Precision Fermentation of Rubber Seed Oil Extracts for Fatty Acid Derivative Production: From Substrate Valorization to Scalable Bioprocesses

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Rubber seed oil (RSO), an abundant agro-industrial by-product of Southeast Asia's rubber plantations, represents an underutilized yet chemically rich feedstock for biotechnological valorization. Rich in C18 polyunsaturated fatty acids — including oleic (C18:1, ~24.6%), linoleic (C18:2, ~39.6%), and linolenic (C18:3, ~16.3%) acids — RSO offers a compelling low-cost, renewable substrate for the microbial production of high-value fatty acid derivatives.

This talk presents an integrated approach to RSO valorization through precision yeast fermentation, with emphasis on the oleaginous yeast *Yarrowia lipolytica* as a metabolic chassis for converting RSO-derived lipids into value-added products including biosurfactants, structured lipids, and functionalized fatty acid esters. We highlight upstream substrate engineering strategies — encompassing degumming, deacidification, and peroxide reduction — that are critical for generating a fermentation-compatible RSO extract, followed by rational strain and process optimization to redirect carbon flux toward target fatty acid derivatives.

Key bioprocess considerations — including fed-batch fermentation design, nutrient-to-oil feeding strategies, and dissolved oxygen management — that govern productivities and titers at bench scale are discussed. Critically, we address the scale-up challenges inherent to oil-based fermentation systems, including emulsification, mass transfer limitations, and downstream recovery, drawing from our laboratory's experience in transitioning lipid fermentation processes from flask to pilot-scale bioreactors.

This work demonstrates the feasibility of RSO as a platform feedstock within a yeast-based biorefinery framework, contributing to both circular bioeconomy goals and Thailand's natural rubber value chain.