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PRESERVATIVE EFFECT OF GINGER (*ZINGIBER OFFICINALE*) PASTE ON FRESH NILE TILAPIA, *OREOCHROMIS NILOTICUS* AT ROOM TEMPERATURE

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Abstract

Fish begin to degrade the moment they are removed from the water. It requires extensive post-harvest processing to extend its shelf life and maintain its quality. Freezing, smoking, canning, sun-drying, pickling, and salting are the most common methods of preserving fish. The ability of fresh Oreochromis niloticus (Nile tilapia), a popular fish food in Ghana, to be preserved by ginger (Zingiber officinale) paste was investigated. Fresh fish samples were collected from the Bontanga reservoir's landing site and were divided into two; the ginger paste group and untreated group (control) kept at room temperature in a laboratory environment. During storage, fish samples from both the ginger-treated and control groups were subjected to daily physical inspection, proximate analysis, and microbiological quality testing. After the ginger treatment, the fish had a three-day longer shelf life. The fresh fish that had not been treated (the control) had spoiled by the end of the second day, showing signs of severe physical deterioration and maggot infestation in the flesh. Microbial research also revealed that all treated samples had a lower mean microbial population than untreated samples. In contrast to 10.50 x 10^5 cfu/cm^2 for the treated sample, the total Escherichia coli (EC) count for the untreated sample was 70.25 x 10^5 cfu/cm^2. This demonstrates that the ginger paste gradually slowed microorganism growth in the treated samples. The study found that ginger has bactericidal and anti-spoilage properties against conditions and microbes that cause fish to spoil. Future research could alter the concentration, lengthen the study period, and include different fish species.

Keywords: Tilapia, Ginger, Microbes, Preservation

Introduction

Thirty-five (35) percent of the world's fish catch, or 25 million, are lost after harvest (Kirkpinar et al., 2014; Kuley et al., 2019). Fish is the fresh food that is most susceptible to tissue breakdown, odour production, and microbiological deterioration (Gheisari and Ranjbar, 2012; Du et al., 2020). Fish start to deteriorate as soon as they are taken out of the water. Fishermen's efforts are wasted if their catch deteriorates and run into spoilage as a result of poor storage. Poor households that lack the resources to maintain fresh fish for usage in the least amount of time will be forced to store it in alternative forms that won't keep it that way (Viji et al., 2017; Lin et al., 2021). Finding effective ways to keep fish in a fresh state that may be used in the shortest amount of time has become more important. The key to extending the shelf life of fresh fish, maintaining its freshness, and preventing spoiling is the application of natural preservatives with no adverse effects. The appearance, odour, and texture of the raw fish are typically the only factors used in the trade to determine freshness (Negari et al., 2015).

Ginger is inexpensive, and it is also "Generally Recognized as Safe" (GRAS). Secondary metabolites found in the rhizome include phenolic compounds (gingerol, paradol, and shogaoal), volatile sesquiterpenes (zingiberene and bisabolene), and monoterpenoids (curcumene and citral) (Ali et al., 2008). Previous research has shown that *Z. officinale* plant extracts have strong antioxidant and free radical scavenging properties (Bakhouche et al., 2021; Erkmen and Bozoglu, 2016), as well as antibacterial, antifungal, anticancer, and anti-inflammatory effects (Yazhiniprabha et al., 2015; Ali et al., 2018; Islam et al., 2019). As a result, there is a great deal of interest in using ginger extract to improve the safety and quality of fish after harvest. This research sought to determine the effect of ginger paste on the preservation of *Oreochromis niloticus* appearance, odour and texture.

Materials and Methods

Study area

The study area (Fig. 1) is located in the Kumbungu District of Ghana, between latitude 9° 30" and 9° 35" N and longitude 1° 20" and 1° 04" W. The irrigation sys-

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tem is a 12 m high earth fill dam with a crest level of 5.00 m. The spillway level is 5.8 m above sea level, and the surface area at the spillway elevation is 770 m^2. The reservoir holds 25 million m^3 of water. The dead storage elevation is approximately 1.52 m, and the capacity is 5 million m^3. The spillway is a drop inlet with an 83.7 m length and a design discharge of 85 m^3/sec. There is also an emergency spillway. The irrigation system has a total potential area of 570 ha, of which all areas have been developed (Abdul-Ganiyu and Prosper, 2012).

Collection of Fish

Fifty (50) fresh Nile tilapia, *Oreochromis niloticus*, with an average weight of 200 grams were obtained from the Bontanga reservoir landing site. The fresh fish samples obtained directly from fishermen at the Bontanga reservoir landing site were packaged into sterilised polythene bags (175 mm 165 mm) and immediately transported to the Council for Scientific and Industrial Research (CSIR) - Water Research Institute (WRI), laboratory Tamale, where the experiment was carried out.

Ginger Paste

The ginger used in the experiment was purchased at the Tamale local market. One kilogram of ginger was obtained and immediately transported to the laboratory in a clean polythene bag. Green's field identification guide (2006) was used to confirm the identity of the ginger samples. It was then washed, blended with an Akai blender, and stored for future use.

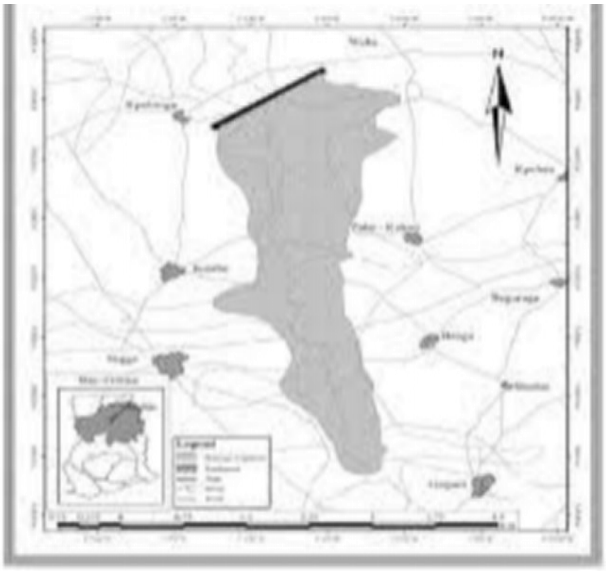

Fig.1: Map of Bontanga Irrigation Scheme Showing the Reservoir
Source: Energy commission, 2011

Experimental Design

The guts and scales of fresh samples were thoroughly removed and cleaned under running tap water. They were split into two groups of 25 fish (control and ginger paste). The ginger paste group was uniformly smeared with 200 g of ginger paste, ensuring that every part of the body, including the internal organs, were covered. The control group's remaining 25 fish were smeared with plain distilled water. The fresh fish samples, both untreated (control) and treated (ginger paste), were then placed on two separate trays in the laboratory for three days at room (ambient) temperature. The trays were left uncovered during the monitoring period.

Examination of Physical Characteristics

The physical changes in characteristics of the stored fresh fish were examined. During the storage period, there were noticeable changes in the texture, appearance, odour, and colour of the fish. During the experiment, these examinations and recordings were conduced at 8 am and 5 pm daily.

Microbial Quality Analysis

Tested fish samples (200 g) and 90 ml of 0.9 percent NaCl solution were placed in a sterile flask and homogenized using a homogenizer (Wisetis HG 15A, Germany). One ml of each sample was diluted serially (101 to 106) in 0.9 percent NaCl solution. The MacConkey agar media was prepared according to the manufacturer's instructions. One hundred (100) L of the dilution was inoculated onto specific culture media and incubated for 24 hours at 37 °C. Individual colonies were counted after incubation and the microbial load was calculated by multiplying the average number of colonies by the dilution factor. The total *Salmonella* spp. (SS), total *Escherichia coli* (EC), and total *Staphylococcus* spp. (StS) were all analysed in triplicate and expressed as log (cfu/g).

Data Analysis

R statistical software was used to analyze the data collected from the experiment (Version 3.3.2). For retrieved targeted bacteria from treated and untreated fresh *Oreochromis niloticus*, descriptive statistics such as means, standard deviation, and standard error were calculated.

ANOVA was used to determine whether there was a significant difference in the levels of retrieved targeted bacteria from treated and untreated fresh *Oreochromis niloticus* and the proximate analysis.

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Results

Physical Examination

At the start of the study, all the fresh fish samples had red blood gills, firm flesh, and a fresh fishy odour. However, only a few hours after the various treatments, significant differences were observed between the treated group and the control group, indicating that spoilage had already begun and was rapidly increasing in the control fish (Table 1).

Table 1: Changes in Physical (aesthetic) Characteristics in Ginger (*Zingiber officinale*) Treated and Untreated (control) Nile Tilapia (*Oreochromis niloticus*) During Ambient Laboratory Storage Conditions

Fish treatment	Day	Observed Changes
Ginger treated (200 g)	1	Firm flesh, red blood gills, ginger odour
Control		Soft flesh, pale gills, no ginger odour
Ginger treated (200 g)	2	Firm flesh, light red/pinkish gill, ginger odour
Control		Decomposing flesh, very bad odour, maggots and presence of houseflies
Ginger treated (200g)	3	Firm flesh, light red/pinkish gill, ginger odour
Control		Maggot flesh, tearing flesh, very bad odour, and houseflies

Proximate Composition

Results from the proximate composition of fish quality of both ginger treated and untreated were investigated as shown in Table 2. All the tested parameters for the proximate composition in the ginger treated including moisture, protein, fat, ash and carbohydrate content were significantly superior compared to the untreated (control).

Table 2: Proximate Chemical Composition of Nile Tilapia Fillet and Patties

Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	*P*- Values
Ginger treated fish	62.16 ± 0.17^{a}	22.18 ± 0.28^{a}	3.89 ± 0.16^{b}	1.88 ± 0.24^{a}	2.23 ± 1.26^{a}	0.002
Control fish	13.21 ± 0.26^{b}	9.02 ± 0.12^{b}	1.21 ± 0.23^{b}	0.97 ± 0.12^{b}	0.77 ± 0.14^{b}	0.07

All values reflect the mean and standard error (SE). Mean values in the same column bearing the same superscript do not differ significantly ($P < 0.05$)

Microbial Analysis

The daily average microbial count for total *Salmonella* spp., total *Escherichia coli*, and total *Staphylococcus* spp. for the untreated and treated samples is shown in Table 3. It is worth noting that samples treated with ginger paste had the lowest mean population of bacteria and were statistically superior to the control most especially at the third day ($P < 0.05$).

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Table 3: Daily Mean Bacterial Population in Ginger Treated and Untreated (control) Fresh *Oreochromis Niloticus* Under Ambient Laboratory Storage Condition

Days	Targeted bacteria	Treatment	Mean ±SE	*P*-value
1	**EC**	Ginger treated (200 g)	10.50 ± 6.01	0.18
	(x10³cfu/cm²)	Control	70.25 ± 38.63	
	SS	Ginger treated (200g)	0.00 ± 0.00	0.36
	(x10²cfu/cm²)	Control	0.25 ± 0.25	
	StS	Ginger treated (200g)	12.00 ±13.12	0.66
	(x10³cfu/cm²)	Control	16.75 ± 12.22	
2	**EC**	Ginger treated (200g)	126.00 ± 24.37	0.03
	(x10³cfu/cm²)	Control	468.50± 15.69	
	SS	Ginger treated (200g)	12.00 ± 5.67	0.50
	(x10²cfu/cm²)	Control	16.75 ± 3.33	
	StS	Ginger treated (200g)	123.00 ± 44.42	0.02
	(x10³cfu/cm²)	Control	139.50 ± 42.75	
3	**EC**	Ginger treated (200g)	129.00 ± 49.42	0.01
	(x10³cfu/cm²)	Control	176.50 ± 36.75	
	SS	Ginger treated (200g)	132.00 ± 24.31	0.002
	(x10²cfu/cm²)	Control	191.43 ± 27.15	
	StS	Ginger treated (200g)	144.20 ± 33.42	0.03
	(x10³cfu/cm²)	Control	168.44 ± 25.37	

Values are significant at P < 0.05

Discussion

A few hours after the ginger paste treatment, significant differences were visible between the treated and control fresh fish, indicating that spoilage had already begun and was rapidly increasing in the control fresh fish. Lim et al. (2011) and Ali et al. (2018) agreed that spoilage begins within 12 hours of capture in the tropics at room (ambient) temperature. On the second day of the experiment, maggot infestations and the presence of houseflies were noticeable in the control fish samples. The maggots appeared to have emerged from eggs laid by houseflies at the Bontanga landing site, where the fish were obtained. According to Ahmed et al. (2019), the composition of the microflora on freshly caught fish is determined by the microbial content of the water in which the fish lives. Furthermore, the ambient laboratory storage conditions favored egg incubation and hatching into maggots. The absence of this observation on the flesh of ginger-treated fish suggests that ginger contains chemicals that prevent the hatching of eggs that were deposited on the fish prior to treatment with ginger paste, preventing spoilage and extending the shelf life of fish. According to Idris et al. (2010) and Obemeata et al. (2011), the chemicals in ginger that are responsible for its antimicrobial activity are [6]-gingerol and [6]-shogaols.

Furthermore, significant differences in moisture, protein, fat, ash, and carbohydrate contents between the ginger-treated group and the control group demonstrate the ability of the ginger paste to preserve the fish by maintaining the qualities mentioned above when compared to the control. As a result, it suggests that right after harvest, fish shelf life and quality could be extended, thereby reducing the majority of postharvest losses by the use of ginger extract (Erkmen and Bozoglu, 2016; Ehsani et al., 2020).

Pathogenic bacteria such as *E. coli*, *Salmonella* spp., and *Staphylococcus* spp. were identified as a result of this research. The results clearly show that ginger inhibited the growth of microbes in samples treated with ginger paste (Khalafalla et al., 2015; Tairu et al., 2017). This suggests that ginger paste has an effect on the growth of bacteria (*Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* spp) (Sivasothy et al., 2014; Frank et al., 2014). The high mean population of total *Escherichia coli* (EC) in the un-

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treated sample compared to the treated sample at the third day indicates that ginger paste has been progressive in inhibiting microbial growth in the treated samples. According to Kumolu-Johnson et al. (2015) and Ayeloya et al. (2019), the chemicals in ginger that are responsible for its antimicrobial activity are [6]-gingerol and [6]-shogaols. Moreover, the growth of microbes in ginger paste treated group such as *E. coli*, *Staphylococcus aureus*, and *Salmonella* spp. could occur as a result of contamination during handling at the Bontanga reservoir landing site.

In addition, Ayeloya et al. (2019) suggests that pathogenic bacteria can be found in contaminated waters where fish is harvested. According to Sivasothy et al. (2014), the product is easily susceptible to bacteria and microbial attack due to the high nutritional value of the fish. According to Ayeloya et al. (2019), the survival of microorganisms responsible for spoilage during storage is dependent on the type of microorganisms and fish species, the fish history, means of catch and handling, and preservation processes aboard the fishing vessel. According to the International Commission on Microbiological Specification for Food, the maximum recommended bacteria count for high-quality fish products is 5.0×10^5 (5.0 cfu/g) (Legan et al., 2001). According to Legan et al. (2001) standards, the microbial population detected in the ginger paste treated fish samples in this study, including *Salmonella* spp., *E. coli*, and *Staphylococcus* spp., were somehow higher as recommended for good quality fish products. However, the quantity and quality of biologically active rhizome components are affected by cultivation activities and post-harvest treatment (Jajere et al., 2021). Regardless, this study found that ginger inhibited microbe growth and extended the shelf life of fresh *Oreochromis niloticus*.

In a similar situation, Iheagwara (2013) discovered that ginger extract is effective in slowing lipid oxidation in a smoke mackerel. However, studies show that when smoked mackerel is treated with ginger extract, the moisture content decreases while the fat, protein, and ash content increases (Iheagwara, 2013). Kumolu-Johnson et al. (2015) reported in a similar study that ginger extract is effective in preventing rancidity in hot-smoked catfish.

Conclusion

The study recorded the least mean values for the ginger treated samples indicating that ginger paste is responsible for the delay in microbial growth, improving upon flesh quality and extending the shelf-life of treated fresh fish (Nile tilapia) under ambient storage conditions during the experimental period. Ginger also inhibited the development and emergence of maggots in the fish flesh. Ginger paste and extracts may therefore be used in place of refrigeration for short duration preservation of perishable foods in households that do not have freezers. Ginger paste could also be used during power shortage to safe keep fish fresh before power is restored.

Further research may consider varying different species of fish with varying concentration of ginger paste.

Competing and Interest

Authors have declared no conflict of interest for this research.

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