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Preservative effect of garlic (*Allium sativum*) paste on fresh Nile tilapia, *Oreochromis niloticus* (Cichlidae)

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ABSTRACT

Fish begins to deteriorate as soon as it is captured from water and requires proper post-handling and preservation to increase its shelf life and retain its quality. The most popular methods used to preserve fish are freezing, canning, smoking, sun-drying, salting and pickling. This study explored the preservative effect of garlic (Allium sativum) paste on fresh Nile tilapia, Oreochromis niloticus, a widely preferred food fish in Ghana. Whole fresh fish samples obtained from a local market in Navrongo were treated with garlic paste and stored under ambient laboratory conditions. Garlic treated and untreated (control) fish samples were subjected to microbiological quality analysis and physical examination daily during the storage period. The garlic treatment extended the shelf life of the fish for three days. The untreated (control) fish had become spoiled by the end of the third day with evidence of extensive aesthetic deterioration and maggot infestation of the carcass. The study demonstrated that, garlic possesses bactericidal and other antispoilage properties against agents of fish spoilage.

Keywords: *Garlic, Nile tilapia, antibacterial, preservation, spoilage*

INTRODUCTION

Fisheries and aquaculture make an important contribution to the animal protein supplies of many communities in both the industrialized and developing worlds (Nautilus, 1997). At present, fish provides about 17 % of the world's animal protein intake and 6.7 % of all protein intake (FAO, 2016). Most of the world's edible fish catch directly goes to consumers in raw state and careful inspection is required for its freshness before purchase and consumption.

Fish is recognized as being a highly perishable commodity, with a relatively short shelf life (Regenstein and Regenstein, 1991). As soon as it is caught or it dies, fish loses its natural resistance to microbial attack and starts to undergo spoilage due to intrinsic enzymes, bacteria and fat oxidation

(rancidity) (Huss, 1994). The spoilage is easily noticed as it consists of changes in colour, odour or flavour, appearance and texture (Quang, 2005). Therefore, fish requires proper post-handling and preservation to increase its shelf life and retain its quality (FAO, 2011).

Berkel *et al*. (2004) defined preservation as the processing of foods so that they can be stored longer. The most popular methods of fish preservation used all over the world are freezing, canning, smoking, sun-drying, salting and pickling (Mayer and Ward, 1991; Obodai *et al*., 2011; Wilbur, 2002). However, treatment with spices known to possess antimicrobial properties has also been used to reduce the spoilage processes of food (Farag *et al*., 1989; Shelef, 1983).

Garlic (*Allium sativum*), a popular medicinal plant, has several benefits, such as reducing food-borne illnesses and food poisoning while preserving food as well as providing vitamins (Sherman and Billing, 1999). Garlic is native to central Asia and has long been a staple in the Mediterranean region. It is frequently used as seasoning in Asia, Africa and Europe (Rajsekhar *et al*., 2013). It is a bulbous perennial herb closely related to onion. It has a tall, erect flowering stem that reaches 2 – 3 feet in height. The plant has pink or purple flowers and the part used medicinally is the bulb. Formerly classified in the lily (Liliaceae) family, garlic, is now a member of the family Alliaceae and include two basic types - hard neck and soft neck. The hard neck garlics are characterized by hard, woody central stalks that extend down to the basal plate at the bottom of the bulb while the soft neck garlics have a non-woody pseudostem formed from overlapping leaf sheaths and rarely send up a flower stalk, unless stressed by climatic conditions (THSA, 2006).

This study therefore investigated the effect garlic paste has on preservation of fresh Nile tilapia (*Oreochromis niloticus*) obtained from a local market in Navrongo, Ghana.

MATERIALS AND METHODS

Collection of fish and garlic samples

Twenty (20) fresh Nile tilapia, *Oreochromis niloticus,* with average length of 20 cm were obtained from the local market in Navrongo where fresh fish are sold in the open on shallow pans. The fresh fish in this market is mostly supplied from fishers fishing in the Tono Reservoir which is located in Tono in the Kassena-Nankana Municipility of the Upper East Region of Ghana. The reservoir is approximately 10 km from Navrongo, the municipal's capital. The fish is often transported to the local market on ice in large ice chests by means of bicycles and motorbikes.

The 20 fresh fish samples obtained from the market were packaged in sterile polyethene bags and placed in an ice chest containing ice and immediately transported to the Danida sponsored Food Microbiology Laboratory of the University for Development Studies, Navrongo campus, where the experiment was conducted. The identity of the samples was confirmed using the field identification guide of Dankwa *et al*. (1999).

The garlic used for the experiment was also obtained from the same local market in Navrongo. About 5 Kg of garlic was obtained and placed in a clean polyethene bag and immediately transported to the laboratory. Identity of the garlic samples was confirmed using the field identification guide of Green (2006).

The experiment was started immediately the samples were delivered to the laboratory

within the early hours of the day, between 9 – 11 am.

Pretreatment of the fish with garlic paste

The garlic was peeled, washed with running tap water, rinsed in distilled water and macerated into a paste in a sterilized blender. Scales and guts of all 20 fresh fish samples were removed and the fish were thoroughly cleaned under running tap water. Ten (10) of the fish were uniformly smeared with the garlic paste, ensuring that every part of the body was covered, including the internal parts. The remaining 10 fish were not treated and these served as the control for the experiment. The treated and untreated (control) fresh fish samples were then placed on separate trays in the laboratory at ambient temperature for three days. The trays were left uncovered within the three-day period of the experiment.

Physical (aesthetic) examination

The stored fish were examined for changes in their physical (aesthetic) characteristics. Noticeable changes in the colour, odour, appearance and texture of the fish during the storage period were recorded. These examinations and recordings were done at 5 pm each day during the experiment.

Microbial quality analysis

Microbial quality analysis for target organisms was performed according to the protocols described in APHA (2005) for total heterotrophic bacteria (HB), total *Salmonella* sp. (SS), total coliforms (TC) and total *Staphylococcus* sp. (StS). Enumeration of 0.1 ml of each target bacterial population was done using the colony counter after spread plating and incubating the samples at 37 ^{o}C for 24 - 48 hours in duplicates on recommended media prescribed in APHA (2005). Bacterial populations were recorded as colony forming units per gram (cfu/g) of fish.

Statistical analysis

Analyses of the data collected from the experiment was done using the XLSTAT statistical software (2014 version). Descriptive statistics such as mean, standard deviation and standard error were computed. A one-way analysis of variance (ANOVA) was used to test the significant difference in levels of retrieved bacteria from the treated and untreated fresh tilapia. The Tukey's post-hoc test (HSD) was used if the means of two different groups under comparison were significantly different in the normally distributed population from which the samples were drawn. $p < 0.05$ was regarded as statistically significant.

RESULTS AND DISCUSSION

At the beginning of the study, all the fish samples possessed blood-red gills, firm flesh and fresh fishy odour characteristic of the species. However, after the garlic treatment, noticeable differences were evident between the treated and the control fish, implying spoilage had already begun and progressing in the control fish with time (Table 1). Maggots were found in the carcass of the control fish by the end of the third day. Apparently, the maggots emerged from eggs that might have been deposited by houseflies on the exposed fish in the market before the sampling was done. The ambient laboratory storage conditions favoured the incubation and hatching of the eggs into maggots. The absence of this observation in the carcass of the treated fish suggests that garlic has chemicals that inhibit spoilage.

Table 1: Changes in physical (aesthetic) characteristics in garlic (*Allium sativum*) treated and untreated (control) Nile tilapia (*Oreochromis niloticus*) during ambient laboratory storage conditions

Fish treatment	Day	Observed characteristics
Garlic treated	1	Firm carcass; blood red gills; garlic odour
Control		Soft carcass; pale gills, no garlic odour
Garlic treated	2	Firm carcass; light red/pinkish gills; garlic odour
Control		Flabby flesh; grey gills; objectionable odour;
Garlic treated	3	Dry flesh/carcass; light red/pinkish gills; maggots absent; garlic odour
Control		Decomposing flesh/carcass; very bad odour; maggots present

The various bacterial (total heterotrophic, total coliform, total *Staphylococcus* and total *Salmonella*) populations observed in the treated fish were significantly ($p < 0.05$) lower than the populations in the control fish throughout the storage period (Table 2). This demonstrates the efficacy of the garlic treatment as a preservative.

Table 2: Mean daily bacterial populations in the garlic-treated and untreated (control) Nile tilapia (*Oreochromis niloticus*) under ambient laboratory storage conditions

		Bacterial populations			
Treatment	**Day**	**HB ($x10^4$cfu/g)**	**TC ($x10^3$cfu/g)**	**StS ($x10^2$cfu/g)**	**SS ($x10^2$cfu/g)**
Garlic-treated	1	2.1 ± 0.70^a	0.7 ± 0.70^a	1.5 ± 0.70^a	0 ± 0.00^a
control		29.5 ± 0.70^b	11.8 ± 0.70^b	16.3 ± 0.70^a	2.8 ± 0.70^b
Garlic-treated	2	1.3 ± 0.70^a	0.3 ± 0.00^a	0.9 ± 0.00^a	0 ± 0.00^a
control		251 ± 1.41^b	25.3 ± 0.70^b	22.0 ± 0.70^b	3.5 ± 0.70^b
Garlic-treated	3	0.8 ± 0.00^a	0.2 ± 0.00^a	0.4 ± 0.00^a	0 ± 0.00^a
Control		1284 ± 1.41^b	255 ± 1.41^b	245 ± 1.41^b	7.4 ± 0.70^b

HB - Total heterotrophic bacteria; TC - Total Coliform; StS - Total *Staphyloccocus* sp.; SS - Total *Salmonella* sp. Values in a column bearing the same superscript are not significant at 5% ($p < 0.05$).

The microbial populations observed in the treated fish samples in this study including *E. coli, Salmonella, Staphylococcus* and *Coliforms,* were all within the recommended limits for good quality fish and fish products according to ICMSF (1986) standards.

The identification of the responsible active chemicals in the garlic and elucidation of the mechanisms of their antimicrobial activity were not investigated in this study. However, this study demonstrated that garlic can effectively delay microbial growth and extend the shelf-life of fresh fish (Nile tilapia) under ambient storage conditions. In addition to this ability of garlic, it is also known to help prevent cardiovascular diseases such as atherosclerosis, high cholesterol and hypertension; and certain types of cancer including stomach and colon cancers (Kemper, 2000; Rajsekhar *et al*., 2013). In other studies, it has been demonstrated that garlic chemicals exhibit

inhibitory effects on bacterial growth and spread in some meat (Antonia da Silva *et al*., 2008). Mukhtar and Ghori (2012) reported that it is therapeutically effective because of its oil and water soluble organosulphur compounds while Hughes and Lawson (1991) also explained that thiosulfinates are mainly responsible for garlic's antibiotic activity since extracts free of thiosulfinates normally lose their antimicrobial capacity.

CONCLUSION

This study has demonstrated that garlic can effectively delay microbial growth and extend the shelf-life of treated fresh fish (Nile tilapia) under ambient storage conditions for three days. Garlic also inhibited the development and emergence of maggots in the fish carcass. Garlic paste and extracts may therefore be used in place of refrigeration for short duration preservation of perishable foods in poor households. Further work may consider identification and extraction of the antibactericidal agent(s) in garlic for both academic interest and commercial purpose.

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