Using household food waste extract for continuous bio-hydrogen production through dark fermentation

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Introduction

In this study, the long term, continuous, fermentative biohydrogen production, was investigated, using household food waste (biowaste) (rotten fruits and vegetables like carrots, beetroot, oranges, tomatoes, lettuce etc.). The biowaste was squeezed and used as the substrate in a CSTR – type lab- scale bioreactor of 0.4 L working volume, which operated at 35.5°C under different operational conditions. Initially, the effect of hydraulic retention time (HRT) (12, 18 and 24 h) and feed substrate concentration (20, 30 and 40 g of carbohydrates /L), was assessed, when the organic loading rate (OLR) was maintained at 40 g carbohydrates /L.d, and when the OLR increased (40, 50 and 60 g of carbohydrates /L.d), through maintaining the HRT at 24 h and increasing the feed substrate concentration (40, 50 and 60 g of carbohydrates /L) and was correlated to the hydrogen yields and the distribution of the metabolic products generated in the reactor.

Materials & Methods

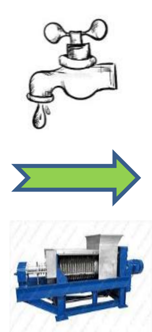

***Table 1:** Characteristics of the biowaste extract*

Characteristics	Values
Total carbohydrates (g/L)	86.80 ± 2.51
Soluble carbohydrates (g/L)	79.13 ± 2.24
Total COD (g/L)	101.76 ± 4.52
pH	4.17 ± 0.25

- ✓ CSTR-type bioreactor
- ✓ Reactor volume: 0.4 L
- ✓ Temperature: 35 ± 0.5°C

***Table 2:** Operational characteristics of the CSTR*

HRT (h)	Initial carbohydrates concentration (g/L)	OLR (g/L.d)
12	20	40
18	30	40
24	40	40
24	50	50
24	60	60

- ✓ Feed composition: : Biowaste extract, properly diluted supplemented with NaOH + KH_2PO_4
- ✓ Inoculum: indigenous microbial species contained in biowaste extract

Results & Discussion

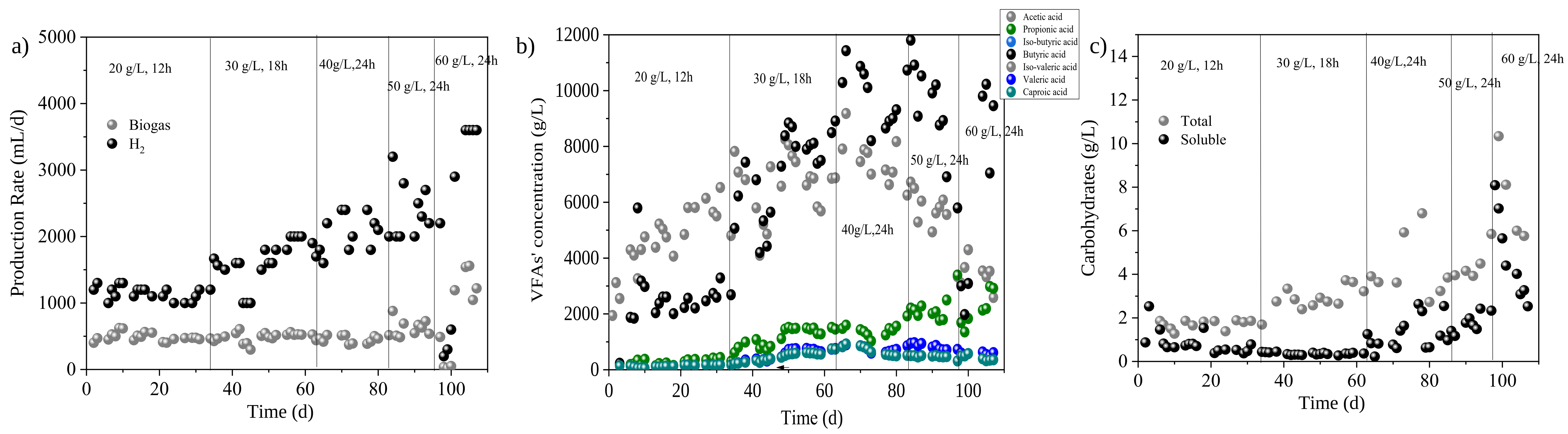

***Figure 1:** (a) The hydrogen and biogas production rates , (b) the VFAs concentration and (c) the concentration of carbohydrates, throughout the CSTR operation*

***Table 3:** The main characteristics of the steady states of CSTR*

	20 g /L HRT= 12 h	30 g/ L HRT= 18 h	40 g /L HRT= 24 h	50 g /L HRT= 24 h	60 g /L HRT= 24 h
H_2 (%)	42.99 ± 4.43	27.23 ± 0.73	23.51 ± 2.57	25.85 ± 2.40	37.27 ± 3.44
pH	6.40 ± 0.17	6.28 ± 0.05	6.19 ± 0.03	6.01 ± 0.15	6.30 ± 0.24
L H_2/$L_{reactor}$/d	1.17 ± 0.02	1.33 ± 0.04	1.19 ± 0.10	1.50 ± 0.22	3.35 ± 0.63
$Y_{H2/feed}$ (L H_2/L feed)	0.59 ± 0.01	1.00 ± 0.03	1.19 ± 0.10	1.50 ± 0.22	3.35 ± 0.63
$Y_{H2/extract}$ (m^3 H_2/m^3 biowaste extract)	2.35 ± 0.04	2.65± 0.08	2.38 ± 0.22	2.40 ± 0.36	4.47 ± 0.83
Carbohydrates removal efficiency (%)	97.4	98.8	97.0	96.1	94.6
$Y_{H2/Su}^{mol}$ (mol H_2/mol consumed carbohydrates)	0.22± 0.01	0.25± 0.01	0.23± 0.01	0.23 ± 0.01	0.44 ± 0.02

- ✓ Fermentative hydrogen production of biowaste extract was investigated in a CSTR at different HRTs and OLRs
- ✓ High hydrogen rates and yields were achieved in high OLRs, indicating lower dilution with tap water and maximum exploitation of the biowaste, generated by open markets (rotten fruits and vegetables).
- ✓ The experimental results from the CSTR showed that the OLR of 60 g /L.d (HRT of 24 h and initial carbohydrates concentration of 60 g/L) led to the higher hydrogen production rates and yields which were accompanied by high butyrate and acetate production.

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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