Impact of thermal pre-treatment of food wastes on anaerobic digestion performances

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In order to decrease the environmental impact caused by landfill disposal, sustainable food waste management routes consist nowadays mainly in anaerobic digestion and composting.
Anaerobic digestion seems to be a promising option, using the organic fraction of the substrate for energy production, adding a surplus value to the substrate.
Nevertheless, it is widely reported that in mesophilic conditions a part of the organic carbon introduced is not degraded, reducing the possibility to fully exploit the energy potential of the waste, and opening the research to advanced processes that can increase the anaerobic digestion process efficiency, allowing higher biogas and/or methane productions.

Thermal pre-treatments are able to enhance the rate limiting biological hydrolysis of particulate matter in the complex anaerobic digestion process (Bougrier et al., 2006) by reducing the particle sizes, increasing the porosity of the materials, breaking down lignin and hemicellulose and maximizing the bioavailability of organic matter (Rincón et al., 2013).

Aim of this work was to investigate the impact of thermal pre-treatment on the solubilisation degree of food wastes, and consequently on the biogas conversion rate and COD reduction during batch mesophilic or thermophilic anaerobic digestion, assessing the role of pH in hydrogen/methane production.

Food wastes, collected from CNR Research Campus canteen, was characterized as feedstock with high organic content (COD = 165-200 g/L, VS/TS = 95-97 %), and high carbohydrates fractiondue to the significant amount of pasta and bread. The CFW (Canteen food waste) was sampled, mixed, shredded, and diluted to 13-15%TS before characterization and anaerobic digester introduction. Table 1 reports the characterization of untreated and thermal pre-treated (T=120°C, p=4 bar, time= 20 minutes) CFWs.

Table 1. Canteen food waste characterization, before and after thermal pre-treatment

	Untreated CFW	thermal pre-treated CFW
TS (%)	12.8-15.5	13.1-15.8
VS/TS (%)	96±1	96±1.2
soluble COD (g/L)	67-87	86-110
total COD (g/L)	165-200	165-200
Total carbohydrates (% TS)	18.7-19.0	25.4-32.4

The thermal treatment induced a significant release of organic matter into solution, while total and volatile solids did not change significantlysuggesting that in these conditions, no evaporation or mineralization wasinduced. Moreover, thanks to the structure modification occurring at high temperature and pressure, the carbohydrate fraction in the thermal pre-treated CFWs was significantly higher, due to the “extraction” of embedded carbohydrates, rendering them more accessible to the colorimetric reaction and determination with the Dubois method (1956).

Mixed batch anaerobic reactors were operated under mesophilic (T=37°C) or thermophilic (T=55°C) conditions, at fixed food/inoculum ratio of 0.6 (VS/VS) by feeding either untreated or pre-treated CFW. The initial pH was around 8 for test #1 (meso) and test#2 (thermo), while in test #3 (meso) and #4 (thermos)the pH was corrected up to 7.

Average specific biogas production from untreatedand pre-treated CFW under mesophilic conditions was 738 and 663 mL/gVS, respectively, with high methane content (67-68%), while at thermophilic conditions (test#2) the specific biogas production was 806 and 786 mL/g VS for untreated and pre-treated CFW, respectively, with methane content of 45-46%.
These preliminary results indicate that the investigated thermal pretreatment affected thechemical characteristics of canteen FW to a large extent, but no effect onmethaneyields wasobserved.

On the contrary, by lowering the initial pH (as in test #3 and test #4)hydrogen production occurred during the first hours, and the cumulative hydrogen production obtained was higher for the thermal pre-treated substrate. In fact in mesophilic conditions the hydrogen specific production was 21 mL/g VS for pre-treated CFW (against 5 mL g/VS for same substrate, untreated), while in thermophilic conditions the hydrogen production decreased to 3 and 5 mL g/VS, for untreated and pre-treated CFW.
This result agrees with other research studies reporting that carbohydrates rich substrates, as in this study the pretreated CFW, have higher hydrogen yields than protein and lipids rich substrates (Okamoto et al., 2000).

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