
RECENT RESEARCH ACTIVITIES

Structure, Biosynthesis, and Bioengineering of Lignocellulose and Phenylpropanoid Metabolites for Future Biorefinery

(Laboratory of Metabolic Science of Forest Plants and Microorganisms,
RISH, Kyoto University)

Toshiaki Umezawa, Yuki Tobimatsu, Shiro Suzuki, Masaomi Yamamura, Takuji Miyamoto,
and Rie Takada

It is becoming increasingly important to establish a sustainable society by reducing our heavy reliance on fossil resources. 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 structure, biosynthesis and bioengineering of lignocellulosic biomass using various model plants and biomass crops. In addition, we are interested in understanding biosynthesis of plant-derived phenylpropanoid metabolites displaying various useful biological activities. Our program typically integrates research ideas and approaches based on chemistry, biochemistry, and molecular biology.

Among a wide variety of biomass feedstocks, large-sized grass species, such as *Erianthus*, *Sorghum*, sugarcane, and bamboo, have attracted particular attention especially due to their high biomass productivity and superior environmental adaptability. To explore new breeding strategies to improve the production of 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 lignin biosynthetic pathway are down- and/or up-regulated. Some of our developed transgenic lines appeared to display notably enhanced biomass properties that can be exploited for productions of bioenergy and biomaterials [1-3]. In parallel, we are working on selective breeding of grass crop varieties, such as *Erianthus* spp. and *Sorghum* spp., with superior lignins suited for bioenergy and biomaterial productions [4]. In addition, we also work on development of new analytical methods using various chemical methods, NMR spectroscopy, and fluorescence imaging techniques, to scrutinize elusive details of architecture and development of lignocellulosic biomass [5].

In another front, aiming at biological production of useful phytochemicals, we have been characterizing plant and microbial enzymes 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* [6], unravelling crystal structures of hinokiresinol synthases, unique enzymes responsible for the enantioselective formation of bioactive norlignans [7], and identification of new enzymes/genes involved in the formation of estrogenic mammalian lignans (enterolignans) via human intestinal bacteria [8].

Selected Publications and Presentations (FY2016)

- [1] Koshiha T, Yamamoto N, Tobimatsu Y, Yamamura M, Suzuki S, Hattori T, Mukai M, Noda S, Shibata D, Sakamoto M, Umezawa T. (2017) *Plant Biotechnol.* **34**:7-15.
- [2] Lam PY, Tobimatsu Y, Takeda Y, Suzuki S, Yamamura M, Umezawa T, Lo C. (2017) *Plant Physiol.*, **174**:972-985.
- [3] Takeda Y, Koshiha T, Tobimatsu Y, Suzuki S, Murakami S, Yamamura M, Rahman M, Takano T, Hattori T, Sakamoto M, Umezawa. (2017) *Planta*, **246**:337-349.
- [4] Miyamoto T, Mihashi, A, Yamamura M, Tobimatsu Y, Suzuki S, Takada R, Kobayashi Y, Umezawa T. (2017) Abstracts of the 2017 annual meeting of the Japan Society for Bioscience, Biotechnology and Agrochemistry.
- [5] Tobimatsu Y. (2017) A “Double Click” for illuminating plant cell walls. *Cell Chem. Biol.* **24**:246-247.
- [6] Kumatani M, Yamamura M, Ono E, Shiraishi S, Umezawa T (2017) Abstracts of the 67th Annual meeting of the Japan Wood Research Society.
- [7] Azuma A, Saka N, Suzuki S, Yamamura M, Mikami B, Umezawa T (2017) Abstracts of the 67th Annual meeting of the Japan Wood Research Society.
- [8] Hisadome N, Suzuki S, Utsumi R, Umezawa T. (2017) Abstracts of the 2017 annual meeting of the Japan Society for Bioscience, Biotechnology and Agrochemistry.