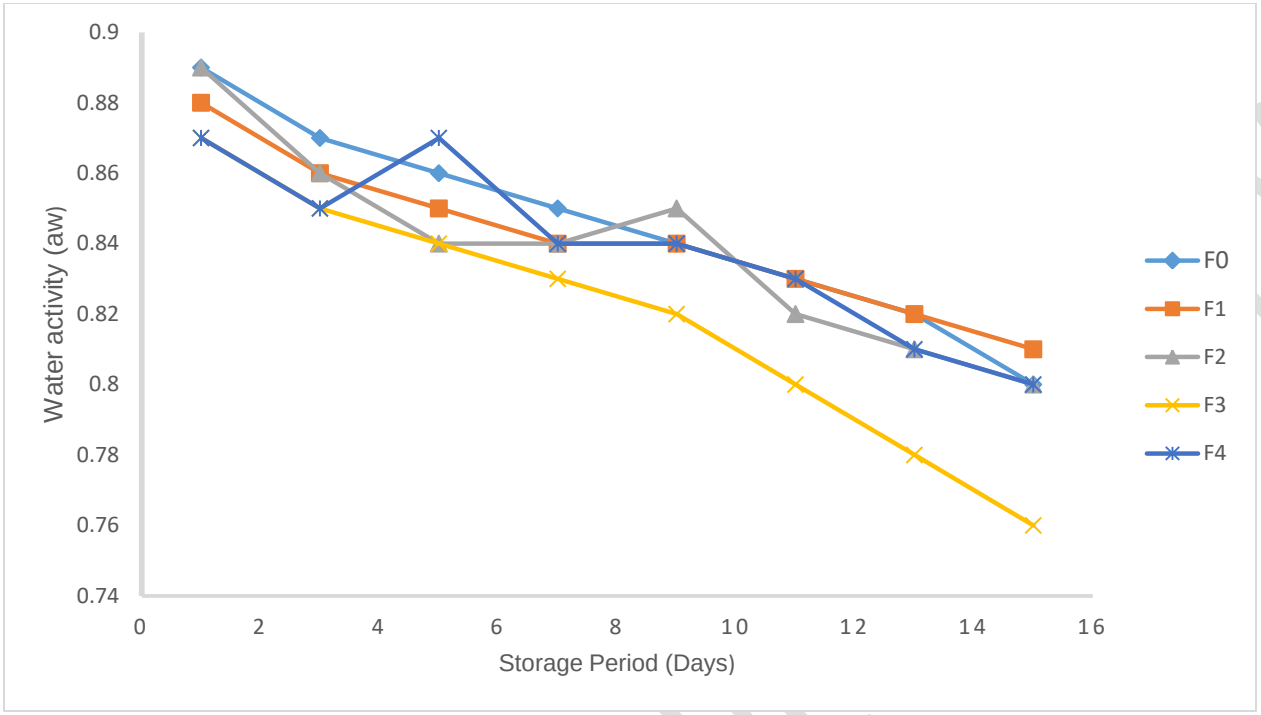

Figure 3: Changes in water activity content of ginger spiced smoked fish stored for 20 days
Key: F0= smoked fish without ginger paste; F1= smoked fish with 1% ginger paste , F2 smoked fish with 2% ginger paste F3= smoked fish with 3 % ginger paste;F4= smoked fish with 4% ginger paste

4.4 Microbiological Analysis

The effect of different concentration of ginger paste on mould count is shown in Table 2. The values of the mould count showed that there were significant variations ($P \leq 0.05$) among the samples. Samples treated with ginger paste were significantly lower than the control. After 20 days of storage, the mould count of the control sample F_0 was 8.5×10^2 cfu/g, while that of the sample treated with the highest ginger paste concentration sample F_4 (4% ginger paste) was 3.0×10^2 cfu/g. The Mould count on the various fish samples increased as storage progressed but decreases as concentration of ginger paste increases. However, there was a general decrease in mould count after 2 weeks of storage. The decrease in mold count after 2 weeks could be as a result of the subsequent decrease in water activity during the period figure (3). Organisms will not only cease to grow below their minimum water activities but death may also occur at a rate determined by the method used to lower the water activity and how far the water activity is below the minimum (27). The superiority of samples treated with 3 % and 4 % ginger paste is evident from the lower microbial count obtained from these samples. This indicates the effectiveness of the ginger paste as an antimicrobial agent, and is dependent on the concentration applied. This result agrees with the reports by Iheagwara (4); Magawata and Shina (14); Kumolu-Johnson and Ndimele (26). It also implies that ginger can compare with synthetic antimicrobial agents like potassium sorbate, citric acid and sodium metabisulphate.

Table 2: Effect of different concentration of ginger paste on mould count (c f u/ g) of smoked mackerel during storage

Period (days)	Mold count(cfu/g) F_0	F_1	F_2	F_3	F_4
1	1.5×10^3	1.2×10^3	9.0×10^2	7.5×10^2	6.5×10^2
5	1.9×10^3	1.3×10^3	1.4×10^3	1.1×10^3	8.9×10^2
10	2.1×10^3	1.3×10^3	1.5×10^3	1.3×10^3	9.3×10^2
15	2.0×10^3	1.4×10^3	1.0×10^3	4.3×10^2	4.0×10^2
20	8.5×10^2	1.0×10^3	1.0×10^2	3.2×10^2	3.0×10^2

F0 = Control Smoked fish with 0 % ginger paste; F1 = Smoked fish with 1 % ginger paste per gram of fish;
F2 = smoked fish with 2 % ginger paste per gram of fish; F3 = smoked fish with 3 % ginger paste per gram;
F4 = smoked fish with 4 %. Ginger paste per gram of fish.

4.5 Sensory Analysis

The results of sensory analysis for the smoked mackerel fish were presented in Table 2. There was significant variation ($P \leq 0.05$) in some of the tested parameters except for rancidity where there was no significant difference in panelist rating. The results of taste panel of smoked mackerel fish showed that the unspiced sample F0 received lower panel scores than the spice treated samples with regards to appearance, Juiciness, flavor, saltiness and general acceptability. Samples treated with 4 % ginger paste had the highest acceptability score. The results of this research are in agreement with the reports of Ikeme & Bhandary (12), Ihuahi *et al*. (22); Magawata and Shina (14) in which spice treated samples were generally preferred over untreated samples. When the effect of period of storage was analyzed it was found that storage periods significantly affected the panels rating for appearance and rancidity while the other attributes were not affected significantly by storage period.

Table 3: Effect of ginger application on the organoleptic quality of hot smoked mackerel fish.

Treatments	Appearance	Juiciness	Saltiness	Rancidity	flavour	Gen.acceptability
F_0	3.03 ± 0.17^{a}	2.37 ± 0.27^{a}	2.76 ± 0.21^{a}	3.77 ± 0.10^{a}	2.50 ± 0.26^{a}	2.67 ± 0.23^{a}
F_1	3.43 ± 0.20^{ab}	2.98 ± 0.29^{b}	2.99 ± 0.20^{b}	3.83 ± 0.07^{a}	3.05 ± 0.16^{b}	3.23 ± 0.18^{bc}
F_2	3.60 ± 0.12^{b}	3.17 ± 0.19^{bc}	3.08 ± 0.21^{b}	3.73 ± 0.13^{a}	3.45 ± 0.17^{c}	3.37 ± 0.23^{bc}
F_3	3.37 ± 0.22^{a}	2.39 ± 0.30^{a}	2.75 ± 0.16^{a}	3.87 ± 0.07^{a}	2.80 ± 0.26^{ab}	3.20 ± 0.26^{bc}
F_4	3.50 ± 0.19^{b}	3.30 ± 0.21^{c}	3.01 ± 0.22^{b}	3.83 ± 0.10^{a}	3.45 ± 0.32^{c}	3.40 ± 0.28^{c}

Means within columns with different superscripts are significantly different ($P \leq 0.05$). Key: F_0=control smoked fish with 0% ginger paste; F_1=Smoked fish with 1% ginger paste per gram of fish;F_2= Smoked fish with 2% ginger paste per gram of fish; F_3 Smoked fish with 3% ginger paste /g of fish;F_4= Smoked fish with 4% ginger paste/g of fish.

5. Conclusion

The results of this research indicate that samples treated with ginger were microbiologically more stable than the control sample as these had longer shelf-life and no visible mould growth, during the storage period. Lipid oxidation was drastically reduced in ginger treated samples. Sensory evaluation study revealed a general preference for ginger-treated products. All this shows that ginger paste at 4% concentration can be used to retard oxidative rancidity and inhibit mold growth hence improve the shelf life stability of smoked fish.

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