Abbassa Int. J. Aqua., V0l.10 No.(1) 2017. *157-177*

EFFECTS OF GARLIC OR GINGER EXTRACTS ON QUALITY CHARACTERISTICS OF CATFISH *(CLARIAS GARIEPINUS)* FILLETS SMOKED DURING REFRIGERATION STORAGE PERIOD

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Received 14/ 11/ 2017 *Accepted 5/ 12/ 2017*

Abstract

Catfish fillets contains high amount of fatty acids making it very prone to lipid oxidation by high temperature during smoking, also makes it susceptible to microbial spoilage and proliferation of pathogenic bacteria which may cause foodborne diseases outbreaks. So must be used natural antioxidants and antimicrobial agents such as herbs and spices.

This study designed to determine the antioxidant and antimicrobial effects of equivalent concentrations of both garlic (GE) and ginger (GIE) extracts separately on quality attributes of liquid smoked catfish (*Clarias Gariepinus*) during chilled storage were investigated for a period of 28 days. The control and the treated fish samples were analyzed periodically for physicochemical (body composition, peroxide value (PV), thiobarbituric acid (TBA), total volatile basic nitrogen, (TVB-N) characteristics and microbiological (TVC). The results showed that the percentage of moisture content decreased and protein, lipid and ash content increased significantly ($p<0.05$) due to water loss. Also, the results showed in all treatment compared to control from initial period to end of storage period that each spice treatment significantly ($P < 0.05$) reduced in growth of microorganisms, significant reduction ($p<0.05$) in lipid peroxidation as displayed in (PV&TBA) values and decreased significantly ($p<0.05$) in TVB-N values reflected in decreasing chemical spoilage, microbial activities and extending the shelf-life smoked catfish.

The organoleptic showed that the highest overall acceptability was obtained in 50 g/kg ginger extract during storage period. The acceptability increased as the concentration of spice increased, they

were significantly different ($p < 0.05$) among the treatments and this results show that the highest concentration of ginger and garlic extracts were more acceptable compared to the control at 28 days.

The results obtained from this study suggests that ginger and garlic extracts, through their combined antioxidant and antimicrobial effects, are potentially useful in preserving, extending the shelf-life through retarded the spoilage and enhancing quality attributes of liquid smoked catfish fillets stored at 4 ± 1°C.

INTRODUCTION

Fish have rich source of essential nutrients required for supplementing both infant and adult diets**.** Fish proteins containing all of the essential amino acids (EAA), also fish contain lipid, phospholipids, vitamins and minerals; needed for proper growth and development of the animal body. Fatty fish as catfish have a high content in lipid and phospholipids with long chain fatty acid which are highly unsaturated and these circumstances have important consequence for spoilage process under aerobic storage condition. (Abdullahi *et al.,* 2001). It is an extremely perishable food. Quality loss can also occur very rapidly after catch (Zakhia, 2002). 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).

Processing is carried out with the aim of either to supply distant markets or to produce a range of products with different flavor and texture. Smoking makes the product highly acceptable bright brown and reddish color. Besides, smoke gives highly relished characteristic smoke flavor (Horner, 1992). Smoked fish is fish that has been preserved by the application of smoke with the aid of salting, drying, and heat treatment. Smoking is a very old preservation method and the most popular method of fish preservation widely used in many developing countries (Eyo, 2001).

Fatty fishes such as Africa catfishes are suitable for smoking. However, the high fat content makes them unstable to oxidation leading to the development of fishy, rancid odors and thus, reduces its nutritional health

benefits and quality. The oxidation of fatty acids is one of the most fundamental reactions in food chemistry (Geoffroy, *et al.,* 2000). It involves a reaction between lipid and molecular oxygen (Richards and Hultin, 2002). The unsaturation of EPA and DHA in fatty acids undergoes rapid oxidative deterioration (Gokoelu *et al.,* 2012) and (Frankel *et al.,* 2002). Lipids are susceptible to oxidative processes in the presence of catalytic system such as light and heat, due to this catalytic system, high temperature is believed to accelerate the rate of lipid oxidation. The process of smoking, combined with frozen storage, is believed to make fish more prone to oxidative rancidity. The high temperature during smoking contributes to the destabilization of fatty acids (Asimi *et al.,* 2013). On the other hand, the increasing occurrence of foodborne disease outbreaks caused by foodborne pathogenic microorganisms raise awareness to the public about food security parameters (Asimi *et al.,* 2013).

Foodborne pathogens and microbial contamination pose a difficult problem to health concerns. Furthermore, foodborne illness usually arises from improper handling, preparation or food storage (Doyle, 2007).

However, there is a little data on antimicrobial activities and most medicinal plants. The use of synthetic anti-oxidants such as Butylated Hydroxytoluence (BHT) and synthetic antibiotics has been widely used in most smoked-fish industries to retard rancidity of oil in fish and thus preventing the entry of pathogens. However, the use of these synthetic anti-oxidants has been banned in many countries because of their negative effects on the enzymes of the liver and lungs (Sallam *et al.,* 2004). and the use of synthetic antibiotics, if use regularly, will only creates a defensive mechanism for the pathogens. This necessitated the need to use of natural anti-oxidants and antimicrobial agents such as herbs and spices to prevent rancidity in smoked fish (Kumolu-Johnson *et al.,* 2013), and the entry of pathogens to food. Two of the common spices that could be used as anti-oxidants and anti-bacterial for smoking are ginger and garlic. The antioxidant and antimicrobial ability of these two spices has been reported in various studies. Garlic (Allium sativum L.) is one of the commonly use spices to enhance flavor in food. Apart from it, Allium sativum L. has a

wide spectrum of actions which include antibacterial, antifungal, antioxidant and beneficial effects on the cardiovascular and immune system of human (Sallam *et al.*, 2004). The presence of allicin, a sulfur-containing compound found in garlic, that enables the antimicrobial effects.

This study aims to determine the effects of garlic (GE) and ginger (GIE) extracts on reduction of oxidative rancidity, microbiological, and organoleptic qualities of liquid-smoked African Catfish fillets *(clarias gariepinus)* during chilled storage at 4 ± 1°C.

MATERIALS AND METHODS

Materials:

Ginger rhizomes (*Zingiber officinal*) and Garlic (*Allium sativum*) were obtained from local market. Full details of the extraction methodology and determinations of active compounds are given in (Baker *et al.*, 2012a). Briefly, batches of one hundred grams from ginger and Garlic were extracted separately with 1 liter of 95% ethanol. The tincture was kept in darkness for 24h and then filtered; the ethanol was evaporated in a vacuum oven at 40 °C. The extracts were stored in containers in the refrigerator until use. By using HPLC, it was found that the active compounds in ginger Gingerol, Zingiberene, α-farnesne, ß-sesqulphellanderene, ß-bisabolene and α-Curcumene (Baker *et al.*, 2012a). The active compound present in garlic is the allicin, allyl alcohol which is a thiosuffinate compound reported for its anti-microbial activity (Chung *et al.*, 2007).

Preparation of fish:

Sixty Fresh catfish (*Clarias gariepinus)* were obtained from a private Fish pond with average weight of 980.12 ± 15.66 g were purchased from a local market, transported within 1 h in sealed polystyrene foam boxes containing ice to the Food Processing Technology Laboratory, where processing was carried out, then randomly divided into 5 groups for further treatments after they were

gutted, eviscerated, deboned, the scale, skin, pin bones, debris were removed and filleted.

Sample treatment and brining with liquid smoke:

Catfish were cleaned in running water and soaked in 15% saturated brine solution and different amount of garlic extract for 90 minutes and drained for 15 minutes. C: The samples without garlic or ginger extracts treatment, treatment (T1) was soaked in brine solution with 20 g/L garlic extract, treatment (T2) in brine solution with 50 g/L garlic extract, treatment (T3) in brine solution with 20 g/L ginger extract and treatment (T4) in brine solution with 50 g/L ginger extract.

All the samples above were immersed in brine containing 10% sodium chloride and 1% liquid smoke solution at a ratio of 1:1(w/w) for 4 h at 4 ± 1°C according to (Fijelu *et al.*, 2014).

Drying, heating and cooling of samples:

All samples were air dried at 20°C for 40 min. The samples were then heated in an oven at 75°C for 80 min. After cooling at 20°C for 30 min, the smoked products were wrapped in aluminium foil, and stored at + 4°C until analysis performed in replicates on day 0, 7, 14, 21 and 28 of storage period.

Analytical methods:

Moisture content, total protein, lipids and ash were determined according to methods described in (A.O.A.C., 2000). Peroxide values (PV) were determined in the lipid extract according to the method described by (A.O.A.C., 2000). Results were expressed as milliequivalents oxygen per kg lipid (meq O_2/kg lipid). Thio-barbituric acid (TBA) was determined calorimetrically by the Porkony and Dieffenbacher method as described by (Buege and Aust, 1978). Results are expressed as mg malonaldehyde/kg (mg MAL/kg fish muscle). Total volatile bases-nitrogen (TVB-N) values were measured according to (Goulas and Kontomians, 2005). The results (TVB-N) values were expressed as mg/100 g fish muscle. Total bacterial count was

detected according to the methods described by (Gilliland *et al.,* 1976).The bacterial counts values were expressed as mean log 10 CFU/g sample.

Samples were organoleptically evaluated for appearance, color, odour and overall acceptability every month during storage as described by (Teeny and Miyauchi, 1972) according to the following scheme:

Score	Description	Score	Description
10	Ideal	4	Fair
9	Excellent	3	Poorly fair
8	Very good	2	Poor
7	Good	1	Very poor
6	Fairly good	0	Repulsive
5	Acceptable		

Statistical analysis:

Three replications of each trial were performed. Moisture, protein, fat, ash, peroxide value (PV), thiobarbituric acid (TBA), total volatile bases nitrogen (TVBN), Total viable counts, and sensory data were analyzed using A NOVA and means were separated by Duncan at a probability level of < 0.05 (SAS, 2000).

RESULTS AND DISCUSSION

Proximate Composition:

The proximate composition of fresh catfish fillets determined in the initial fish samples before being treated with preservatives and for treated liquid smoked catfish fillets showed in Table (1). Nutrients fresh and smoked/ginger T4 (50g/L); Moisture% content 76.72±0.13 and 65.24±2.1; Protein % 85.10±1.1 and 71.51±1.2; Fats % 9.1±0.6 and 19.10±0.2; Ash % 2.30±0.5 and 5.19 ±0.3 and Carbohydrates % 3.50±0.7 and 4.20 ± 0.1, respectively.

During smoke-drying, the percentage of moisture content decreased and protein, lipid and ash content increased significantly ($p<0.05$) due to water loss. This observation is in agreement with the findings of Atlantic mackerel and

European eel, pike perch and rainbow trout (Bhuiyan *et al.,* 1986), (Unlusayin *et al.,* 2001). The observed reduction in moisture content on smoked sample was due to loss of moisture during smoking as observed also by (Salihu-Lasisi *et al.,* 2013).This was based on report of (Kumolu and Ndimele, 2011) which asserted that spoilage of fish resulting from action of enzymes and bacteria can be slowed down during smoking. The percentage of total protein and fats were significantly higher in smoked fish's samples than fresh, which was in line with reported by (Puwastein, *et al.,* 1999), reported that smoking was increased in concentration of nutrients like protein and fat.

Table 1. Showing the Proximate Content of fresh and liquid smoked catfish fillets.

		Garlic		Ginger	
Nutrients	**Fresh**	**T1 (20g/L)**	**T2 (50g/L)**	**T3 (20 g/L)**	**T4 (50g/L)**
Moisture content %	76.72±1.8^{a}	65.26±2.1^{b}	65.25±2.1^{b}	65.26±2.1^{b}	65.24±2.1^{b}
Protien %	85.1 ± 1.1^{a}	71.50±1.2^{b}	71.51±1.2^{b}	71.49±1.2^{b}	71.51±1.2^{b}
Fats %	9.1 ± 0.6^{b}	19.21±0.2^{a}	19.11±0.2^{a}	19.11±0.2^{a}	19.10±0.2^{a}
Ash %	2.30 ± 0.5^{b}	5.13±0.3^{a}	5.22±0.3^{a}	5.20±0.3^{a}	5.19±0.3^{a}
Carbohydrates %	3.50 ± 0.2^{b}	4.16±0.1^{a}	4.16±0.1^{a}	4.20±0.1^{a}	4.20±0.1^{a}

$^{a-b}$Means with the same letter in each column are not significantly different (P≥0.05).

Table 2. Effect of various concentration of garlic (GE) or ginger (GIE) extracts on Peroxide values (meq O_2/kg lipid) in liquid-smoked catfish fillets during chilled storage period at 4±1°C.

Storage period (Days)	**Control (C)**	**Garlic**		**Ginger**	
		T1 (20g/L)	**T2 (50g/L)**	**T3 (20 g/L)**	**T4 (50g/L)**
0	5.71±0.02^{a}	3.55±0.01^{b}	2.98±0.01^{c}	3.02±0.02^{bc}	2.77±0.01^{c}
7	5.15±0.13^{a}	3.51±0.02^{b}	3.22±0.04^{b}	3.36±0.03^{b}	2.89±0.05^{c}
14	6.55±0.07^{a}	4.94±0.04^{b}	4.64±0.05^{b}	4.82±0.04^{b}	4.13±0.06^{bc}
21	8.91±0.11^{a}	5.36±0.06^{b}	4.98±0.04^{bc}	5.19±0.05^{b}	4.72±0.06^{c}
28	12.65±0.15^{a}	7.03±0.08^{b}	6.61±0.05^{c}	6.78±0.04^{c}	6.30±0.05^{c}

$^{a-c}$Means with the same letter in each column are not significantly different (P≥0.05).

Peroxide values:

Results imply that the control (not treated with garlic or ginger extracts) is more prone to oxidative rancidity development than the garlic and ginger treated samples. The changes of peroxide value as primary products of lipid oxidation are shown in Table (2), the degree of lipid autoxidation in untreated samples were generally high than those treated samples by garlic and ginger extracts throughout chilled storage period at +4±1°C for 28 days. The initial PV values of untreated as control(C) and treated with garlic (T1) 20g/l, (T2) 50g/l and ginger (T3) 20g/l, (T4) 50g/l samples of catfish fillets were in the range of 5.71 to 2.77 meq/kg. PV values in the control and treated samples started to increase significantly ($p<0.05$) from initial storage period to reach the end of storage period. The mean PV values of control increased from 5. 71 to reached 12.65 meq/ kg of untreated smoked fish at end of storage period which is higher than those of other treated samples which were found to be 7.03, 6.61, 6.78 and 6.30 **(**meq/ kg) for T1, T2, T3 and T4, respectively, at day 28 of storage period. This finding was in agreement with the study conducted by (Kumolu *et al.*, 2013) when the antioxidant activity of fresh garlic was evaluated on smoked catfish having a lower peroxide values than the untreated sample. Accordingly, the acceptability limit for peroxide value of crude fish oil is between 7-8 meq/kg and not more than ≤ 5.0 meq/kg as maximum level for fish products *(*Guiñares *et al.,* 2014). This result is in agreement with reported by (Kumolu and Ndimele, 2011) which showed that ginger extract is effective in retarding rancidity in hot-smoked catfish. It also agrees with the studies of (Siripongvutikorn *et al.,* 2009) that spices activities as antioxidant are directly related to their concentration.

Thiobarbituric acid (TBA):

In the present study results of TBA showed in (Table 3), TBA values in control (C) and treated samples with garlic extracts T1 (20g/l), T2 (50g/l) and ginger extracts T3 (20g/l), T4 (50g/l) of catfish fillets were started to increase significantly ($p>0.05$) from initial storage period to reach the end of storage

period. The mean TBA values of control increased from 0.72 to reached 1.79 meq/kg of untreated smoked fish muscle at end of storage period which is higher than those of other samples which were found to be 1.51, 1.19, 1.42 and 0. 91 meq/kg for T1, T2, T3 and T4, respectively, at day 28 of storage period. The TBA values of all catfish fillets samples increased as storage period increased, the increasing of TBA values in fish meat with increasing storage period is normal (Rong *et al.,* 2009). Fish meat is particularly susceptible to oxidative changes because of the processing conditions, exposure of unsaturated fat and proteins to molecular oxygen. 2-Thiobarbituric acid (TBA) is widely used as an indicator of degree of lipid oxidation, and the presence of TBA reactive substances is due to the second stage auto-oxidation (Rezaei and Hosseini, 2008) during which peroxides are oxidized to aldehydes and ketones. There are two possible reasons for this phenomenon in the effectiveness of this product: first, reduction in TBARS using garlic and ginger is related to peroxide-scavenging enzyme activity, which could reduce unsaturated fatty acid and total unsaturated fatty acid oxidation and second, some active components in the garlic and ginger may involve desaturase and elongase activities (Mariutti *et al.,* 2008).

Table 3. Effect of various concentrations of garlic (GE) or ginger (GIE) extracts (on thiobarbituric acid (TBA) value (meq/kg fish muscle) in liquid-smoked catfish fillets for 28 days of chilled storage period at 4±1°C.

Storage period (Days)	Control (C)	Garlic		Ginger	
		T1 (20g/L)	T2 (50g/L)	T3 (20 g/L)	T4 (50g/L)
0	0.72±0.02^{a}	0.66±0.01^{b}	0.63±0.02^{b}	0.65±0.02^{b}	0.61±0.01^{b}
7	0.84±0.03^{a}	0.78±0.03^{b}	0.69±0.02^{c}	0.73±0.02^{b}	0. 67±0.01^{c}
14	0.98±0.04^{a}	0.82±0.03^{b}	0.77±0.03b^{c}	0.79±0.02^{bc}	0.75±0.02^{c}
21	1.42±0.07^{a}	0.90±0.05^{b}	0.82±0.03^{c}	0.86±0.04^{c}	0.79±0.01^{cd}
28	1.79±0.06^{a}	1.51±0.05^{ab}	1.19±0.04^{b}	1.42±0.03^{ab}	0. 91±0.02^{c}

$^{a - b}$Means with the same letter in each column are not significantly different (P≥0.05).

There was a steady increase in TBA values of the control samples from 0 to 28 days. This clearly attests the preservative capability of garlic and ginger extracts which lends credence to our earlier studies (Adeyemi *et al.,* 2013a and Adeyemi *et al.,* 2013b) in which garlic and ginger extracts maintained the chemical and microbiological quality of liquid-smoke catfish. The antioxidant effect of garlic and ginger extracts could be attributed to the presence of phenolic compounds, which donate hydrogen atoms from their hydroxyl groups thus reducing the formation of hydroperoxides, the first product of lipid peroxidation. Phenolic compounds exert their antioxidant properties by three main processes (Velasco and Williams, 2011).

Table 4: Effect of various concentrations of garlic (GE) or ginger (GIE) extracts on (TVB-N) values (mg/100 g fish muscle) in liquid-smoked catfish fillets for 28 days of chilled storage period at 4±1°C.

Storage period (Days)	Control (C)	Garlic		Ginger	
		T1 (20g/L)	T2 (50g/L)	T3 (20 g/L)	T4 (50g/L)
0	10.71±0. 15^{a}	9.73±0.12^{b}	9.41±0.12^{b}	9.50±0.11^{b}	9.20±0.13^{b}
7	11.57±0.14^{a}	10.72±0.13^{ab}	10.03±0.16^{ab}	10.43±0.18^{ab}	9. 78±0.13^{b}
14	13.23±0.15^{a}	11. 81±0.13^{b}	10.74±0.12^{c}	11.31±0.013^{b}	10.36±0.14^{c}
21	15.54±0.14^{a}	12.77±0.13^{b}	11.53±0.11^{c}	11.31±0.12^{c}	11.15±0.12^{c}
28	17.81±0.21^{a}	13.08±0.20^{b}	12.17±0.15^{c}	12.65±0.14^{c}	11.82±0.13^{d}

a - d± Means with the same letter in each column are not significantly different (P≥0.05).

Total volatile base nitrogen (TVB-N):

Changes in TVB-N of different samples during the entire storage period are shown in Table 4. The initial TVB-N value of untreated control(C) and treated with garlic T1 (20g/l), T2 (50g/l) and ginger T3 (20g/l), T4 (50g/l) samples of catfish fillets were in the range of 10.71 to 9.20mg /100 g. TVB-N values decreased significantly ($p<0.05$) in all treatment compared to control from initial storage period to end of storage period. The mean TVB-N values of control (untreated) increased from 10.71 to reached 17.81 mg/100 g of smoked catfish fillets at end of storage period which is higher than those of

other treated samples which were found to be 13.08, 12.17, 12.65 and 11.82 mg/100 g for T1, T2, T3 and T4, respectively, at day 28 of storage period. The TVB-N of fish is an indicator of the freshness of the raw material (Limbo *et al.*, 2009) and (Choi *et al.,* 2003).TVB-N values of all samples were lower than 25mg/100 g which was considered as the threshold for a good-quality fish product, high TVB-N values are unacceptable and are associated with unpleasant smell in the meat (Limbo *et al.,* 2009). Assumably, this is because of the impact of the various treatments of TVB-N, which primarily includes nitrogen from ammonia, TMA, and dimethylamine which reflects the extent of degradation of proteins and non-protein nitrogenous compounds which can be explained by proteolysis, due to enzymatic and microbial activities in the samples during storage period (Erkan and Ozden, 2008). In the present study, the results establish the effectiveness of garlic and ginger as antioxidants and antimicrobials due to reduction in TVB-N on treated samples as observed, it is supposed that the spices used to treat catfish fillets were involved in TVB-N reduction.

Table 5. Total viable counts (log10 CFU/g) for liquid smoked catfish fillets during chilled storage period at 4±1°C.

Storage period (Days)	Control (C)	Garlic		Ginger	
		T1 (20g/L)	T2 (50g/L)	T3 (20 g/L)	T4 (50g/L)
0	3.95±0.05^{a}	3.40±0.04^{a}	3.31±0.02^{a}	3.38±0. 03^{a}	3.10±0.02^{a}
7	4.24±0.06^{a}	3.90±0.05^{b}	3.52±0.03^{b}	3.76±0.04^{b}	3.28±0.03^{b}
14	4.78±0.05^{a}	4.25±0.05^{a}	3.97±0.02^{b}	4.11±0.03^{a}	3.7±0.02^{b}
21	5.03±0.04^{a}	4.41±0.05^{b}	4.21±0.04^{b}	4.32±0.04^{b}	4.01±0.05^{bc}
28	5.39±0.05^{a}	4.67±0.06^{b}	4.41±0.04^{b}	4.55±0.03^{b}	4.30±0.04^{b}

$^{a-c}$Means with the same letter in each column are not significantly different (P≥0.05).

Total viable counts:

As shown, initial total viable counts (TVC) in all samples as control (C) and treated with garlic extracts T1 (20g/l), T2 (50g/l) and ginger extracts T3 (20g/l), T4 (50g/l) samples were in the range of 3.95 to 3.10 log10 CFU/g indicating very good fish quality, TVC values decreased significantly ($p<0.05$)

in all treatment compared to control from initial storage period to end of storage period. The mean TVC values of control increased from 3.95 to reached 5.39 mg/100 g of smoked catfish fillets at end of storage period which is higher than those of other treated samples which were found to be 4.67, 4. 41, 4.55 and 4.30 mg/100 g for T1, T2, T3 and T4, respectively, at the end of storage period. The control values was found to increase ($p < 0.05$) but remained below 7 log10 CFU/g in all treatments for 28 days of storage period, which is the Maximal Permissible Limit (MPL) for TVC recommended (ICMSF, 1986 and Ojagh *et al.,* 2010) in all samples. The values in the control samples were higher than their counterpart samples with storage period (Table 5). The increase of TVC in smoked catfish flillets during storage period has been demonstrated by (Bahmani *et al.,* 2011). The high levels of microorganisms shown on control samples from day 7 of storage period, resulted into significant differences ($P<0.05$) in TVC when compared with counterpart samples due to the strong antimicrobial activity of the organ sulfur compounds and other active components contained in garlic and ginger extracts (Lu *et al.,* 2011). TVC is the most common microbiological method aimed to detect and enumerate high proportion of the microbial population as possible. In practice, this usually means mesophilic, aerobic or facultative anaerobic bacteria, which account for the major part of the microflora in fish. A TVC method can only provide an estimate of the microbial population based on those cells that are recoverable under the test conditions. Some viable cells may not be recoverable by any existing method, while others may only grow at low temperatures, in the presence of specific growth factors, or in the absence of oxygen (Fulford *et al.,* 2004).

Organoleptic assessment of smoked catfish *(C. gariepinus)* fillets with different concentration of garlic or ginger extracts:

The organoleptic assessment of untreated control (C) and treated smoked catfish fillets samples with garlic extracts T1 (20g/l), T2 (50g/l) and ginger extracts T3 (20g/l), T4 (50g/l) were recorded at 0, 7, 14, 21 and 28 days

showed in (Table 6&7), indicated that colour, flavour appearance and overall acceptability during chilled storage period at +4±1°C decreased.

Table 6. Color and Flavour scores of liquid-smoked catfish fillets that were pretreated by various concentration of garlic (G.E.) or ginger(GI.E.) extracts throughout chilled storage period at 4±1°C for 28 days.

Storage period (Days)	Control (C)	Garlic		Ginger	
		T1 (20g/L)	T2 (50g/L)	T3 (20 g/L)	T4 (50g/L)
Colour					
0	9. 0 ± 0.21^{a}	9.1 ± 0.22^{a}	9.30 ± 0.21^{a}	9.2 ± 021^{a}	9.4 ± 0.20^{a}
7	8.6± 0.17^{b}	8.8 ± 0.15^{b}	9.1 ± 0.16^{a}	8.9 ± 0.15^{ab}	9.3 ± 0.16^{a}
14	8.3 ± 0.16^{b}	8.6± 0.16^{b}	9.0 ± 0.16^{a}	8.7 ± 0.15^{b}	9.1± 0.16^{a}
21	7.5±0.15^{b}	7.8±0.15^{b}	8.2±0.14^{a}	7.9±0.14^{ab}	8.4±0.14^{a}
28	7.2±0.14^{b}	7.6±0.13^{b}	8.10±0.12^{a}	7.9±0.12^{ab}	8.3±0.15^{a}
Flavour					
0	8.9 ± 0.18^{ab}	9.0 ±0.17^{a}	9. 2 ± 0.18^{a}	9.1 ± 0.18^{a}	9. 3 ± 0.17^{a}
7	8.4 ± 0.17^{b}	8.6 ± 0.16^{b}	8.9 ± 0.16^{ab}	8.7 ± 0.17^{b}	9. 0 ± 0.16^{a}
14	7.8 ± 0.16^{b}	8.1 ± 0.16^{a}	8.4 ± 0.15^{a}	8.3 ± 0.17^{a}	8.5 ± 0.16^{a}
21	7.5 ± 0.16^{b}	7.9 ± 0.14^{ab}	8.1 ± 0.13^{ab}	8.0 ± 0.15^{ab}	8.3 ± 0.16^{a}
28	7.2±0.14^{b}	7.5±0.14^{b}	8.0±0.15^{a}	7.8±0.13^{b}	8.0±0.15^{a}

$^{a-b}$Means with the same letter in each column are not significantly different (P≥0.05).

Smoking has been reported to affect the color of food (Espe and Maria, 2004), (Martinez *et al.*, 2007). The formation of the smoke color is believed to originate from an uptake of colored smoke constituents, oxidation and polymerization of smoke compounds, and reaction of smoke compounds with proteins; therefore, condensation reactions take place between carbonyls and amines, leading to the appearance of the typical smoke color (Toth and Potthast, 1984).

Cardinal *et al.* (2006) and Cardinal *et al.* (2001) indicated that color development depended mainly on carbonyls, while the flavor afforded was largely due to the type and amounts of phenolic compounds present. These compounds also influence the antioxidant effect of the liquid smoke.

Table 7. Appearance and Overall acceptability scores of liquid-smoked catfish fillets that were pretreated by various concentration of garlic (G.E.) or ginger(GI.E.) extracts throughout chilled storage period at 4±1°C for 28 days.

Storage period (Days)	Control (C)	Garlic		Ginger	
		T1 (20g/L)	T2 (50g/L)	T3 (20 g/L)	T4 (50g/L)
			Appearance		
0	9.0±0.15^{a}	8.9±0.13^{ab}	9.1±0.14^{a}	9.0±0.12^{ab}	9.2±0.13^{a}
7	8.1±0.14^{a}	8.3±0.14^{a}	8.6±0.13^{a}	8.4±0.15^{a}	8.7±0.14^{a}
14	7.9±0.03^{ab}	8.2±0.13^{a}	8.5±0.14^{a}	8.3±0.14^{a}	8.6±0.13^{a}
21	7.5±0.13^{b}	7.8±0.12^{b}	8. 1±0.13^{a}	7. 9±0.12^{ab}	8.3±0.13a
28	7.1±0.12^{b}	7.2±0.12^{ab}	7. 6±0.13^{a}	7. 3±0.13^{a}	7.8±0.13^{a}
			Overall acceptability		
0	8.9±0.14^{b}	9.0±0.13^{ab}	9.2±0.14^{a}	9.1±0.14^{a}	9.3±0.13^{a}
7	8.6±0.13^{b}	8.9±0.13^{ab}	9.1±0.14^{a}	9.0±0.14^{ab}	9.2±0.15^{a}
14	8.2±0.13^{b}	8.5±0.14^{ab}	8.8±0.13^{a}	8.6±0.14^{ab}	8.9±0.13^{a}
21	7.7±0.12^{b}	7.9±0.12^{ab}	8.1±0.13^{a}	8.0±0.13^{ab}	8.2±0.12^{a}
28	7.5±0.11^{b}	7.7±0.11^{b}	7.9±0.12^{ab}	7.8±0.12^{b}	8.0±0.13^{a}

^{a} - ^{b}Means with the same letter in each column are not significantly different (P≥0.05).

The highest overall acceptability was obtained in 50 g/l from ginger extracts (9.3; 9.2; 8.9; 8.2 and 8.0) and garlic extracts (9.2; 9.1;8.8; 8.1 and 7.9) after smoking 0, 7, 14, 21 and 28 days respectively, followed by in ginger extract (20 g/l),then garlic extract (20 g/l). Finally the lowest overall acceptability was obtained in control.

The acceptability decrease as weeks of storage period increased and increased as the concentration of spice increased, they were significantly different ($p < 0.05$) among the treatments and this results show that the highest concentration of ginger and garlic extracts were more acceptable compared to the control at 28 days of storage period. The result of organoleptic assessment shows that ginger and garlic extracts retards the activities of bacteria, enzymes and chemicals in fish. This is due to the movement of water out of bacteria cell that is more than into the cell and this result is in agreement with the report of Omojowo *et al.* (2010).

CONCLUSION

This study demonstrated the effect of liquid smoked with various concentration of garlic or ginger extracts on proximate composition, oxidative rancidity, microbial loads and organoleptic qualities of liquid-smoked catfish *(Clarias gariepinus*) fillets stored at (4±1°C.) during chilling storage period for 28 days. Using garlic or ginger extracts may be useful in reduction of oxidative rancidity, microbiological, improving the shelf life and consumer acceptability of smoked *C. gariepinus* and it was concluded that 50g/l of ginger or garlic extracts would positively influence shelf life, reduce oxidative rancidity and reduce or prevent pathogens in smoked catfish.

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تأثير مستخلص الثوم أوالزنجبيل على خصائص جودة تدخين شرائح أسماك القراميط المدخنة *(Clarias gariepinus)* خلال فترة التخزين بالتبريد

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الملخـص العربـى

تحتوى شرائح اسماك القراميط ***(Clarias gariepinus)*** على كمية مرتفعة من الأحماض الدهنية غير المشبعة مما يجعلها عرضة جدا لأكسدة الدهون اثناء التدخين .وعلاوة على ذلك، فإن طبيعة المنتج أيضا يجعلها عرضة للتلوث الميكروبي وانتشار البكتيريا المسببة للأمراض التي قد تسبب تفشي الأمراض المنقولة بالأغذية. لذلك يجب استخدام مضادات الأكسدة والعوامل المضادة للميكروبات الطبيعية مثل الأعشاب والتوابل.

صممت هذه الدراسة لتقييم التأثير المضاد للأكسدة و الميكروبات من تركيزات متساوية لمستخلصات الثوم (GE) والزنجبيل (GIE)على صفات الجودة الكيميائية و الحسية من شرائح اسماك القرموط***(Clarias gariepinus)*** المدخنة بطريقة التدخين السائلة خلال التخزين بالتبريد لمدة 28 يوما .ثم تم إجراء اختبارات مركبات الجودة الكيميائية (القواعد النيتروجينية الكلية الطيارة (TVB-N) ، وحمض الثيوباربتيوريك(TBA) ، ورقم البيروكسيد (PV) وكذلك الخواص الحسية و التقييم الميكروبيولوجي . .اظهرت النتائج ان نسبة المحتوى من الرطوبة انخفضت بينما ارتفع المحتوى من البروتين والدهون والرماد معنويا ($p <0.05$) . ايضا اظهرت كل النتائج انخفاض فى قيم PV و TBA في جميع المعاملات انخفاضا معنويا ($p<0.05$) بالمقارنة بالكنترول ،كما لوحظ انخفاض فى نمو الكائنات الحية الدقيقة (TVC)انخفاضا معنويا ($P <0.05$) بالمقارنة بالكنترول خلال فترة التخزين . كما اظهرت النتائج انخفاض فى قيم (TVB-N)بشكل ملحوظ ($p<0.05$) في جميع المعاملات مقارنة بالكنترول خلال فترة التخزين، وهذا يظهر تناقص تلف الانسجة والنشاط الميكروبى في جميع المعاملات أثناء فترة التخزين مقارنة بالكنترول.

وأظهر التقييم الحسي أن أعلى قابلية كانت للعينات المعاملة ب 50جرام / كجم من مستخلص الثوم خلال فترة التخزين .وارتفعت القابلية مع زيادة تركيز التوابل، وكانت مختلفة معنويا ($p <0.05$) بين المعاملات، وأظهرت هذه النتائج أن أعلى تركيز من مستخلصات الثوم والزنجبيل كانت أكثر قبولا مقارنة بالكنترول خلال 28 يوما .

النتائج التي تم الحصول عليها من هذه الدراسة تشير إلى أن مستخلصات الثوم أوالزنجبيل، من خلال آثارهما المضاد للأكسدة والمضاد للميكروبات ، يمكن أن تكون مفيدة في حفظ ، واطالة فترة التخزين من خلال تعطيل التلف وتحسين صفات الجودة لشرائح لاسماك القرموط المدخن بطريقة التدخين السائل والمخزنة على درجة حرارة $4 \pm 1\ ^\circ C$.