RECENT RESEARCH ACTIVITIES

Structure, biosynthesis, and bioengineering of lignocellulose and phenylpropanoid metabolites for future biorefinery

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It is becoming increasingly important to establish a sustainable society by reducing our excessive reliance on fossil resources and mitigate global climate change. As lignocellulosic biomass represents the most abundant renewable and carbon-neutral resources on earth, technologies to improve their utilizations are key for realizing the goal. In this context, we investigate the structure, biosynthesis and bioengineering of lignocellulose using various model plants and biomass crops. In addition, we are interested in understanding the biosynthesis of plant-derived phenylpropanoid metabolites with useful biological activities. Our program typically integrates research ideas and approaches based on chemistry, biochemistry, and plant molecular biology. Among a wide variety of biomass feedstocks, grass biomass crops, such as *Erianthus*, *Sorghum*, sugarcane and bamboo, have attracted particular attention due to their high biomass productivity and superior environmental adaptability. To explore new breeding strategies to improve the production of useful fuels and materials from grass biomass, we seek to develop transgenic rice plants that produce biomass with improved utilization properties. Our research particularly focuses on manipulating lignin, a phenylpropanoid polymer accounting for 15-30 wt% of lignocellulosic biomass. We have developed various rice transgenic lines in which specific genes encoding enzymes and transcription factors functioning in the lignin biosynthetic pathway are down- and/or up-regulated. Some of our developed transgenic lines display notably improved biomass utilization properties. In parallel, we are also working on selective breeding of grass crop varieties, such as *Erianthus* spp. and *Sorghum* spp., with superior lignins suited for bioenergy and biomaterial productions. In addition, aiming at biological production of useful phytochemicals, we have been characterizing plant and microbial enzymes/genes involved in formations of bioactive phenylpropanoids such as lignans and norlignans. Our recent projects include elucidation of the biosynthesis of antitumor podophyllotoxin in *Anthriscus sylvestris*, unravelling crystal structures of hinokiresinol synthases, unique enzymes responsible for the enantioselective formation of bioactive norlignans, and identification of enzymes/genes involved in the formation of estrogenic mammalian lignans (enterolignans) via human intestinal bacteria.

Selected Publications (AY2019)

[1] Lam PY et al. (2019) Recruitment of specific flavonoid B-ring hydroxylases for two independent biosynthesis pathways of flavone-derived metabolites in grasses. *New Phytologist* 223: 2014-219.
[2] Suzuki S et al. (2019) *De novo* transcriptome analysis of needles of *Thujopsis dolabrata* var. *hondae. Plant Biotechnology* 36: 113-118.
[3] Gui J et al. (2019) Phosphorylation of LTF1, a MYB transcription factor in *Populus*, acts as a sensory switch regulating lignin biosynthesis in wood cells. *Molecular Plant*, 12:1325-1337.
[4] Lam PY et al. (2019) OsCAldOMT1 is a bifunctional O-methyltransferase involved in the biosynthesis of tricin-lignins in rice cell walls. *Scientific Reports* 9: 11597.
[5] Martin AF et al. (2019) Altered lignocellulose chemical structure and molecular assembly in CINNAMYL ALCOHOL DEHYDROGENASE-deficient rice. *Scientific Reports* 9: 17153.
[6] Wahyuni Y et al. (2019) Variation in lignocellulose characteristics of 30 indonesian Sorghum (*Sorghum bicolor*) accessions. *Industrial Crops and Products* 142: 11840.
[7] Kanomata K et al. (2020) Lignin-inspired surface modification of nanocellulose by enzyme-catalyzed radical coupling of coniferyl alcohol in Pickering emulsion. *ACS Sustainable Chemistry and Engineering* 8:1185-1194.
[8] Gui J et al. (2020) Recruitment of specific flavonoid B-ring hydroxylases for two independent biosynthesis pathways of flavone-derived metabolites in grasses. *New Phytologist* 226: 1074-1087.
[9] Nge TT et al. (2020) Effect of heat treatment on the chemical structure and thermal properties of softwood-derived glycol lignin. *Molecules* 25: 1167.