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Advances in Pharmaceutical Processing and Particle Engineering of Garlic Extract-Based Formulations for Antifungal Therapy Against *Candida tropicalis*

Bindu Sadanandan and Kavyasree Marabanahalli Yogendraiah

Department of Biotechnology, M S Ramaiah Institute of Technology, Bengaluru 560054, Karnataka, India

Introduction

•*Candida tropicalis* → emerging drug-resistant fungal pathogen.
•Garlic (*Allium sativum*) contains 33 bioactive sulfur compounds (Allicin, Ajoene, Diallyl sulfides, S-allylcysteine).
• Water-soluble/polar compounds → Alliin, SAC, SAMC, γ-glutamyl peptides, etc
•Non-polar / oil-soluble compounds → allicin, ajoene, diallyl sulfides, vinyldithiins, polysulfides, etc.
•These compounds have strong antifungal activity.

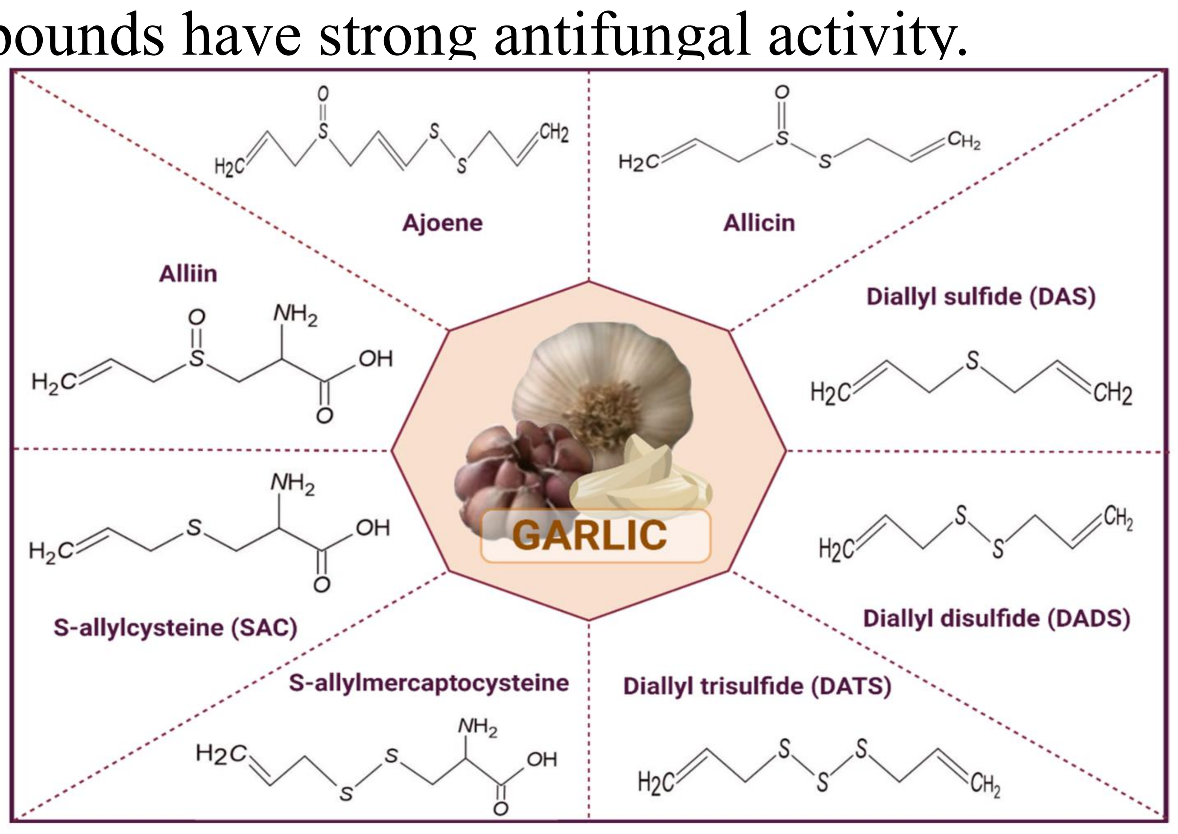

Figure 1. Major organosulfur compounds present in Garlic

Potential Mechanism of action of Garlic in treating Candida Infections

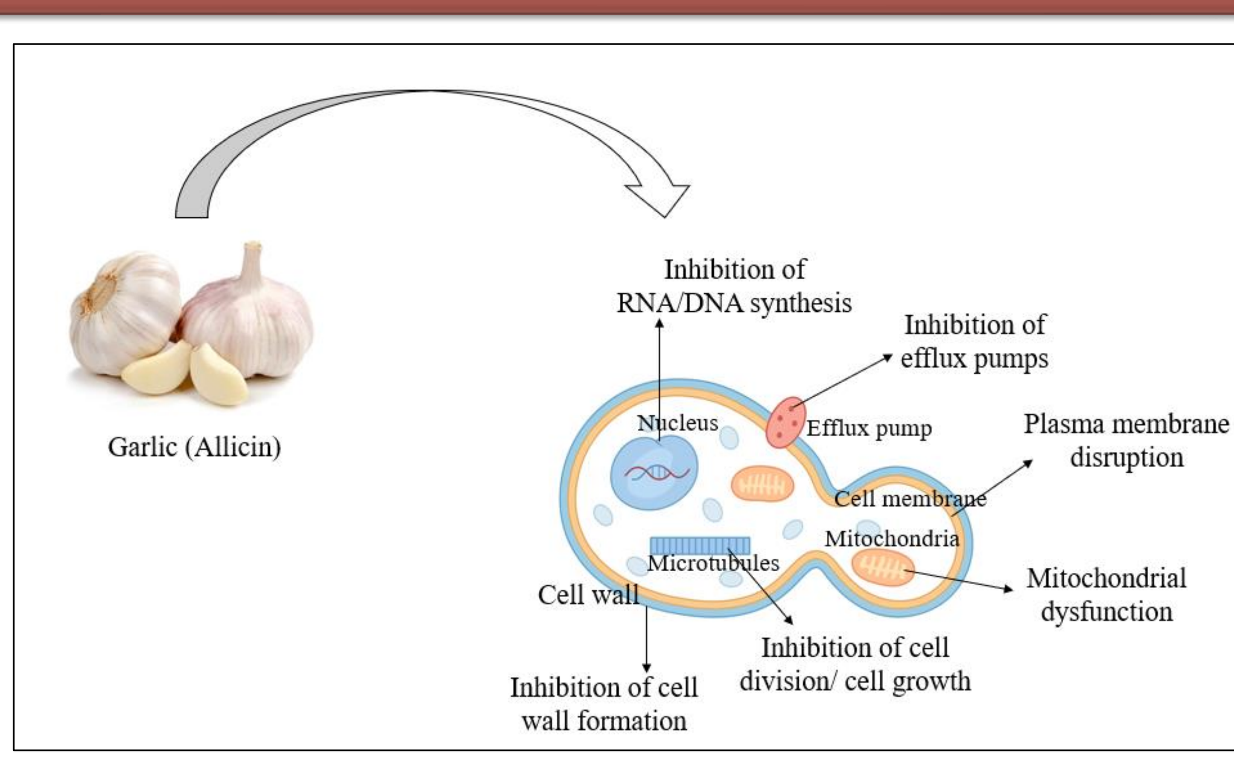

Figure 2. Mechanism of action of Garlic against *C. tropicalis*

- Allicin, the major sulfur compound in garlic, exhibits antifungal activity by inhibiting the *C. tropicalis* plasma membrane, cell wall formation, cell division, RNA/DNA synthesis, efflux pumps and causes cell death.
- These mechanisms collectively contribute to the inhibition of *C. tropicalis* biofilm formation

Evaluation of Antifungal Efficacy

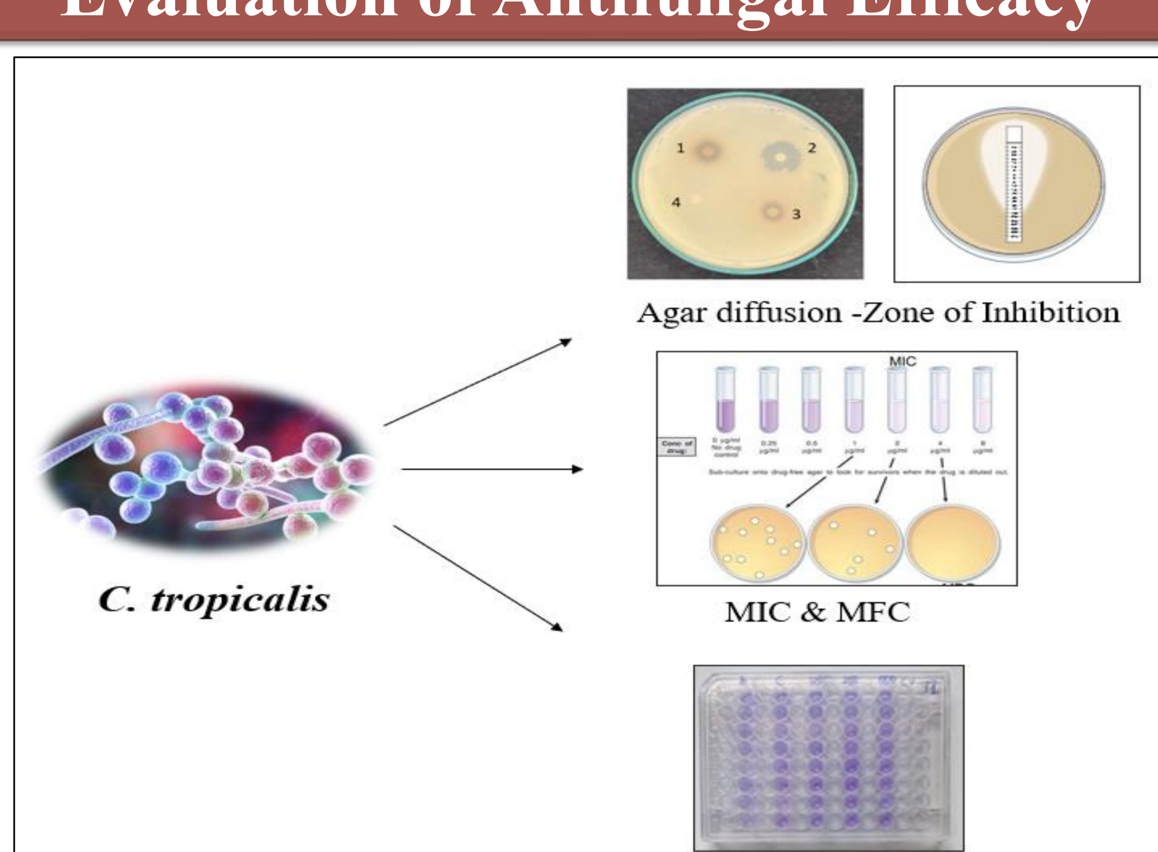

Figure 3. Evaluation Parameters of Garlic against *C. tropicalis*

- In vitro testing methods: Agar diffusion, MIC, MFC
- Biofilm inhibition assays for *C. tropicalis*

Challenges in Formulating Garlic Extract

•**Poor solubility & bioavailability:** Limited absorption and rapid metabolism.
•**Instability:** Allicin rapidly degrades on exposure to heat, pH, and oxygen.
•**Strong odor & volatility:** Affects patient compliance.
•**Lack of standardization:** No uniform pharmacopeial references.
•**Short shelf life:** Poor long-term stability in liquid/semisolid forms.

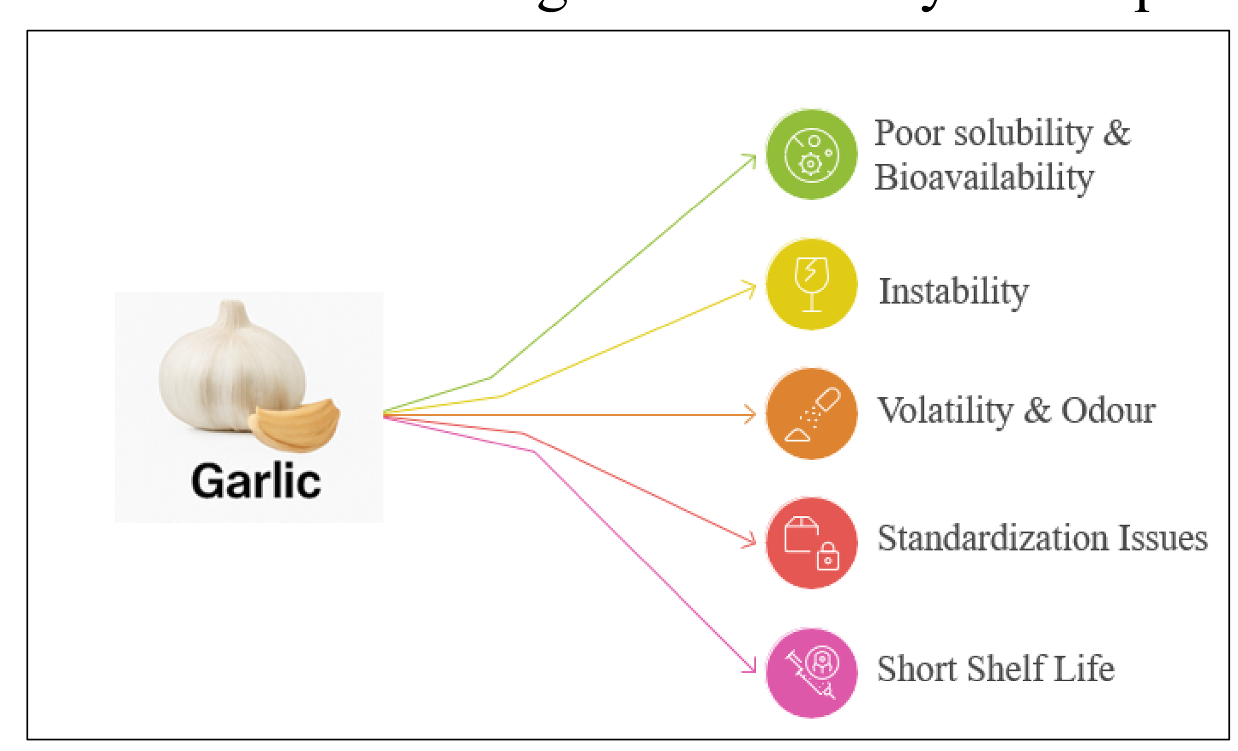

Figure 4. Challenges in Formulating Garlic Extract

Pharmaceutical Processing & Particle Engineering Strategies

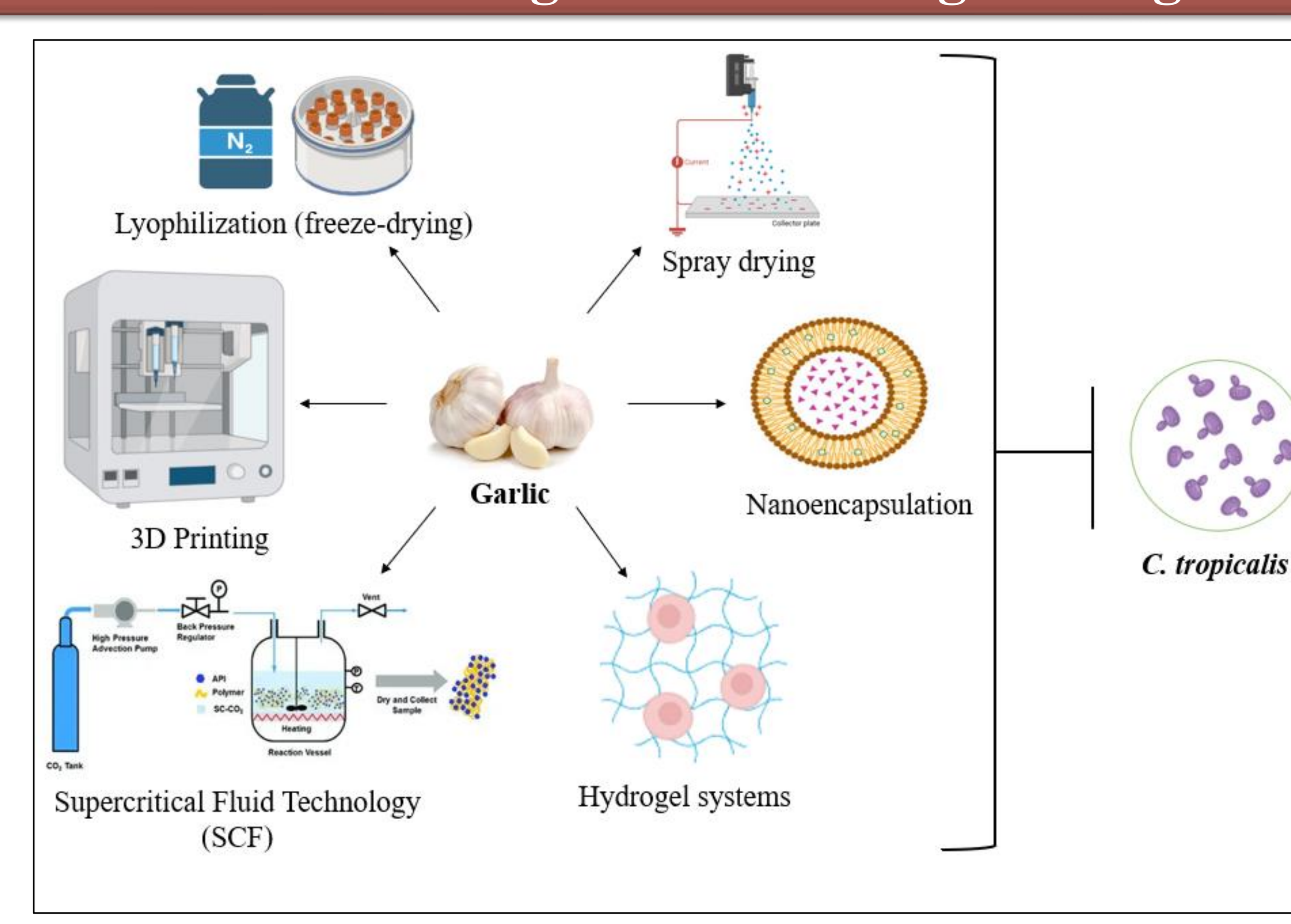

Figure 5. Pharmaceutical Processing & Particle Engineering Strategies of Garlic against *C. tropicalis*

- **Nanoencapsulation** → improved delivery & penetration.
- **Lyophilization (freeze-drying)** → enhances stability & shelf life.
- **Spray drying** → scalable particle formation.
- **Hydrogel systems** → mucoadhesive, sustained release, localized therapy.

Conclusion

- Garlic extract shows strong antifungal action against *C. tropicalis*.
- Particle engineering improves its stability and delivery.
- Particle engineering strategies such as Nanoencapsulation, Lyophilization, Spray drying, SCF, and Hydrogel systems improve garlic bioactive stability, bioavailability, and penetration into fungal biofilms.
- These engineered systems offer a promising, eco-friendly strategy to combat multidrug-resistant *C. tropicalis* infections and bridge natural therapy with modern drug delivery science.

References

- Li, N., Zhang, J., Yu, F., Ye, F., Tan, W., Hao, L., ... & Hu, X. (2024). Garlic-derived quorum sensing inhibitors: a novel strategy against fungal resistance. *Drug Design, Development and Therapy*, 6413-6426.
- Hassanzadeh, H., Rahbari, M., Galali, Y., Hosseini, M., & Ghanbarzadeh, B. (2023). The garlic extract-loaded nanoemulsion: study of physicochemical, rheological, and antimicrobial properties and its application in mayonnaise. *Food Science & Nutrition*, *11*(7), 3799-3810.