Optimization of Volatile Fatty Acids production from household food waste for the biorefinery supply chain

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The European Union countries produce 88 million tonnes of household food wastes (HFWs) each year. This production corresponds to about one third of the food production and it is composed for the 45% by fruit and vegetables, for the 35% by fish and seafood, for the 30% by cereals, for the 20% by dairy products and for another 20% by meat (Stenmarck *et al*., 2016). It was estimated that this HFWs amount corresponds to some 300 grams per capita per day, equivalent to some 50-60 g dry matter per person every day. HFWs are usually disposed of in landfill or sent to incineration with null or limited recovery of resources and high emission of greenhouse gases and toxic compounds in the atmosphere and in the soil in both the cases (Ren *et al*., 2018). A sustainable alternative is the HFWs exploitation for the production of Volatile Fatty Acids (VFAs). These are linear short-chain aliphatic mono-carboxylate compounds, having from two (acetic acid) to six (caproic acid) carbon atoms. Due to their functional groups, VFAs are extremely useful for the chemical industry: carboxylic acids are precursors of reduced chemicals and derivatives (esters, ketones, aldehydes, alcohols and alkanes) in conventional organic chemistry. Moreover, they are also well-known substrates for the production of biofuels like methane and hydrogen as well as biopolymers, such as polyhydroxyalkanoates (Strazzera *et al*., 2018). Figure 1 summarized the main biofuels and bioproducts by VFAs obtained from HFWs.

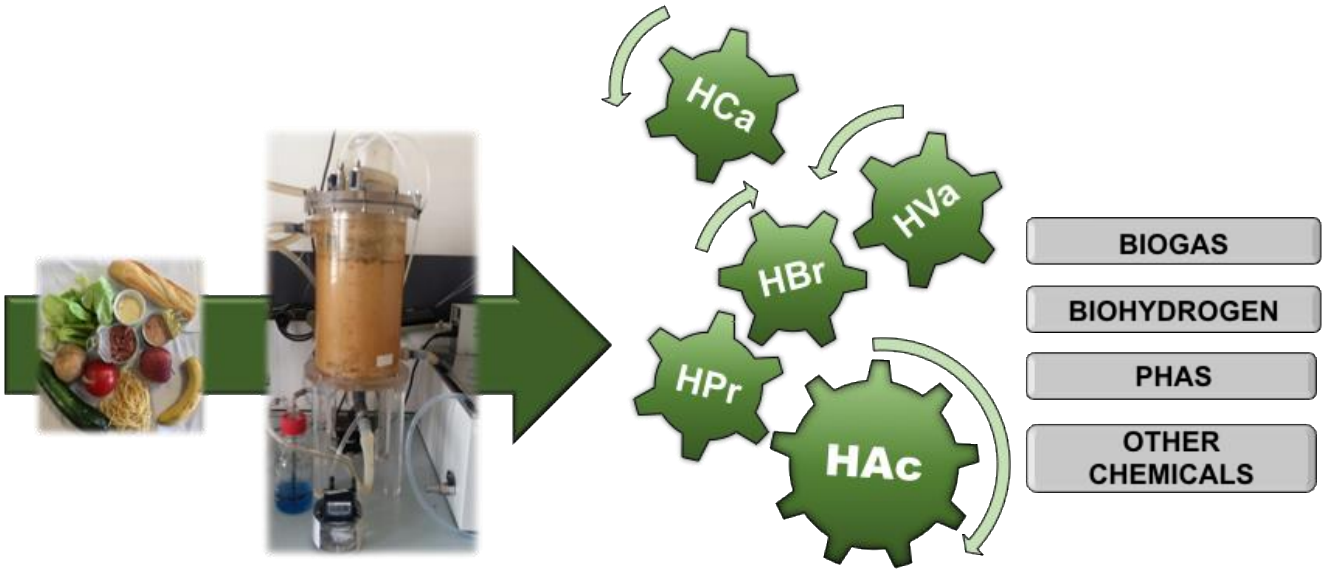

Figure 1. Graphical concept of the research work.

This study investigated the influence of different operative parameters, the pH, the Organic Load Rate (OLR) and temperature, on the acidogenic fermentation for VFAs production from HFWs. The tests have been conducted in a laboratory scale CSTR with a working volume of 4.2 L in semi-continuous mode at mesophilic (35°C) and thermophilic (55°C) conditions. HFW stream was simulated by a standardized HFW to simulate the chemical and physical characteristics of the real substrate. In particular, fresh foods, available all the year long, were chosen, milled and mixed to obtain similar carbohydrates, lipids, proteins and fibers contents of the real HFWs collected in Mediterranean Area.
The experimental campaign was articulated in five experimental runs with different operative parameters. During the first run acidogenic fermentation was tested at uncontrolled pH, high OLR (22 gTS/Ld) and mesophilic temperature (35°C); then the pH was set up at 5.5 (second stage). These conditions avoided the reaching of a steady state condition in VFAs production. Thus, the OLR was reduced at 11 gTS/Ld keeping constant the pH at 5.5 in the third run of the experimental campaign. Then, the pH was increased at 7 (fourth run). These parameters lead to good performances in terms of VFAs productivity. Consequentially, OLR and pH were kept at 11 gTS/Ld and t, respectively, during the last experimental run when the temperature was shifted from mesophilic to thermophilic conditions (55°C).

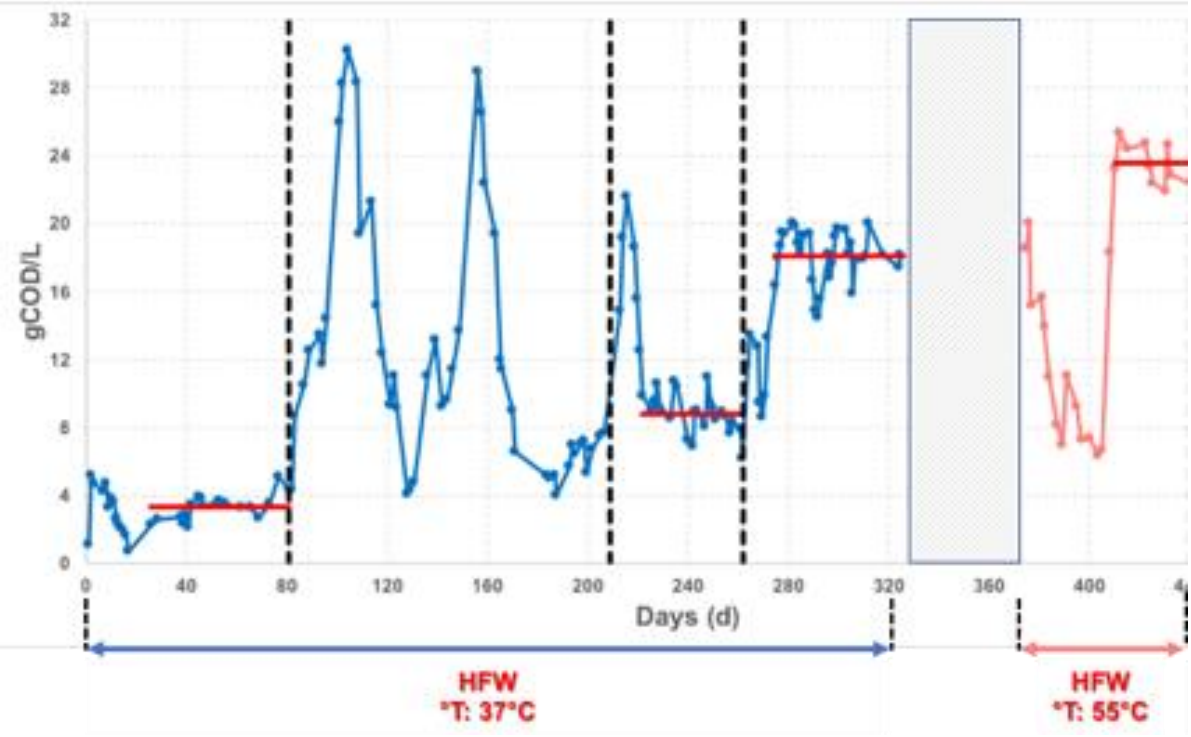

Figure 2. The VFAs performance of acidogenic fermentation at different operative parameters.

Figure 2 shows the VFAs production rate along the experimental campaign. Uncontrolled acid pH and high OLR did not assure a good VFAs production or the reaching of steady state conditions. On the contrary, the reduction of the OLR and the increasing of the pH towards neutral values assured a stable VFAs production of around 18 g/L with a yield of 0.29 gVFA/gTVS fed. The analysis of the acidogenic fermentation's products showed a heterogeneous distribution of the different VFAs with butyrate as main product, accounting for around 50% of total VFAs, and similar concentrations of acetate and propionate (about 20%). The performances improved with the adoption of thermophilic conditions when a stable total VFAs production of around 23.5 g/L was achieved, corresponding to a yield of 0.38 gVFA/gTVS. Butyric acid represented the main product, accounting for around 65% of total VFAs, while acetic, propionic and caproic acids constituted the 9.0, the 4.0 and 19%, respectively, of total VFAs.

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