Towards maximum value creation from potato protein liquor: volatile fatty acid production from the effluent of fungal cultivation

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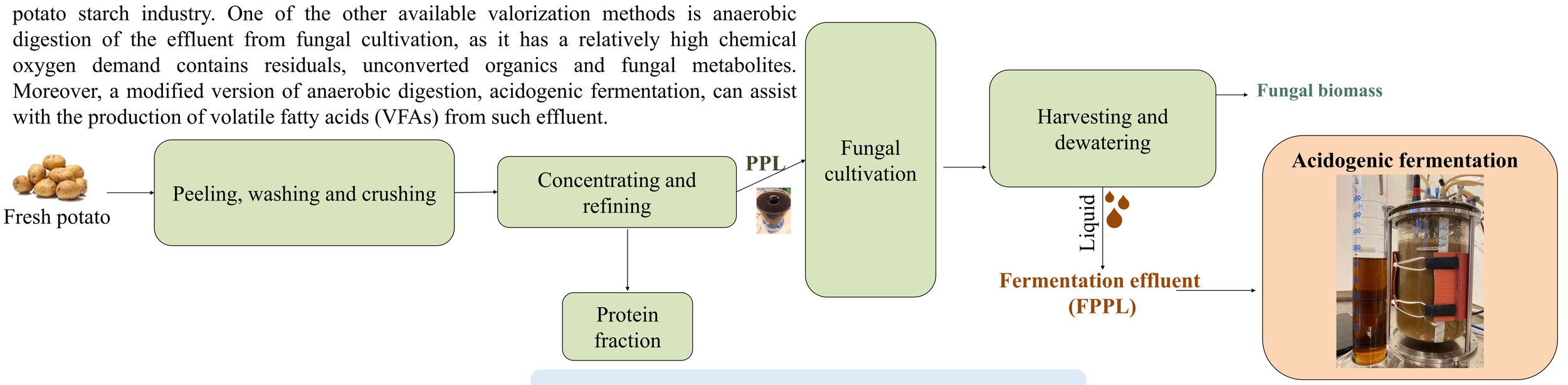
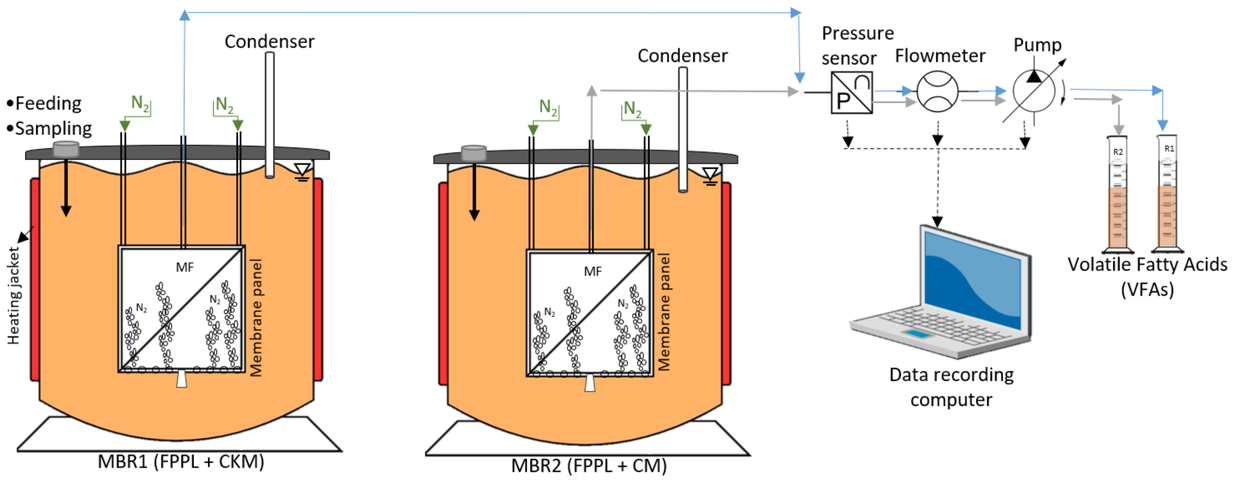
Introduction

Global annual potato production is now over 370 million tons, of which 826 400 tons will be produced in Sweden in 2021, corresponding to an area of 23 750 ha under cultivation [1]. However, the potato industry brings side streams that take up a significant portion of the original biomass. The potato liquor is treated with steam to coagulate the protein fraction, which is separated by a decanter. The remaining potato liquid, consisting mainly of the soluble fraction of waste from potato starch production, is concentrated to produce potato protein liquor (PPL). PPL was utilized in a previous study [2] by converting a large portion of the nutrients into food- and feed-grade fungal biomass. This partial valorization of waste generates another type of waste stream that can be used to maximize value in the potato starch industry. One of the other available valorization methods is anaerobic digestion of the effluent from fungal cultivation, as it has a relatively high chemical oxygen demand contains residuals, unconverted organics and fungal metabolites. Moreover, a modified version of anaerobic digestion, acidogenic fermentation, can assist with the production of volatile fatty acids (VFAs) from such effluent.

In order to seek maximum nutrient recovery, increase resource efficiency and apply circularity in potato starch production industry by further removing organics from PPL while generating high value products, in this study, the potential for high-yield VFAs production from effluent of the fungi biomass cultivation on PPL, FPPL, was investigated. The pH control without chemical addition (adjustment of I:S ratio), the influence/choice of inoculum (CM and CKM) and methanogen inhibition in the initial batch fermentation were evaluated. In order to have continuous VFAs production and recovery, two immersed membrane bioreactors (MBRs) operating at different organic loading rate and inoculum type were applied.



Results & Discussion

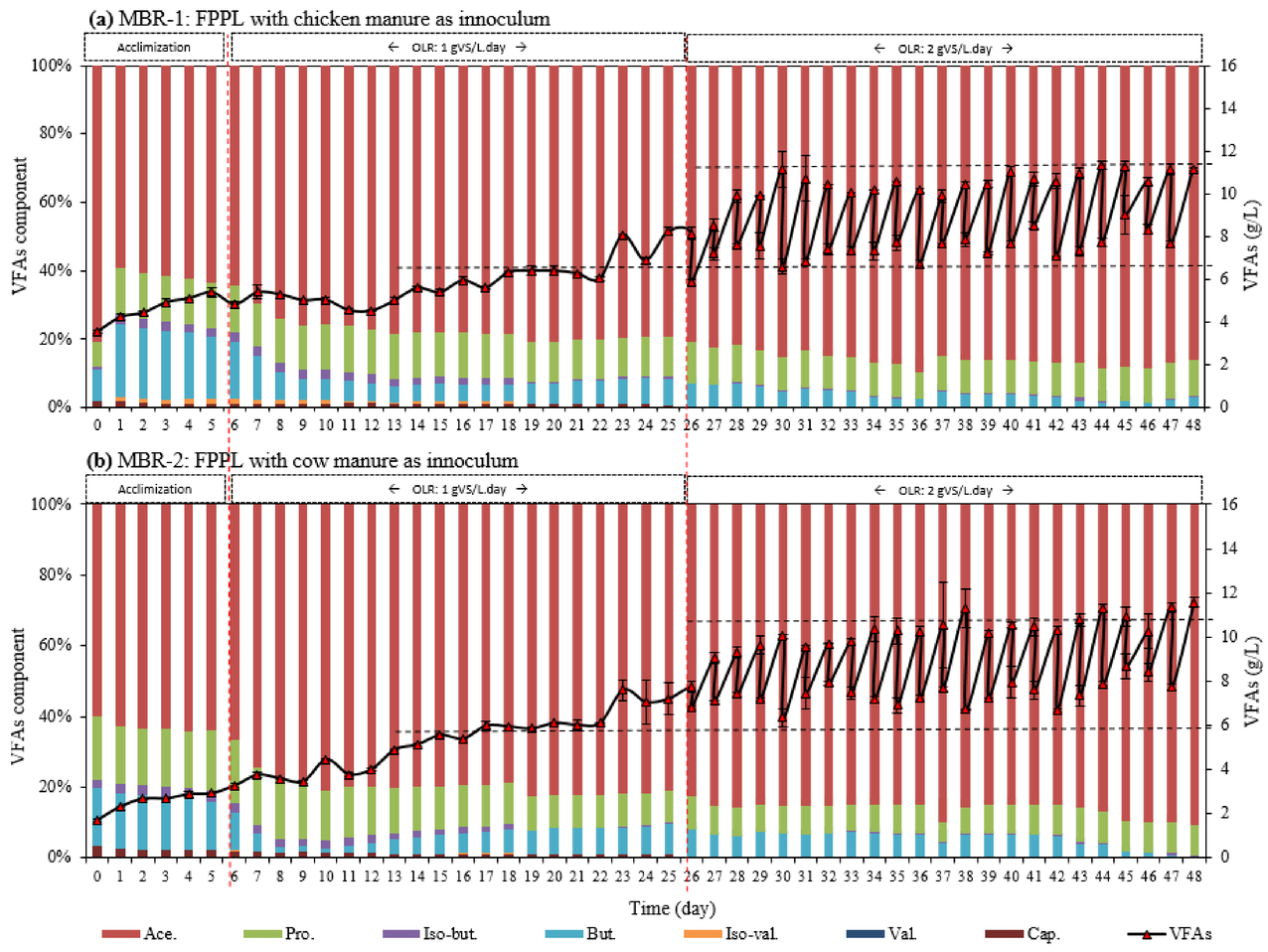


In order to investigate the potentials of VFAs generation from FPPL, batch tests were conducted considering different types of inoculums (CKM and CM) and inoculum to substrate ratios. The maximum VFA concentration of 5.89 ± 0.10 g/L and 5.76 ± 0.20 g/L was obtained from the conditions with CKM as inoculum with an inoculum:substrate (I:S) ratio of 1:4 (initial pH of 7.56) and CM as inoculum with an I:S ratio of 1:1 (initial pH of 7.41), respectively. In this study the pH of inoculum and FPPL mixtures (with 1:1 and 1.4 I:S ratios) was the defining pH hence pH of 7.90, 7.56. 7.41 and 7.02 was studied without chemical addition in batch study.

The semi-continuous anaerobic iMBRs were used for the production and in situ recovery of VFA-rich permeate from acidogenic fermenter using FPPL as feed and CKM (MBR1) and CM (MBR2) as inoculum as shown above. Semi-continuous production and recovery of VFAs was performed at an HRT of 10 days by filtering out 350 ml of the liquid medium as permeate before feeding on daily basis. Membrane filtration was performed over a 48-day period at a set initial permeate flux of 20 L/m²/h (LMH).

Acetic acid is often the main component of the total VFAs (tVFAs) during AD, this was also the case in the present study, where acetic acid comprised 59 – 97% of the tVFAs in both reactors and both operating OLRs. Following acetic acid, butyric acid (1 – 21%) and propionic acid (6 – 18%) were the second and third largest VFA components in the fermentation of FPPL. Membrane filtration performance and membrane surface condition and extent of fouling could be tracked by observing changes in TMP as well as the concentration of TSS during fermentation.

TMP fluctuated between 0.011 – 0.103 bar, and 0.064 – 0.219 bar throughout the fermentation period for MBR1 and MBR2, respectively. The average of tVFAs on MBR1 and MBR2 were 5.84 ± 1.03 g/L and 5.26 ± 1.31 g/L, respectively, during the period of day 6 to day 26. At the doubled OLR (2 g VS /L/d), the average total production of VFAs in both reactors increases to 10.40 ± 0.79 g/L for MBR1 and 10.22 ± 0.86 g/L for MBR2 The maximum VFAs yield was calculated as 0.65 g VFAs/g VS_{fed} and 0.36 g VFAs/g VS_{fed} for OLR 1 and 2 g VS/L/d in MBR1, and 0.54 g VFAs/g VS_{fed} and 0.35 g VFAs/g VS_{fed} for OLR 1 and 2 g VS/L/d, respectively in MBR2.



Conclusions

- The effluent from fungal cultivation on PPL, containing unconverted organics and fungal metabolites, was used to maximize the added value of the potato starch industry through acidogenic fermentation and production of VFAs.
- Based on the results obtained in this study, an iMBR inoculated with either cow or chicken manure can produce a particle- and microorganism-free VFA-containing effluent with a maximum yield of 0.65 g VFAs/g VSfed and recovered at a flux of 20 LMH in a long-term, 48-day stable filtration and fermentation process.
- The results prove that multi-stage bioconversion of potato starch industry residues into value-added products can be realized with the goal of nutrient reuse and resource recycling.

References

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