

Thermophilic AD consortium CULTURE TECHNIQUE

Higher bacterial diversity in two-phase thermophilic anaerobic digestion of food waste after micronutrient supplementation

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Abstract

A continuous two-phase thermophilic AD system (10 L acidogenic + 20 L methanogenic; Winpact, USA) ran for 210 days on food waste at 55 °C. Supplementing Ca, Mg, Co and Ni raised methane yield by up to 40% and increased bacterial Shannon diversity from 1.112 to 2.046.



Winpact Fermentation System

Introduction

Motivation: thermophilic AD is more productive than mesophilic AD but far less stable, and trace-metal deficiency drives instability and inoculum washout in the methanogenic phase.

Gap: the authors had already shown that a Ca/Mg/Co/Ni cocktail recovers a destabilised digester and lifts methane yield 40%, but the underlying change in the bacterial community had not been identified.

Objective: use next-generation sequencing to determine which bacterial groups drive the recovery, stabilisation and improvement of the process after supplementation.

Materials and Methods

Reactor setup:

Continuous two-phase thermophilic AD, comprising a 10 L reactor for hydrolysis and acidogenesis and a 20 L reactor for methanogenesis (Winpact, USA), monitored for pH, ORP and biogas production. The methanogenic vessel was held at temperature by a thermal jacket.

Operating conditions:

Both reactors at 55 °C; HRT 5 days (acidogenic, 2 L/day) and 15 days (methanogenic, 1.3 L/day), 20 days total; feedstock food waste at OLR 3 gVS/L/day and pH 4.5 ± 0.3; acidogenic effluent fed the methanogenic phase; total run 210 days.

Supplementation (control period):

The first 149 days ran without micronutrients, giving overacidification and washout. On day 150 a cocktail of 303, 777, 7 and 3 mg/L of Ca, Mg, Co and Ni was dosed, then repeated twice at 20-day intervals.

Analysis:

Sludge sampled at days 149, 170 and 210; genomic DNA sequenced on the Illumina MiSeq platform and analysed with QIIME, visualised with Krona.

Results

Before supplementation the community was dominated by a single Thermotogales species (83% of reads) with Shannon diversity of only 1.112. Twenty days after the first dose, diversity rose to 1.683 with Coprothermobacter and Pseudomonas caeni enriched; by day 210 diversity reached 2.046, Thermotogae fell to 38%, and Arcobacter (20%) and Bacteroides (15%) emerged, adding acetate oxidation, denitrification and VFA production. The result was a functionally redundant community, stable methane production up to 0.5 L/gVS/day and a roughly 40% gain over the unsupplemented mode. Fermentor relevance: the 20 L Winpact methanogenic reactor, held at 55 °C by a thermal jacket and monitored for pH, ORP and biogas, ran continuously for 210 days and supplied the sludge samples for all three community analyses (days 149, 170 and 210).

References

Higher bacterial diversity in two-phase thermophilic anaerobic digestion of food waste after micronutrient supplementation. Biomass Conversion and Biorefinery (2021)

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