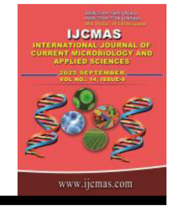
Int.J.Curr.Microbiol.App.Sci (2025) *14*(09): 54-57

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 14 Number 9 (2025)**
Journal homepage: http://www.ijcmas.com



Review Article https://doi.org/10.20546/ijcmas.2025.1409.006

Microbial Metabolism and Virulence

Susinjan Bhattacharya*

School of Agriculture and Allied Sciences, The Neotia University, Sarisa, West Bengal, India

**Corresponding author*

Keywords

Metabolism, Virulence, Infective Propagule Count

Article Info

Received:
09 July 2025
Accepted:
24 August 2025
Available Online:
10 September 2025

A B S T R A C T

Metabolism, an important activity is essential for microbial population build up. This activity is joined with metabolism interfering virulence factors leading to dominance of one species in a mixed culture. In a linear relation, more microbial growth leads to more infective propagule (I.P.) count, and mixed culture activity is seen in many environments including organic matter decomposition. The present work will be studying the interaction between metabolism, virulence and I.P. count of microorganisms, and will be emphasizing on the understandings and advancements between metabolism and virulence.

Introduction

Organic matter breakdown results in the formation of humus and other products, beneficial for soil health and functioning. Humus, an amorphous, stable brown material is essential for nutrient cycling and soil health. The breakdown of organic materials as well as composting of agricultural residues and other forms of waste also encourages buildup of beneficial micro-organisms. Those microbes support the further development of microbial biofertilizers or microbial biopesticides or microbial bioagents. The rate of organic matter decomposition is dependent on microbial metabolic activity. There are diverse and varied metabolic pathways for microbial breakdown of organic materials, wherein some can result in formation of humus (Yang, 2023; Forsmark, 2024; Aguilar-Paredes, 2023). Furthermore, increased metabolic activity also results in increased infective propagule count of microorganisms which can result in formation of pathogenic virulence either of beneficial microbes or harmful microbes (Raihan *et al.,* 2021; Nasslahsen *et al.,* 2022; Bidondo *et al.,* 2016; Samantaray *et al.,* 2024). Increased I.P. count of beneficial microbes is helpful for good agricultural practices. Organic matter has been taken in this current work as an exemplarily natural environment wherein rate of organic matter breakdown resulting in nutrient and energy supply for new microbial cell formation and supports growth and metabolism. The current work will be studying in brief the interaction between metabolism, virulence and I.P. count of microorganisms, and will be emphasizing on the understandings and advancements between metabolism and virulence.

Metabolic pathway and virulence

A bacterial life and living inside the host needs nutritional exchange and cross talk mechanism. Metabolic adaptation of bacteria plays key role in bacterial pathogenesis, and helps in pathogenic virulence. A prime set of metabolites plays role in competition between host and pathogen (Bhagwat *et al.,* 2025). This occurs because bacteria need to survive in a rapidly changing environment wherein nutrient availability will be also changing. In order to meet their nutrient and energy requirement, survival demands expression of enzyme encoding genes for growth, and additionally expression of virulence genes in pathogenesis. Thus, environmental and nutritional signal directs the virulence (Somerville and Proctor, 2009). This further helps pathogenic forms to exploit host resources by evading defense mechanism. Furthermore, metabolic profiles of microbes within the same population vary.

Virulence in organic matter breakdown and humus formation

Virulence understood from the virulent factors and organic matter decomposition are distinct but can be conceptualized at critical view points as a similar process. Virulence is restricted to pathogens and understood when with regard to their host interaction. Organic matter decomposition is carried out primarily by decomposers. However, pathogenic microbes if present in organic matter content may slow down the rate of activity of decomposers, resulting in slowed down organic matter decomposition. Virulent factors, organic acids increase the rate of decay, which in turn provides nutrient and energy to support microbial growth and virulence. Secretion of organic acids, gluconic acid, oxalic acid, citric acid in situations of infection by plant pathogenic fungi, *Penicillium* spp., *Botrytis cinerea*, and *Sclerotinia sclerotiorum* leads to fruit decay and postharvest losses (Jiao *et al.,* 2022). A deeper insight will help to manage plant and animal diseases and for promoting healthy ecosystems. Interestingly, decay and decomposition are both a natural process wherein the complex forms of substance will be broken down to simpler forms. However, presence of pathogens can inhibit the activity of beneficial decomposers in the soil, potentially slowing down the breakdown of organic matter.

Metabolism, decomposition and virulence, and I.P. count

Metabolism and virulence are interlinked processes. Regulatory factors for nutrient acquisition, or enhanced nutrient scavenging ability boosts up microbial virulence. Accelerated virulence and metabolism will lead to generation of population diversity and can also generate a new metabolic resource (Hardie, 2019). Infective propagule count, defining the potential of infection indirectly is linked to the virulence and metabolism of a pathogenic micro-organism (Lively, 2005), as in situations of higher number of propagule, higher virulence can be seen but need not be true in all situations.

Microbial decomposition and rates effecting decomposition

The rate of microbial organic matter decomposition, a complex process is dependent upon multiple factors, substrate quality, temperature, pH, moisture, aeration, and presence, or absence of inorganic chemicals. Additionally, presence as well as diversity of microbial infective propagules effects on the rate of decomposition. Ardestani *et al.,* (2025) established the influence of microbial diversity to support decomposition.

Factors influencing microbial metabolism

There are many factors to influence microbial metabolism and growth in different conditions. Presence of optimum condition effects upon the desired growth, however, limited condition slows down growth, apart from severe limitations, wherein microbial cells grow at near zero rate (Gonzalez and Aranda, 2023).

Enhancers and inhibitors in metabolism

Enhancers in microbial metabolism accelerates metabolic activity, while inhibitors limit metabolism. Understanding of interactions here will help to study on varied activities, synergistic effects, antimicrobial resistance, metabolic engineering, etc. Cate *et al.,* (2024) reported upon organic acids as the best bacterial growth inhibitors both in broth culture and biofilm experiments. Apart from this bioenergetic inhibitors are gaining interest in drug discovery research (Hasenoehri *et al.,* 2021).

Interaction studies

The interlinkages and interactions between metabolism, virulence and infective propagule count is essential to construct strategies for fight against infectious diseases.

Pajon *et al.,* (2023) observed in a coculture study that dominance of one species is due to the interactions between growth, metabolism, and metabolism changing virulence factors. They concluded upon that disturbances in spatial community structure can change the linkage between absolute growth and components of a final population.

Microbial organic matter decomposition will lead to the generation of nutrient and energy supporting growth of varied microorganisms. This will lead to a spurt in the metabolic activities and increase in microbial infective propagule count. Though this activity is a stage dependent process, however addition of enhancers or inhibitors can modulate the activity.

Data Availability

No statistically presentable data has been generated.

Author Contributions

Susinjan Bhattacharya: Investigation, formal analysis, writing—original draft.

Declarations

Funding: This work received no specific grant from any funding agency in the public, commercial or not- for-profit sectors.

Ethical Approval The article does not contain any studies involving human participants or animals.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

Aguilar-Paredes, A., Valdés, G., Araneda, N., Valdebenito, E., Hansen, F., Nuti, M., (2023). Microbial community in the composting process and its positive impact on the soil biota in sustainable agriculture. Agronomy 13, 542. https://doi.org/10.3390/agronomy13020542

Ardestani, M.M., Kukla, J., Cajthaml, T., Baldrian, P., Frouz, J., (2025). Microbial diversity drives decomposition more than advantage of home environment-evidence from a manipulation experiment with leaf litter. Microorganisms 13(2), 351. https://doi.org/10.3390/microorganisms13020351 . PMID: 40005718; PMCID: PMC11858187

Bidondo, L.F., Colombo, R., Bompadre, J., Benavides, M., Scorza, V., Silvani, V., Pérgola, M., Godeas, A., (2016). Cultivable bacteria associated with infective propagules of arbuscular mycorrhizal fungi. Implications for mycorrhizal activity. Applied Soil Ecology 105, 86-90. https://doi.org/10.1016/j.apsoil.2016.04.013.

Cate, J.D., Sullivan, Y.Z., King, M.D. (2024). Inhibition of Microbial Growth and Biofilm Formation in Pure and Mixed Bacterial Samples. Microorganisms 12, 1500. https://doi.org/10.3390/microorganisms12071500

Forsmark, B., Bizjak, T., Nordin, A., Rosenstock, N.P., Wallander, H., Gundale, M.J., (2024). Shifts in microbial community composition and metabolism correspond with rapid soil carbon accumulation in response to 20 years of simulated nitrogen deposition. Sci Total Environ 918, 170741. https://doi.org/10.1016/j.scitotenv.2024.170741. Epub 2024 Feb 6. PMID: 38325494.

Gonzalez, J.M., Aranda, B., (2023). Microbial Growth under Limiting Conditions-Future Perspectives. Microorganisms. 11(7), 1641. https://doi.org/10.3390/microorganisms11071641 . PMID: 37512814; PMCID: PMC10383181

Hardie, K., (2019). Where bacterial metabolism and virulence intersect. https://microbiologysociety.org/publication/past-issues/metabolism-health-and-disease/article/where- bacterial-metabolism-and-virulence-intersect.html Accessed 22 August 2025

Hasenoehrl, E.J., Wiggins, T.J., Berney, M., (2021). Bioenergetic Inhibitors: Antibiotic Efficacy and Mechanisms of Action in Mycobacterium tuberculosis. Front Cell Infect Microbiol 10, 611683. https://doi.org/10.3389/fcimb.2020.611683

Jiao, W., Liu, X., Li, Y., Li, B., Du, Y., Zhang, Z., Chen, Q., Fu, M., (2022). Organic acid, a virulence factor for pathogenic fungi, causing postharvest decay in fruits. Molecular Plant Pathology 23, 304–312. https://doi.org/10.1111/mpp.13159

Lively, C.M., (2005). Evolution of virulence: coinfection and propagule production in spore-producing parasites. BMC Evol Biol 5, 64. https://doi.org/10.1186/1471-2148-5-64

Nasslahsen, B., Prin, Y., Ferhout, H., Smouni, A., Duponnois, R., (2022). Mycorrhizae helper bacteria for managing the mycorrhizal soil infectivity. Front Soil Sci 2, 979246. https://doi.org/10.3389/fsoil.2022.979246

Pajon, C., Fortoul, M.C., Diaz-Tang, G., Marin Meneses, E., Kalifa, A.R., Sevy, E., Mariah, T., Toscan, B., Marcelin, M., Hernandez, D.M., Marzouk, M.M., Lopatkin, A.J., Eldakar, O.T., Smith, R.P., (2023). Interactions between metabolism and growth can determine the co-existence of *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Elife 12, e83664. https://doi.org/10.7554/eLife.83664. PMID: 37078696; PMCID: PMC10174691.

Raihan, T., Rabbee, M.F., Roy, P., Choudhury, S., Baek, K.-H., Azad, A.K., (2021). Microbial Metabolites: The Emerging Hotspot of Antiviral Compounds as Potential Candidates to Avert Viral Pandemic Alike COVID-19. Front Mol Biosci 8, 732256. https://doi.org/10.3389/fmolb.2021.732256

Samantaray, A., Chattaraj, S., Mitra, D., Ganguly, A., Kumar, R., Gaur, A., Mohapatra, P.K.D., Santos- Villalobos, S.L., Rani, A., Thatoi, H., (2024). Advances in microbial based bio-inoculum for amelioration of soil health and sustainable crop production. Curr Res Microb Sci 7, 100251. https://doi.org/10.1016/j.crmicr.2024.100251. PMID: 39165409; PMCID: PMC11334944.

Somerville, G.A., Proctor, R.A., (2009). At the crossroads of bacterial metabolism and virulence factor synthesis in Staphylococci. Microbiol Mol Biol Rev 73(2), 233-48. https://doi.org/10.1128/MMBR.00005-09. PMID: 19487727; PMCID: PMC2698418.

Yang, H., Ma, L., Fu, M., Li, K., Li, Y., Li, Q., (2023). Mechanism analysis of humification coupling metabolic pathways based on cow dung composting with ionic liquids. J Environ Manage 325(Pt A), 116426. https://doi.org/10.1016/j.jenvman.2022.116426. Epub 2022 Oct 11. PMID: 36240639.

Bhagwat, A., Haldar, T., Kanojiya, P., & Saroj, S. D. (2025). Bacterial metabolism in the host and its association with virulence. Virulence, 16(1), Article 2459336. https://doi.org/10.1080/21505594.2025.2459336

How to cite this article:

Susinjan Bhattacharya. 2025. Microbial Metabolism and Virulence. *Int.J.Curr.Microbiol.App.Sci.* 14(09): 54-57.
doi: https://doi.org/10.20546/ijcmas.2025.1409.006