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Exploring Nutrient Competition and Antimicrobial Strategies in Microbial Communities

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Abstract

The research evaluates the effect of acetic acid and sodium chloride solutions on the competition between microorganisms while studying fungal development patterns in chilli. The research included three distinct chilli groups, which received acetic acid treatment (Group A), sodium chloride treatment (Group C) or no treatment applied (Group B). The observation of macroscopic alterations and fungal infections occurred throughout twelve days. The microbial strains grown on Sabouraud Dextrose Agar (SDA) at 25°C and 37°C underwent microscopic analysis using lactophenol cotton blue stain.

Groups A and C experienced tissue deterioration and fungal growth faster than Group B, which developed visible spots during the eighth day. Most fungi grown on Sabouraud Dextrose Agar (SDA) showed high-temperature tolerance and could probably belong to the genera Aspergillus or Penicillium. The microscopic examination showed hyphae with septations together with conidiophores. Microbial diversity decreases when organisms are exposed to acetic acid and sodium chloride, thus enabling pathogenic fungi to take control since competing microorganisms are harmed. Various microorganisms inside Group B's specimens stopped fungal growth because different microbes competed.

The research demonstrates how microbial diversity maintains fungal-limiting conditions but also shows that we need different preservation techniques to protect beneficial microorganisms. The study successfully determined how microbial competition affects spoilage processes and preservation methods.

Keywords: peppers, nutrient competition, chemical materials, acetic acid , sodium chloride

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Introduction

Microbial species, alongside pathogenic fungi, rely on nutrients to determine their competition outcome. The competition depends on necessary resources, including sugars and amino acids alongside minerals, since these substances support natural fruit functions and fungal reproductive needs. The knowledge of nutrient effects on microbial interactions endorses developing methods to boost fruit resistance [1].

Fructicolous fungi demand their particular nutrients as their germination trigger alongside their disease infiltration through appropriate fruit tissues. Fungal colonization depends heavily on sugar contents because these compounds function as main carbon sources for microbial growth. Certain fruits maintain controlled chemical operations that minimize free sugar distribution to infection zones, resulting in pocketed nutritional depletion areas that prevent fungal spore sprouting and mycelial expansion. The secondary metabolites of fruits, including phenolic compounds, create barriers through nutrient binding, which obstructs pathogenic fungi [2].
Fungal growth response to nutrients depends on the maturity stage of the fruits. Fungal growth shows variable reactions to metabolic changes and pH level modifications during ripening since these factors help and hinder fungal proliferation. Pathogenic fungi tend to select against immature fruit because of its high acidity and low sugar concentration. The increasing sugar levels in ageing fruits create conditions that attract fungal microorganisms. Fruits manifest resistance through two defence strategies: releasing harmful proteins and proteolytic enzymes that damage fungal cellular walls [3].

Fungi have developed multiple defensive strategies that aid them in microbial competition and predator prevention. Fungi protect themselves against competition through chemical means by making toxins that stop the development or survivability of competitors. Defensive compounds of fungi are made up of proteins, peptides, and secondary metabolites that block targeted molecules in opponent organisms. Most antifungal substances protect fungi from the microbial prey structure inside fungal cells until the predator consumes them. In contrast, substances that block larger predators are released outside fungal cells into the environment [4,5].

The antifungal agent acetic acid remains accessible on the market as a safe and economical choice that halts bacterial and fungal growth. According to the Australian Mould Guideline, antifungal contamination of surfaces can be eliminated using solutions such as detergent, vinegar (acetic acid), or alcohol. The antifungal market includes acetic acid, bleach, quaternary ammonium compounds, and formaldehyde as surface treatment agents [6,7]. Laboratory studies indicate that acetic acid shows significant antifungal power across its different usages. As per research, vinegar demonstrates its ability to block conidial germination in multiple fruit-decay fungi, including *Colletotrichum coccodes* in tomatoes, *Penicillium expansum* and *Monilinia fructicola* and *Botrytis cinerea*, which infect strawberries and apples and stone fruits [8,9].

The fungal cell wall directs crucial functionality through its composition of mannoproteins, chitins, and both α- and β-linked glucans to support cell shape, metabolism, and host relationships. Acetic acid impairs cell wall integrity because it blocks protein glycans during glycosylation, thus stopping mannoprotein development, which sustains cell wall structure [10–12].

Scientists have used sodium chloride (NaCl) as a food preservative technique for centuries. Conventional food preservation practices in fig-processing facilities employ NaCl solution at 5–10% (w/v) concentrations. NaCl is a food preservative that removes water from microbes to cause cell death and growth inhibition through an osmotic effect. Sodium and chloride ions impact water molecules through interactions, which decreases water activity, thus controlling microbial growth according to [13,14].

Aim of study

This study aimed to investigate the nutrient competitive mechanism and the roles of some chemical materials in this mechanism.

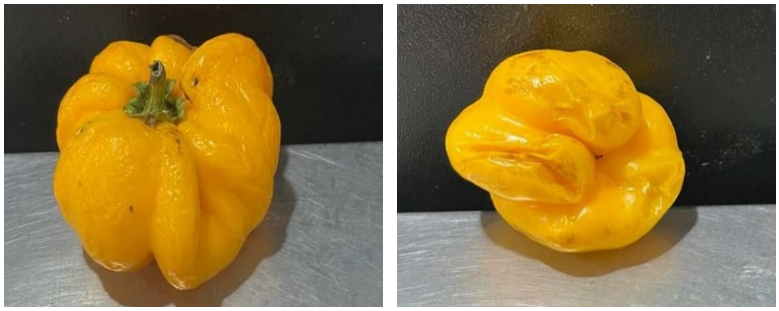
Experimental design

The red peppers and tomatoes used in this test were divided into four groups:

- **Group A:** Two red peppers treated with a fruit and vegetable sanitizer (acetic acid solution).
- **Group B:** Tomatoes that remained untreated (no washing or handling).
- **Group C:** Tomatoes washed or treated with salt (NaCl).
- **Group D:** Tomatoes washed or treated with acetic acid.

The Result

1. Groups A and C exhibited macroscopic texture changes in peppers faster than the other groups. These groups also showed fungal infections, as observed in Figure 1, after 8 days of handling. In contrast, Group B displayed macroscopic changes after 10 to 12 days (Figures 2 and 3).



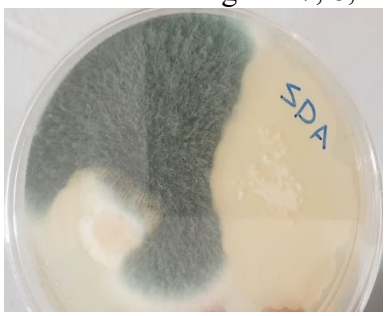
(Figure 1) showed the macroscopic change after 8 days.

(Figure 2) showed the macroscopic change after 10days

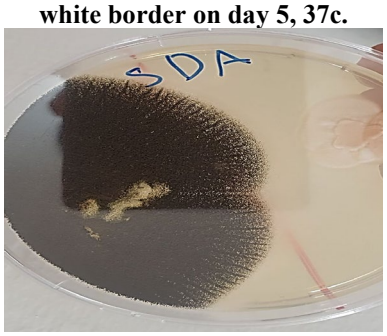
(Figure 3) showed the macroscopic change after 13days

The rapid fungal infection observed in Groups A and C is likely due to acetic acid and salt-eliminating saprophytic fungi and other microorganisms. This reduction in microbial diversity disrupts the competition mechanism, allowing pathogenic fungi to thrive. In contrast, Group B maintained a diverse microbial community, where commensal microorganisms helped prevent or delay pathogenic fungal invasion and texture degradation.

2. Swabs were taken from the fungal lesions and cultured on Sabouraud Dextrose Agar (SDA). The samples were incubated at two different temperatures to differentiate between yeast and mould growth:
    - 37°C to promote yeast growth
    - 25°C to promote mold growth
3. After 5 days, fungal growth was observed, as shown in Figures 4 and 5. When incubation continued for 9 days, fungal colonies became more pronounced, as observed in Figures 6A and 6B.
4. Microscopic examination was performed using lactophenol cotton blue (LPCB) staining, revealing distinct fungal characteristics in Figures 7, 8, and 9.

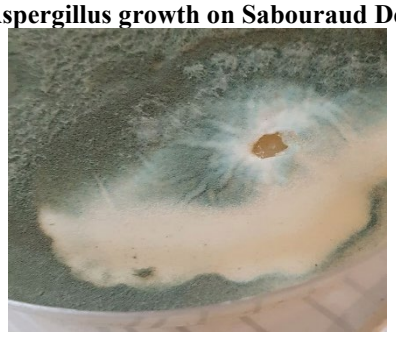


(Figure 4) showed the Aspergillus growth on sabouraud dextrose agar that appears grey green with a narrow white border on day 5, 37c.

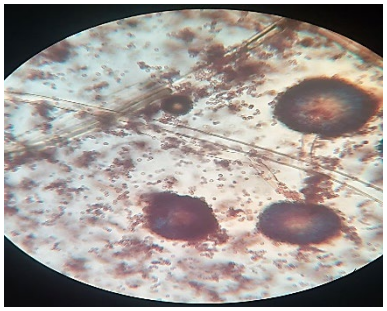


(Figure 5) showed the Aspergillus niger growth on Saboraud-Dextrose Agar that appear black color on day 5, 37c .

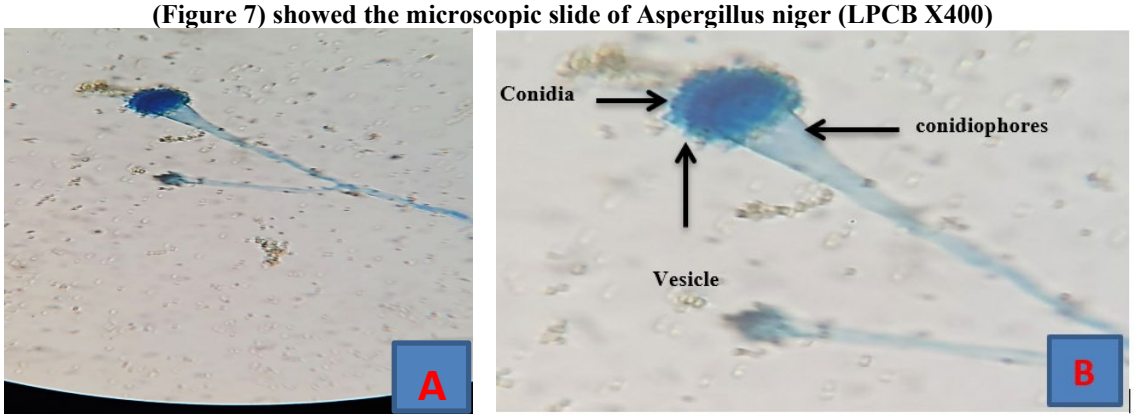
(Figure 6) (A) showed the Aspergillus growth on Sabouraud Dextrose agar on day 9 , 37c .



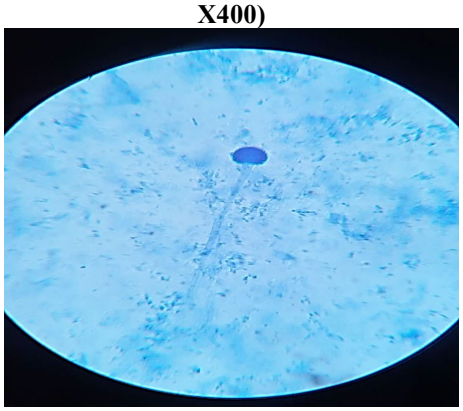
(Figure 6) (B) showed the Aspergillus growth on Sabouraud Dextrose agar on day 9 , 37c .



(Figure 7) showed the microscopic slide of Aspergillus niger (LPCB X400)



(Figure 8) A and B showed the microscopic slide of Aspergillus with conidiophores, Vesicle and Conidia (LPCB X400)



(Figure 10) showed the microscopic slide of *Aspergillus* (LPCB X400)

The study's conclusions highlight the significant role of acetic acid and sodium chloride in the microbial ecology of chilli, particularly concerning fungal growth and nutrient competition. The macroscopic texture changes and microbial competitive mechanisms observed emphasize how environmental stress influences microbial communities. Compared to Group B, which maintained microbial diversity, Groups A and C experienced accelerated fungal infections, demonstrating the impact of microbial competition on food preservation and spoilage

Discussion

The microbial antibacterial properties of acetic acid together with sodium chloride in Groups A and C caused fast macroscopic changes and fungal infections. The compounds establish a microenvironment unfavourable for saprophytic fungi and other microbes, thus diminishing their population diversity. The reduced microbial diversity allows dangerous fungi to spread because their competitors vanish from the environment. The research results support the study by Hibbing ME Fuqua [15] about how microbial membranes and metabolic functions become damaged by acid solutions combined with salt, resulting in resistant pathogens establishing their dominance.

Without chemical agent treatment, Group B retained a wider spectrum of microbial species inside their samples. Although pathogenic fungi grow best at 25°C, elemental treatments enable competing microorganisms to exclude pathogenic fungi through competitive exclusion mechanisms. Studies show that diverse microbial populations generate active defence against pathogen establishment, according to [16].

Fungal growth patterns on Sabouraud Dextrose Agar plates exposed to 25°C and 37°C temperature conditions strengthen the understanding of how external stressors can impact fungal expansion. The fungal species in Groups A and C demonstrated their ability to grow under 25°C and 37°C temperature conditions, as displayed in Figures 4, 5, and 6. Pathogenic fungi demonstrate an adaptive nature because they maintain broad temperature tolerance, allowing them to survive in different environmental conditions [17].

Group B showed reduced microbial growth because its microbial community demonstrated effective resistance against fungal colonization. The microbial community resisted fungal growth because its inhabitants either contested resources or generated compounds that blocked fungal development. The study results correspond with [17] demonstrating that resource competition determines fungal community composition.

The taxonomic identification of governing fungi species became possible through microscopic inspection of stained specimens with lactophenol cotton blue (Figures 7, 8, and 9). The pathogenic fungi Aspergillus and Penicillium would enter the infection based on the microscopic observation of septate hyphae combined with conidiophores, which commonly infect chilli after harvest [18]. The fungi demonstrate great flexibility through their ability to survive under multiple environmental settings and their particular physical characteristics. The fungi's adaptability corresponds with their metabolic ability to create dangerous chemical compounds like mycotoxins that block similar microbial species and establish their superior position [19].

This study produces substantial findings regarding food safety alongside microbial ecological research. Acetic acid, together with sodium chloride, effectively minimizes microbial contamination. Still, their use may unintentionally favour the development of harmful fungi that survive because saprophytic microorganisms responsible for competition perish during treatment. The research finds that maintaining microbial diversity stands vital for pathogen prevention because of findings presented by Foster KR, Bell T [20].

Group B's natural foodborne microbial communities appeared to contribute to minimizing food safety risks based on their delayed emergence of disease-causing effects. The application works in harmony with biocontrol technology since beneficial microbial agents are used to fight against pathogens, according to Olaimat AN [16, 21].

Conclusion

This research shows how various environmental factors with microbial competition affect fungal growth dynamics in the chilli production process. The combination of acetic acid and sodium chloride successfully decreases microbial diversity, yet this reduction creates an environment where damaging fungi have an opportunity to develop and thrive. Preserving diverse microbial communities helps delay and prevent pathogenic changes regarding food preservation methods. Research in the following stage should analyze how natural microbial communities could act as biocontrol methods and understand which microbial methods stop pathogen growth.

References

1. Samson RA, Visagie CM, Houbraken J, Hong SB, Hubka V, Klaassen CHW, et al. Phylogeny, identification and nomenclature of the genus *Aspergillus*. *Stud Mycol*. 2014 Jun;78:141–73.
2. Egbuta MA, Mwanza M, Babalola OO. A review of the ubiquity of ascomycetes filamentous fungi in relation to their economic and medical importance. *Adv Microbiol*. 2016;6:1140–58. doi:10.4236/aim.2016.614103.
3. Shabani F, Kumar L, Esmaeili A. A modelling implementation of climate change on biodegradation of Low-Density Polyethylene (LDPE) by *Aspergillus niger* in soil. *Glob Ecol Conserv*. 2015;4:388–98.
4. Sabotič J, Ohm RA, Kunzler M. Entomotoxic and nematotoxic lectins and protease inhibitors from fungal fruiting bodies. *Appl Microbiol Biotechnol*. 2016;100(1):91–111.
5. Vuong MF, Waymack JR. Aspergillosis. *StatPearls* [Internet]. 2020 [cited 2021 23 April]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482241/
6. Tzortzakis NG. Ethanol, vinegar and *Origanum vulgare* oil vapour suppress the development of anthracnose rot in tomato fruit. *Int J Food Microbiol*. 2010;142:14–8.
7. Kemp P, Neumeister KH. *Australian Mould Guidelines* [Internet]. [cited 2015 16 April]. Available from: [Insert URL if available]
8. Gubbins PO, Anaissie EJ. Chapter 12: Aspergillosis. In: *Clinical Mycology*. 2nd ed. Elsevier; 2009.
9. Davidson PM, Taylor TM. Chemical preservatives and natural antimicrobial compounds. In: Doyle MP, Buchanan RL, editors. *Food Microbiology: Fundamentals and Frontiers*. 3rd ed. Wiley Online Library; 2017. p. 713–45.
10. Free SJ. Fungal cell wall organization and biosynthesis. *Adv Genet*. 2013;81:33–82.
11. Ibe C, Walker LA, Gow NAR, Munro CA. Unlocking the therapeutic potential of the fungal cell wall: clinical implications and drug resistance. In: Prasad R, editor. *Candida albicans: Cellular and Molecular Biology*. Springer; 2017. p. 313–46.
12. Gow NAR, Latge JP, Munro CA. The fungal cell wall: structure, biosynthesis, and function. *Microbiol Spectr*. 2017;5(3).
13. Kumar R, Tiwari BK. Sodium chloride as a natural preservative: mechanisms and applications in food industry. *Food Biosci*. 2022;46:101567.
14. Oliveira M, Ferreira V. Sodium chloride and its role in controlling foodborne pathogens: a review. *Food Res Int*. 2023;164:112345.
15. Treesuwan K, Jirapakkul W, Tongchitpakdee S, Chonhenchob V, Mahakarnchanakul W, Tongkhao K. Antimicrobial mechanism of salt/acid solution on microorganisms isolated from trimmed young coconut. *Microorganisms*. 2023;11(4):873.
16. Hibbing ME, Fuqua C, Parsek MR, Peterson SB. Bacterial competition: surviving and thriving in the microbial jungle. *Nat Rev Microbiol*. 2010;8(1):15–25.
17. Boddy L, Hiscox J. Fungal ecology: principles and mechanisms of colonization and competition by saprotrophic fungi. *Microbiol Spectr*. 2016;4(6).
18. Pitt JI, Hocking AD. *Fungi and Food Spoilage*. Springer; 2009.
19. Künzler M. How fungi defend themselves against microbial competitors and animal predators. *PLoS Pathog*. 2018;14(9):e1007184.
20. Foster KR, Bell T. Competition, not cooperation, dominates interactions among culturable microbial species. *Curr Biol*. 2012;22(19):1845–50.
21. Olaimat AN, Holley RA. Factors influencing the microbial safety of fresh produce: a review. *Food Microbiol*. 2012;32(1):1–19.