Sequential treatment of food waste by hydrothermal carbonization and thermophilic dark fermentation to enhance hydrogen production.

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Hydrogen is a promising energy vector and a sustainable alternative to fossil fuels due to its high energy content (141.6 MJ/kg) and zero carbon emissions. Dark fermentation (DF) offers a renewable and environmentally friendly route for hydrogen generation from organic matter, while hydrothermal carbonization (HTC) of biomass wastes is presented as a treatment that can effectively transform the organic matter into a hydrochar and a process water (PW) rich in biodegradable compounds, which can be used as partially hydrolyzed substrate on DF to enhance biohydrogen production efficiency [1]. This study focuses on the treatment of food waste (FW), composed of fruit and vegetables wastes from a local store (91.2% moisture, 89.1 g_{COD}/L) by sequential treatment of HTC and DF to maximize hydrogen production by modulating the DF key operational parameters: pH (4.8, 5.5), hydraulic retention time (HRT; 3.5, 5 d) and organic loading rate (OLR; 2.5, 5.0, 7.5 g_{COD}/L d). Moreover, the volatile fatty acids production, as a value-added byproduct, is also determined.

Dark fermentation process, at thermophilic range (55 ºC) using adapted mixed sludge from a wastewater treatment plant as inoculum, and PW from the HTC of food waste (Parr Instrument model 4524; 180 ºC, 1 h), as a substrate, was carried out in a 3 L continuously stirred tank reactor. Experimental results showed an optimal H_2 production of 54.0 ± 1.4 mL H_2/ g_{COD} at pH 5.5, HRT 5 d and OLR of 5 g_{COD}/L·d, which means 37%$_{v/v}$ of total biogas. pH showed the most significant impact over H_2 production, with 92% lower performance at pH 4.8 than optimal conditions. Regarding OLR, H_2 production at pH 5.5 and HRT 5 d reaches 32.9 ± 1.6 mL H_2/ g_{COD} at 2.5 g_{COD}/L·d and 34.1 ± 2.5 mL H_2/ g_{COD} at 7.5 g_{COD}/L·d, associated with lack of substrate and substrate inhibition, respectively [2]. HRT showed a minor impact on reactor performance, showing the second highest H_2 production (44.2 ± 1.4 mL H_2/ g_{COD}) at HRT 3.5 d, pH 5.5 and OLR 5 g_{COD}/L d.

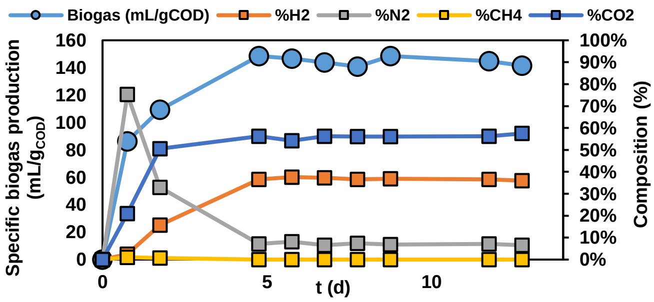

Fig 1. Biogas production and composition under optimal conditions.

At the above-mentioned optimal H_2-producing conditions, the system achieved the highest total carbohydrates removal (72%), and an acidification degree of 0.31, with acetate (2.36 ± 0.12 g/L) and butyrate (2.17 ± 0.13 g/L) as main metabolites. Taxonomic analysis of the initial sludge was dominated by *Prevotellaceae* (22%) and *Bacteroidaceae* (13%), while the effluent at the end of the optimized H_2-producing conditions was constituted by *Thermoanaerobacterales III* (23%), *Acetobacteraceae* (20%), and *Clostridiaceae* (8%) species, associated with H_2 production pathways [3], and *Lactobacillaceae* (18%) species, that carry out lactate production and could enhance hydrogen production by lactate-driven DF pathways [4]. Therefore, we can conclude that the sequential process of HTC and DF emerges as a promising strategy of material and energy recovery from FW.

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