



# Development of a novel three-stage fermentation system converting food waste to hydrogen and methane

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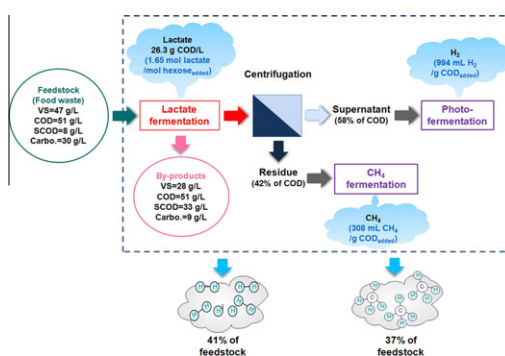
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## HIGHLIGHTS

- ▶ Three-stage (lactate- + photo- $H_2$  +  $CH_4$ ) fermentation system treating food waste.
- ▶ First fermenting food waste to lactate, rather than acetate and butyrate.
- ▶ Lactate fermented effluent was used for  $H_2$  production by photo-fermentation.
- ▶ 41% and 37% of the energy content in food waste into  $H_2$  and  $CH_4$ , respectively.
- ▶  $H_2$  yield of 8.35 mol  $H_2$ /mol hexose<sub>added</sub>, the highest value ever reported to date.

## GRAPHICAL ABSTRACT



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## ABSTRACT

In this study, a novel three-stage (lactate- + photo- $H_2$  +  $CH_4$ ) fermentation system was developed, which converts food waste to  $H_2$  and  $CH_4$ , with an emphasis on achieving high  $H_2$  yield. The system begins by first fermenting food waste to lactate, rather than acetate and butyrate, using indigenous lactic acid bacteria. Lactate fermentation effluent was then centrifuged, and the supernatant was used for  $H_2$  production by photo-fermentation, while the residue was used for  $CH_4$  production by anaerobic digestion. Overall, via the three-stage fermentation system, 41% and 37% of the energy content in the food waste was converted to  $H_2$  and  $CH_4$ , respectively, corresponding to the electrical energy yield of 1146 MJ/ton-food waste, which is 1.4 times higher value than that of previous two-stage dark ( $H_2$  +  $CH_4$ ) fermentation system. The  $H_2$  yield based on hexose input was 8.35 mol  $H_2$ /mol hexose<sub>added</sub>, the highest value ever reported from actual organic waste.

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## 1. Introduction

Across the world, waste management represents a growing developmental, environmental, and social challenge. Since the late twentieth century, anaerobic digestion (AD) has gained popularity

as a means to convert organic wastes such as food waste, sewage sludge, and livestock wastes into valuable energy sources, embraced by both the international community and domestic governments (Asam et al., 2011). The EU, for example, aims to deliver 2–3% of its total primary energy demand through AD by 2020 (AEBIOM, 2009).

AD converts organic wastes to methane ( $CH_4$ ) through a series of biological reactions that consist of hydrolysis, acidogenesis, and methanogenesis. Other than production of  $CH_4$ , the advantages of AD include reducing pathogens and odorous materials in organic wastes during fermentation and lessening carbon dioxide ( $CO_2$ ) emissions (Kim et al., 2011). While usually used to produce  $CH_4$ ,

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