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Roles of engineered lignocellulolytic microbiota in bioaugmenting lignocellulose biomethanation

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A B S T R A C T

The recalcitrance and physiochemical complexity of lignocellulosic biomass limit its hydrolysis and subsequent anaerobic digestion to produce biomethane. Restricted lignocellulose hydrolysis reduces the substrate supply to catabolic pathways of anaerobic digestion, altering the indigenous digester microbiota by affecting the syntrophy between hydrolytic, acidogenic, and acetogenic bacterial and methanogenic archaeal communities. This can considerably impede the maximum utilization of this potential biomass resource, resulting in poor biomass-to-biomethane conversion. Bioaugmentation of anaerobic digestion with potent lignocellulolytic microbes can enhance rate-limiting hydrolytic pathways to convert lignocellulosic biomass into biomethane efficiently. Bioaugmentation can enrich lignocellulose-degrading microbiota in digesters through complementary metabolic and transcription processes. Although the positive roles of bioaugmentation in improving lignocellulose digestion have been well-established, efforts are still underway to properly attribute the role of bioaugmentation to specific microbiota compositions and their metabolic functions. Assessing the stability, dynamics, and specific metabolic roles of different microbial guilds of the bioaugmenting lignocellulolytic microbiota and their intricate interactions with the indigenous microbiota, along with deterministic process factors, is pivotal for the successful real-scale execution of bioaugmented lignocellulose digestion. To clarify, studies have adopted an integrated approach of high-throughput meta-omics to identify the unique metabolic functional niches filled by core microbial communities in bioaugmented digester microbiota. Enhanced bioconversion of lignocellulosic biomass into methane can considerably contribute to the Sustainable Development Goals by addressing affordable and clean energy production. This review emphasizes the significance of lignocellulolytic microbiotas in bioaugmentation of anaerobic digestion and the understanding of their ecological functions in the intricate interspecies nexus during biomethanation.

1. Introduction

Lignocellulosic biomass is one of the most sustainable feedstocks for bioenergy production, with an estimated annual global yield of 220 billion tons [1]. Biomethanation of lignocellulose through anaerobic digestion (AD) has received extensive consideration as an effective, environmentally sustainable, and economical approach to obtaining energy-rich biofuels, which can significantly contribute to the biobased circular economy, meeting important Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) requirements [2,3]. The seventh SDG (Affordable and Clean Energy) is directly linked to biogas production through AD, which can also help accomplish other sustainable development goals. Unlike other clean fuels, biogas

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