Comparing *In Planta* and Microbial Production of Bioproducts

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Project Goals: Establish the scientific knowledge and new technologies to transform the maximum amount of carbon available in bioenergy crops into biofuels and bioproducts.

Plants and microbes share common metabolic pathways for producing a range of bioproducts that are potentially foundational to the future bioeconomy. However, *in planta* accumulation and microbial production of bioproducts have never been systematically compared on an economic basis to identify optimal routes of production. Detailed technoeconomic analysis using four biochemicals as exemplar compounds (4-hydroxybenzoic acid (4-HBA), catechol, muconic acid, and 2-pyrone-4,6-dicarboxylic acid (PDC)) is conducted with the highest reported yields and accumulation rates to identify economically-advantaged platforms and calculate break-even targets for plants and microbes. The results indicate that *in planta* mass accumulation ranging from 0.1 dry weight % (dwt%) to 0.3 dwt% achieve costs comparable to microbial routes with 40–55% of maximum theoretical yield. At small volumes and high market prices consistent with specialty chemicals ($20-50/kg), *in planta* accumulation rates in the 0.1 dwt%–0.3 dwt% are sufficient to be cost-competitive. At prices more consistent with commodity chemicals, an order of magnitude increases in accumulation rates for plants and and/or yields nearing theoretical maxima for microbial platforms are needed. This comparative analysis revealed that the accumulation rates of 4-HBA (3.2 dwt%) and PDC (3.0 dwt%) in engineered plants vastly outperform microbial routes, even if microbial platforms were to reach theoretical maximum yields. Their recovery and sale as part of a lignocellulosic biorefinery could enable biofuel prices to be competitive with petroleum. Muconic acid and catechol, in contrast, are currently more attractive when produced microbially. Ultimately both platforms can play an important role in replacing fossil-derived products.

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