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Editorial: Metabolic engineering of valuable compounds in photosynthetic organisms

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Editorial on the Research Topic
Metabolic engineering of valuable compounds in photosynthetic organisms

Photosynthetic organisms, including plants and algae, possess a remarkable ability to harness carbon dioxide and solar energy, enabling them to produce a vast array of complex compounds such as phenolic acids (Zhou et al., 2021), terpenes (Miller et al., 2020), unsaturated fatty acids (Kokabi et al., 2020; Gan et al., 2022), and other lipid products (Zienkiewicz and Zienkiewicz, 2020). This inherent capability positions them as highly promising platforms for the sustainable production of valuable biomolecules. While the industrial application of photosynthetic organisms in synthetic biology is not as advanced as that of model heterotrophs or mammalian systems, their significance as primary contributors to global biomass can be further developed. In fact, they are increasingly emerging as key players in the booming field of synthetic bioproducts, driven by advancements in genome editing tools and other innovative technologies. As we explore and exploit the potential of photosynthetic organisms, we open up exciting possibilities for the production of environmentally friendly and renewable biomaterials that can address pressing societal and ecological challenges.

This Research Topic includes eight original research and two review articles, with a special focus on the metabolic engineering of valuable biomaterials in plants and algae. Taparia et al., developed modular CRISPR/Cas9 constructs for the model diatom *Phaeodactylum tricornutum* that allow the multiplexed targeting and creation of marker-free genome-edited lines. The system was used to knock out *StLDP*, the gene encoding Stramenopile-type lipid droplet protein essential for lipid droplet biogenesis (Figure 1). Mellor et al. expressed human P450s in tobacco chloroplasts to produce indican, suggesting a strategy for producing high-value chemicals or drug metabolites in photosynthetic organisms (Figure 1). Another research ariticle investigated the biosynthesis of isoprenoids in poplar, and revealed that the 3-hydroxy-3-methylglutaryl-CoA reductase (HMGR) and 1-deoxy-D-

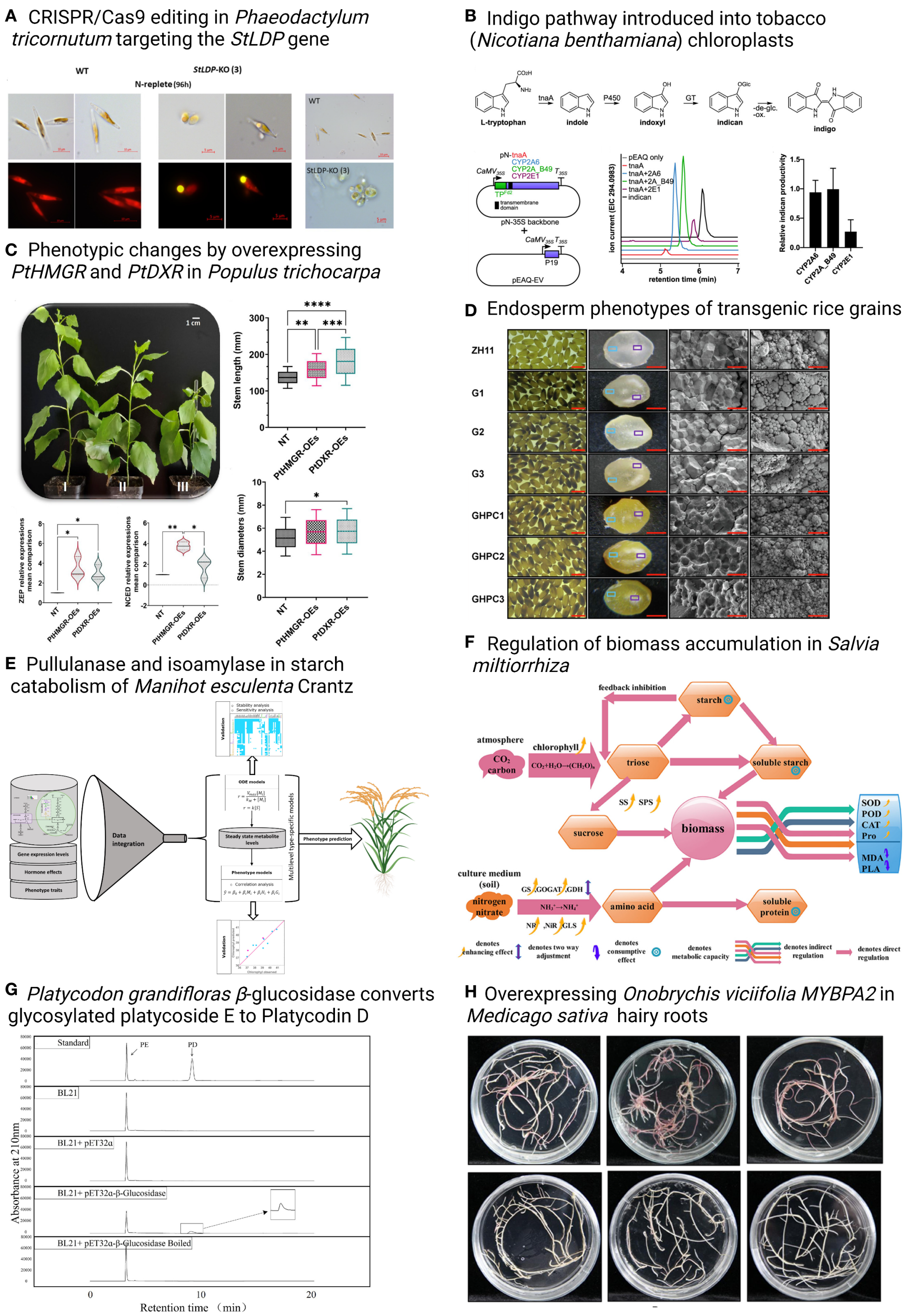

FIGURE 1
Overview of the original research articles in this Synthetic Biology Research Topic. Asterisks indicate statistically significant differences, *p <0.05, **p <0.01, ***p <0.001, ****p <0.0001

xylulose5-phosphate reductoisomerase (DXR) play important roles in regulating the genes in methylerythritol phosphate (MEP) and mevalonic acid (MVA) pathways and isoprenoids made from the MEP and MVA pathways (Figure 1) (Movahedi et al.). Li et al. produced carotenoids in rice (*Oryza sativa*) endosperm by overexpressing rice GOLDEN2-LIKE (*OsGLK*) transcription factor and *OsGLK* with three other carotenogenic genes, *tHMG1* (truncated *Saccharomyces cerevisiae* 3-hydroxy-3-methylglutaryl-CoA reductase), *ZmPSY1* (*Zea mays* L. phytoene synthase), and *PaCrtI* (*Pantoea ananatis* phytoene desaturase), to improve the nutritional composition of rice (Figure 1). Another research article in rice developed models by multilevel mathematical modeling using the data from rice lines with genome modification in MVA pathways, providing tools that can help prioritize metabolic engineering strategies for specific metabolic goals through exogenous pathways (Figure 1) (Basallo et al.). In perennial herbs, Wang et al. identified physiological/biochemical indicators, such as enzyme activities of glutamine synthetase (GS), glutamate synthase (GLS), glutamate dehydrogenase (GDH), peroxidase (POD), and catalase (CAT), were related to biomass accumulation in *Salvia miltiorrhiza* (Figure 1); Su et al. characterized the β-glucosidase in *Platycodon grandifloras*, which can convert glycosylated platycoside E to Platycodin D *in vitro* (Figure 1); Jin et al. identified an MYB transcription factor OvMYBPA2 in *Onobrychis viciifolia* by transcriptome analyses and confirmed its function in the regulation of proanthocyanidins in transgenic *Medicago sativa* (Figure 1). Strand and Walker reviewed bioengineering from an energetics perspective using photosynthetic organisms for bioproducts of interest (Figure 1). Another review article discussed the recent progress in engineering fatty acids and storage lipids in various plant species and tissues and summarized an inventory of specific lipogenic factors for plant lipid products (Figure 1) (Cai et al.).

Author contributions

Z-YD: Funding acquisition, Resources, Visualization, Writing – original draft, Writing – review & editing. WB: Writing – review & editing. GK: Writing – review & editing. IK-G: Writing – review & editing. X-HY: Writing – review & editing. AZ: Writing – review & editing. KZ: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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