Journal of Nutrition & Food Sciences
ISSN: 2155-9600

Iheagwara, J Nutr Food Sci 2013, 3:3
DOI: 10.4172/2155-9600.1000199

Research Article Open Access

Effect of Ginger Extract on Stability and Sensorial Quality of Smoked Mackerel (*Scomber scombrus*) Fish

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Abstract

The effect of ginger extract on the stability and sensorial quality of smoked mackerel fish stored at 28 ± 2°C was determined over 20 days. Chemical, microbiological and sensory analyses were performed to investigate quality changes, and to determine the shelf stability of the products. The proximate, thiobarbituric acid (TBA) value, peroxide value (PV), mould count, and trimethylamine (TMA) were found statistically significant (P ≤ 0.05), in the smoked mackerel fish throughout storage. Protein, fat and ash contents of the ginger extract treated samples had marked % increase compared to the control. The lowest TBA (0.08 mg MDA/kg), peroxide (4.50 mEq/kg) and TMA (3.46 mg N/100 g) values were recorded in 5% ginger extract treated samples, while the highest TBA (1.45 mg MDA/kg), PV(30.07 mEq/kg) and TMA (15.52 mg N/100 g) occurred in the control. The result also revealed that samples treated with ginger extract had lower mould count than the control. The organoleptic results showed that samples treated with 5% ginger extract had the best acceptance, and were significantly different (P ≤ 0.05), when compared to the control after 10 days of storage.

Keywords: Smoked mackerel fish; Ginger; Stability; Quality; Lipid oxidation; Thiobarbituric acid; Peroxide; Storage

Introduction

Fish constitutes a very important component of diet for many people, and often provides much needed nutrients for a healthy living. Fish serves as a principal source of dietary protein, which is very inexpensive in relation to other protein foods [1]. It is the characteristics of fish as a cheap source of animal protein, which is now evident throughout the world that makes it an excellent component of human diet. Fish protein now takes precedence over other protein of animal origin, and compares favorably with that of milk, egg and meat in its amino acid composition. It is this quality that makes fish protein to be practically indispensable to developing countries, such as Nigeria, for diet supplementation, where the staple diet or food consist primarily of starchy foods [2]. Besides, fish is known to contain a very high quality of fats and oil, and fish fat is very high in polyunsaturated fatty acids, which are very important in lowering blood cholesterol level. The fish oil, on the other hand, contains the fat soluble vitamins. Fish is also a very good source of thiamine and riboflavin, and contains minerals, phosphatids sterols, enzymes, hormones, hydrocarbons and pigments [3,4]. However, fish is an extremely perishable food commodity, and hence, is subject to post harvest losses ranging from bacterial and autolytic spoilage to other factors. These causes cause fish to lose its organoleptic qualities, and generally unacceptable for human consumption. It is this perishability of fish that makes it to be processed into fish based products, such as smoked and canned fish, fish cake, fish meal, fish burger, etc. [5]. Fish smoking is one of the traditional methods of preservation of fish in Africa. Smoke curing, as applied to fish, is a method of preservation effected by combination of drying and the deposition of naturally produced chemicals, resulting from the thermal breakdown of wood [6]. Dried fish spoilage has been characterized by reddening, browning, or other discoloration mould attack, and development of rancidity. The use of synthetic antioxidant has been very effective in controlling rancidity. However, synthetic antioxidants have frequently been associated with certain health problems [7]. This has necessitated the use of natural antioxidants, such as spices, in the prevention of rancidity in smoked fish [8,9]. Spices (ginger, onion, garlic, etc.) are edible plant materials that possess anti-oxidant, antiseptic and bateriostatic properties. They are added to foods to delay onset of deterioration, such as rancidity, and also function as seasonings to foods as well as impart flavor to the foods [10]. Ginger as a spice has a geographical spread that covers every part of the globe and it is consumed whole as a delicacy, used in traditional oriental medicine, or as spice in foods, such as fish [11-13]. Ginger 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 flavour of ginger, and account for about 1-3% of the weight of fresh ginger [13]. This present study is designed to investigate the effect of ginger extract in improving the stability and organoleptic quality of smoked mackerel fish.

Materials and Methods

Materials

The raw whole mackerel fish (*Scomber scombrus*) used for the study was bought from a cold store in Owerri market, and identified at the Department of Fisheries and Aquacultural Technology, Federal University of Technology, Owerri. The spice used is extract from ginger (*Zingiber officinalae*) rhizomes. All chemicals used were of analytical grade.

Generation of samples

One hundred and eighty (180) fish samples with weight ranging from 220-250 g were selected for the study. Each of the raw whole

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Received March 10, 2013; **Accepted** March 18, 2013; **Published** March 20, 2013

Citation: Iheagwara MC (2013) Effect of Ginger Extract on Stability and Sensorial Quality of Smoked Mackerel (*Scomber scombrus*) Fish. J Nutr Food Sci 3: 199. doi:10.4172/2155-9600.1000199

mackerel fish were cut into two equal halves, longitudinally, by cutting through the head to the tail section, eviscerated, washed, brined by dipping in 10% saturated sodium chloride solution, at a contact time of 5 min, and then rinsed and allowed to drain. Subsequently, they were separated into six batches of 30 fish each. To prepare the spice extract, fresh ginger (*Zingiber officinalae*) rhizomes were properly cleaned, washed, their skin removed and ground. One hundred grams (100 g) of the ground spice was weighed into a round bottom flask and 1500 ml distilled water added. The mixture was heated to boil, refluxed for 10 min, hot filtered and the filtrate cooled to room temperature, and used to soak the different batches of the fish samples at concentration of 0.0% (control), 1.0%, 2.0%, 3.0%, 4.0% and 5.0%, respectively. 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.

Storage stability and sampling

The smoked fish samples were stored for 20 days at ambient temperature and samples were drawn at specified days, and subjected to organoleptic evaluation, microbial and chemical analysis.

Chemical analysis

The samples used for the analysis were assayed in duplicate. The moisture, protein, fat and ash content of the fish samples were determined using the standard methods of AOAC [14]. TBA and peroxide values were determined, according to the method described by Nielsen [15]. Trimethylamine (TMA) was determined according to the method reported by Unlusayin et al. [16].

Microbial analysis

The mould counts in the smoked fish samples were determined, according to the method described by Fawole and Oso [17].

Sensory quality assessment

Organoleptic attributes of appearance, juiciness, saltiness, rancidity, flavour and general acceptability of the fish samples were evaluated by a 10-member in-house consumer panelist, selected from among students and staff of Department of Food Science and Technology of the University. A 9-point hedonic scale was used with 9 for like extremely, down to 1 for dislike extremely [18]. 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.

Statistical analysis

All the analysis was carried out in triplicates, and data obtained were analyzed using the analysis of variance (ANOVA) method. Where the variance ratio (F-values) proved significant, Fishers least significant difference (LSD) was used to separate the means.

Ginger extract Conc. (%)	Protein (%)	Fat (%)	Ash (%)	Moisture (%)
0	29.50 ± 0.28^a	23.87 ± 0.2^a	4.25 ± 0.18^a	27.02 ± 0.37^a
1	29.89 ± 0.24^a	25.82 ± 0.43^b	4.37 ± 0.11^b	26.79 ± 0.33^a
2	30.08 ± 0.36^b	28.30 ± 0.45^c	4.42 ± 0.16^c	24.94 ± 0.33^b
3	31.51 ± 0.62^c	30.55 ± 0.51^d	4.50 ± 0.18^d	22.35 ± 0.35^c
4	31.84 ± 0.31^c	32.04 ± 0.48^e	4.62 ± 0.21^e	22.10 ± 0.42^c
5	32.03 ± 0.25^d	33.10 ± 0.52^f	4.74 ± 0.30^f	20.09 ± 0.64^d

Means within columns with different superscripts are significantly different (P ≤ 0.05).

Table 1: Proximate composition of smoked mackerel fish.

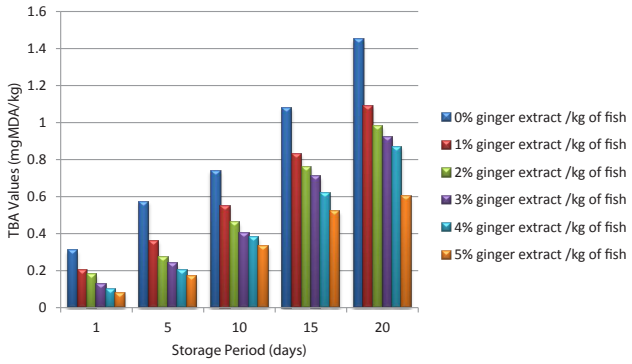

Figure 1: Effect of ginger extract concentrations and storage duration on TBA values of smoked mackerel fish.

Results

Proximate composition

Table 1 presents the effect of ginger extract concentrations on the proximate composition of the smoked mackerel fish. Results obtained reveals that there were significant variations (P ≤ 0.05) among the samples. Moisture content (g/100 g) of the samples significantly decreased, but the contents of protein, fat and ash were significantly increased. Decrease of moisture content and relative increase of protein, fats and ash contents due to reduction of moisture were the most prominent changes after smoking, and this low moisture content indicates that the dried smoked mackerel fish have the tendency to be very stable. This observation is in agreement with the findings of Rowland et al. [19] and Crapo et al. [20]. The highest value of crude protein (32.03 ± 0.25%), fat content (33.10 ± 0.52%) and ash content (4.74 ± 0.20%) were recorded in smoked mackerel fish treated with 5% ginger extract. The high ash content obtained could be tied to the mineral content of the ginger extract applied, and this is in agreement with the findings of Turan and Sonmez [21], while that of protein and fat could be due to smoking and subsequent dehydration of the fish samples during storage [22].

Thiobarbituric Acid (TBA)

TBA 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 oxidized to aldehyde and ketones, which impart the disagreeable fishy or rancid odours and flavour [23,24]. The effect of different concentrations of ginger extract on thiobarbutric acid values of smoked fish mackerel fish stored at ambient temperature (28 ± 2°C) for 20 days is shown in figure 1. The TBA values increased in all the samples over time, particularly in the control sample. The initial TBA values ranged from 0.08 mgMDA/kg in the fish sample treated with 5% ginger extract to 0.31 mgMDA/kg in the control. After 20 days of storage at 28 ± 2°C, the TBA values ranged from 0.60 mg MDA/kg in the fish sample treated with 5% ginger extract to 1.45 mg MDA/kg in the control, thus indicating that the TBA of the fish samples treated with 5% of ginger extract only increased by 0.52 mg MDA/kg, while the TBA value of the control increased by 1.14 mg MDA/kg after 20 days. This result indicates that ginger extract is effective in retarding lipid oxidation, and is in agreement with reports by Kumolu-Johnson and Ndimele [25]. 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 [26].

Peroxide Value (PV)

The changes of peroxide value as primary products of lipid oxidation are shown in figure 2. The PV content significantly increased ($P \leq 0.05$) in all the treatments during the 20 days storage, and there were significant differences ($P \leq 0.05$) among the samples. The highest value (30.07 mEq/kg) of peroxide was recorded for the control, while the lowest value (4.50 mEq/kg) was observed in the sample treated with 5% ginger extract. Also, it was observed that the PV content decreased progressively, as the concentration of the ginger extract increases. Since peroxides are inversely related to development of rancidity, it is inferential that the sample with the highest concentration (5%) of ginger extract was the most effective in slowing down primary peroxidation, when compared to other samples. This result is in agreement with report by Kumolu-Johnson and Ndimele [25], which showed that ginger extract is effective in retarding rancidity in hot-smoked catfish. It also agrees with the studies of Siripongvutikorn et al. [7], that spices activities as antioxidant are directly related to their concentration.

Mould count

The mould count of the smoked mackerel (*Scomber scombrus*) fish during the 20 days storage is shown in figure 3. The values of the mould count shows that there were significant variations ($P \leq 0.05$) among the samples. However, samples treated with ginger extract were significantly lower than the control. After 20 days of storage, the mould count of

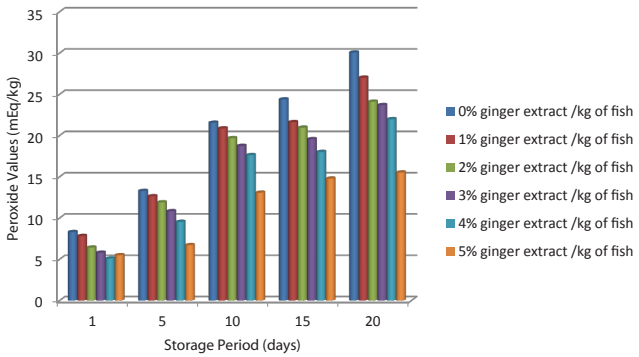

Figure 2: Effect of ginger extract concentrations and storage duration on peroxide value of smoked mackerel fish.

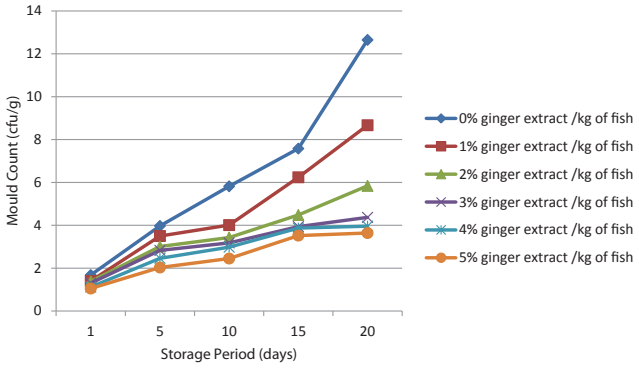

Figure 3: Effect of ginger extract concentrations and storage duration on mould count of smoked mackerel fish.

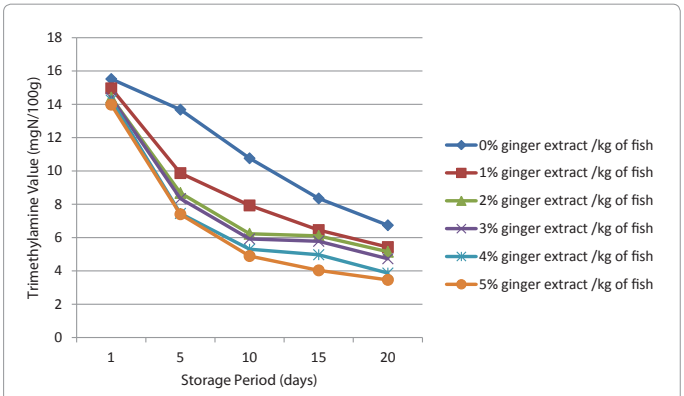

Figure 4: Effect of ginger extract concentrations and storage duration on trimethylamine value of smoked mackerel fish.

the control sample is 12.65×10^4 cfu/g, while that of the sample treated with the highest ginger extract concentration (5% ginger extract) was 3.64×10^4 cfu/g. This indicates the effectiveness of the ginger extract as an antimycotic agent, and is dependent on the concentration applied. This result agrees with report by Kumolu-Johnson and Ndimele [25], Sallem et al. [27], Idris et al. [2] and Tagoe et al. [28]. Also, in consonance with storage duration, samples stored one day had the least mould count, and were grossly more acceptable than those stored for 20 days. However, samples treated with ginger extract showed no detectable mould growth after 20 days of storage, thus indicating that ginger extract as a natural spice have antimycotic properties that can compare with synthetic antimicrobial agents, like potassium sorbate, citric acid and sodium metabisulphate [29,30].

Trimethylamine Value

Trimethylamine (TMA), resulting from bacterial reduction of trimethylamine oxide (TMA-O), is associated with the fish odour of spoiling seafood [31]. It is a very useful index for spoilage in fresh and lightly preserved seafood [32], and is directly related to microbial spoilage in various species of fish during their storage [7]. The effect of different concentrations of ginger extract on trimethylamine (TMA) values of smoked mackerel fish is shown in figure 4. The result obtained shows that the TMA values of the treated samples were significantly ($P \leq 0.05$) lower compared to the control, and this suggests that all the concentrations of the ginger extract inhibited the production of TMA from TMAO, and this agrees with report by Idris et al. [2]. Also, there was significant variation ($P \leq 0.05$) among the samples, as the storage period increases. After 20 days of storage at 28 ± 2°C, the TMA values ranged from 3.46 mgN/100 g in the fish samples treated with 5% ginger extract to 6.74 mgN/100 g in the control. This may be related to the high temperature and low relative humidity, leading to the decrease in TMA values. This result agrees with earlier results of Negbenebor et al. [33], where 2.5% clove and ginger individually and in combination, reduced the TMA values. It also confirms the reports of Idris et al. [2], on the effect of ginger concentrations on the quality of smoked dried catfish.

Organoleptic analysis

The organoleptic evaluation of food products to any food processing technology is very important in determining the consumer acceptability [34]. The results of sensorial 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. In the freshly smoked samples (day 0), the panelist found or preferred the flavor of the control sample (% ginger extract) to the pungent flavor of the ginger treated smoked mackerel

Storage period (days)	Ginger extract conc. (%)	Appearance	Juiciness	Rancidity	Flavour	Overall acceptability
0	0	8.51 ± 0.23^{a}	8.22 ± 0.41^{a}	7.06 ± 0.24^{a}	8.00 ± 0.36^{a}	7.81 ± 0.33^{a}
	1	8.60 ± 0.31^{a}	8.01 ± 0.36^{a}	7.46 ± 0.33^{b}	7.85 ± 0.42^{b}	7.80 ± 0.31^{a}
	2	7.73 ± 0.25^{b}	7.83 ± 0.24^{b}	8.02 ± 0.47^{c}	7.72 ± 0.39^{c}	7.73 ± 0.35^{b}
	3	7.68 ± 0.33^{c}	7.64 ± 0.32^{c}	8.16 ± 0.34^{d}	7.61 ± 0.40^{d}	7.70 ± 0.34^{b}
	4	7.68 ± 0.35^{c}	7.58 ± 0.40^{d}	8.43 ± 0.28^{e}	7.53 ± 0.38^{e}	7.53 ± 0.33^{c}
	5	7.43 ± 0.24^{d}	7.47 ± 0.38^{e}	8.56 ± 0.33^{f}	7.38 ± 0.41^{f}	7.50 ± 0.30^{c}
	0	3.40 ± 0.28^{a}	3.51 ± 0.28^{a}	3.42 ± 0.24^{a}	4.48 ± 0.21^{a}	3.98 ± 0.19^{a}
	1	4.47 ± 0.25^{b}	4.23 ± 0.30^{b}	5.15 ± 0.28^{b}	5.97 ± 0.38^{b}	4.08 ± 0.20^{b}
	2	4.96 ± 0.21^{c}	4.28 ± 0.19^{c}	5.89 ± 0.24^{c}	6.14 ± 0.31^{c}	4.95 ± 0.22^{c}
	3	5.07 ± 0.30^{d}	4.77 ± 0.21^{d}	6.68 ± 0.30^{d}	6.83 ± 0.36^{d}	5.63 ± 0.26^{d}
	4	7.02 ± 0.33^{e}	5.23 ± 0.23^{e}	7.03 ± 0.32^{e}	7.12 ± 0.32^{e}	6.18 ± 0.24^{e}
	5	7.35 ± 0.42^{f}	5.86 ± 0.22^{f}	7.25 ± 0.26^{f}	7.73 ± 0.33^{f}	6.37 ± 0.28^{f}
20	0	2.08 ± 0.13^{a}	2.10 ± 0.15^{a}	1.06 ± 0.03^{a}	2.22 ± 0.13^{a}	2.05 ± 0.17^{a}
	1	4.01 ± 0.21^{b}	4.01 ± 0.11^{b}	4.18 ± 0.17^{b}	4.12 ± 0.18^{b}	3.38 ± 0.19^{b}
	2	4.63 ± 0.18^{c}	4.35 ± 0.20^{c}	4.26 ± 0.21^{c}	4.63 ± 0.21^{c}	3.88 ± 0.18^{c}
	3	5.26 ± 0.28^{d}	4.68 ± 0.28^{d}	4.81 ± 0.23^{d}	5.48 ± 0.24^{d}	4.63 ± 0.21^{d}
	4	5.26 ± 0.32^{e}	5.03 ± 0.19^{e}	5.48 ± 0.25^{e}	6.09 ± 0.30^{e}	5.23 ± 0.29^{e}
	5	5.69 ± 0.28^{f}	5.46 ± 0.28^{f}	6.01 ± 0.28^{f}	6.43 ± 0.32^{f}	5.56 ± 0.26^{f}

Means within columns with different superscripts are significantly different ($P \leq 0.05$).

Table 2: Effect of ginger extract concentrations and storage duration on the organoleptic quality of smoked mackerel fish.

fish. However, for day 10 and day 20, the taste panel rating for the ginger treated smoked fish were better than the untreated samples in all the parameters evaluated [25]. The panelist score for the smoked mackerel fish on the 20th day is closely related to the flavor and degree of rancidity of the product. From the scores, the panelist detected rancid odor in the control sample. The detection of rancidity in the control sample was as a result of increase in lipid oxidation, and this affected the flavor and overall acceptability of the smoked mackerel fish. The overall acceptability scores decreased while the storage time increased in all the samples, and this agrees with the findings of Idris et al. [2].

Conclusion

The present work has demonstrated that ginger (*Zingiber officinale*) extract has antioxidative and antimicrobial properties that can retard oxidative rancidity and inhibit mould growth, thus, extending the shelf life of the smoked fish. This is justified by the low TBA and peroxide values, as well as mould count of the ginger treated samples, compared to the untreated samples. Organoleptically, the general pattern of consumer preference to the products indicates that the ginger treated samples were most acceptable in relation to storage stability.

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