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Title : Biosynthesis and bioengineering of flavonolignin (tricin-lignins): a unique cell wall component in grass biomass

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Related RISH mission : Mission 5-2 (Establishing a Society with Reduced Dependence on Fossil Resources: Plants, Biomass, Energy, and Materials)

Abstract :

Grasses are potent biomass resources for the sustainable generation of biomass-based fuels and materials due to their high growth rate and biomass productivity. However, biorefinery processes such as production of fermentable sugars from plant biomass are hindered by lignins, a major component in the plant secondary cell walls. Understanding lignin structure and biosynthesis may facilitate bioengineering and molecular breeding approaches for reducing lignin recalcitrance and improve the biomass utilization processes. The biosynthesis and structure of grass lignins are substantially different from those of lignins in other typical vascular plants (i.e., dicots and gymnosperms). Relatively recently, it was discovered that grass lignins uniquely incorporate a flavonoid triclin, apart from monolignols, canonical lignin monomers commonly found in all vascular plants. However, not much was known about the enzymes involved in triclin biosynthesis, functions of triclin-incorporated lignin (triclin-lignin or flavonolignin), and how manipulating triclin biosynthesis impacts cell wall chemistry and biomass utilization properties in grasses. Here, I summarize our recent findings on identification of triclin biosynthetic genes and characterization of their loss-of-function rice mutants with emphasis on their cell wall chemotypes and biomass utilization properties. Rice mutant deficient in flavone synthase II (FNSII) produced lignins devoid of triclin and heterologously incorporated with a non-canonical flavonoid monomer, naringenin. A novel apigenin 3'-hydroxylase/chrysoeriol 5'-hydroxylase (A3'H/C5'H; CYP75B4) involving in both 3' and 5'-hydroxylation steps crucial for triclin biosynthesis was identified, and its mutant lignins were likewise depleted in triclin and incorporated with non-canonical apigenin monomer. By contrast, the close homolog of A3'H/C5'H, flavonoid 3'-hydroxylase (F3'H; CYP75B3), appeared to contribute insignificantly in triclin-lignin biosynthesis but was the major 3'-hydroxylase for the parallel biosynthetic pathway leading to the formation of soluble flavone C-glycosides. On the other hand, rice mutant deficient in 5-hydroxyconiferaldehyde *O*-methyltransferase (CAldOMT) was depleted in both triclin-lignins and the canonical syringyl (S)-lignins, suggesting its bifunctional roles in both triclin and monolignol biosynthetic pathways. All these triclin-depleted mutants displayed improvement in biomass digestibility. As the triclin biosynthetic enzymes are highly conserved in grasses, they might serve as potent molecular targets for bioengineering to improve biomass utilization properties for biorefinery applications in other grass species.

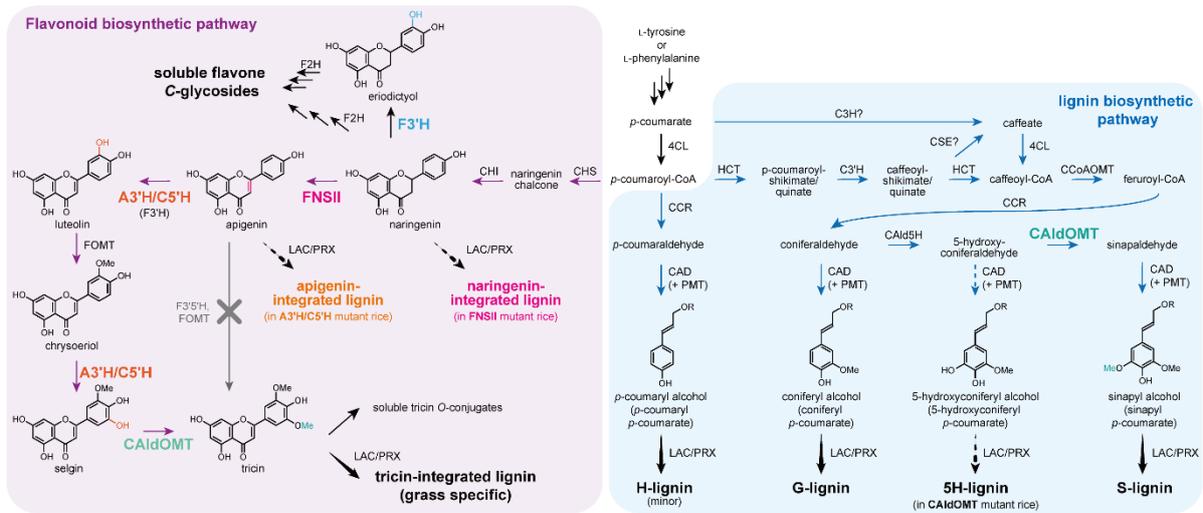


Fig. 1 Proposed tricrin and monolignol biosynthetic pathways in rice. Enzymes characterized in this study are labelled with different colours.