Plants as Biofactories – A Green Revolution in Health, Nutrition, and Industry

Imagine a world where plants are not only essential for food but also serve as biofactories, producing pharmaceutical, nutritional, and industrial products and tools for scientific research. Traditional methods for sourcing these products, whether from native plant sources, intricate chemical processes, or animal-derived sources, often come with high costs, negative environmental impact, and ethical concerns. In response to the growing global demand for sustainable and ethical alternatives, scientists are turning to *Nicotiana benthamiana,* a close relative of tobacco, to produce valuable proteins, bioactive compounds, novel food ingredients and vaccines. This plant-based 'bio-manufacturing' offers a promising alternative to traditional methods, providing a more sustainable and ethical way to produce valuable proteins, bioactive compounds, novel food ingredients, and vaccines.

My research explored utilizing plants as biofactories to produce a range of beneficial substances, addressing the following critical questions: 1) How can a plant-based system effectively produce a key enzyme needed for synthesizing an antimalarial drug, and why might this approach be superior to traditional methods? 2) Can plant expression systems serve as sustainable sources for producing terpenoids—bioactive compounds widely used in food, pharmaceuticals, cosmetics, and biofuels—thereby reducing reliance on chemical synthesis? 3) Can we use plants to produce antigens for influenza vaccines more rapidly, safely, and cost-effectively than conventional vaccine production methods? 4) Can human fetal hemoglobin be produced in plants, potentially providing a new, affordable, and safe source of blood substitutes? 5) Can plant-produced myoglobin become a viable source of heme protein, improving human diets and enhancing oxygen therapies that depend on oxygen-carrying proteins? 6) How can plants be engineered to produce antioxidant proteins to treat diseases linked to oxidative damage? 7) Can cyprosin, an enzyme from the artichoke thistle (cardoon) plant, be produced in *N. benthamiana*, replacing animal rennet in cheese-making and creating a more sustainable, eco- and vegetarian-friendly dairy alternative?

Our findings show that leveraging plants as biofactories can offer safe, cost-effective, and scalable solutions to pressing health, nutrition, and industry challenges while aligning with global sustainability and health equity goals.

At the end of my lecture, I will share my vision for the future of bioactive substances produced in plant expression systems and their potential applications in human health and environmental resilience. For example, this technology could be harnessed to enhance plant resistance to pests and diseases, reducing reliance on chemical pesticides. Additionally, by enhancing the production of bioavailable heme iron in *N. benthamiana* through metabolic engineering, we could offer a sustainable and effective solution to combat global iron deficiency, outperforming traditional synthetic supplements. By transforming plants into biofactories, we are paving the way for a sustainable future where plant-based systems meet the world's needs.