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

D. Misailidou[1], M. Alexandropoulou[2], G. Antonopoulou[2,3], I. Ntaikou[2], G. Lyberatos[2,4]

[1]*Department of Chemical Engineering, University of Patras, 1 Karatheodori str., GR 26504, Patras, Greece.*
[2]*School of Chemical Engineering, National Technical University of Athens, GR 15780 Athens, Greece.*
[3]*Department of Sustainable Agriculture, University of Patras, 2 Georgiou Seferi str., GR 30100, Agrinio, Greece.*
[4]*Institute of Chemical Engineering Sciences, Stadiou 1, Platani, Patras, GR 26504, Greece.*

Presenting author email: geogant@upatras.gr

SYMSITES

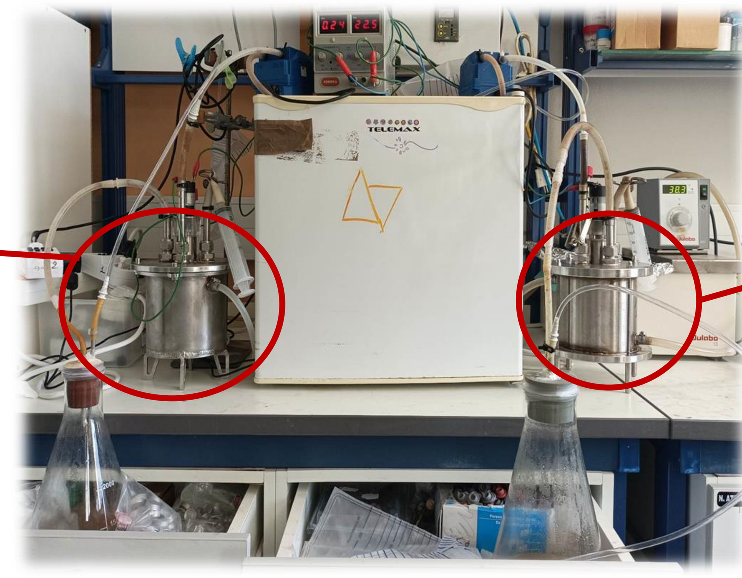
Introduction

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. Specifically, 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 were fed with the diluted fraction of dried and shredded household food waste (FORBI) [1], after centrifugation, with initial total carbohydrates' concentration of 13 g/L. 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 & Methods

CSTR-1

- ✓ Reactor volume: 0.45 L
- ✓ Temperature: 35 ± 0.5°C
- ✓ Hydraulic Retention Times (HRTs): 24, 12, 8 and 4 h
- ✓ **Feed composition:** Diluted fraction of centrifugation of 62 g FORBI + ***1 L of tap water,*** supplemented with 5 g NaOH + 6.8 g KH_2PO_4
- ✓ Inoculum: indigenous microbial species contained in 43.5 g FORBI diluted in L of WM



CSTR-2

- ✓ Reactor volume: 0.45 L
- ✓ Temperature: 35 ± 0.5°C
- ✓ HRTs: 24, 12, 8 and 4 h
- ✓ **Feed composition:** Diluted fraction of centrifugation of 62 g FORBI + ***1 L of MW*** supplemented with 5 g NaOH + 6.8 g KH_2PO_4
- ✓ Inoculum: indigenous microbial species contained in 43.5 g FORBI diluted in 1 L of MW

Results & Discussion

Figure 1: The percentage of hydrogen in the gas phase and the hydrogen production rate in a) CSTR-1 and b) CSTR-2

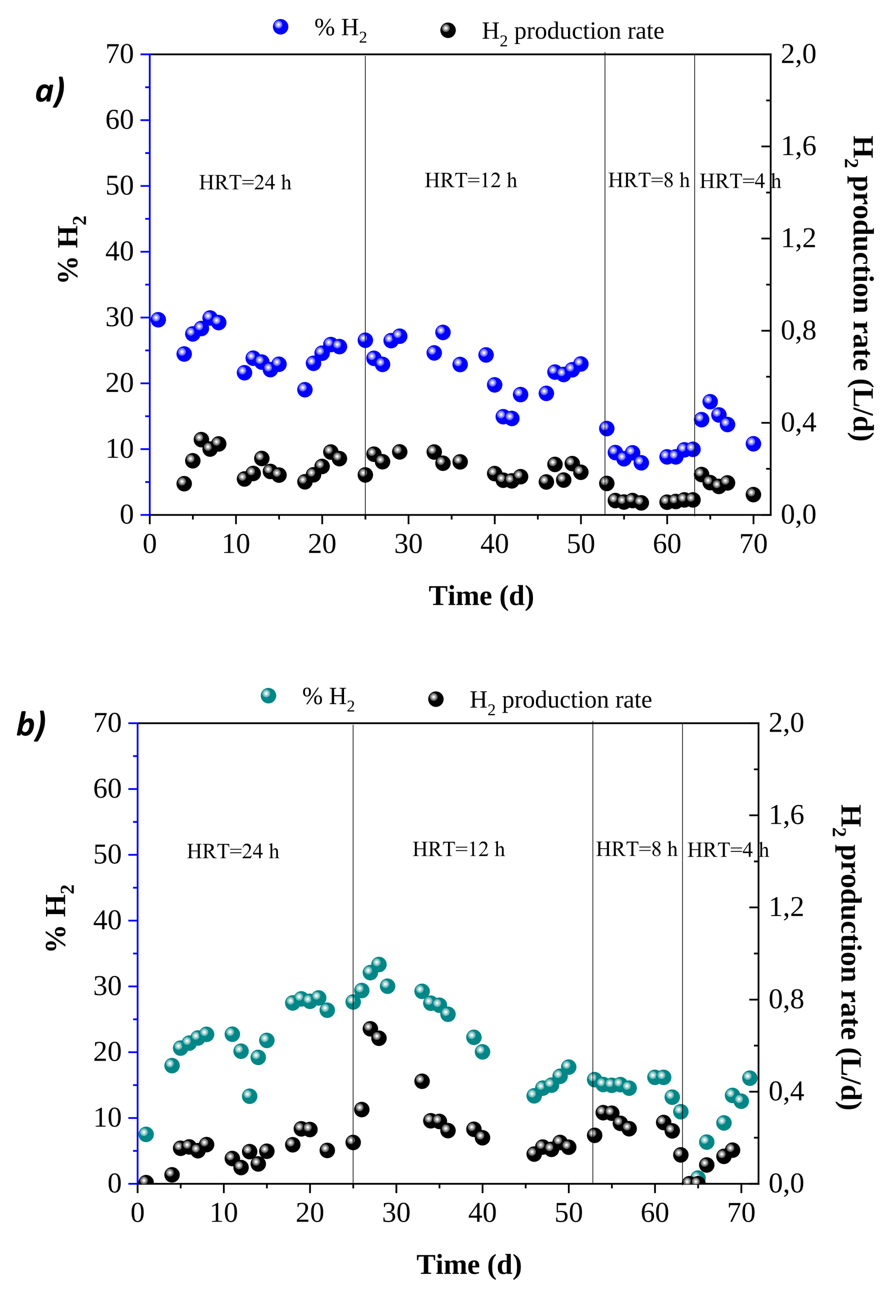


Figure 2: The concentration of the feed and non- consumed carbohydrates in a) CSTR-1 and b) CSTR-2

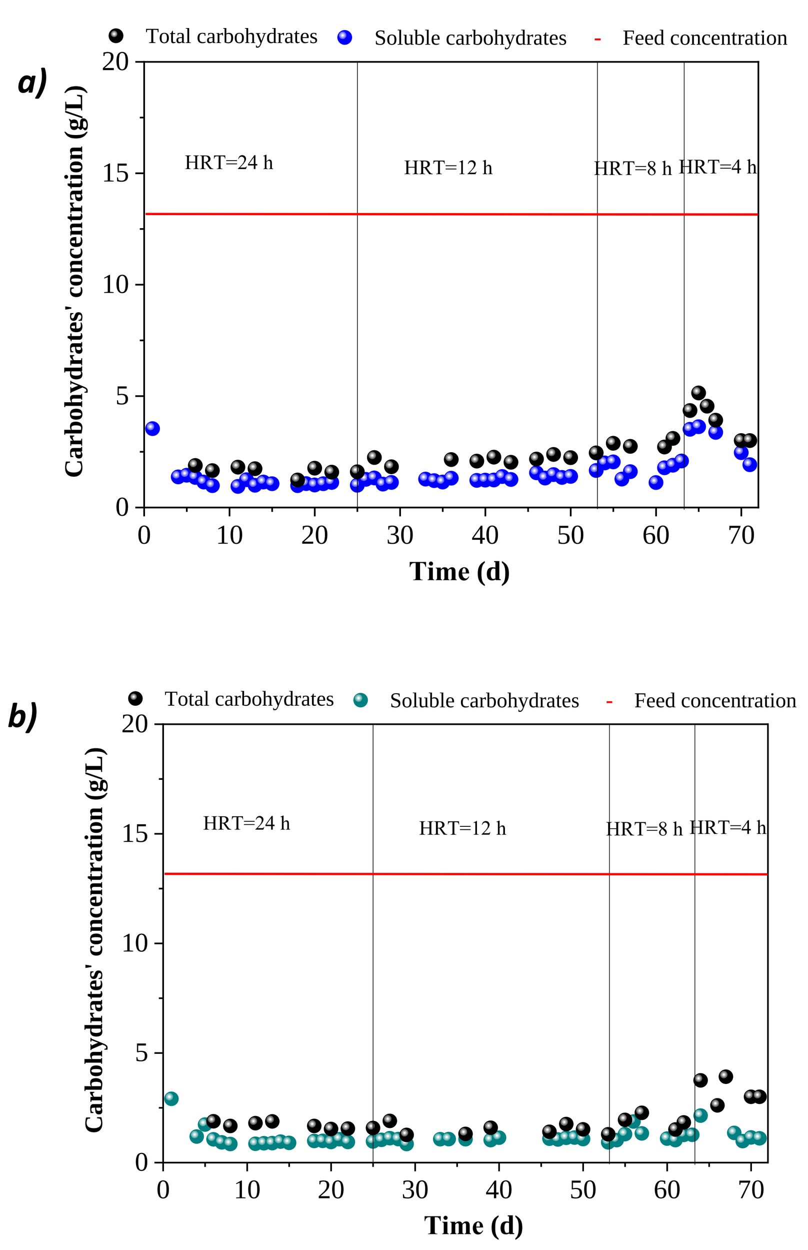


Figure 3: The concentration of volatile fatty acids (VFAs) in a) CSTR-1 and b) CSTR-2

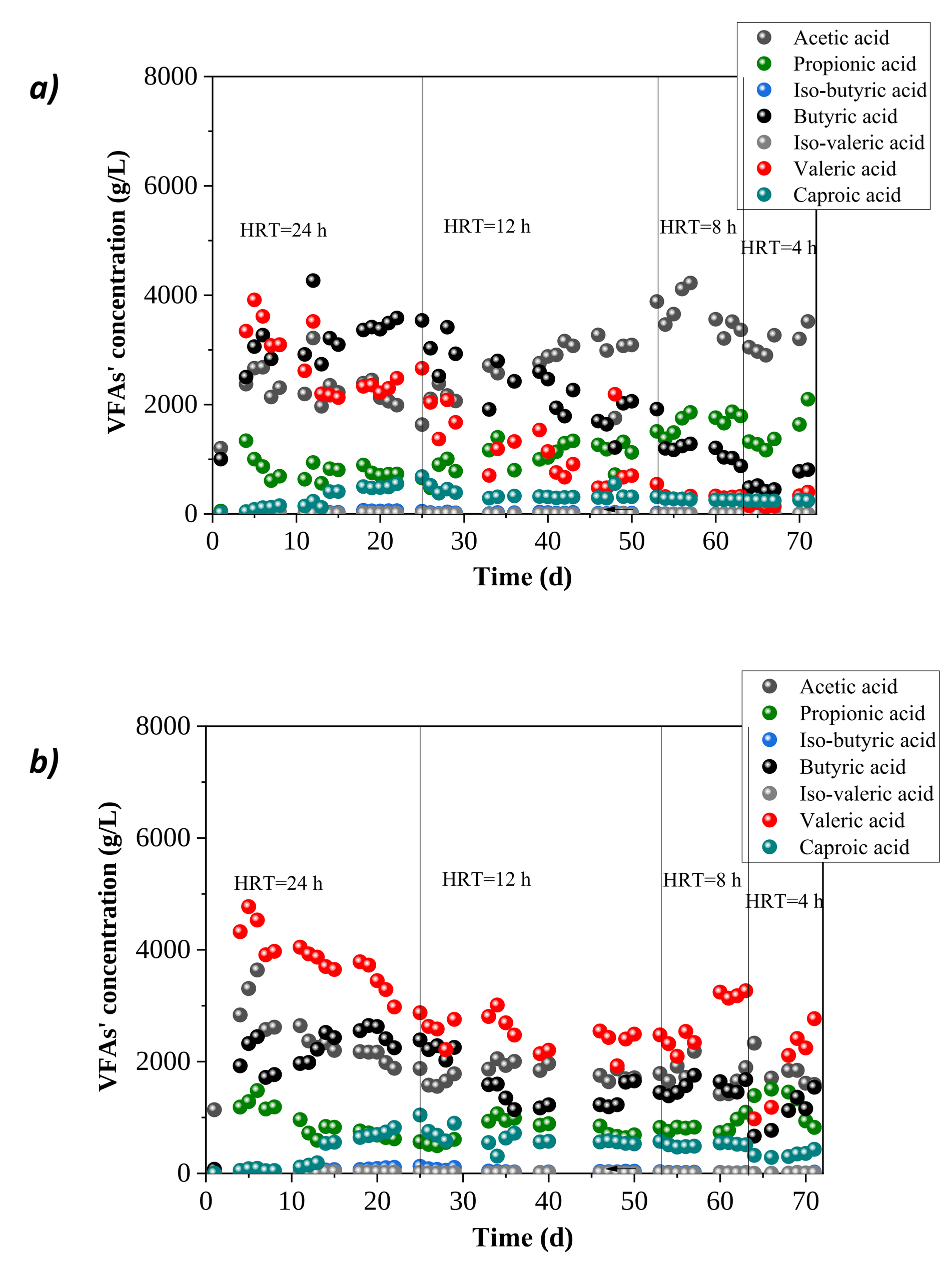


Table 1: The main characteristics of the four steady states of CSTR-1

	HRT=24 h	HRT=12 h	HRT=8 h	HRT=4h
pH	5.82 ± 0.03	5.17 ± 0.09	5.23 ± 0.07	5.43 ± 0.14
TSS (g/L)	4.31 ± 0.27	4.55 ± 0.03	5.17 ± 0.61	6.54 ± 0.39
VSS (g/L)	3.15 ± 0.22	3.43 ± 0.21	4.11 ± 0.52	5.51 ± 0.48
Hydrogen Content (%)	25.12 ± 1.35	22.00 ± 0.68	9.36± 0.63	12.02 ± 1.59
d COD (g/L)	20.42 ± 0.67	18.86 ± 1.08	19.90 ± 0.57	20.72 ± 0.77
% COD (theoretical/measured)	83.24	64.27	57.16	49.73
Hydrogen production rate ($L/L_{reactor}/d$)	0.50 ± 0.09	0.44 ± 0.07	0.14 ± 0.01	0.26 ± 0.05
Hydrogen yield ($L\ H_2/L_{feed}$)	0.50 ± 0.09	0.22 ± 0.03	0.04 ± 0.00	0.04 ± 0.00
Hydrogen yield ($L\ H_2$/kg FORBI)	8.14± 0.57	3.51 ± 0.06	0.73 ± 0.06	0.71 ± 0.00

Table 2: The main characteristics of the four steady states in CSTR-2

	HRT=24 h	HRT=12 h	HRT=8 h	HRT=4h
pH	6.00 ± 0.32	5.72 ± 0.17	5.73 ± 0.12	5.66 ± 0.08
TSS (g/L)	4.82 ± 0.35	4.13 ± 0.84	4.53 ± 0.44	9.11 ± 2.39
VSS (g/L)	3.56 ± 0.22	3.04 ± 0.69	3.23 ± 0.58	7.81 ± 1.26
Hydrogen Content (%)	27.49 ± 0.79	15.88 ± 1.25	15.58 ± 0.67	12.81 ± 1.20
d COD (g/L)	20.44 ± 0.52	18.86 ± 1.04	45.42 ± 4.11	18.98 ± 100
% COD (theoretical/measured)	82.17	66.79	86.21	67.71
Hydrogen production rate ($L/L_{reactor}/d$)	0.42 ± 0.10	0.38 ± 0.05	0.57 ± 0.03	0.38 ± 0.07
Hydrogen yield ($L\ H_2/L_{feed}$)	0.42± 0.10	0.19 ± 0.02	0.19 ± 0.01	0.06 ± 0.01
Hydrogen yield ($L\ H_2$/kgFORBI)	6.73± 1.65	3.10 ± 0.44	1.27 ± 0.16	1.03 ± 0.19

- ✓ Fermentative hydrogen production of FORBI diluted in tap water or MW was investigated in CSTR 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.

www.symsites.eu

This work was funded by the European Union's Horizon Europe research and Innovation programme under SYMSITES project, No 101058426.

Funded by the European Union