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Effect of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) on the microbial and sensorial quality of smoked mackerel fish (*Scomber scombrus*)

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Abstract
This study examined the effect of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) on the microbial and sensorial quality of smoked mackerel fish (*Scomber scombrus*). Thirty six (36) pieces of fresh frozen Mackerel fish of 1.09kg average weight were purchased, dressed, dipped in a solution of 0% garlic or ginger (T0), 10% garlic (T1), 10% Ginger (T2) and 5% garlic and 5% ginger (T3) solution for 30 min, smoked dried and stored at 28 ± 2°C over the period of 60 days. Microbiological and sensory analyses were performed on the smoked fish samples. The result revealed that the garlic and ginger treatment of the smoked preserved fish sample were found very influential. The values of the total bacterial count and mould and yeast count shows that there were significant variations ($P \leq 0.05$) among the samples. Samples treated with ginger and garlic had lower total bacterial count, yeast and mould count than the control. The organoleptic results showed that samples treated with garlic/ginger (T3) had the best acceptance than the other treatments.

Keywords: Smoked mackerel fish; Ginger, garlic, microbial, sensorial, quality

Introduction

Fish is extremely perishable compared to other muscle foods and will enter into rigor mortis where fish lose their flexibility due to the steeping of their muscle just a few hours after death. Studies show that the spoilage of fish results from three basic factors: enzymatic autolysis, oxidation, and microbial growth (Akbary *et al*. 2016) [1]. Spoilage and freshness are the two qualities that have to be clearly defined. A fresh product is defined as the one whose original characters remain unchanged. Spoilage therefore is the indicative of post-harvest change. This change may be graded as the change from absolute freshness to limits of acceptability to unacceptability. Spoilage is usually accompanied by change in physical characteristics. Change in colour, odour, texture, colour of eyes, color of gills and softness of the muscle are some of the characteristics observed in spoiled fish (Gawi and Sogbesan, 2019) [4]. Mackerel fish (Scomber scombrus) present problems during its processing and utilization due to the higher variations in its fat content and high enzymatic activity. The successful storage of raw mackerel for processing is, therefore, subject to the temperature used. Frozen storage at-18 to-30 °C could give a storage life of about 2–3 months. Storage with crushed ice (0 °C) would keep the fish fresh for about 48 hours (Froese *et al*. 2017) [3]. However, the most prominent fish preservation in northern Nigeria is smoke drying. This could be adduced to the fact that most of fish communities have no access to electricity to freeze their products. Prevailing processing technologies present critical challenges, especially in terms of safety and quality aspects, and thus there is an urgent need for the development of more efficient and safer systems (Jeya *et al*. 2014) [8]. Natural preservatives generally come from three sources: microorganisms, animals, and plants. Various bio-active compounds extracted from algae, mushrooms and so on can provide a potential source of new natural preservatives in the food industry (Adelaja *et al*. 2013) [18]. Natural preservatives guarantee that the food is free of microorganisms and safe to eat. Ideally, natural preservatives should have broad bactericidal and fungicidal activities, be non-toxic, be active at low concentrations, impart no flavor or color to food, have no pharmaceutical applications, label friendly, and finally cost effective (Mukherjee, 2020) [12]. The

use of such antimicrobial compounds inhibits the growth of spoilage and pathogenic bacteria. This improves the shelf life of the product and ensures food safety. The main component responsible for the antimicrobial activity of garlic is allicin which also provides garlic its distinct flavour and aroma. Garlic inhibits the pathogenic disease-causing organisms, increases growth performance and disease resistance in fish (Idris *et al*., 2010) [6]. The essential oil present in garlic is responsible for the antimicrobial activity. Fresh garlic and its essential oil are applied as natural antimicrobial agent, flavouring agent and antioxidant. Ginger oil inhibits Aspergillus, a fungus known for production of aflatoxin, a carcinogen and contains spectra of biologically active compounds, such as curcumin, 6-gingerol, 6-shagaols, zingiberene, bisabolene and several other types of lipids that confer on it, the properties of being pungent and a stimulant. These compounds are responsible for the unique aroma and flavor of ginger (Negbenebor *et al*., 2016) [13].

Materials and Methods

The thirty six (36) pieces of experimental fish of 1.09kg average weight were sectioned into four (4) treatments (T0, T1, T2 and T3) in triplicate. The various treatments was variously spiced (garlic paste + ginger paste, garlic paste only, ginger paste only) with a control (without garlic and ginger spices). Fish smoking of various treatments was done at a regulated temperature for 48 hours. After the smoking process, the fish were stored in a carton box for 60 days where samples were taken to the laboratory bi-monthly for microbiological analysis.

Microbiological Analysis

The bacterial load and mould counts in the smoked fish samples were determined according to the method described by Ananou *et al*., (2007) [2]. 0.1ml of each required dilution was aseptically spread and plated on potato dextrose agar using L-shapped glass rods into a labeled petri-dish in triplicate. The petri-dish was inverted and inoculated in an incubator at 35oC for 48–72 hours. Final count of the colonies form was done using colony count.

Sensory Evaluation

Organoleptic attributes of appearance, color, juiciness, rancidity, flavor/aroma, texture, consistency/viscosity, taste and overall acceptability of the fish samples were evaluated bi-weekly for 8 weeks by a 10-member in-house consumer panelist, selected from among staff of Department of Fisheries and Aquaculture, Adamawa State University, Mubi. A 9-point hedonic scale was used with 1 for like extremely, down to 9 for dislike extremely. For the evaluation, the samples were rinsed with water for 1 min, covered with aluminum foil, heated in an oven at 80°C for 30 min and allowed to cool at ambient temperature, before presentation to the panelists. Water was provided for the panelist to rinse their mouth after each bite to eliminate the taste of the previous fish sample (Iheagwara, 2013) [7].

Data Analysis

All data were collected and analyzed using simple descriptive statistical tool like frequency distribution, total and percentage which was used to determine differences between the samples attribute. Analysis of Variance (ANOVA) was carried out to determine the treatment levels of significance ($P \leq 0.05$). Means of data that was generated was represented using tabular and graphical representations.

Results

Table 1 presents the result of the microbial analysis carried out. The values obtained shows that there were significant differences ($p<0.05$) among the samples and the mould count increased as the storage duration increased. The result shows that the highest level of bacterial load was 9.5 x 106 cfu/g obtained in week 8 of the control sample and the least value of the bacterial load was 2.1 x 103 cfu/g in week 8 of Garlic treated sample. For the yeast and mould count, the highest value 8.4 x 104 cfu/g in Week 4 of the control sample and the least value of 2.7 x 103 cfu/g in week 8 of the Ginger treated sample. Consequently, the mean score result of the effect of garlic and ginger on the organoleptic quality of preserved smoked mackerel fish is shown in Table 2. There was significant variation ($P \leq 0.05$) in some of the tested parameters in panelist rating. The result shows that the control sample (T0) with no treatment of either Garlic or Ginger, received lower panel scores than the spice treated samples with regards to appearance, juiciness, flavor, rancidity, texture and general acceptability throughout the storage period. Samples treated with both garlic and ginger (T3) had the highest acceptability score. Similarly, in the freshly smoked samples (initial), the panelist found or preferred the flavor of the T3 to the control or pungent flavor of the either ginger or garlic treated smoked mackerel. When the effect of period of storage was analyzed, it was found that storage periods significantly affected the panels rating for all parameters as the mean score results continually decreasing with relation to the storage periods.

Table 1: Microbial Loads of Ginger – Garlic preserved smoked Mackerel Fish

Microorganism	Treatments	Initial	Bi-Weekly Storage			
			Week 2	Week 4	Week 6	Week 8
Total Bacterial Count (cfu/g)	T0	6.8×10^3	8.3×10^5	8.9×10^5	7.9×10^3	9.5×10^6
	T1	7.4×10^2	8.2×10^5	8.5×10^5	6.5×10^4	2.1×10^3
	T2	4.7×10^2	8.9×10^4	7.3×10^5	7.3×10^5	5.7×10^3
	T3	5.9×10^2	8.7×10^4	8.6×10^4	7.7×10^4	4.6×10^3
Moulds and Yeast (cfu/g)	T0	4.7×10^3	7.8×10^3	8.4×10^4	6.2×10^5	7.5×10^5
	T1	5.6×10^2	5.7×10^3	5.4×10^4	4.8×10^5	5.6×10^3
	T2	2.8×10^2	3.3×10^3	4.8×10^4	8.7×10^4	2.7×10^3
	T3	3.6×10^2	2.8×10^3	6.1×10^3	7.1×10^3	3.4×10^3

T0 = Control, T1 = Garlic, T2 = Ginger, T3 = Garlic and Ginger

Table 2: Effect of Garlic and Ginger on the organoleptic quality of preserved smoked mackerel fish

Storage period	Samples	Appearance/ color	Texture	Taste	Consistency/ viscosity	Juiciness	Rancidity	Flavour/ aroma	Overall acceptability
Initial	T0	8.16 ± 0.03^{a}	8.16 ± 0.03^{a}	8.18 ± 0.03^{a}	8.16 ± 0.03^{a}	8.12 ± 0.03^{a}	8.16 ± 0.03^{a}	8.10 ± 0.03^{a}	8.11 ± 0.03^{a}
	T1	8.16 ± 0.31^{a}	8.16 ± 0.31^{a}	8.03 ± 0.31^{a}	8.03 ± 0.31^{a}	8.03 ± 0.36^{a}	8.16 ± 0.33^{b}	8.03 ± 0.42^{b}	8.03 ± 0.31^{a}
	T2	8.16 ± 0.31^{a}	8.16 ± 0.31^{a}	8.23 ± 0.31^{a}	8.13 ± 0.31^{a}	8.23 ± 0.36^{a}	8.16 ± 0.33^{b}	8.13 ± 0.42^{b}	8.21 ± 0.31^{a}
	T3	8.68 ± 0.33^{b}	8.68 ± 0.33^{b}	8.68 ± 0.33^{b}	8.68 ± 0.33^{b}	8.64 ± 0.32^{b}	8.46 ± 0.34^{c}	8.61 ± 0.40^{c}	8.67 ± 0.34^{b}
Week 2	T0	7.80 ± 0.28^{a}	7.90 ± 0.28^{a}	7.90 ± 0.28^{a}	7.90 ± 0.28^{a}	7.91 ± 0.28^{a}	7.72 ± 0.24^{a}	7.98 ± 0.21^{a}	7.98 ± 0.19^{a}
	T1	8.07 ± 0.25^{b}	8.15 ± 0.25^{b}	8.17 ± 0.25^{b}	8.07 ± 0.25^{b}	8.07 ± 0.30^{b}	8.15 ± 0.28^{b}	8.07 ± 0.38^{b}	8.08 ± 0.20^{b}
	T2	8.06 ± 0.21^{c}	8.06 ± 0.21^{c}	8.06 ± 0.21^{c}	8.06 ± 0.21^{c}	8.28 ± 0.19^{c}	8.19 ± 0.24^{c}	8.14 ± 0.31^{c}	8.15 ± 0.22^{c}
	T3	8.47 ± 0.30^{d}	8.47 ± 0.30^{d}	8.57 ± 0.30^{d}	8.37 ± 0.30^{d}	8.47 ± 0.21^{d}	8.48 ± 0.30^{d}	8.53 ± 0.36^{d}	8.43 ± 0.26^{d}
Week 4	T0	4.78 ± 0.13^{a}	5.24 ± 0.13^{a}	4.65 ± 0.13^{a}	5.08 ± 0.13^{a}	4.10 ± 0.15^{a}	5.06 ± 0.03^{a}	4.22 ± 0.13^{a}	4.95 ± 0.17^{a}
	T1	6.01 ± 0.21^{b}	6.41 ± 0.21^{b}	5.71 ± 0.21^{b}	6.01 ± 0.21^{b}	5.01 ± 0.11^{b}	5.18 ± 0.17^{b}	5.12 ± 0.18^{b}	5.78 ± 0.19^{b}
	T2	5.63 ± 0.18^{c}	6.23 ± 0.18^{c}	6.60 ± 0.18^{c}	6.63 ± 0.18^{c}	5.35 ± 0.20^{c}	5.26 ± 0.21^{c}	5.63 ± 0.21^{c}	5.88 ± 0.18^{c}
	T3	5.56 ± 0.28^{d}	6.76 ± 0.28^{d}	7.06 ± 0.28^{d}	6.26 ± 0.28^{d}	5.68 ± 0.28^{d}	5.81 ± 0.23^{d}	6.98 ± 0.24^{d}	6.63 ± 0.21^{d}
Week 6	T0	4.26 ± 0.32^{a}	4.26 ± 0.32^{a}	3.26 ± 0.32^{a}	5.06 ± 0.32^{a}	3.03 ± 0.19^{a}	4.48 ± 0.25^{a}	3.09 ± 0.30^{a}	3.53 ± 0.29^{a}
	T1	5.69 ± 0.28^{a}	5.69 ± 0.28^{a}	5.69 ± 0.28^{a}	5.69 ± 0.28^{a}	4.46 ± 0.28^{a}	4.01 ± 0.28^{a}	4.43 ± 0.32^{a}	5.36 ± 0.26^{a}
	T2	4.63 ± 0.18^{b}	4.63 ± 0.18^{b}	4.63 ± 0.18^{b}	4.63 ± 0.18^{b}	4.35 ± 0.20^{b}	4.26 ± 0.21^{b}	4.63 ± 0.21^{b}	5.18 ± 0.18^{b}
	T3	5.43 ± 0.18^{c}	4.77 ± 0.18^{c}	6.63 ± 0.18^{c}	4.63 ± 0.18^{c}	4.35 ± 0.20^{c}	4.62 ± 0.21^{c}	5.13 ± 0.21^{c}	5.88 ± 0.18^{c}
Week 8	T0	2.26 ± 0.32^{a}	2.20 ± 0.32^{a}	1.03 ± 0.19^{a}	4.26 ± 0.32^{a}	2.03 ± 0.19^{a}	2.80 ± 0.28^{a}	3.90 ± 0.28^{a}	2.90 ± 0.28^{a}
	T1	4.09 ± 0.28^{b}	3.90 ± 0.28^{b}	3.46 ± 0.28^{b}	5.69 ± 0.28^{a}	3.46 ± 0.28^{a}	3.07 ± 0.25^{a}	4.15 ± 0.25^{a}	3.97 ± 0.25^{b}
	T2	3.22 ± 0.18^{b}	4.27 ± 0.18^{b}	4.35 ± 0.20^{b}	4.63 ± 0.18^{b}	3.35 ± 0.20^{b}	3.06 ± 0.21^{a}	4.06 ± 0.21^{a}	3.46 ± 0.21^{c}
	T3	4.00 ± 0.18^{c}	3.63 ± 0.18^{c}	5.95 ± 0.20^{c}	5.43 ± 0.18^{c}	3.51 ± 0.20^{c}	4.47 ± 0.30^{a}	5.11 ± 0.30^{b}	4.57 ± 0.30^{d}

Discussion

The Microbial loads of the smoked mackerel (Scomber scombrus) fish during the 8 weeks storage is shown in Table 1. The values of the total bacterial count, mould and yeast count shows that there were significant variations (P≤0.05) among the samples. However, samples treated with ginger and garlic solution were significantly lower than the control. After 8 weeks of storage, the mould count of the control sample is 7.5 x 105 cfu/g, while that of the sample treated with the Ginger solution was 2.7×103 cfu/g followed by the sample treated with the garlic/ginger treatment with 3.4 x 103. Likewise, the total bacterial count of the control sample is 9.5 x 106 cfu/g, while that of the sample treated with the Garlic solution was 2.1×103 cfu/g followed by the sample treated with the garlic/ginger treatment with 4.6 x 103. This indicates the effectiveness of the garlic and ginger as an antimycotic agent. This result agrees with report by Kumolu-Johnson and Ndimele (2011) [10], Sallem *et al.* (2004) [19], Idris *et al.* (2010) [6] and Tagoe *et al.* (2011) [17]. Also, in consonance with storage duration, samples stored at initial (freshly smoked) had the least bacterial and mould count, and were grossly more acceptable than those stored for 8 weeks. However, samples treated with ginger and garlic showed low detectable mould growth after 8 weeks of storage, thus indicating that ginger and garlic as a natural spice have antimycotic properties that can compare with synthetic antimicrobial agents, like potassium sorbate, citric acid and sodium metabisulphate (Omojowo *et al.*, 2008, Omojowo *et al.*, 2009) [19, 13]. This result shows that the treatment of ginger had the higher antifungal effects. This result agrees with earlier results of (Negbenebor, et.al. 2016) [13] where clove and ginger individually and in combination reduced the fungal loads of smoked fish. Mould rather than bacterial growth is the major problem in this type of product because of its low water activity (Negbenebor *et al.*, 2016) [13]. The ability of the ginger and garlic to inhibit mould growth would in a way enhance the over-all quality of the product.

The sensory properties of food products have an impact on consumer appreciation and acceptability of food (Hegazy *et al.*, 2021) [5]. Organoleptic evaluation of food products to any food processing technology is very important in determining the consumer acceptability (Mohamed *et al*, 2019) [11]. The results of sensorial analysis for the smoked mackerel fish were presented in Table 2. The taste panel rating for the ginger/garlic treated smoked fish (T3) was found to be better than the other treatments in most of the parameters evaluated with an overall acceptance rate of 8.67 ± 0.34b and 4.57 ± 0.30d both at the initial and at the end of the storage period (week 8) respectively followed by T2 and T1. However, the lowest score both prior and after storage was recorded in the control sample (T0) with an overall acceptability mean score of 8.11 ± 0.03a and 2.90±0.28a respectively. This reveals that the panelist found or preferred the treated samples in terms of appearance, taste and flavor, aroma, texture and mouth feel, consistency and viscosity, and overall acceptability to that of the control sample of the smoked mackerel fish. This is in agreement with the result obtained by Sallam *et al.* (2014) [16] in which they examined the effects of garlic in chicken sausage for 21 days. Also, it conforms to the reports of Kumolu-Johnson and Ndimele (2011) [10] and Idris *et al.* (2010) [6] in their study on the antioxidative and antifungal effects of fresh garlic on the shelf life of hot smoked catfish. Generally, evaluation of sensory attributes of smoked Mackerel fish during the 8 weeks of storage depicted that smoked fish samples treated with both garlic and ginger T3 were of better quality. Besides, ginger/garlic smoked fish have higher mean scores in all the attributes than other smoked treated fish products or the control sample.

Conclusion

The present work has demonstrated that garlic (Allium sativum) and ginger (Zingiber officinale) has antioxidative and antimicrobial properties that can retard oxidative rancidity and inhibit mould growth, thus, extending the shelf life of the smoked mackerel fish under ambient storage conditions. This is justified by the low microbial load on the treated fish sample of the garlic and ginger treated samples compared to the untreated sample (T0). Organoleptically, the general pattern of consumer preference to the fish samples indicates that the garlic/ginger treated samples were

most acceptable than the other samples. This research however provides an alternative for consumers to find increased satisfaction with the processed fish as indicated by the sensory quality of the product. This would substantially improve fish protein intake in Nigeria and reduce protein malnutrition and its associated problems in the country.

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