Acid whey permeate valorisation through bioconversion strategies

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Acid whey is a side-stream in fermented dairy product production and presents a persistent utilisation challenge due to its high organic load and limited processing options. This necessitates the development of alternative processing routes for acid whey. In parallel, the growing demand for sustainable protein sources highlights the potential of converting dairy side-streams into nutritionally valuable products. This study evaluates a bioprocessing approach for converting acid whey permeate into yeast-based mycoprotein, providing a practical route for integrating dairy by-product valorisation into circular food systems.

Two lactose-assimilating yeast strains — *Kluyveromyces marxianus* MSCL 79 and *Cyberlindnera jadinii* MSCL 87 (Microbial Strain Collection of Latvia) — were cultivated on partly concentrated acid whey permeate with 13% and 20% total solids. The effects of lactose hydrolysis, supplementation of $(NH_4)_2HPO_4$, KH_2PO_4, $MgSO_4 \cdot 7H_2O$ and active biomass addition were examined to identify strain-specific optimisation strategies. The fermentation process was carried out in a batch-type bioreactor for up to 72 hours, maintaining a temperature of 30 °C and pH 5.0, with constant agitation at 70 rpm throughout the process.

Both yeasts were able to grow on acid whey permeate, confirming its feasibility as a carbon source for biomass synthesis. Distinct differences emerged between the strains. *K. marxianus* showed consistently higher substrate utilisation efficiency and achieved the highest biomass yields, particularly in hydrolysed whey with 20% total solids. Under these conditions, biomass formation approached 59 g L^{-1} when active biomass was added. *C. jadinii* produced lower biomass yields (up to ~31 g L^{-1}), indicating comparatively limited performance under the same conditions.

Increasing substrate solids from 13% to 20% enhanced wet biomass formation for both species but resulted in a proportional decrease in protein concentration, reflecting a shift between biomass accumulation and protein density. Lactose hydrolysis improved fermentation efficiency and supported higher protein concentration in both yeasts, while mineral supplementation further promoted protein synthesis at elevated solids levels.

Optimal fermentation conditions differed between strains. *K. marxianus* achieved the most favourable outcomes in hydrolysed whey with 20% solids in combination with supplementation of $(NH_4)_2HPO_4$, KH_2PO_4, $MgSO_4 \cdot 7H_2O$. *C. jadinii* achieved better results in hydrolysed whey permeate with 13% solids without active biomass addition. These strain-specific responses underline the need to tailor process parameters to the physiological characteristics of each yeast.

Overall, the study demonstrates a technically feasible method for converting acid whey into nutritionally valuable mycoprotein. By supporting more efficient use of dairy by-products and providing an alternative protein source, this approach contributes to improved resource management and the development of sustainable food and feed strategies.

Keywords
Acid whey, mycoprotein, yeast fermentation, dairy waste-stream, biomass