Continuous bio-hydrogen production from household food waste: the possibility of symbiosis with municipal wastewaters treatment

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Introduction

Biohydrogen production is an attractive option to meet the ever increasing energy demands due to the fact that its combustion leads to the formation of water, instead of CO_2 and its high energy density. Fermentative hydrogen production of food waste can contribute to both food waste minimization and energy recovery. However, the dilution of waste with tap water, still remains a major environmental issue during dark fermentative hydrogen production.

In this study, long term continuous biohydrogen production from household food waste through dark fermentation, was investigated, exploring simultaneously the possibility of water minimization, during dilution. Specifically, two identical CSTR – type lab- scale bioreactors of 0.46 L working volume were operated at 35.5^{o}C and fed with the liquid fraction after centrifugation of dried and shredded household food waste (FORBI). At the first one, FORBI was diluted with tap water and at the second one with municipal wastewater (MW), obtained from a local wastewater treatment plant.

Materials and Methods

FORBI

Food waste was collected at municipality level. It was source-separated and included fermentable waste which was subjected to heat-drying and shredding at 95–98 °C, for 9 h, resulting in a homogeneous organic product (FORBI), with the following characteristics: total solids (TS) 91.59± 0.75 %, volatile solids (VS) 89.32±0.73 % of TS, soluble carbohydrates 0.21±0.01 g/g TS, total carbohydrates, 0.34±0.03 g/g TS. The MW which was used as dilution factor had the following characteristics: total suspended solids (TSS) 0.18 ±0.02 g/L, volatile suspended solids (VSS) 0.14 ±0.01 g/L, total chemical oxygen demand (TCOD) 0.62 ±0.05 g/L, Soluble COD 0.40 ±0.05 g/L.

Hydrogen production process

The experiments were performed in two identical CSTR – type lab- scale bioreactors of 0.46 L, described in Alexandropoulou et al. (2018). The liquid fraction after centrifugation of 62 g FORBI diluted in 1 L of tap water (CSTR-1) or 1 L of MW (CSTR-2), supplemented with 5 g NaOH and 6.8 g KH_2PO_4 was used as the feeding substrate, which was inserted in the reactors via a peristaltic pump, at a fixed flow rate, so as to ensure the hydraulic retention times (HRTs) of 24, 12, 8 and 4 h.

During start-up, both reactors, were filled with the liquid fraction after centrifugation of 43.5 g FORBI diluted in 1 L of MW and operated anaerobically in batch mode for 24 h, in order to activate the indigenous microbial species. Following start-up, the operation of the reactor was switched to continuous mode. The reactor's performance (biogas production rate and composition in H_2, carbohydrates, volatile fatty acids (VFAs)), was monitored and characterized according to Alexandropoulou et al. (2018).

Results and discussion

Both CSTRs operated for 72 days, during which four different HRTs were tested (24,12,8 and 4 h). The biogas produced consisted mainly of hydrogen and carbon dioxide and it was free of methane, indicating that there was not methanogenic activity in the reactor. The percentage of hydrogen in the biogas and the hydrogen production rate, the total and soluble carbohydrates and the concentration of VFAs in both reactors, are depicted in Figure 1. It is obvious that shortly after the start-up the hydrogen content in the gas phase was quite high, while in the sequence it decreased gradually.

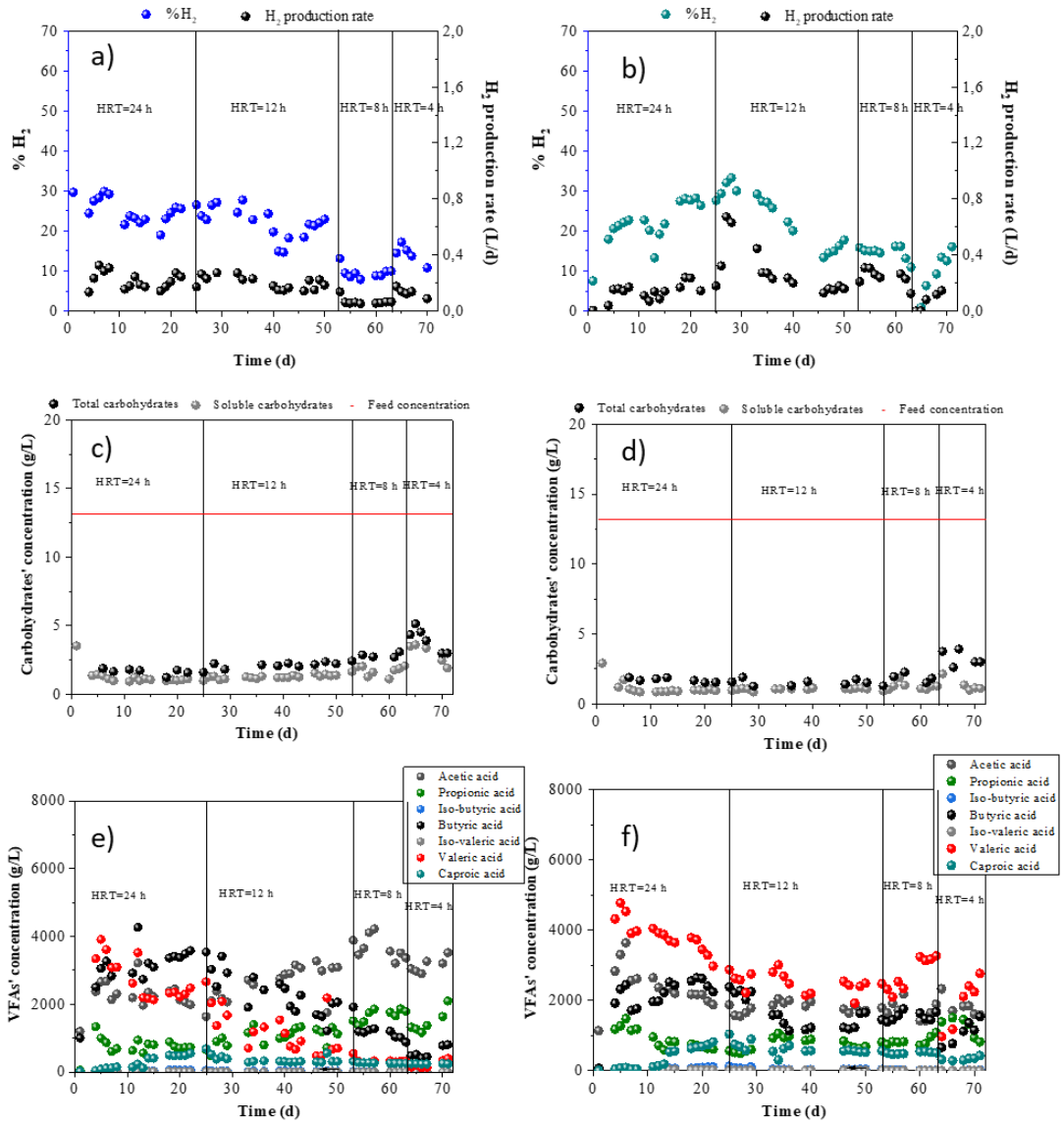

Figure 1: The percentage of hydrogen in the biogas and the hydrogen production rate of a) CSTR-1 and b) CSTR-2, the concentration of the feed and non- consumed carbohydrates in c) CSTR-1 and d) CSTR-2 and VFAs concentration in e) CSTR-1 and f) CSTR-2.

Conclusions

- Fermentative hydrogen production of FORBI diluted in tap water or MW was investigated in CSTRs at different HRT values
- Similar rates and yields were achieved in both cases, indicating that dilution with MW could be a promising solution for minimizing the dilution requirements
- The experimental results from both CSTRs showed that the HRT of 24 h led to higher hydrogen production, which was accompanied by higher butyrate and acetate production as well as lower propionate production.

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References

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