Integral biowaste management: Energy recovery by hydrothermal carbonization and anaerobic co-digestion

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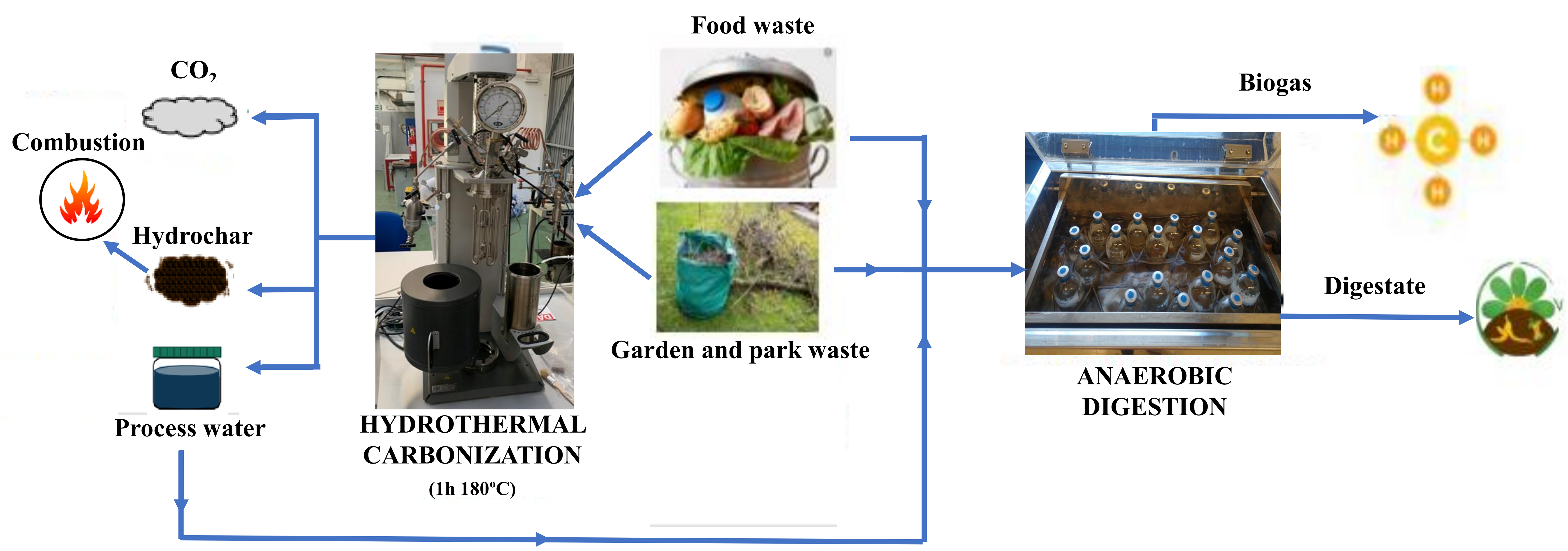
INTRODUCTION

Hydrothermal carbonization (HTC) is a promising thermochemical process for treating wet biomass under mild temperatures (180–250 °C), such as food waste (FW) and garden and park waste (GPW), the most abundant biowaste (BW). HTC yields a solid hydrochar (HC) with an increased higher heating value (HHV) and a process water (PW) mostly composed of short-chain organic compounds, a potential substrate for anaerobic co-digestion (ACoD). In this work, the synergistic effects of HTC and ACoD of biowaste with PW to enhance process stability, biogas production and energy produced has been studied.



METHODS

Initially, raw substrates (FW and GPW) were subjected to HTC. Later, both substrates were digested alone (100FW and 100GPW) or mixed with the PW obtained from the HTC of FW, and the one generated from GPW was also combined with FW. The mixture contained low percentages of PW (5% and 10% on a COD basis) to avoid inhibition by non-biodegradable compounds. AcoD assays, carried out in 120 mL glass serum vials at initial inoculum concentration of 15 g VS/L, are denoted as the main substrate (F or GP), and percentage (5 or 10) and type of PW (GP for the obtained from GPW and F for the obtained from FW), that is, F5GP, F10GP, F5F, F10F, GP5F, and GP10F, respectively.

RESULTS AND DISCUSSION

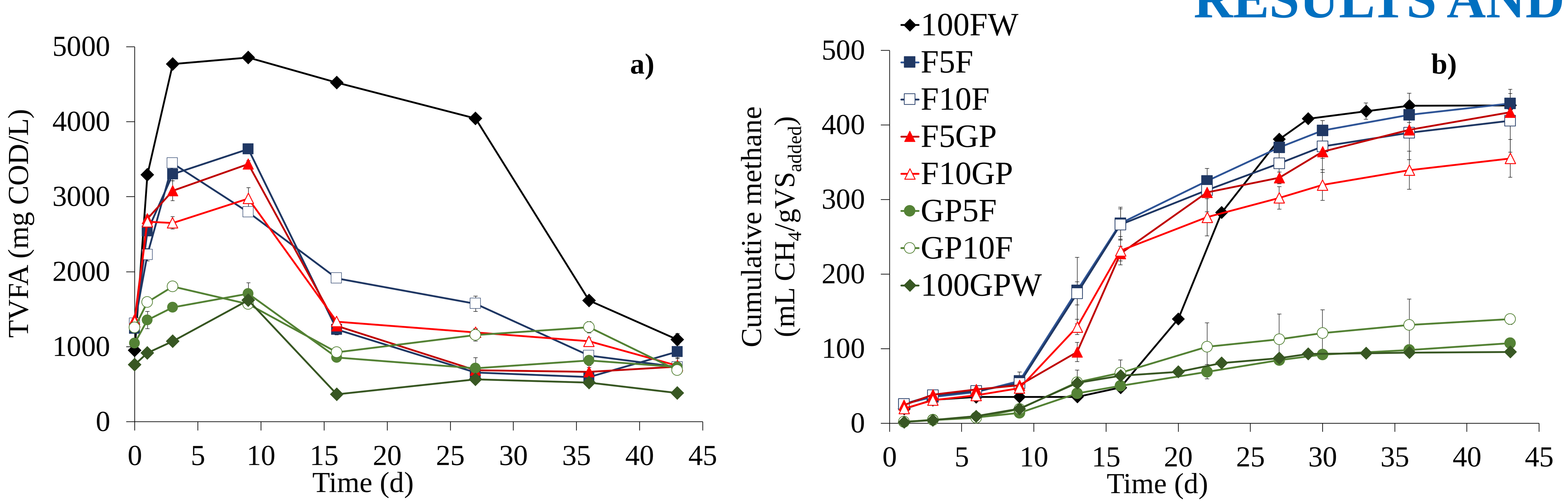


Figure 1. Time course of a) Total volatile fatty acids and b) Cumulative methane yield along the anaerobic co-digestion of BW and HTC PW

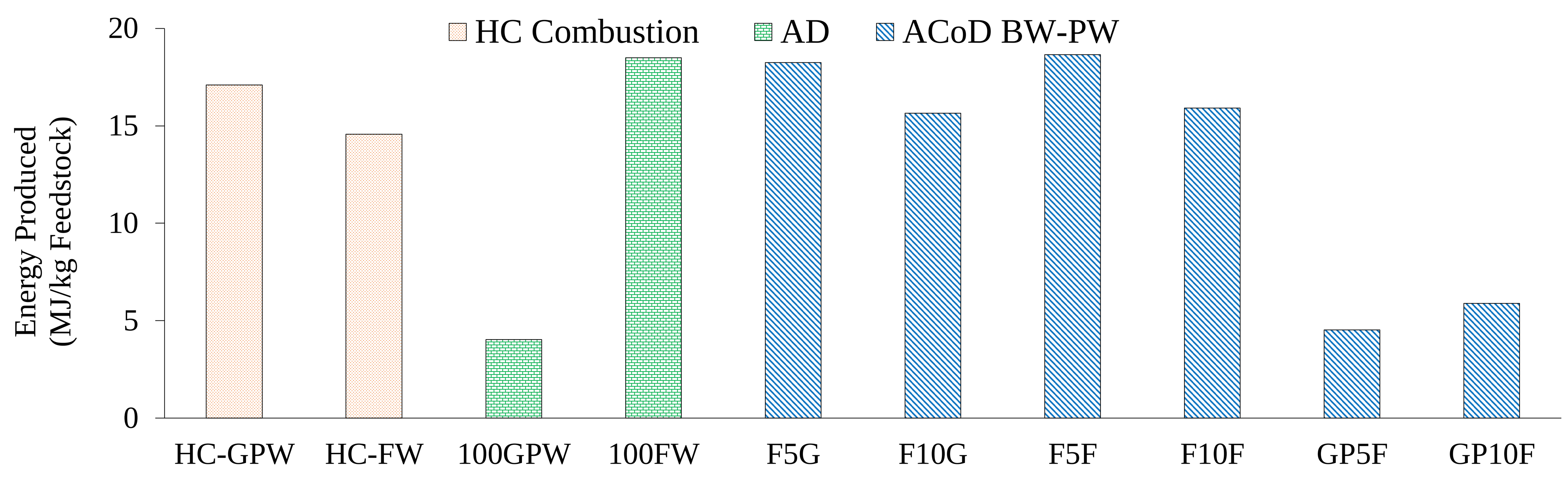


Figure 2. Energy produced through combustion of HC, AD of feedstocks, and AcoD of feedstocks with PW from HTC

Significant differences on total volatile acid (TVFA) content (Fig. 1a) and biogas production (Fig. 1b) were reported based on main BW used. 100FW showed a very high TVFA accumulation which required almost 15 days for degradation and methane production. AcoD of FW with 5% PW avoided instability by TVFA accumulation but recorded similar methane production, as well as energy produced (100FW, F5G, F5F) (Fig. 2). HTC resulted in a better approach for GPW management, actually HC-GPW fulfilled the quality standards for thermally treated biomass (HHV of >18 MJ/kg; volatile matter <75%; S <0.3%; N <2.5%).

CONCLUSIONS

The work addresses the implementation of an integrated waste management concept in a circular economy framework, combining hydrothermal treatment of GPW and biological treatment (AcoD) of the PW generated with the raw FW, improving the overall recovery of the energy stored in the GPW. Hydrothermal treatment proved to be the most attractive technology for GPW, obtaining a hydrochar with high higher heating value and a PW with high organic matter content. AcoD of 95% FW and 5% PW (on a COD basis) improved process stability by balancing the C/N ratio and achieved similar results in terms of energy recovery from AD of raw FW.

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