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***In Vitro* Assessment of the Antibacterial and Antifungal Activities of Water Berry (*Syzygium guineense*) Leaf Extracts on Post-Harvest Microorganisms Associated with Tomato Fruits Spoilage**

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Abstract

Tomato is a common perishable fruit which spoil few days after harvest mainly due to microbial activities. The study evaluated the antibacterial and antifungal activities of ethanolic and aqueous extracts of *Syzygium guineense* leaves against microorganisms associated with post-harvest spoilage of tomato fruits. Bacterial (*Bacillus cereus*, *Micrococcus luteus*, *Erwinia carotovora*, *Escherichia coli*, *Xanthomonas campestris*, *Lactobacillus plantarum*) and fungi (*Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporium*, *Rhizopus stolonifer* and *Saccharomyces cerevisiae*) were isolated from tomato fruits undergoing spoilage. Pathogenicity of isolate was determined by re-inoculation of the isolates into healthy, surface-sterilized tomato fruits using established pathogenicity criteria. Antimicrobial activity of ethanolic and aqueous extracts of *S. guineense* leaves was assessed against the above microorganisms by the agar well diffusion method, and minimum inhibitory concentrations (MICs) were determined for both extracts. The ethanolic extract demonstrated significantly higher inhibitory activity than the aqueous extract across all test organisms ($p < 0.05$). MIC values ranged from 12.5–25 mg/mL for bacteria, while higher concentrations were required for fungal inhibition, indicating differential susceptibility. These findings highlight the broad-spectrum antimicrobial potential of *S. guineense* leaf extracts and support their application as eco-friendly, plant-based alternatives to synthetic preservatives. The study revealed prospects for potentially active antimicrobial agents from *S. guineense* leaf extracts.

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1.0 Introduction

Tomato (*Lycopersicon esculentum* Mill) is one of the most widely consumed horticultural crops, valued for its nutritional content, culinary versatility, and economic importance (González et al. 2011; Umeohia and Olapade, 2024). However, high moisture content and delicate tissue structure make tomatoes highly perishable after harvest. Loss of tomato quality after harvest are

attributed to a complex mix of physiological, pathological, microbiological, and mechanical processes (Snyder, 2024). Losses due to microbial spoilage remain substantial, especially under tropical and subtropical conditions with limited cold-chain infrastructure. These losses undermine food security and household income, particularly in developing regions (Peralta-Ruiz et al., 2020).

Post-harvest spoilage is a complex process driven by a diverse array of bacteria and fungi that compromise fruit integrity through enzymatic and metabolic activity (Fadiya and Chhaya, 2024; Zaman et al., 2025). Conventional control strategies such as refrigeration, modified atmosphere packaging, and synthetic preservatives have been used. Nonetheless, synthetic antioxidants and preservatives such as BHA and BHT have been associated with potential health risks including carcinogenicity and endocrine disruption, raising regulatory and consumer concerns (Kator et al., 2018; Nieto et al., 2024). As a result, interest in plant-derived antimicrobials has surged, due to their biodegradability, safety, and cultural acceptability in food systems.

Syzygium guineense (Myrtaceae) is a tree native to West Africa (Badou et al., 2020), possesses leaves rich in bioactive compounds such as triterpenes, flavonoids, and phenolic acids (Nguyen et al., 2016), and have demonstrated antimicrobial properties against several human pathogens (Mavanza et al., 2023). However, there remains a gap in the literature regarding its application against food spoilage organisms specifically within a food matrix context, as required for direct relevance in food microbiology research. The present research aims to address this gap by evaluating the antimicrobial efficacy of aqueous and ethanolic extracts of *S. guineense* leaves against spoilage microbes isolated from decaying tomatoes.

2.0 MATERIALS AND METHODS

Sample Collection

Tomato (*Lycopersicon esculentum* Mill) were purchased from retailers at Shasha market (5°14'35" E, 7°16'40" N) in Akure, Ondo state into a sterile plastic container and transported into the laboratory for analysis. The samples were identified and authenticated at the herbarium of Department of Crop, Soil and Pest Management of the Federal University of Technology, Akure. At the laboratory, healthy fruits were sorted out to obtain homogeneous batches based on colour, size, texture, and absence of bruises. Fruits were selected to obtain samples ranging from 80g to 85g.

2.1 Isolation of Microorganisms Associated with Spoilt Tomato Fruits

A batch consisting of 10 tomato samples was allowed to stand at room temperature for 7-14 days to hasten spoilage of the samples. On the seventh day of exposure, the samples were

macerated using mortar and pestle. Serial dilution of the samples was carried out and 0.1 mL aliquot from 10^{-2} - 10^{-4} dilutions were aseptically inoculated into different sterile petri dishes. The nutrient agar plates for bacteria isolation were incubated at 37 °C for 24 h while potato dextrose agar plates for the isolation of yeast and molds were incubated at 27 °C for 72 h.

2.2 Identification of Microorganisms Associated with Spoilt Tomato Fruits

Colonies formed after incubation were sub-cultured on nutrient agar and Potato Dextrose agar to produce distinct pure cultures of bacteria and fungi respectively and these were further studied for identification. The cultures were preserved by inoculating them on agar slant prepared from double strength nutrient agar and Potato Dextrose agar in McCartney bottles. Identification of bacterial isolates was done using morphological and biochemical characterization according to the methods described by Cheesbrough (2010).

2.3 Pathogenicity Testing

Pathogenicity was confirmed by re-inoculation of the isolates into healthy, surface-sterilized tomato fruits using established pathogenicity criteria (Danaski, 2022). Healthy tomato samples were washed under running tap to exclude dirt from the surfaces. These were then surface sterilized in 1% NaCl for three minutes, rinsed in three changes of sterile distilled water and wiped dry using a sterile blotting paper. A sterile 5mm cork-borer was used to punch the tomatoes and the cut portion was removed. The same size of the cork-borer was used to cut the sections of each of the cultures of the previously isolated fungal pathogens and the discs were used to inoculate the healthy wounded tomatoes. The wound on the inoculated tomatoes was sealed using a sterile adhesive tape. The control was also set in the same manner, with sterile PDA used in place of the fungal cultures. The samples were placed in a sterile desiccator as treatment, replicated three times and stored at room temperature (25 °C) in the laboratory. Disease development was checked daily for 5 days. The pathogens were isolated and identified as described earlier. Symptoms were observed over a 7-day period and compared with uninoculated controls.

2.4 Preparation of Extracts

Fresh matured leaves of *S. guineense* were collected, washed, air dried under shade for 14 days. Dried material was grinded and extracted

separately with distilled water and absolute ethanol using cold maceration for 72 hours with periodic agitation. Extracts were filtered with Whatman filter paper (150 mm size and concentrated under reduced pressure. A total of 400 g powder was extracted by maceration for 72 h, filtered with Whatman filter paper (150 mm size), and the residue extracted further two times by maceration with the same duration (72 h each). Finally, the combined filtrate was kept in an oven (40 °C) for concentration. Further drying process was carried out in a desiccator for removal of water. Finally, the dried extract was maintained at -4 °C till the beginning of the actual experiment.

2.5 Preparation of McFarland turbidity standard

The reference stock (McFarland Turbidity Standard) for adjusting bacteria turbidity was made by mixing 9.95 ml of 1% sulfuric acid and 0.5 ml of 1.2% barium chloride dihydrate in a 10ml sterile test tube which was shaken to maintain the suspension, closed tightly and stored at 25±2 °C awaiting use.

2.6 Antimicrobial Screening

Antimicrobial activity was assessed by agar well diffusion method according to Chen et al. (2025). Mueller-Hinton agar plates were inoculated by spreading 100 µL of bacterial suspension (1.5×10^8 CFU/mL) uniformly across the surface. Sterile 9mm wells were bored into the agar. Each well was filled with 50 µL of extract solution at predetermined concentrations - 100, 75, 50, 25 mg/mL in each well under aseptic conditions. Ethanol (70 %) and Streptomycin solution (1 mg/mL) were included as negative and positive controls,

respectively. Plates were allowed to diffuse at room temperature (~20 min), then incubated at 37 °C for 18–24h. Zones of inhibition (clear halos) were measured (mm, with well diameter) with a ruler. suspensions before addition of extract wells.

2.7 Minimum Inhibitory Concentration (MIC)

MIC values were determined using serial dilution methods (Kadeřábková et al., 2024). Extract concentrations ranged from 6.25 to 200 mg/mL. MIC was defined as the lowest concentration without visible growth.

2.8 Statistical Analysis

All experiments were conducted in triplicate. Data were analyzed via one-way ANOVA with significance at $p < 0.05$. Post hoc comparisons were made using Duncan's Multiple Range Test.

3.0 Results

3.1 Isolation and identification of isolates

Bacterial species isolated included *Bacillus cereus*, *Erwinia carotovora*, *Micrococcus luteus*, *Escherichia coli*, *Xanthomonas campestris*, and *Lactobacillus plantarum*. Fungal isolates were *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporium*, *Rhizopus stolonifer*, and *Saccharomyces cerevisiae* (Tables 1 & 2).

3.2 Pathogenicity test

Pathogenicity test in the present study demonstrated that all isolated fungi induced rot in healthy tomato fruits. Re-isolation of the fungi from symptomatic fruits confirmed that the same organisms originally inoculated were responsible for disease, satisfying Koch's postulates. The wound created by the cork-borer initiated spoilage as it formed opening for the easy penetration of the pathogen. *Aspergillus niger* and *Lactobacillus plantarum* shows the highest severity of rot in both inoculated fungi and bacteria respectively (Plates 1a and 1b).

Table1: Biochemical Characteristics of bacteria isolated from tomato fruits undergoing spoilage.

ISOLATES	BIOCHEMICAL CHARACTERISTICS										SUGAR FERMENTATION								TENTATIVE IDENTITY	
	CITRATE	COAGULASE	OXIDASE	CATALASE	INDOLE	MOTILITY	SPORE	HYDROGEN SULPHIDE	STARCH HYDROLYSIS	METHYL RED	SUCROSE	ARABINOSE	GLUCOSE	LACTOSE	MALTOSE	MANNITOL	FRUCTOSE	SORBITOL		
A	+	-	-	+	-	+	+	+	+	+	-	-	+	-	+	-	AG	-	<i>Bacillus cereus</i>	
B	-	-	-	+	-	-	-	-	+	-	+	+	-	+	+	+	+	+	<i>Micrococcus luteus</i>	
C	+	-	-	+	-	+	-	-	-	+	AG	AG	AG	AG	+	+	+	+	<i>Erwinia carotovora</i>	
D	-	-	-	+	+	+	-	-	-	+	-	AG	AG	AG	+	AG	AG	AG	<i>Escherichia coli</i>	
E	-	-	-	+	-	+	-	+	+		+	+	+	+	+	+	+	+	<i>Xanthomonas campestris</i>	
F	-	-	-	+	-	-	-	-	+	-	+	+	AG	AG	AG	AG	+	+	<i>Lactobacillus plantarum</i>	
KEYS:			+ = positive				- = negative				AG = Gas production;									

PATHOGENICITY TEST



Plate 1a: Pathogenicity of *A. niger* on fresh tomato sample



Plate 1b: Pathogenicity of *L. plantarum* on fresh tomato samples

Plate 1: (a) Pathogenicity of *A. niger* on fresh tomato samples (b) Pathogenicity of *L. plantarum* on fresh tomato samples.

Table 2: Characteristics of fungal isolates obtained from tomato samples undergoing spoilage

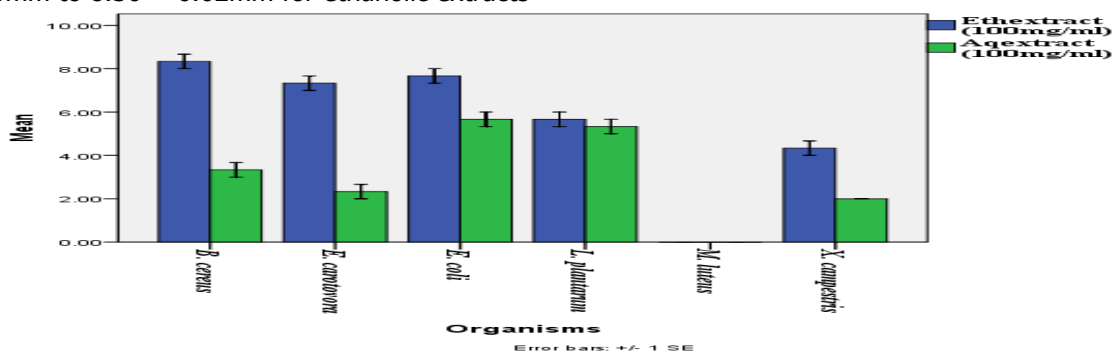
Isolates	Cultural characteristics	Microscopic observation	Tentative identity
A	Growth rate is rapid and texture of colonies varied from downy to powdery, producing radial fissures in the agar and surface colony colour is initially white becoming black with conidial production while the reverse is pale yellow	Black coloured rough conidia in chain	<i>Aspergillus niger</i>
B	The surface colony colour is olive green, and the reverse is cream or pale. Growth rate is rapid and the texture of colonies varied from woolly to cottony to granular	Conidiophores are with roughened walls especially near vesicle. Hyphae are septate and hyaline. Vesicles are globuse	<i>Aspergillus flavus</i>
C	Whitish cream with smooth, dry, surface raised, bacterial-like growth	Blastoconidia are unicellular, globuse and ellipsoid to elongate in shape	<i>Saccharomyces cerevisiae</i>
D	Whitish cotton-like mycelia becoming brown black with age	Non septate mycelia, sporangiospores are directly opposite the branched rhizoids.	<i>Rhizopus stolonifer</i>
E	White cotton-like mycelia spreads round whole plate	Mycelium have phialides that is bearing a bean pod-like microconidia borne singly or in chain	<i>Fusarium oxysporium</i>

3.3 Antibacterial activities of crude leaf extracts

The antibacterial activities of *Syzygium guineense* leaf extracts are shown in Figure 1. The ethanolic and aqueous extract of the leaf inhibited all the organisms at 50mg/ml except *M. luteus*.

For bacteria, inhibition zones ranged from $4.30 \pm 0.05\text{mm}$ to $8.30 \pm 0.02\text{mm}$ for ethanolic extracts

and $2.00 \pm 0.01\text{ mm}$ to $5.70 \pm 0.03\text{mm}$ for aqueous extracts. There was significant difference between the mean zones of inhibition of antibacterial activities of *Syzygium guineense* leaf at $P < 0.05$.


Figure 1: Antibacterial activity of *S. guineense* crude extracts on isolates

3.4 Antifungal activities of crude leaf extracts

The antifungal activity of extract as shown in Figure 2 revealed that both ethanolic and aqueous extracts had an inhibitory effect on all the fungi isolate except *R. stolonifer* and *S. cerevisiae* which were resistant to 100mg/ml concentration of aqueous extract of *S. guineense* leaf. The antifungal activity of the ethanolic extract was more pronounced on *F. oxysporium* with 18.00 ± 0.02 mm zone of

inhibition while *S. cerevisiae* gave the least zone of inhibition of 6.68 ± 0.05 mm. The aqueous extract also gave the highest inhibitory zone of 5.33 ± 0.05 mm on *A. niger* and *F. oxysporium* while *A. flavus* had the least zone of inhibition of 3.33 ± 0.05 mm. There was significant difference between the mean zones of inhibition of antifungal activities of both the ethanolic and aqueous extracts of *Syzygium guineense* leaf at $P < 0.05$.

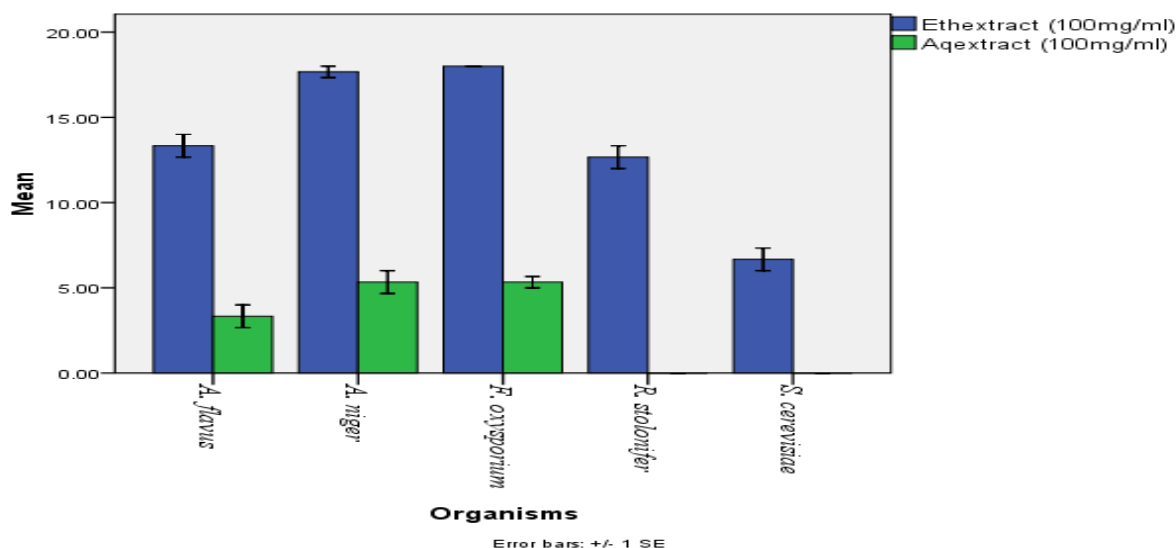


Figure 2: Antifungal activity of *S. guineense* crude extracts against fungal isolates.

3.5 Minimum inhibitory concentration (MIC) of crude extracts on the bacterial isolates

Table 3 shows the result of the MIC of the extracts on the isolated bacteria. For the

ethanolic extract the MIC value ranges from 12.5mg/mL to 25mg/mL. It was also revealed that the MIC value of the aqueous extract ranges from 25mg/mL to 50mg/mL.

Table 3: Minimum Inhibitory Concentration (mg/mL) of *S. guineense* leaf extracts tested against bacterial isolates

Organisms	Extract Type/ Minimum Inhibitory Concentration(mg/mL)	
	Ethanol	Aqueous
<i>Escherichia coli</i>	12.5	25
<i>Xanthomonas campestris</i>	25	50
<i>Bacillus cereus</i>	12.5	25
<i>Lactobacillus plantarum</i>	25	50
<i>Micrococcus luteus</i>	ND	ND
<i>Erwinia carotovora</i>	25	50

KEY: ND = NOT Determined

3.6 Minimum inhibitory concentration (MIC) of crude extracts on the isolated fungi

Table 4 shows the result of the MIC of the extracts on the isolated fungi. The MIC values of

both ethanolic and aqueous extracts of *Syzygium guineense* leaf ranges from 50mg/ml to 100mg/mL, reflecting differential susceptibility patterns.

Table 4: Minimum Inhibitory Concentration (mg/mL) of *S. guineense* leaf extracts tested against fungal isolates

Organisms	Extract Type/ Minimum Inhibitory Concentration(mg/mL)	
	Ethanol	Aqueous
<i>Aspergillus niger</i>	50	100
<i>Aspergillus flavus</i>	50	50
<i>Rhizopus stolonifer</i>	100	100
<i>Saccharomyces cerevisiae</i>	100	100
<i>Fusarium oxysporium</i>	50	50

4.0 Discussion

All isolates induced spoilage symptoms upon re-inoculation. Earlier studies have also documented similar spoilage organisms. Okey and Okop (2024). reported that *Rhizopus stolonifer*, *Fusarium moniliforme*, and *Geotrichum candidum* were associated with tomato spoilage, while Oyagbola et al. (2019) isolated *Bacillus coagulans*, *B. stearothermophilus*, and lactic acid bacteria. Rima (2021) found that *F. oxysporum*, *F. moniliforme*, *A. niger*, and *R. stolonifer* were predominant in decayed fruits. These early studies established that filamentous fungi are major spoilage agents across different regions. More recent research supports and expands these findings. A 2024 survey of tomato fruits from major markets in Port Harcourt, Nigeria identified *A. niger*, *R. stolonifer*, *F. oxysporum*, *S. cerevisiae*, *Alternaria alternata*, *Penicillium digitatum*, and *Geotrichum candidum* among dominant spoilage fungi, with *A. niger* being most prevalent, further confirming the widespread involvement of multiple fungal species in post-harvest decay (Amaechi et al., 2024).

Tomato fruits are particularly susceptible to microbial spoilage because of their high-water content, rich nutrient composition, and relatively low pH, which collectively create an ideal

environment for microbial growth (Okpewho et al., 2025). These biochemical properties facilitate fungal colonization and bacterial soft rots during storage and handling (Bento de Carvalho et al., 2024).

Mechanical injuries made using a cork borer significantly accelerated spoilage by providing entry points for colonization, supporting earlier observations that wounds facilitate pathogen penetration. The role of mechanical injury in promoting fungal invasion has been noted as a key factor predisposing fruits to spoilage (Bano et al., 2023; Liu et al., 2025). Among the isolated fungi, *Aspergillus niger* showed the fastest colonization rate and was frequently the first fungus to appear on inoculated fruits. This mirrors recent market studies where *A. niger* was the most often recovered spoilage fungus and caused extensive decay, suggesting its competitive advantage in post-harvest environments (Dukare et al., 2022; He et al., 2024).

In summary, post-harvest spoilage of tomato fruits involves multiple bacterial and fungal agents, with variation in specific taxa depending on regional practices and environmental

conditions. The dominance of *A. niger*, *R. stolonifer*, and *F. oxysporum* among spoilage fungi is well documented (Samuel and Orji, 2015; Adamu et al., 2025; Tula et al., 2026). Effective post-harvest handling, including minimizing mechanical damage and improving storage conditions, is essential to reduce microbial spoilage and extend the shelf life of tomatoes (Zewdie et al., 2021).

The enhanced antimicrobial effects observed with ethanolic extracts likely result from ethanol's higher polarity relative to water, facilitating the extraction of phenolics and other bioactive compounds with stronger antimicrobial properties (Mavanza et al., 2023; Socaci et al., 2018). Phenolic compounds can disrupt microbial cell walls and interfere with enzyme systems, leading to growth inhibition (Takó et al., 2020; Ecevit et al., 2022).

Prior studies have documented antimicrobial effects of *S. guineense* against clinical pathogens, but its activity against food spoilage organisms specifically in tomato systems has been under-reported (Kator et al., 2018; Idowu et al., 2024). The higher antimicrobial activity of ethanolic extracts observed in this study agrees with findings by Fasuan (2025) who reported extended shelf life of tomatoes treated with *Syzygium guineense* extracts. This study confirms that extracts can inhibit both bacterial soft-rot agents and filamentous fungi, suggesting broad-spectrum action relevant to food preservation.

The use of botanical extracts aligns with consumer demand for natural preservatives and can be integrated into post-harvest handling protocols, such as dip treatments or biodegradable coatings (Nxumalo, 2023; Howlader et al., 2026). However, future work should validate these effects in vivo within food matrices under storage conditions aligned with real supply chains, as recommended for food microbiology research submissions.

While in vitro results are promising, this study does not assess sensory impacts, consumer acceptability, or regulatory compliance for food use. Further research should focus on formulation development, mechanism elucidation, and toxicological safety profiling.

The antimicrobial activities of the extract against test organisms which is measured by their respective zones of inhibition also vary with the

type of solvent used for the extraction and the organism involved. Mavanza et al. (2023) reported that the ethanol extracts of *S. guineense* and *M. indica* showed in vitro antibacterial activity against *E. coli*, *S. typhi*, *S. aureus* and *B. subtilis*. There was variation in inhibitory potency of aqueous and ethanol extracts of *S. guineense*. This might be as a result of the phytochemicals which was more extracted by ethanol from plant leaves. Bacteria were observed to be more susceptible to the antimicrobial activities of the extracts than fungi at same concentration as reported by Chen et al. (2025).

The antifungal activity presented in Figure 2 revealed that both ethanolic and aqueous leaf extracts of *Syzygium guineense* exhibited inhibitory effects against most of the fungal isolates tested. However, *Rhizopus stolonifer* and *Saccharomyces cerevisiae* were resistant to the aqueous extract at the highest concentration tested (100 mg/mL). The observed antifungal activity may be attributed to the presence of several biologically active secondary metabolites in *S. guineense*, including phenolic compounds, flavonoids, tannins, saponins, alkaloids and terpenoids. (Dogara et al., 2023).

Recent reviews of *S. guineense* have documented a diverse phytochemical profile, with more than 200 compounds reported from different parts of the plant, and have linked these compounds to several biological activities. Raj et al. (2021) also provides more evidence that *Syzygium* leaf extracts can show selective antifungal effects against different yeast species. The present findings are also consistent with previous reports showing that members of the genus *Syzygium* possess antifungal properties. A review of the genus reported antifungal activity for several *Syzygium* species and showed that leaf extracts prepared using ethanol, water and other organic solvents could inhibit different fungal organisms (Dogara et al., 2023). In particular, aqueous, ethanol and dichloromethane extracts of *Syzygium cordatum* leaves demonstrated antifungal activity, although the magnitude of inhibition varied considerably with the extraction solvent and fungal species (Uddin et al., 2022).

The antibacterial activity of *Syzygium guineense* leaf extracts varied with both the extraction solvent and the bacterial species tested. The ethanolic extract generally showed greater antibacterial activity than the aqueous extract, suggesting that ethanol was more effective in

extracting the bioactive compounds responsible for the observed inhibition. This observation is consistent with studies showing that extraction solvent significantly influences the phytochemical composition and antibacterial potency of plant extracts, since compounds such as phenolics, flavonoids, tannins and terpenoids differ in their solubility in aqueous and organic solvents (Mehmood et al., 2022; Li et al., 2024). Recent investigation of *S. guineense* also demonstrated considerable antibacterial activity in solvent extracts, with ethanol extracts containing substantial levels of phenolic and flavonoid compounds and exhibiting activity against both Gram-positive and Gram-negative bacteria (Dessalegn et al., 2025)

Variation in susceptibility was also observed among bacterial isolates having the same Gram reaction. *Escherichia coli*, *Erwinia carotovora* and *Xanthomonas campestris* are Gram-negative bacteria, yet they demonstrated different responses to the *S. guineense* extracts. This finding indicates that bacterial susceptibility to plant-derived antimicrobials is not determined solely by Gram classification but may also depend on species-specific differences in cell-envelope structure, membrane permeability, efflux activity, extracellular polymeric substances and other physiological characteristics. Bacteria may also differ in their ability to form capsules or biofilms, which can reduce the penetration and effectiveness of antimicrobial compounds. Similar species-dependent differences in susceptibility to plant extracts have been reported previously, including the work of Ogunniran (2009) on *Ocimum gratissimum* and *Piper guineense* extracts against *E. coli* and *Staphylococcus aureus*. Recent reviews likewise emphasize that the antibacterial effectiveness of plant-derived compounds depends on both the chemical characteristics of the antimicrobial constituents and the physiological properties of the target microorganism (Woo et al., 2023; Li et al., 2024).

4.0 Conclusion

Ethanollic and aqueous leaf extracts of *Syzygium guineense* demonstrated significant antimicrobial effects against bacterial and fungal spoilage microorganisms associated with tomato fruits. The antimicrobial activity was more apparent in ethanol than aqueous extracts of the plant. Ethanollic extracts were consistently more potent, suggesting their enhanced suitability as natural antimicrobial agents. These findings support the potential of *S. guineense* leaves as a promising

source of plant-derived antimicrobial agents for managing microbial spoilage and reducing post-harvest losses of tomatoes.

Conflict of Interest Statement

The authors declare that there is no conflict of interests.

5.0 References

- Adamu, H., Umar, D. M., & Abubakar, K. U. (2025). Prevalence and Morphological Identification of Fungal Pathogens Causing Tomato Spoilage in Gombe Metropolis. BIMA Journal of Science and Technology Gombe, 9(4A), 106-113.
- Amaechi, G., Oridikitorusinyaa, O., & Emmanuel, O.O. (2024). Fungi associated with the spoilage of post-harvest tomato fruits sold in major markets in Port Harcourt, Nigeria. Journal of Advances in Microbiology Research, 5(2): 58-63.
- Badou, R. B., Yedomonhan, H., Ewedje, E. E., Dassou, G. H., Adomou, A., Tossou, M., & Akoegninou, A. (2020). Floral morphology and pollination system of *Syzygium guineense* (Wild.) DC. subsp. macrocarpum (Engl.) F. White (*Myrtaceae*), a subspecies with high nectar production. South African Journal of Botany, 131, 462-467.
- Bano, A., Gupta, A., Prusty, M. R., & Kumar, M. (2023). Elicitation of fruit fungi infection and its protective response to improve the postharvest quality of fruits. Stresses, 3(1), 231-255.
- Bento de Carvalho, T., Silva, B. N., Tomé, E., & Teixeira, P. (2024). Preventing fungal spoilage from raw materials to final product: Innovative preservation techniques for fruit fillings. Foods, 13(17), 2669.
- Chen, D., Liu, L., Gao, Z., Zhao, J., Yang, Y., & Shen, Z. (2025). Preservation of Fruit Quality at Postharvest Through Plant-Based Extracts and Elicitors. Horticulturae, 11(10), 1186.
- Cheesbrough, M. (2010). District Laboratory Practice in Tropical Countries—Part 2. 2nd Edition, Cambridge University Press, New York.
- Danaski, A. I., Shugaba, A., Milala, M. A., Ndirmbula, J. B. & Gidado, A. (2022). Isolation, Identification and Pathogenicity Study of the Microbes Causing Tomato Post-Harvest Spoilage in Maiduguri Metropolis, Maiduguri, Nigeria.

Nigerian Journal of Biochemistry and Molecular Biology. 37(4), 303-313.

Dessalegn, E., Mathewos, M., Gebremeskel, H., & Tuasha, N. (2025). Determination of total phenolic and flavonoid contents, antioxidant and antibacterial potential of the bark extracts of *Syzygium guineense* (Wild.) DC. BMC Complementary Medicine and Therapies. 25(1):35.

Dogara, A.M., Bradosty, S.W., Al-Zahrani, A.A., Hamad, S.W., & Almalki, H.D. (2025) Ethnobotany, bioactive compounds and pharmacology of *Syzygium guineense* (Willd.) DC: A review. Journal of Ethnopharmacology, 339:119149

Dukare, A. S., Singh, R. K., Jangra, R. K., & Bhushan, B. (2022). Non-fungicides-based promising technologies for managing post-production penicillium induced spoilage in horticultural commodities: a comprehensive review. Food Reviews International, 38(3), 227-267.

Ecevit, K., Barros, A. A., Silva, J. M., & Reis, R. L. (2022). Preventing microbial infections with natural phenolic compounds. Future Pharmacology, 2(4), 460-498.

Fadiya, R. & Chhaya, R. (2024). Microbial spoilage of fruits: Reasons and preservation. International Journal of Biology Sciences; 6(2): 14-17

Fasuan, O. S. (2025). Assessment of Bio-Preservative Effects of Aqueous and Ethanolic Extracts of *Syzygium guineense* Leaves on Tomato Fruit. International Journal of Latest Technology in Engineering, Management and Applied Science, 14(5):504-513

González, M., Cid, M. C., & Lobo, M. G. (2011). Usage of tomato (*Lycopersicum esculentum* Mill.) seeds in health. In Nuts and seeds in health and disease prevention (pp. 1123-1132). Academic Press.

He, Y., Degraeve, P., & Oulahal, N. (2024). Bioprotective yeasts: Potential to limit postharvest spoilage and to extend shelf life or improve microbial safety of processed foods. Heliyon, 10(3).

Howlader, N. C., Hossain, M. M., Roy, T. K., Ahsan, S. M., Injamum-Ul-Hoque, M., & Miah, M. H. (2026). Application of Botanical Extracts for Postharvest Preservation and Quality Enhancement of Horticultural Produce in Developing Countries: a Potential Review. Journal of Crop Health, 78(1), 17.

Idowu, P. A., Amali, E. D., Okunye, O. L., & Adeyemo, E. O. (2024). Phytochemical Screening and Antimicrobial Activity of Methanol Extracts of *Usteria guineensis* and *Sphaerocoryne gracilipes* on Pathogens and ESBL-Producing *Escherichia coli*. Journal of Pharmaceutical Research International, 36(8), 177-186.

Kadeřábková, N., Mahmood, A.J.S. & Mavridou, D.A.I. (2024). Antibiotic susceptibility testing using minimum inhibitory concentration (MIC) assays. npj Antimicrobials and Resistance. 2, 37.

Kator, L., Iheanacho, A.C., & Aloho, K.P. (2018). Effect of organic preservatives on postharvest shelf life and fruit quality of tomatoes during storage. Asian Journal of Research in Crop Science 2(1): 1-34.

Li, S., Jiang, S., Jia, W., Guo, T., Wang, F., Li, J., & Yao, Z. (2024). Natural antimicrobials from plants: Recent advances and future prospects. Food Chemistry, 432, 137231.

Liu, F., Hai, M., Mei, B., Yi, L., & Xie, S. (2025). How does mechanical damage affect the preservability of postharvest fruits and vegetables? LWT, 118781.

Mavanza, S. A., Omwenga, G. I. & Ngugi, M. P. (2023) Antibacterial and phytochemical effects of ethanol extracts of *Syzygium guineense* (Willd.) DC barks and *Mangifera indica* L seeds. Journal of Advanced Biotechnology Experimental Therapeutics. 6(2): 337-349.

Mehmood, A., Javid, S., Khan, M.F., Ahmad, K.S., & Mustafa, A. (2022). In vitro total phenolics, total flavonoids, antioxidant and antibacterial activities of selected medicinal plants using different solvent systems. BMC Chemistry. 16(1):64.

Nguyen, T. L., Rusten, A., Bugge, M. S., Malterud, K. E., Diallo, D., Paulsen, B. S., & Wangensteen, H. (2016). Flavonoids, gallotannins and ellagitannins in *Syzygium guineense* and the

traditional use among Malian healers. *Journal of ethnopharmacology*, 192, 450-458.

Nieto, G., Martínez-Zamora, L., Peñalver, R., Marín-Iniesta, F., Taboada-Rodríguez, A., López-Gómez, A., & Martínez-Hernández, G. B. (2024). Applications of Plant Bioactive Compounds as Replacers of Synthetic Additives in the Food Industry. *Foods*, 13(1), 47.

Nxumalo, K. A. (2023). Formulation, characterization and application of bio-inspired nano/composites coatings for postharvest preservation of horticultural crops. University of Johannesburg (South Africa).

Ogunniran, K. O. (2009). Antibacterial effects of extracts of *Ocimum gratissimum* and *Piper guineense* on *Escherichia coli* and *Staphylococcus aureus*. *African Journal of Food Science*, 3(3), 077-081.

Okey, E. N., & Okop, I. J. (2024). Control of fungal diseases of tomato (*Lycopersicon esculentum* Mill) fruits using various plant extracts. *Dutse Journal of Pure and Applied Sciences*, 10(3a), 202-212.

Okpewho, O. P., Agbogidi, O. M., Solomon, E. J., Ogunoye, O. A., & Ebulola, T. E. (2025). Nutritional composition of fresh and spoilt tomato (*Solanum lycopersicum* L.) fruits and associated spoilage fungi in Delta state, Nigeria. *Journal of Basics and Applied Sciences Research*, 3(3), 92-98.

Oyagbola, E. O., Gana, E. O., Olarongbe, G. O., Towobola, E. O., Rajis, B. T., & Aderibigbe, A. (2019). Isolation of spoilage microorganisms and methods of extending the shelf life of tomato (*Solanum lycopersicum*) fruits. *International Journal of Advanced Biotechnology and Research*, 10(1), 111.

Peralta-Ruiz, Y., Tovar, C. D. G., Sinning-Mangonez, A., Coronell, E. A., Marino, M. F., & Chaves-Lopez, C. (2020). Reduction of postharvest quality loss and microbiological decay of tomato "Chonto" (*Solanum lycopersicum* L.) using chitosan-e essential oil-based edible coatings under low-temperature storage. *Polymers*, 12(8), 1822.

Raj, S., Vinod, V., Jayakumar, J., Suresh, P., Kumar, A., & Biswas, R. (2021). Antifungal activity of *Syzygium samarangense* leaf extracts

against *Candida*. *Letters in Applied Microbiology*. 73(1):31-38.

Rima, R. F. (2021). Isolation and identification of fungi associated with the spoilage postharvest tomato fruits in different local markets in dhaka city (doctoral dissertation, department of plant pathology, sher-e-bangla agricultural university, sher-e-bangla nagar, dhaka-1207).

Samuel, O., & Orji, M. U. (2015). Fungi associated with the spoilage of postharvest tomato fruits sold in major markets in Awka, Nigeria. *Universal Journal of Microbiology Research*, 3(2), 11-16.

Snyder, A.B., Martin, N. & Wiedmann, M. (2024). Microbial food spoilage: impact, causative agents and control strategies. *Nature Reviews Microbiology*. 22, 528–542.

Socaci, S. A., Fărcaș, A. C., Diaconeasa, Z. M., Vodnar, D. C., Rusu, B., & Tofană, M. (2018). Influence of the extraction solvent on phenolic content, antioxidant, antimicrobial and antimutagenic activities of brewers' spent grain. *Journal of cereal science*, 80, 180-187.

Takó, M., Kerekes, E. B., Zambrano, C., Kotogán, A., Papp, T., Krisch, J., & Vágvolgyi, C. (2020). Plant phenolics and phenolic-enriched extracts as antimicrobial agents against food-contaminating microorganisms. *Antioxidants*, 9(2), 165.

Tula, M. Y., Danchal, B. T., Onyeje, G. A., Okpalauwaeke, E. O., Okon, N. O., & Filgona, J. (2026). Occurrence and Pathogenicity of fungi Associated with Tuber Spoilage: Evidence from Mubi Main Market, Adamawa State, Nigeria. *BIMA Journal of Science and Technology Gombe*, 9(4b), 66-77.

Uddin, A.B.M.N., Hossain, F., Reza, A.S.M.A., Nasrin, M.S., Alam, A.H.M.K. (2022) Traditional uses, pharmacological activities, and phytochemical constituents of the genus *Syzygium*: A review. *Food Science and Nutrition*. 10(6):1789-1819.

Umeohia, U. E. & Olapade, A. A (2024). Quality Attributes, Physiology, and Postharvest Technologies of Tomatoes (*Lycopersicon esculentum*) – A Review. *American Journal of Food Science and Technology*, 12(2), 42-64

Woo, S., Marquez, L., Crandall, W. J., Risener, C. J., & Quave, C. L. (2023). Recent advances in the

discovery of plant-derived antimicrobial natural products to combat antimicrobial resistant pathogens: insights from 2018–2022. *Natural product reports*, 40(7), 1271-1290.

Zaman, W., Amin, A., Khalil, A. A. K., Akhtar, M. S., & Ali, S. (2025). Plant–microbe interactions for improving postharvest shelf life and quality of

fresh produce through protective mechanisms. *Horticulturae*, 11(7), 732.

Zewdie, T., Desaiagn, A., Olijira, G., Amare, H., Fetene, K., & Gebrie, L. (2021). Review on effects of pre and post-harvest factors affecting the quality and shelf life of tomato (*Lycopersicon esculentum* Mill.). *South Asian Journal of Agricultural Sciences*, 1 (1), 51-56