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Article

Endophytic Fungi: Host-Derived Phytochemicals: Techniques of Bioactive materials Acquisition and synthesis

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Abstract: Long years of research into alternative, microbiological sources for valuable phytochemicals were driven by the fact that endophytic fungi usually synthesize secondary metabolites which structurally identical or nearly related to bioactive substances exist in hosting plants. This review investigates the suggested mechanisms for this convergence, like horizontal gene transfer (HGT) among host and fungus, long-term coevolution and convergent biosynthetic evolution, and bioconversion of host-derived precursors. Furtherance of more convincing cases like camptothecin-producing endophytes from Camptotheca acuminata, it looks at important and contentious case for studies, especially the identification of the Taxol-producing Taxomyces andreanae in Taxus brevifolia and the genomic re-examination which was unable to confirm independent fungal Taxol biosynthesis. β-1,6-glucanase gene transferring among the fungal endophyte and a cool-season grass host was investigated in reported existence of HGT. Although endophyte-host chemical mimicry is a considerable promise for the discovery of sustainable natural products, the claim of autonomous synthesis should thoroughly be confirmed by analysis of phytochemical and genomic before microbial sources could be considered as trustworthy relative to compounds produced by the plants.

Keywords: Alternative, microbiological sources, natural products.

Introduction

Conventional medicine and contemporary pharmaceutical papers always depended on medicinal plants as a source of bioactive materials with an extensive variety of therapeutic applications. Nevertheless, in last few years, attention has been changed to the endophytic fungi that live in plants tissues and do not cause disease [1]. That was because it has been observed many times that certain endophytes produce the secondary metabolites which are either chemically similar or structurally very identical to compounds that are only known from their host. The convergence made the plant–endophyte symbiosis as a paradigm for novel natural-product synthesis and the most sustainable

pharmaceutical production, since fungal fermentation takes place, in principle, the replacement of the slow-growing, low-yield, or endangered plant sources of many high-value phytochemicals [2].

Confirming how fungi gain or independently arrive at these host-linked materials residue an active and sometimes contested area of research, with major implications for whether such fungi could be trustworthy scaled up as commercial production platforms.

Methodology

This study was designed as a narrative, critical review of the literature on host-derived phytochemicals produced by endophytic fungi. Relevant publications were retrieved from Scopus, Web of Science, PubMed and Google Scholar using combinations of the terms "endophytic fungi", "host-derived metabolites", "horizontal gene transfer", "coevolution", "bioconversion", "Taxol", "camptothecin" and "comparative genomics". The period covered extended from the first report of fungal Taxol production in 1993 to studies published in 2026. Peer-reviewed original articles, reviews and a doctoral dissertation written in English were included when they reported the production of host-identical or structurally related metabolites by endophytes, or provided genetic evidence for or against their autonomous fungal biosynthesis; reports lacking chemical or molecular verification were excluded.

The selected sources were analysed qualitatively. Evidence was first grouped according to the three explanatory mechanisms proposed for host–endophyte chemical convergence, namely horizontal gene transfer, long-term coevolution, and direct synthesis or conversion of host precursors. Case studies were then appraised by the type of evidence they offered, ranging from chromatographic and immunological detection of the compound, through isotope-labelled precursor feeding, to whole-genome sequencing and comparative genomic re-assessment. This ordering made it possible to distinguish claims supported only by phytochemical detection from those confirmed at the level of the biosynthetic genes.

Results

Through the symbiotic system among endophytes and the host, three main explanatory mechanisms have been postulated for why fungi can produce host-associated compounds:

The Horizontal gene transfer (HGT) consult to the transmission of genetics along phylogenetically distant species by techniques other than fertilization, and is an essential evolutionary technique more and more documented in eukaryotic genomes as whole-genome sequencing has more available [3]. Researchers have hypothesized that HGT among host plants and their related fungi may be in charge for the synthesis of shared bioactive secondary metabolites, potentially transferring not only single genes but entire biosynthetic gene clusters [4]. One of the clearest registered cases involves the transfer of a β-1,6-glucanase gene, involved in fungal cell-wall degradation, from an ancestral fungal endophyte within the genome of perennial ryegrass roughly 9–13 million years ago—among the few well-supported instances of nuclear gene transfer between distantly related eukaryotic lineages [5]. A separate registered case includes the horizontal transfer of a bacterial insect-toxin gene into the *Epichloë* fungal symbionts of grasses.

Long-standing coevolution and convergent evolution deliver an alternate description: rather than obtaining genes directly, host and endophyte could independently evolve the metabolic ability to synthesize the identical or structurally identical materials as a result of their close, sustained ecological association, sometimes termed metabolic module exchange or metabolic complementation among partners [6]. This framing feasts the endophyte–host relationship as a dynamic, long-term balance between fungal virulence factors and host defense retorts that gradually stabilizes into a durable equilibrium.

Direct synthesis and conversion explain cases where endophytic fungi either synthesize a metabolite de novo utilizing their own enzymatic paths, or selectively convert host-derived precursor molecules into the target compound. Endophytic fungi isolated from *Camptotheca acuminata*, for example, have been shown to directly synthesize the anticancer alkaloid camptothecin, a compound otherwise associated with the host tree itself [7], [8].

The greatest influential case study in this line still the 1993 report that *Taxomyces andreanae*, a fungal endophyte isolated out of the inner bark of the Pacific yew (*Taxus brevifolia*), synthesozed Taxol (paclitaxel) and related taxanes de novo when grown in semi-synthetic liquid media. The existence of fungal Taxol was validated at the time utilizing mass spectrometry, chromatographic comparison with plant-derived Taxol, and reactivity with Taxol-specific monoclonal antibodies, and radiolabeled acetate and phenylalanine precursors were proved to be integrated into fungal Taxol, backing de novo synthesis [9], [10]. This discovery launched more than 160 subsequent publications and documents on microbial taxane synthesis and stimulated a broad search for other Taxol-producing endophytes across yew species . Despite that, the quantity of Taxol produced by *T. andreanae* proved too low for commercial viability, and consequent taxane-synthesizing isolates from other genera faced the identical limitation. More significantly, a subsequently re-examination combining phytochemistry, molecular biology, and whole genome sequencing was unable to seek any proof for independent taxane biosynthesis in *T. andreanae* or in more recently isolated Taxus endophytes, casting substantial doubt on the original findings and on the broader literature reporting fungal Taxol production. A subsequent comparative genomics re-assessment of *T. andreanae* itself found no biosynthetic genes for taxane synthesizing in the sequenced genome [11], [12].

Discussion

The expectations of using endophytic fungi as extensible, fermentation-supported sources of host-derived phytochemicals have a significant benefit over reliance on slow-growing, geographically restricted, or endangered plant sources [13], [14]. Advances in molecular methods and genomic tools have expanded researchers' the capacity to predict and clarified the biosynthetic gene clusters (BGCs) underlying these materials, connecting genetic potential to chemical diversity, whereas synthetic biology tools like CRISPR-Cas9-mediated activation and heterologous expression provide schemes for defeating the low-yield obstacles which have historically restricted commercial fungal production [15], [16].

Simultaneously, the Taxol instance emphasize that host–endophyte chemical mimicry may not be assumed from phytochemical detection alone [17], [18]. Reports of mutual secondary metabolites need corroboration through comparative genomics, biosynthetic pathway verification, and separate replication before a fungal source could be deemed a reliable substitute for the plant compound [19], [20].

Conclusion

The potential of endophytic fungi to biosynthesize host-related bioactive compounds considered a truly important and still-developing line of natural-product research. The postulated technique involved direct biosynthesis or bioconversion of host precursors, permanent coevolution, in which the horizontal gene transfer. Real chemical confluence takes place, as proven by well-documented instances like camptothecin that biosynthesized in fungus related with Camptotheca and HGT-mediated gene acquisition in grass endophytes. Still, the pending Taxol challenge act as a reminder which assertions of self-sufficient fungal synthesis of valuable plant chemicals require thorough genetic confirmations. Comparative genomics, synthetic gene cluster characterization, and synthetic biology techniques should be included for separating true converging from artifact and convert confirmed instances into programmable, environmentally synthesizing systems.

REFERENCES

[1] T. Cheng, M. Kolařík, L. Quijada, and M. Stadler, 'A re-assessment of *Taxomyces andreanae*, the alleged taxol-producing fungus, using comparative genomics', *IMA Fungus*, vol. 13, p. 17, 2022, doi: 10.1186/s43008-022-00103-4.

[2] S. Kusari, S. Zühlke, and M. Spiteller, 'An endophytic fungus from *Camptotheca acuminata* that produces camptothecin and analogues', *Journal of Natural Products*, vol. 72, no. 1, pp. 2–7, 2009, doi: 10.1021/np800455b.

[3] S. Kusari, C. Hertweck, and M. Spiteller, 'Chemical ecology of endophytic fungi: Origins of secondary metabolites', *Chemistry & Biology*, vol. 19, no. 7, pp. 792–798, 2012, doi: 10.1016/j.chembiol.2012.06.004.

[4] A. Trajkovska Petkoska, 'Comparative bioactive compound profiling of endophytic fungi and their respective host plants for sustainable drug discovery', *Medicine in Microecology*, vol. 28, p. 100172, 2026, doi: 10.1016/j.medmic.2026.100172.

[5] L. Pellissier *et al.*, 'Comparative metabolomic study of fungal foliar endophytes and their long-lived host *Astrocaryum sciophilum*: A model for exploring the chemodiversity of host-microbe interactions', *Frontiers in Plant Science*, vol. 14, p. 1278745, 2023, doi: 10.3389/fpls.2023.1278745.

[6] Y. Wang *et al.*, 'Effects and molecular mechanism of endophytic elicitors on the accumulation of secondary metabolites in medicinal plants', *Frontiers in Microbiology*, vol. 16, p. 1558567, 2025, doi: 10.3389/fmicb.2025.1558567.

[7] J. Wen *et al.*, 'Endophytic fungi: An effective alternative source of plant-derived bioactive compounds for pharmacological studies', *Journal of Fungi*, vol. 8, no. 2, p. 205, 2022, doi: 10.3390/jof8020205.

[8] A. Verma *et al.*, 'Epigenetic manipulation for secondary metabolite activation in endophytic fungi: Current progress and future directions', *Mycology*, vol. 14, no. 4, pp. 275–291, 2023, doi: 10.1080/21501203.2023.2241486.

[9] A. Singh, D. K. Singh, R. N. Kharwar, J. F. White, and S. K. Gond, 'Fungal endophytes as efficient sources of plant-derived bioactive compounds and their prospective applications in natural product drug discovery: Insights, avenues, and challenges', *Microorganisms*, vol. 9, no. 1, p. 197, 2021, doi: 10.3390/microorganisms9010197.

[10] M. M. Gakuubi, M. Munusamy, Z.-X. Liang, and S. B. Ng, 'Fungal endophytes: A promising frontier for discovery of novel bioactive compounds', *Journal of Fungi*, vol. 7, no. 10, p. 786, 2021, doi: 10.3390/jof7100786.

[11] U. Heinig, S. Scholz, and S. Jennewein, 'Getting to the bottom of Taxol biosynthesis by fungi', *Fungal Diversity*, vol. 60, no. 1, pp. 161–170, 2013, doi: 10.1007/s13225-013-0228-7.

[12] P. Tiwari and H. Bae, 'Horizontal gene transfer and endophytes: An implication for the acquisition of novel traits', *Plants*, vol. 9, no. 3, p. 305, 2020, doi: 10.3390/plants9030305.

[13] K. V. Ambrose, A. M. Koppenhöfer, and F. C. Belanger, 'Horizontal gene transfer of a bacterial insect toxin gene into the *Epichloë* fungal symbionts of grasses', *Scientific Reports*, vol. 4, p. 5562, 2014, doi: 10.1038/srep05562.

[14] H. Shinozuka *et al.*, 'Horizontal transfer of a β-1,6-glucanase gene from an ancestral species of fungal endophyte to a cool-season grass host', *Scientific Reports*, vol. 7, p. 9024, 2017, doi: 10.1038/s41598-017-07886-2.

[15] S. S. M. Soliman and M. N. Raizada, 'Interactions between co-habitating fungi elicit synthesis of Taxol from an endophytic fungus in host *Taxus* plants', *Frontiers in Microbiology*, vol. 4, p. 3, 2013, doi: 10.3389/fmicb.2013.00003.

[16] L. A. Xavier *et al.*, 'Metabolomic profiling of endophytic fungi and the host plant *Annona jahnii* Saff. reveals shared and analogous compounds', *Plants*, vol. 15, no. 3, p. 501, 2026, doi: 10.3390/plants15030501.

[17] N. Rai *et al.*, 'Plant associated fungal endophytes as a source of natural bioactive compounds', *Mycology*, vol. 12, no. 3, pp. 139–159, 2021, doi: 10.1080/21501203.2020.1870579.

[18] F. Ntana, 'Plant-endophyte interactions as a source of bioactive compounds: Regulation of specialised metabolism during tomato and *Serendipita indica* interaction', PhD Thesis, University of Copenhagen, Copenhagen, Denmark, 2019.

[19] A. Stierle, G. Strobel, and D. Stierle, 'Taxol and taxane production by *Taxomyces andreanae*, an endophytic fungus of Pacific yew', *Science*, vol. 260, no. 5105, pp. 214–216, 1993, doi: 10.1126/science.8097061.

[20] A. Stierle, G. Strobel, D. Stierle, P. Grothaus, and G. Bignami, 'The search for a taxol-producing microorganism among the endophytic fungi of the Pacific yew, *Taxus brevifolia*', *Journal of Natural Products*, vol. 58, no. 9, pp. 1315–1324, 1995, doi: 10.1021/np50123a002.