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SHORT COMMUNICATION

Effect of spice treatments on the microbial load of fish floss produced from tilapia (*Oreochromis niloticus*)

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Introduction

Fish floss (Dambun kifi) is a fish product produced mostly in the northern Nigeria by mainly the Hausas and Fulanis. It is a shredded or mashed fish meat/flesh cooked in spices and then stir fried until the fish flesh is dry and powdery. Fish floss is quite different from other flosses; it has very nice and attractive aroma ahead of them. It is quite easier, though, it also requires time and energy, but fish due to its softness do not need grinding or beating with a wooden stick. It requires less oil than other flosses (Lisa, 2019).

Fish floss, known as "abon ikan" in Indonesia, is a traditional dried fish product appreciated for its light, fluffy texture and sweet flavour. This delicacy plays a significant role in various Asian cuisines, including Indonesian, Malaysian, Thai, and Chinese culinary traditions. It is commonly consumed as a topping for rice, congee, and noodles, or as a filling in pastries and buns. Beyond its culinary applications, fish floss offers notable nutritional benefits, making it a valuable addition to diets (Rahayu *et al*., 2022). It is a widely consumed ready-to-eat (RTE) product prized for its convenience, palatability, and shelf stability relative to fresh fish. Process parameters such as shredding, seasoning, prolonged frying, oil drainage, and packaging shape the product's moisture, lipid oxidation, and microbial profile, which together determine shelf life and safety. Within fish and fishery products, spice treatments have demonstrated practical efficacy. Herbal or spice additions such as pepper, thyme, and oregano have been reported to reduce microbial counts and slow oxidation in processed fish matrices (Jaworska *et al.,*2021).

One of the major challenges facing fish utilization is the high rate of post-harvest losses, estimated at 35-50% in developing countries, particularly in sub-Saharan Africa (FAO, 2020). These losses are exacerbated by poor processing and preservation methods, limited infrastructure, and inadequate knowledge of value-added fish products, hence, limited

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availability of fish products with prolonged shelf life to meet up with the protein dietary need of the Nigerian populace as such, huge post- harvest loss is prevalent (Agbabiaka*,* 2015).The current study aims to evaluate the effect of spice treatment on the microbial load of fish floss produced from tilapia (*Oreochromis niloticus*).

Syzygium aromaticum is an aromatic spice that has been widely used for centuries in culinary, medicinal, and industrial applications. Historically, clove was a highly valued spice in global trade, with its origins linked to the Spice Islands of Indonesia. Traders from the Middle East, Europe, and Asia sought after this precious spice due to its rich aroma and medicinal benefits. The demand for clove was so high that it played a crucial role in shaping global trade routes and colonial expansions (Nurdjannah & Bermawie, 2018). Today, clove is extensively cultivated in various parts of the world and remains an integral part of traditional medicine, food preservation, and cosmetic formulations. Its diverse applications continue to make it one of the most significant spices worldwide.

Cloves hold significant importance across various industries, including medicine, food, cosmetics, and agriculture. Its antimicrobial, antioxidant, and anti-inflammatory properties make it a valuable natural remedy for various health conditions (Hussain *et al.,* 2017). Additionally, clove's role in flavour enhancement and food preservation contributes to its widespread use in culinary applications (Rather *et al.,* 2018).

Ginger (*Zingiber officinale*), a flowering plant belonging to the *Zingiberaceae* family, has been widely used for centuries, both as a spice and for its medicinal properties. This rhizomatous plant is indigenous to Southeast Asia, but it has become a staple in kitchens and traditional medicine across the globe (Babu & Srinivasan, 2013). The medicinal value of ginger lies in its bioactive compounds, particularly gingerol, which is responsible for its characteristic aroma and many of its therapeutic effects (Sharma *et al.,* 2021).

Ginger (*Zingiber officinale*) is native to Southeast Asia, where it thrives in tropical and subtropical climates. The plant can grow up to one meter tall and produces narrow, lance-shaped leaves that are alternately arranged along the stem. Its flowers are typically yellow or green, and the fruit is a capsule containing seeds. However, it is the rhizome, or underground stem, that is primarily harvested and consumed due to its medicinal properties and culinary uses. The rhizome is typically knobby and beige in appearance, with a firm texture that softens when boiled or dried (Grzanna *et al.,* 2005). Ginger's use as a spice date back at least 2,000 years in India, where it has been a staple in both cooking and medicine (Gao *et al.,* 2013). The active constituents in ginger are responsible for its medicinal properties, and these compounds are primarily concentrated in the rhizome. Gingerol, the primary bioactive compound, is a phenolic compound that imparts the characteristic pungency and warmth associated with ginger. Gingerol has been shown to have potent anti-inflammatory and antioxidant effects, making it effective in combating chronic diseases. Shogaol, another compound found in ginger, is a dehydration product of gingerol and is known for its stronger pungent taste. It has also been shown to have anti-cancer, anti-inflammatory, and anti-nausea properties (Surh, 2002). Zingerone, which is formed when gingerol is heated, possesses antioxidant activity and has been studied for its potential in protecting cells from oxidative damage.

The volatile oils present in ginger, including camphene, cineole, and zingiberene, also contribute to its medicinal effects. These oils are largely responsible for the aroma of ginger and are known for their antimicrobial and anti-inflammatory effects. These compounds have been found to play a crucial role in protecting the body against bacterial, fungal, and viral infections. Research on the chemical composition of ginger suggests that the various components work synergistically to produce its therapeutic effects, targeting different molecular pathways involved in inflammation, oxidative stress, and disease progression. For instance, gingerol and its derivatives are known to inhibit pro-inflammatory pathways, such as the cyclooxygenase (COX) pathway, which is crucial in the development of inflammation.

The complex array of bioactive compounds in ginger provides its broad spectrum of health benefits, and many of these compounds exhibit antioxidant properties that help prevent damage to cells from free radicals. The antioxidant capacity of ginger has been linked to its potential role in reducing the risk of chronic conditions, including cardiovascular diseases, diabetes, and even certain types of cancer. The chemical composition of ginger also enables it to enhance the bioavailability of other nutrients, further boosting its health-promoting effects. Studies continue to uncover new compounds in ginger and their potential mechanisms of action, highlighting the significance of this herb in modern herbal medicine known for anti- inflammatory, anti-oxidative, analgesic and anti-microbial effect (Surh, 2002).

Materials and Method

Study area

The study was carried out in the Fish Processing Unit and the Hospitality Department of the Federal College of Freshwater Fisheries Technology (FCFFT), New Bussa, Niger State, Nigeria.

New Bussa is the headquarters of Borgu Emirate and Borgu Local Government Area in Niger State, Nigeria. It is approximately located between latitude 9.88°N and 9.89°N and longitude 4.52°E and 4.52° (NIFFR Archives, 2023).

Source of experimental fish and materials

The experimental fish species, African catfish Nile *tilapia* (*Oreochromis niloticus*), was purchased fresh from the Monday Market, New Bussa, Borgu Local Government Area, Niger State, Nigeria.

The materials used in the experiment included fresh fish sodium chloride (NaCl; table salt), ginger (*Zingiber officinale*), clove (*Syzygium aromaticum*), seasoning cubes, onion (*Allium cepa*), pepper (*Capsicum annuum*), vegetable oil, curry powder, thyme, lime (*Citrus aurantiifolia*), stainless steel bowls, sharp knife, cutting slab, turning spoon, frying pot, packaging materials, weighing balance (*Diamond and Five Goats' Products*), and a Smeg electric cooker.

Experimental design

Tilapia (*Oreochromis niloticus*) was used for this study. A total of 20 kg of fish species was processed. Three spice treatments were used: ginger, clove, and a combination of ginger and clove. Each treatment was replicated three times, giving a total of twelve (12) experimental samples laid out in a completely randomized design (CRD). The samples were treated and labeled T0, T1, T2 and T3 for control, ginger, clove and combination of ginger and clove respectively.

Procedure for the production of fish floss

The production of fish floss followed the method described by Isah (2018) with slight modifications. The fish samples were rubbed with lime juice to remove surface slime, washed thoroughly with clean water, descaled, degutted, and de-finned. Each 5 kg portion was weighed using a digital weighing balance. Ten grams (10g) of table salt, five (5) seasoning cubes (4g per cube), two chopped onion bulbs, and 100 g of fresh pepper were added to each sample. The appropriate spice treatments (ginger, clove, or combination) in powdered form were incorporated according to the design.

The fish was cooked at 63 °C for 30 minutes using a Smeg electric cooker, following U.S FDA/USDA (2021) safe cooking guidelines, until the flesh became tender. After cooking, the fish was strained to reduce moisture (Isah, 2018), deboned, and de-skinned to obtain boneless flesh. The flesh was shredded into fine fibres and shallow-fried using two (2) tablespoons (10ml) of vegetable oil at 180 °C (U.S FDA/USDA, 2021) for 30 minutes, until the moisture content reached a level suitable for shelf-life stability.

Microbial analysis

Microbial analysis was conducted to determine the effect of spice treatments on the microbial load of the fish floss samples. The analysis focused on total plate count (TPC), coliform count, and specific pathogenic bacteria.

***Sample preparation*:** Ten grams (10g) of each fish floss sample was aseptically homogenized in 90 mL of sterile peptone water to prepare a 10^{-1} dilution. Serial dilutions up to 10^{-6} were prepared following standard microbiological procedures (ISO 6887-1:2017a).

***Total plate count (TPC)*:** Nutrient agar plates were inoculated with appropriate dilutions using the pour plate method. Plates were incubated at 37 °C for 24 hours, and colonies were counted as CFU/g (Harrigan, 2018).

Staphylococcus aureus Count: Mannitol Salt Agar (MSA) was used for detection of *Staphylococcus aureus.* Plates were incubated at 37 °C for 24–48 hours, and yellow colonies were recorded (Baird-Parker, 2017).

***Salmonella detection*:** Xylose Lysine Deoxycholate (XLD) agar was used. Suspected colonies were confirmed biochemically following ISO 6579-1: (2017b).

***Fungal count*:** Potato Dextrose Agar (PDA) supplemented with chloramphenicol was used for fungal growth. Plates were incubated at 25 °C for 3–5 days and colonies enumerated as CFU/g.

All microbial counts were expressed as log CFU/g, and results were compared across treatments (T0–T3) to evaluate the antimicrobial effects of ginger and clove treatments.

Data analysis

Data collected were transformed as log CFU/g and subjected to two – way analysis of variance (ANOVA) followed by Turkey`s multiple comparison test, with significance set at $P < 0.05$, using Gragh Pad Prism version 8.2.

Results

After third month of storage, bacterial counts increased in all treatments except T1, which recorded zero microbial growth. T0 had the highest growth, followed by T3 and T2.

Significant differences were observed among treatments (*) and over storage period (#), but T0 and T3 showed no significant difference in the fifth month (ns).

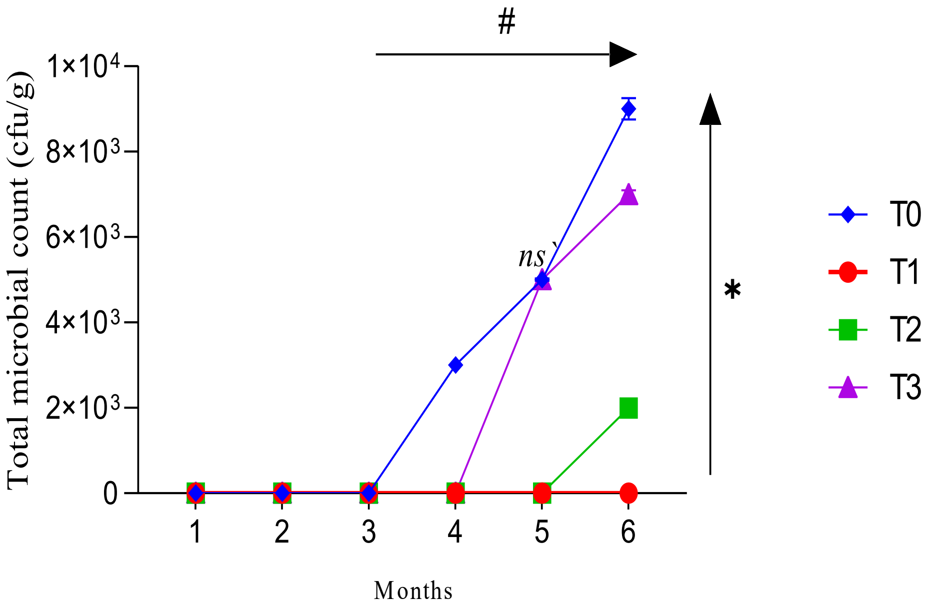

Fig 1: Total bacterial count (cfu/g) of fish floss produced from tilapia
KEY
T0 – Control (untreated)
T1 - Ginger treated sample (5g)
T2 – Clove treated sample (5g)
T3 – Combination of ginger and clove (2,5g of each spice)

The total fungi count (cfu/g) in fish floss made from tilapia increased significantly from fourth to sixth months storage period, particularly in the untreated control group (T0), while the samples treated with spices especially T1 and T2 showed no fungal growth throughout the storage duration; statistical analysis indicated significant differences both among spice treatments (#) and across storage months (*), with no significant differences (ns) observed during the first three months. The bacteria and fungi identified include *Staphylococcus epidermidis, Staphylococcus aureus, Bacillus subtitis, Bacillus megatrend, Salmonella spp and Shigella spp* and *Mucor mucidor*, *Aspergillus niger Penicillium spp* respectively.

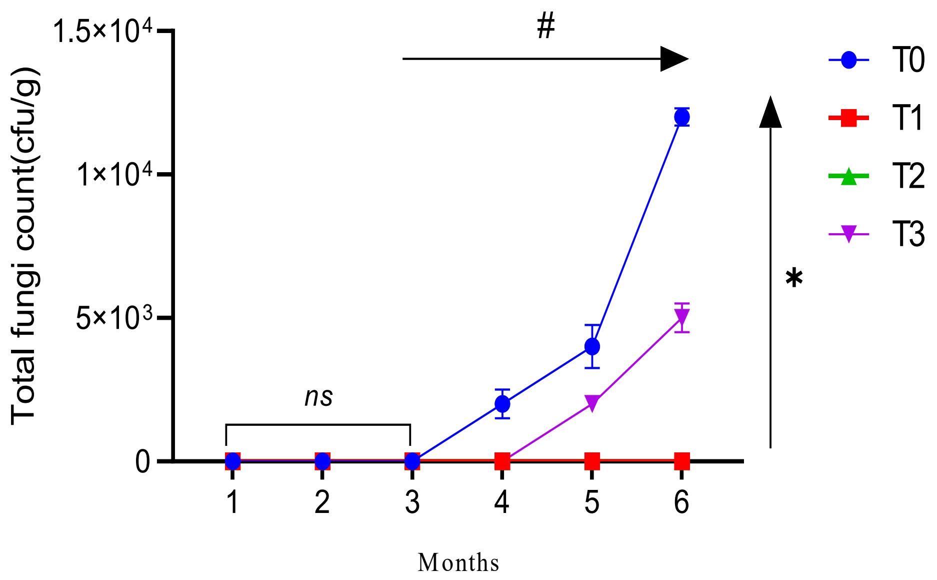

Fig 2: Total fungi count (cfu/g) of fish floss produced from tilapia

Discussion

Clove contains a diverse range of bioactive compounds, including essential oils, tannins, alkaloids, flavonoids, and phenolic compounds. The major constituent of clove essential oil is eugenol, which constitutes about 70–90% of the total oil content. Other important compounds include acetyl eugenol, β-caryophyllene, and vanillin. Eugenol is responsible for the strong, spicy aroma and numerous therapeutic effects of clove. It exhibits antibacterial, antifungal, and antioxidant properties, making it a key ingredient in many medicinal and cosmetic formulations. The presence of other bioactive components enhances the synergistic effects of clove in various applications especially for preservation (Rather *et al.,*2018).

The active constituents in ginger are responsible for its medicinal properties, and these compounds are primarily concentrated in the rhizome. Gingerol, the primary bioactive compound, is a phenolic compound that imparts the characteristic pungency and warmth associated with ginger. Gingerol has been shown to have potent anti-inflammatory and antioxidant effects, making it effective in combating chronic diseases. Shogaol, another compound found in ginger, is a dehydration product of gingerol and is known for its stronger pungent taste. It has also been shown to have anti-cancer, anti-inflammatory, and anti-nausea properties (Surh, 2002). Zingerone, which is formed when gingerol is heated, possesses antioxidant activity and has been studied for its potential in protecting cells from oxidative damage.The volatile oils present in ginger; including camphene, cineole and zingiberene, also contribute to its medicinal effects. These oils are largely responsible for the aroma of ginger and are known for their antimicrobial and anti-inflammatory effects. These compounds have been found to play a crucial role in protecting the body against bacterial, fungal, and viral infections. Research on the chemical composition of ginger suggests that the various components work synergistically to produce its therapeutic effects, targeting different molecular pathways involved in inflammation, oxidative stress, and disease progression. For instance, gingerol and its derivatives are known to inhibit pro-inflammatory pathways, such as the cyclooxygenase (COX) pathway, which is crucial in the development of inflammation.

The complex array of bioactive compounds in ginger provides its broad spectrum of health benefits, and many of these compounds exhibit antioxidant properties that help prevent damage to cells from free radicals. The antioxidant capacity of ginger has been linked to its potential role in reducing the risk of chronic conditions, including cardiovascular diseases, diabetes, and even certain types of cancer. The chemical composition of ginger also enables it to enhance the bioavailability of other nutrients, further boosting its health-promoting effects. Studies continue to uncover new compounds in ginger and their potential mechanisms of action, highlighting the significance of this herb in modern herbal medicine.

In the fish sample, bacterial counts rose over time in all treatments except T1, which recorded zero micrbial load with high evidence of antimicrobial potency. The control (T0) recorded the highest bacterial counts (~1×10^4 cfu/g by the sixth month), followed by T3, with T2 showing moderate increases. Statistically, both spice treatments and storage duration significantly influenced the microbial load (# and *, respectively), though T0 and T3 were not significantly different at month 5 (ns).

These finding support earlier reports on the efficacy of spice-derived bioactives in fish preservation. Essential oils and spice extracts such as cinnamon, clove, and turmeric incorporated into edible films demonstrated significant antimicrobial activity, extending fish shelf life (Sharma *et al.,* 2021).

Fungal counts in tilapia floss similarly rose over storage, with the control (T0) showing a marked increase from month four, peaking at ~1.3×10^4 cfu/g by month six. In contrast, treatments with spices especially T1, and to a lesser extent T3 maintained negligible or undetectable fungal loads across the entire period. Both spice type (#) and storage duration (*) significantly influenced fungal growth ($p < 0.05$), whereas early storage (months 1–3) showed no significant change (ns), consistent with the inherent microbial stability of dried matrices.

This underscores the effectiveness of natural spice-based antimicrobials in prolonging shelf life and suppressing spoilage fungi in fish products, supporting the shift toward plant-based preservation in food technology (Nie *et al.,* 2025; Kamau *et al.,* 2025).

Conclusion

The findings of this study demonstrated that the incorporation of spices significantly influenced the microbial stability of fish floss during storage. Samples treated with spice extracts maintained lower bacterial and fungal loads most especially the sample treated ginger compared to the untreated control, highlighting the antimicrobial and preservative potential of natural spices. This suggests that spices not only enhance the sensory attributes of fish products but also serve as effective bio-preservatives, thereby extending shelf life and ensuring food safety. Consequently, the use of spices offers a sustainable and consumer-friendly alternative to synthetic preservatives in fish processing and storage.

Based on the findings, It is therefore, recommended that spice incorporation be adopted as a natural preservation strategy in the production of fish floss. The demonstrated ability of spices to retard lipid oxidation, suppress microbial and fungal growth, and stabilize protein, mineral, and amino acid profiles indicates their potential to extend the shelf life and nutritional value of fish-based products. Processors should therefore integrate selected spice formulations into fish floss production, as this will not only enhance consumer safety and acceptability but also improve market competitiveness.

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