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Anti-Oxidative and Anti-fungal Effects of Fresh Ginger (*Zingiber officinale*) Treatment on the Shelf Life of Hot-smoked Catfish (*Clarias gariepinus*, Burchell, 1822)

C.A. Kumolu-Johnson and P.E. Ndimele
Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos, Nigeria

Corresponding Author: Kumolu-Johnson, Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos, Nigeria Tel: 234803-324-5426

ABSTRACT

Ginger is a rhizome with an established medicinal value. This study seeks to explore its anti-oxidative and anti-fungal properties when added to fish prior to smoking. An experiment was conducted to determine the effectiveness of ginger (*Zingiber officinale*) spice mixture on the shelf-life of hot-smoked *Clarias gariepinus* at different concentrations {0 g of ginger kg^{-1} of fish (control), 10 g of ginger kg^{-1} of fish, 20 g of ginger kg^{-1} of fish and 30 g of ginger kg^{-1} of fish}. Retardation in lipid oxidation, microbial proliferation and organoleptic qualities were used to assess the efficacy of ginger as an anti-oxidant and anti-fungi in hot-smoked catfish. The fish were divided into four batches and coated with appropriate quantities of ginger paste to give concentrations of 0 g of ginger kg^{-1} fish, 10 g of ginger kg^{-1} fish, 20 g of ginger kg^{-1} fish and 30 g of ginger kg^{-1} fish. They were then smoked for 8 h, cooled and stored in ambient temperature (25-30°C) for 21 days. Chemical, microbial and sensory evaluation studies were carried out on them. The anti-oxidative activity of ginger was evident from lower Thio Barbituric Acid (TBA) and peroxide values of treated samples relative to untreated (control) samples. The lowest TBA (2.88±0.35) and peroxide (5.87±1.48) values were recorded in 30 g of ginger kg^{-1} of fish while the highest TBA (4.08±0.51) and peroxide (13.38±1.97) occurred in the control. The results also showed that samples treated with ginger paste had lower microbial load than the control. Ginger has anti-oxidative and anti-fungal properties which can extend the shelf-life of hot-smoked *Clarias gariepinus*.

Key words: Spice, thiobarbituric acid, peroxide, organoleptic, microbial

INTRODUCTION

The production and consumption of catfish in Nigeria has witnessed a drastic growth in the last two decades. A lot of farmed catfish are turned out annually to provide the much needed animal protein which before now was supplied by beef. However, beef meat has been implicated in coronary disease and most people have avoided it consumption (Afzal *et al*., 2001; Talat *et al*., 2006).

One of the challenges facing the catfish industry is that the fish deteriorate very fast if not well preserved (Kumolu-Johnson and Ndimele, 2011). The spoilage is caused by lipid oxidation and microbial proliferation. Lipids oxidation causes reduction in nutritional quality of fish. It also imparts offensive odour on the fish which affects its consumption and ultimately, its marketability (Sallam *et al*., 2004). Microbial contamination can be dangerous to the health of humans as was

recently reported in Europe (contamination of fruits by *E. coli* in Europe especially, Germany). Apart from nutritional loss, the presence of micro-organisms in fish can result in massive economic loss. This is very common in developing countries with inadequate and inefficient storage facilities (Kumolu-Johnson and Ndimele, 2011).

Some processing methods have been used over the years to extend the shelf-life of fish in Nigeria and other parts of the world; Chilling, freezing, salting, drying, canning and smoking (Kumolu-Johnson and Ndimele, 2001; Kumolu-Johnson and Ndimele, 2011; Akintola and Bakare, 2011). These processing methods have their advantages and disadvantages which dictates their usage in particular parts of the world. Smoking has enjoyed the wildest acceptance and usage in Nigeria (Eyo, 2000). Inspite of the relative success of fish smoking especially in terms of increasing the shelf-life and nutritional quality of fish, the volume of post-harvest losses particularly in sub-saharan Africa is quite worrisome. It becomes imperative to put measures in place that will prevent lipid oxidation and further deter microbial proliferation (Kumolu-Johnson and Ndimele, 2011).

Synthetic antioxidants like Butylated Hydroxytoluene (BHT)) and Butylated Hydroxyanosole (BHA) have been very effective in controlling rancidity (Martinez-Tome *et al*., 2001). However, these synthetic antioxidants have been withdrawn from the market because of their undesirable effects on the enzymes of the liver and lung (Inatani *et al*., 1982).

Spices are edible plant materials (leaf in onion and garlic, rhizome in ginger) that have anti-oxidative, antiseptic and bacterio-static properties. They are added to foods such as fish, meat to delay the onset of rancidity and reduce microbial proliferation (Eyo, 2001). They also function as seasonings to foods as well as impart flavour to the foods (Lafont *et al*., 1984).

Ginger is enjoying wilder usage in the local food industries as it is added to local delicacies to improve their flavour, shelf-life and consumer acceptability (Osuntogun and Aboaba, 2004). Ginger is a spice and the rhizome of the plant *Zingiber officinale*. It geographical spread 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 (Onyeagba *et al*., 2004; Patrick-Iwuanyanwu *et al*., 2007; Abdul *et al*., 2008; Akram *et al*., 2011). A mixture of zingerone, shogaols and gingerols volatile oils are responsible for the unique aroma and flavour of ginger and these components account for about 1-3% of the weight of fresh ginger (Akram *et al*., 2011). In laboratory studies with animals like mouse, the gingerols was found to increase the motility of the gastrointestinal tract. They also have some other medicinal values (analgesic, sedative, antipyretic and antibacterial) which have encouraged their cultivation in many parts of the world (Patrick-Iwuanyanwu *et al*., 2007). Ginger oil can prevent skin cancer in mice while gingerols can kill ovarian cancer cells. Ginger also has anti-microbial, anti-oxidative and seasoning qualities when added to food and these potentials have been exploited over the decades (Onyeagba *et al*., 2004; Abdel-Hamied *et al*., 2009; Tagoe *et al*., 2011).

Hence, there is the need to work on improving the traditional fish smoking methods in order to prolong the shelf-life of smoked fish. This need calls for the introduction of food preservatives and antioxidants which are very good in prolonging the shelf-life of food either by killing micro-organisms or controlling their growth on food (Abdel-Hamied *et al*., 2009).

The purpose of this study was to determine the effectiveness of ginger spice in controlling oxidative rancidity and on the organoleptic quality of smoked *Clarias gariepinus*. Ginger was chosen because they are often added as ingredients in many Nigerian cooked foods.

MATERIALS AND METHODS

The study was conducted between June, 2010 and November, 2010. One hundred and twenty fish were bought from Olamide Farm, Egbeda, Lagos, Nigeria at an average weight of 700±35 g.

For each experiment, the fish were thawed, eviscerated and prepared into" butterfly cuts" according to the method described by Roger *et al.* (1975). The sides were washed, brined by dipping in 15% sodium chloride solution for 3 min, drained and then divided into 4 batches of 30 fish each. Fresh ginger (*Zinger officinalae*), were bought from a local market (Abule Egba, Lagos, Nigeria) and the outer coat scrapped off. They were cleaned, ground properly into fine pastes and applied as ginger spice mixture to the 4 batches of fish at 0 g ginger kg^{-1} of fish (control), 10 g ginger kg^{-1} of fish, 20 g ginger kg^{-1} of fish and 30 g ginger kg^{-1} of fish. The fish were smoked using smoking kiln for 8 h and the smoked samples were cooled, packaged in bulk and stored at ambient temperature of 25- 30°C for 21 days. Samples were subjected to visual observation, chemical, microbiological and sensory evaluations.

Proximate analysis: The determination of crude protein, moisture, ash and fat content of the fish muscle were done using standard methods (AOAC, 1995). Total Free Fatty Acid (FFA) was determined by the method of Barassi *et al.* (1987).

The principle of thiobarbituric acid reactive substance. TBA-RS: The increase in the amount of red pigment formed in the reaction between 2-thiobarbituric acid (TBA) and oxidized lipids as oxidative rancidity has shown that malonaldehyde (an end product of oxidative decomposition) is probably involved in the reaction (AOAC, 1995). Thiobarbituric acid reactive substance (TBA-RS) was determined according to the method described by AOAC (1995).

Peroxide value: The oxidative stability of smoked samples was also measured using titrimetric determination of the amount of peroxide and hydroperoxide group (the initial products of lipid oxidation) according to AOAC (1995).

Microbiological analysis: Mould counts were determined according to standard procedures described by Fawole and Oso (1995).

Sensory (Organoceptic) analyses: Subjective evaluation of the product quality was carried out in accordance with method outlined by Poste *et al.* (1991) by panel of 5. Coded samples accompanied by questionnaires were presented to the panelists. Quality attributes studied include taste, texture, colour, rancidity and general comment. The hedonic scale used was from 1-5, where a score of 5 was “excellent” and a score of 1 was very poor.

Statistical analysis: Analysis of Variance (ANOVA) (SPSS 17.0 version) was applied to the treatment values obtained. Differences between means were determined by the least significant difference test and significance was defined at $p<0.05$.

RESULTS

Table 1 shows the proximate analysis of the four treatment samples before the start of the experiment. The lowest fat content (0.75) was recorded in 10 g ginger kg^{-1} of fish while the highest value (2.90) was observed in the control. The lowest values of protein (30.42) and moisture (6.10) were recorded in the control while the highest values of 46.51 and 47. 90 were observed in 10 g ginger kg^{-1} of fish and 20 ginger kg^{-1} of fish, respectively. Figure 1 shows the effects of different concentrations of ginger on thiobarbituric acid (TBA) values of smoked *Clarias gariepinus* stored

Table 1: Proximate analysis of sample treatments before the start of the experiment

Treatment	Fat	Protein	Ash	Fibre	Moisture
A	2.90	30.42	3.28	2.20	6.10
B	0.75	46.51	3.74	1.80	46.90
C	2.07	43.58	3.65	2.60	47.90
D	2.80	45.75	2.95	1.20	46.90

A = 0 g ginger kg^{-1} of fish; B = 10 g ginger kg^{-1} of fish; C = 20 g ginger kg^{-1} of fish; D = 30 g ginger kg^{-1} of fish

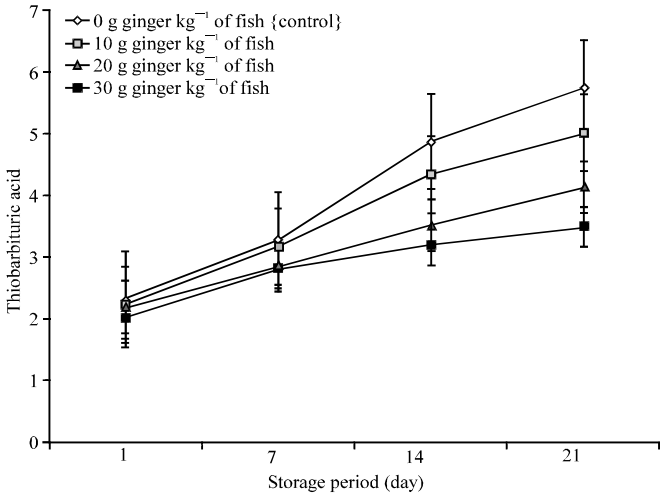

Fig. 1: Thiobarbituric acid (TBA) values (mg malonaldehyde per kg sample) of the ginger-treated *Clarias gariepinus* during the 21 days storage period

at ambient temperature (25-30°C) for 21 days. The initial TBA values ranged from 2.00 in the fish sample treated with 30 g ginger kg^{-1} of fish to 2.31 in the control. After 21 days of storage at 25-30°C, the TBA values ranged from 3.48 in the fish sample treated with 30 g ginger kg^{-1} of fish to 5.73 in the control which implies that the TBA of the sample with the highest concentration of ginger (30 g ginger kg^{-1} of fish) only increased by 1.48 while the TBA of the control increased by 3.42 in 21 days. There was no significant difference ($p>0.05$) in the TBA values of the fish samples treated with different concentrations of ginger paste and the control which was not treated with ginger. However, there was a noticeable trend in which the TBA values of all the treatments (including the control) increased but the rate of increase was fastest in the control.

There was also a general increase in the peroxide values of all the treatments during the 21 days storage period. The highest value (13.38±1.97) of peroxide was recorded in control that was not treated with ginger while the lowest value (5.87±1.48) was observed in the sample treated with 30 g of ginger kg^{-1} of fish (Fig. 2). This difference was statistically significant ($p<0.05$).

The microbial count of the smoked catfish samples, *Clarias gariepinus* during the 21day storage as shown in Fig. 3 reveal a steady increase in microbial count with storage period in all the treatments. However, sample treated with fresh ginger paste, *Zingiber officinale* showed lower counts. After 7 days of storage, the microbial count in fish samples treated with 20 g ginger kg^{-1} of fish and 30 g ginger kg^{-1} of fish were 6.12 $\log_{10}$ CFU/g and 5 $\log_{10}$ CFU/g, respectively. These values are below 7 $\log_{10}$ CFU/g which is the MPL (Maximum Permissible Limit) for Aerobic Plate

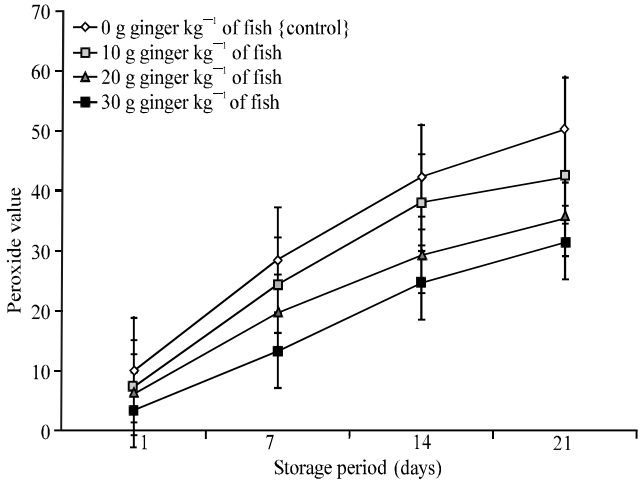

Fig. 2: Peroxide values (milliequivalent peroxide per kg of sample) of the ginger-treated *Clarias gariepinus* during the 21 days storage period

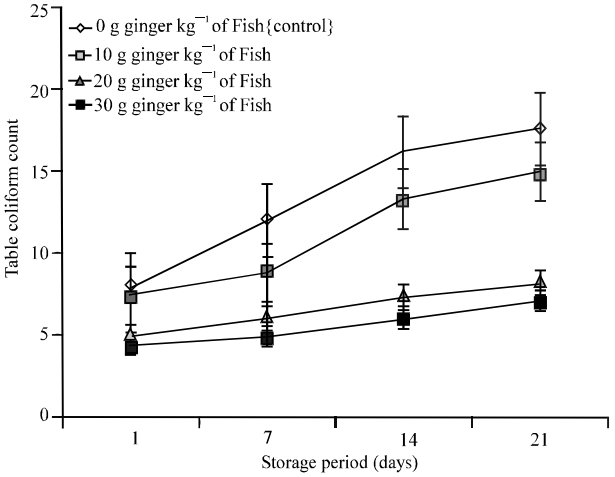

Fig. 3: Microbial growth (Log_{10} CFU g^{-1} of fish sample) of the ginger-treated *Clarias gariepinus* during the 21 days storage period

Count (APC) recommended by ICMSF (1986). At storage day 21, the microbial loads of the control was 17.56 log_{10} CFU/g while that of the sample treated with the highest concentration of ginger (30 g) was 7.16 log_{10} CFU/g which is about 0.16 log_{10} CFU/g higher than the maximum permissible limit. Figure 3 showed that there was significant difference ($p<0.05$) in the microbial loads among the treatments. The microbial loads in the samples treated with ginger were significantly lower than the control which was not treated with ginger.

The result of the organoleptic analyses of the smoked catfish, *Clarias gariepinus* during the 21 days storage showed that the control samples received lower panel scores than the ginger paste-treated samples with regards to rancidity, taste, colour, flavour and general acceptance. The taste panel rating showed that treated samples were rated better than untreated samples in all

the parameters studied. However, there was no significant difference ($p>0.05$) among the treatments in all the organoleptic parameters measured.

DISCUSSION

The oxidative stability of the smoked catfish (*Clarias gariepinus*) measured using thiobarbituric acid (TBA) and peroxide values as shown in Fig. 1 and 2, respectively indicates that there was a steady increase in the TBA and peroxide values for all the samples during the storage period, though at different rates. The rate of increase in TBA and peroxide was fastest in the control (zero ginger) but slowest in the fish sample treated with the highest concentration of ginger (30 g ginger kg^{-1} of fish). However, while the difference in peroxide values among the treatments was significant ($p<0.05$), the difference in TBA among the treatments was not significant ($p>0.05$). Therefore, lipid oxidation was retarded by addition of ginger paste to the fish sample. This observation agrees with the report in previous studies by Pratt and Watts (1964) and Lee *et al.* (1986) who indicated that ginger pastes effectively retarded the development of rancidity in fish, pork and beef. In addition, Saito *et al.* (1976) and Lee *et al.* (1986) had reported that the effectiveness of spices as antioxidants is a function of their concentration.

The difference in the microbial loads of smoked fish samples treated with different concentrations of fresh ginger was significant ($p<0.05$). Therefore, fresh ginger was effective in reducing microbial loads in the smoked fish (*Clarias gariepinus*) stored at 25-30°C for 21 days. A similar result was obtained by Sallam *et al.* (2004) which studied the effect of different concentrations of garlic paste on chicken sausage stored at 3-4°C for 21 days. The anti-fungal activity of ginger could be attributed to its chemical properties (Tagoe *et al.*, 2011). Tagoe *et al.* (2011) studied the anti-fungal properties of onion (*Allium cepa*), garlic (*Allium sativum*) and ginger (*Zinziber officinale*) against *Aspergillus flavus*, *Aspergillus niger* and *Cladosporium herbarum*. The study showed that the extracts of these plants were effective in retarding the growth of those fungi. Sesquiterpenoids and zingiberene are the most important components of ginger. Other components which are equally important are β- sesquiphellandrene, bisabolene and farnesene (O'Hara *et al.*, 1998).

Storage time had no effect on rancidity, colour, taste, flavour and general acceptance of ginger-treated *Clarias gariepinus* and the control which had no ginger. This might be due to the duration of the study (21 days) which may not have allowed a significant change in the organoleptic properties studied. Although, Sallam *et al.* (2004) obtained a similar result in their study in which they examined the effects of garlic in chicken sausage for 21 days.

CONCLUSION

This study has shown that ginger (*Zingiber officinale*) has some anti-oxidative and anti-fungal effects which can retard oxidative rancidity, inhibit fungal growth, impact acceptable flavour and thus, extend the shelf-life of fish like *Clarias gariepinus*. However, the insignificance ($p>0.05$) of thiobarbituric acid (TBA) values and panel rating among the treatments suggest that further studies be carried out. In these studies, the treated fish samples should be stored at lower temperature, say 4°C and the storage period of the experiment should be extended for a clearer result since there was a trend.

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