Upcycling Industrial Side-Streams: Fungal Biotransformation of Acid Whey and Soy Serum into Natural Aroma and Mycoprotein

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The sustainable valorization of agro-industrial side streams is a major scientific and technological challenge for the transition towards a circular bioeconomy. This project demonstrates that edible basidiomycota can serve as highly selective microbial cell factories to simultaneously generate natural aroma compounds and functional protein-rich biomass from two abundant food-processing side streams: acid whey and soy serum.

Systematic screening identified distinct fungus - substrate combinations with unique metabolic capabilities. *Ischnoderma benzoinum* converted acid whey into a product with an intense sweetish, almond-like aroma through the biosynthesis of benzaldehyde and its methoxylated derivatives, while simultaneously reducing lactose and improving the nutritional quality of the substrate. Mechanistic investigations revealed benzaldehyde as the central biosynthetic intermediate and demonstrated that precursor availability together with fermentation parameters - including pH, agitation, and light exposure - enable targeted control of aroma formation. The resulting aroma remained stable after ultra-high-temperature processing, and initial toxicological evaluation provided no evidence of increased cytotoxicity or genotoxicity, supporting its potential for food applications. In parallel, *Cyclocybe aegerita* efficiently transformed soy serum by eliminating undesirable beany off-aroma while generating desirable cereal- and popcorn-like aroma compounds. At the same time, fermentation produced a nearly odorless fungal biomass with favorable protein content, water- and oil-binding capacities, and gel-forming properties, highlighting its potential as a multifunctional ingredient for plant-based food formulations.

Beyond developing two novel fermentation processes, this project establishes a new conceptual framework for fungal biovalorization that integrates metabolic regulation, process engineering, flavor chemistry, and biomass functionality. The work demonstrates that edible fungi can be rationally exploited not only for waste conversion but also as programmable biocatalysts for the sustainable production of high-value food ingredients. Overall, the project provides a foundation for next-generation fungal biorefineries capable of transforming low-value food side streams into natural flavor compounds and functional ingredients, thereby advancing both the scientific understanding of fungal metabolism and the development of sustainable food production systems.