Anaerobic-based biorefinery — A Techno-Economic Analysis

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Abstract: The present abstract highlights the economic profit increase when combining organic waste anaerobic digestion with other mixed culture anaerobic fermentation technologies, e.g., lactic acid fermentation and dark fermentation. The highest profit is obtained by dark fermentation with separation and purification of acetic and butyric acids, i.e., 296 USD/t VS (47 USD/t foodwaste). From the return on investment (ROI) and payback time, the best scenario is the production of polylactic acid, with 98% ROI, and 7.8 years payback time. Production of butyric acid ROI and payback time was 74% and 9.1 years.

Keywords: anaerobic digestion; lactic acid fermentation; dark fermentation

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Introduction
Unlocking value from organic waste is a feasible idea, in contrast to the disposal of these organic wastes into landfills, that has an associated cost ranging from 40–400 USD/t [1]. Anaerobic digestion, for the production of biogas and digestate, has been historically one of chosen technology for the treatment of complex organic residues. However, the conversion of biomass to bulk chemicals is 3.5 to 7.5 times more profitable than its conversion to fuels/energy [1]. This is the main motivation for this techno-economic analysis. In recent years, several mixed culture anaerobic technologies, has emerged. Among these technologies are dark fermentation and mixed culture lactic acid fermentation. The interest in these “new” technologies is their value products, with market prices more attractive than methane and digestate. Their average prices are 400 USD/t and 15 USD/t, respectively.

Materials and Methods
The present techno-economic assessment is based on relevant literature data, and using conservative assumptions [2-14]

Results and Conclusions
Three different scenarios were investigated: a. Anaerobic digestion only, b. Lactic acids fermentation and anaerobic digestion and c. Dark fermentation and anaerobic digestion. Figure 1 shows the revenues, cost and profit of these three different assessed scenarios. The revenues/cost from the organic acids can be improved in the future as the scientific effort could be (re)-directed into finding more environmentally friendly processes and lowering the cost of organic acid separation-purification [15].
Figure 1. Economic assessment results for the different assessed scenarios.

Figure 2 shows the return on investment (ROI) and the payback time for all the assessed scenarios. From the ROI perspective scenario (B2) polylactic acid, generates the highest ROI, 98%. From all the assessed scenarios, only (A2) biogas to power, does not generates ROI, assuming that tipping fees/subsidies are minimal. This is due to the high cost of the combined heat and power generator and the low prices for electricity and digestate sold as soil improver.
The best pay back time was obtained for scenario (B2) polylactic acid fermentation, 7.8 years. The present techno-economic analysis has shown that profitability of food waste conversion to bulk chemicals, e.g., lactic acid or butyric acid, can be increased 5 to 16 times when compared to the base scenario, i.e., production of methane (sold to the grid). From the discussed scenarios, the highest profit is obtained by dark fermentation with separation and purification of butyric acid, 296 USD/t_VS (47 USD/t_foodwaste). From the return on investment (ROI) and payback time, the best scenario is the production of polylactic acid, with 98% ROI, and 7.8 years payback time. From these profit, ROI, and payback time perspectives, the present techno-economic analysis suggests a change in focus from biogas/biohydrogen into butyric acid and polylactic acid production from food waste. These results suggest that industry may refocus effort on bulk chemicals, e.g., butyric acid and/or polylactic acid, rather than only focusing on biofuels, as H₂ and CH₄.

Figure 2. Return on investment (ROI) and payback time for the different assessed scenarios. All the scenarios where evaluated in a time frame of 20 years, with an annual interest of 5%.

References