MethanoX: Machine-Learning-Guided Identification and Validation of Tropical Fruit-Derived Antimicrobials to Mitigate Methane Emissions in Rice Paddy Soils

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Methane (CH4) emissions from flooded rice paddies are a major contributor to agricultural greenhouse gases, driven by the anaerobic activity of methanogenic archaea in soil environments. Reducing paddy methane emissions is essential for climate mitigation and sustainable rice production, as methane has a global warming potential far greater than carbon dioxide. Previous research has demonstrated that altering field conditions, soil amendments, and irrigation strategies can significantly influence methane emission rates and microbial community dynamics in rice systems. The MethanoX project integrates machine learning with empirical validation to identify natural compounds from underexplored tropical fruit extracts that can inhibit methanogenic archaea and thereby reduce methane production in rice paddies. Predictive models were trained on physicochemical and biological data to prioritize candidate compounds with potential antimicrobial activity against methanogens. Experimental testing of top-ranked extracts using plate-based antimicrobial assays confirmed that several fruit-derived compounds demonstrated inhibitory effects on methanogenic activity. These results highlight the feasibility of combining data-driven prediction with laboratory validation to discover biologically-derived methane mitigation strategies that complement existing agronomic practices. By leveraging machine learning and sustainable natural resources, this approach offers a novel avenue for reducing paddy methane emissions while maintaining rice productivity. The insights gained may inform future research and strategies aimed at mitigating greenhouse gas emissions from rice cultivation and other anaerobic soil systems.

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