Energy recovery from food waste and swine manure via hydrothermal treatment: hydrothermal carbonization versus hydrothermal liquefaction

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Hydrothermal technology is gaining research interest in recovering resources and energy contained in wet biomass wastes as value added products and biofuel. Hydrothermal carbonization (HTC) takes places at temperatures within 170 – 250 ºC, while hydrothermal liquefaction (HTL) operates at temperatures ranging from 250 – 370 ºC. Both processes produce a carbonaceous material known as hydrochar, a process water with high organic carbon content, and a gas fraction mainly constituted by CO_2. In addition, HTL transforms the organic waste into water insoluble organics fraction called biocrude. HTC and HTL product distribution and composition are largely dependent on the composition of the raw biomass and the operating conditions. This study aims to assess the best strategy to maximize the energy recovery from the obtained hydrochar and biocrude via hydrothermal treatment of food waste and swine manure.

Food waste (FW), primarily composed of fruits, vegetables, and leafy greens, and swine manure (SM) provided by a pig farm (Ávila, Spain) were selected as feedstocks. HTC experiments were performed in a 2.0 L reactor (4524, PARR Instrument Company, USA), while HTL experiments were carried out in a 1.8 L reactor (4570, PARR Instrument Company, USA). The reactions were carried out between 170 and 330 °C for 60 min under autogenous pressure, feeding the feedstock with 5% and 9% total solids for FW and SM, respectively. Table 1 shows the main characteristics of both wastes.

Table 1. Main characteristics of FW and SM.

Waste	C (%)	Ash (%)	Proteins (%)	Lipids (%)	Hemicellulose (%)	Cellulose (%)	Lignin (%)	HHV (MJ/kg)
FW	45.6	6.5	0.8	22.0	0.4	7.4	11.0	18.9
SM	46.0	12.6	13.2	2.3	12.4	16.9	33.2	18.5

The hydrochar (HC) yield, process waster, biocrude and gas phase are shown in Figure 1. The highest hydrochar yield (80% from FW and 71% from SM) was achieved at 180 ºC regardless of the feedstock. The generation of hydrochar from the two wastes was dramatically different in the transition from HTC to HTL for FW, while in the case of SM, hydrochar production decreased gradually with temperature. This fact is attributed to the higher lipid content of FW, which results in higher biocrude production compared to that obtained from SM under HTL conditions.

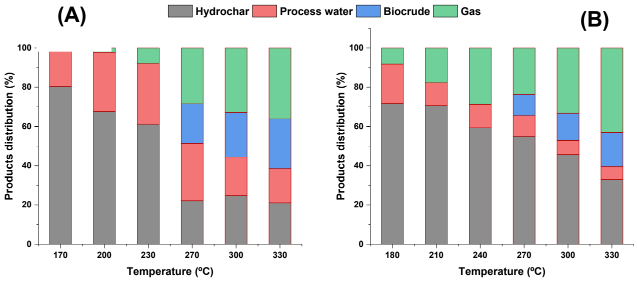

Figure 1. Product distribution for FW (A) and SM (B).

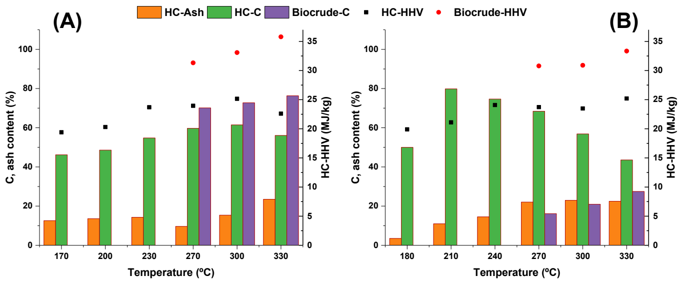

Figure 2. Main characteristics of hydrothermal products from FW (A) and SM (B).

The HHV of hydrochars increased with increasing HTC temperature (Figure 2), achieving a plateau (22-25 MJ/kg) for FW and (23-25 MJ/kg) for SM at HTL conditions. The HHV of biocrudes obtained from FW (31-36 MJ/kg) was slightly higher than those obtained from SM (31-33 MJ/kg). The energy recovery from the biofuels obtained from each waste, hydrochar and biocrude, revealed that the treatment of FW at 170 ºC (HTC) allowed 82% of the energy contained in the FW to be recovered. In the case of SM, the optimum energy recovery (more than 88%) was achieved under HTL conditions at 270 ºC.

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