

FROM DAIRY WASTE TO BIO-BASED SURFACTANTS: ENZYMATIC SYNTHESIS OF *n*-BUTYL 6-*O*-ACYL-GALACTOSIDES

Semproli R.^{1*}; Robescu M.S.¹; Sangiorgio S.²; Donzella S.³; Pargoletti E.²; Rabuffetti M.²; Bavaro T.¹; Cappelletti G.²; Compagno C.³; Molinari F.³; Speranza G.² and Ubiali D.¹

¹ University of Pavia, Department of Drug Sciences, viale Taramelli 12, Pavia, Italy

² University of Milano, Department of Chemistry, via Golgi 19, Milano, Italy

³ University of Milano, Department of Food, Environmental and Nutritional Sciences, via Mangiagalli 25, Milano, Italy

* Corresponding author: riccardo.semproli01@universitadipavia.it

Cheese whey permeate (CWP), a lactose-rich aqueous byproduct of dairy industry, can be exploited as feedstock for the synthesis of fine and commodity chemicals. In the BioSurf project, an integrated bioprocess was set-up for the synthesis of Sugar Fatty Acid Esters (SFAE), valuable non-ionic surfactants.^[1] CWP was used both for enzymatic biotransformations and for growing oleaginous yeasts to produce the galactose-based “head” and the lipid “tail” of SFAE, respectively.

Upon the proof-of-concept with commercial lactose,^[1] CWP was used to synthesize 1-butyl β -D-galactopyranoside (**1**) through a transglycosylation reaction catalyzed by the immobilized β -galactosidase from *Aspergillus oryzae* in a ternary system (buffer/1-BuOH/acetone) at 30 °C (yield: 45%). At the same time, microbial lipids were produced by growing oleaginous yeasts on CWP (cell lipid content: 45%).^[2] Microbial lipids were submitted to acid-catalyzed extraction and *in situ* transesterification giving fatty acid ethyl esters (FAEE, **2a-e**, yield: 80%). 1-Butyl β -D-galactopyranoside (**1**) and FAEE (**2a-e**) were reacted by a *solvent-free* transesterification catalyzed by the immobilized lipase from *Thermomyces lanuginosus* affording a mixture of *n*-butyl 6-*O*-acyl-galactosides (**3a-e**, yield: 40%). The products, characterized by NMR, will be tested for their surfactant properties.

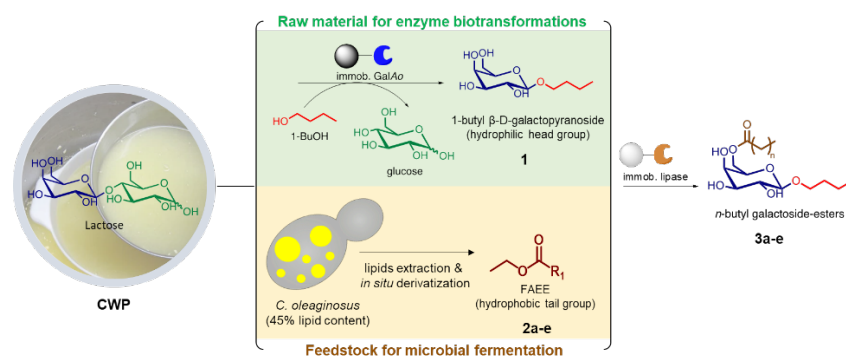


Figure 1: Integrated bioprocess for the upcycling of CWP into bio-based surfactants

- [1] Semproli, R.; Robescu, M.S.; Sangiorgio, S.; Pargoletti, E.; Bavaro, T.; Rabuffetti, M.; Cappelletti, G.; Speranza, G.; Ubiali, D., From lactose to alkyl galactoside fatty acid esters as non-ionic biosurfactants: A two-step enzymatic approach to cheese whey valorization. *ChemPlusChem* **2023**, *88*, e202200331
- [2] Donzella, S.; Fumagalli, A.; Arioli, S.; Pellegrino, L.; D’Incecco, P.; Molinari, F.; Speranza, G.; Ubiali, D.; Robescu, M.S.; Compagno, C., Recycling food waste and saving water: Optimization of the fermentation processes from cheese whey permeate to yeast oil. *Fermentation* **2022**, *8*, 341

This work was financially supported by the Cariplo Foundation (Italy) (call: “Circular Economy for a sustainable future 2020”, project BioSurf, ID 2020–1094).