

Plant Biofactories: Harnessing Nature for Sustainable Production

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Editorial

Received: 02-Sep-2025, Manuscript No. jbs-25-171851; **Editor assigned:** 04-Sep-2025, PreQC No. jbs-25-171851 (PQ); **Reviewed:** 13-Sep-2025, QC No. jbs-25-171851; **Revised:** 20-Sep-2025, Manuscript No. JBS-24-171851(R); **Published:** 29-Sep-2025, DOI: 10.4172/2320-0189.14.4.004.

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Citation: Tang Mei, Plant Biofactories: Harnessing Nature for Sustainable Production. RRJ Botanical Sci. 2025.14.004.

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Introduction

Plant biofactories are genetically engineered plants or plant cells designed to produce valuable biomolecules such as pharmaceuticals, vaccines, enzymes, and industrial compounds. By leveraging the natural biosynthetic abilities of plants, scientists can use them as “green factories” to produce complex substances that are otherwise expensive or difficult to synthesize chemically. This innovative approach combines plant biotechnology, genetic engineering, and metabolic pathway optimization to develop sustainable and cost-effective production systems.

Discussion

The concept of plant biofactories is rooted in the idea that plants can serve as living production platforms. Through genetic modification, specific genes responsible for the synthesis of target molecules are inserted into plant genomes, enabling the plant to produce these compounds naturally during growth. Common host plants include tobacco (*Nicotiana tabacum*), maize (*Zea mays*), rice (*Oryza sativa*), and algae. Tobacco, in particular, is favored due to its high biomass yield and ease of genetic transformation.

Plant biofactories have gained attention for their ability to produce biopharmaceuticals such as antibodies, vaccines, and therapeutic proteins. For example, plants have been used to produce vaccines against hepatitis B, rabies, and even COVID-19. These plant-derived products, often referred to as “molecular farming,” are advantageous because plants can be cultivated on a large scale at relatively low cost and without the risk of contamination by animal patho-

gens. Additionally, the production process can be rapidly scaled up during global health emergencies.

Beyond pharmaceuticals, plant biofactories are used to produce industrial enzymes, biodegradable plastics, and biofuels. Metabolic engineering enables the modification of plant pathways to enhance the accumulation of desired compounds, such as fatty acids, alkaloids, or secondary metabolites used in cosmetics and food industries. Furthermore, the use of plant cell cultures allows controlled production in bioreactors, ensuring consistency and quality.

Despite their potential, plant biofactories face challenges such as variable expression levels, regulatory hurdles, and public acceptance of genetically modified organisms (GMOs). Advances in gene editing tools like CRISPR/Cas9, improved promoter systems, and containment strategies are helping to overcome these obstacles.

Conclusion

Plant biofactories represent a promising frontier in biotechnology, offering a sustainable, scalable, and safe alternative for producing high-value biomolecules. By integrating plant biology with modern genetic engineering, they can contribute significantly to healthcare, industry, and environmental sustainability. As research progresses, plant biofactories may become key contributors to a greener and more resilient global bioeconomy.

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