Circular Economy in Food Industry Waste Management (BIVALIA Workshop2 - 2026)

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P.I.7 — Fermentable sugars recovery from agro-food by-product for bioethanol production

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The treatment of waste from the agri-food supply chain is expected to intensify with global population growth. A major challenge in using food waste as a biorefinery feedstock is sample heterogeneity. The food manufacturing industry offers more homogeneous materials, which is key to the optimal valorisation of these residues, since variations in feedstock lead to differences in the chemical composition of the wastes [1].

This study evaluates the potential of three abundant by-products—brewer's spent grain (BSG), grape stalks, and cheese whey—for bioethanol production, comparing their characteristics, processing requirements, and fermentation performance. BSG, a by-product from the beer-brewing process, requires pretreatment to improve cellulose accessibility; steam explosion was selected because it effectively disrupts the biomass structure and partially solubilises hemicelluloses, producing a glucose- and xylose-rich prehydrolysate [2]. Grape stalks, lignocellulosic waste obtained after destemming in winemaking, were processed by aqueous extraction, yielding a solution containing mainly glucose and fructose. Cheese whey was pasteurised and then subjected to enzymatic hydrolysis.

The fermentation performance of the three sugar-rich streams was evaluated using an industrial yeast, focusing on the effects of nutrient supplementation and yeast inoculum concentration on sugar utilisation and ethanol yield. The results showed that BSG prehydrolysate required both nutrient supplementation and a higher yeast inoculum concentration (up to 1 g/L) to achieve efficient fermentation, yielding ethanol above 0.44 g/g sugar consumed. In contrast, grape stalk extract and cheese whey achieved comparable ethanol yields without nutrient supplementation and at a much lower inoculum concentration (0.2 g/L), although fermentation proceeded more slowly.

Overall, the study demonstrates that each feedstock requires a specific processing strategy determined by its chemical composition and carbohydrate profile. Steam explosion substantially enhances the digestibility of lignocellulosic biomass, whereas cheese whey offers a simpler processing route because its sugars are readily fermentable after enzymatic hydrolysis of lactose.

These findings highlight the feasibility of integrating brewery, winery, and dairy residues into regional biorefinery schemes, contributing to waste valorisation, renewable solvent production, such as bioethanol, and greenhouse gas emissions reduction while supporting the development of a sustainable circular economy.

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