Simplified Harvesting Achieved by Cyanobacterial Cell Surface Engineering Economically Enables Machine Learning-informed Semi-continuous Cultivation for Sustainable Biofuel Production

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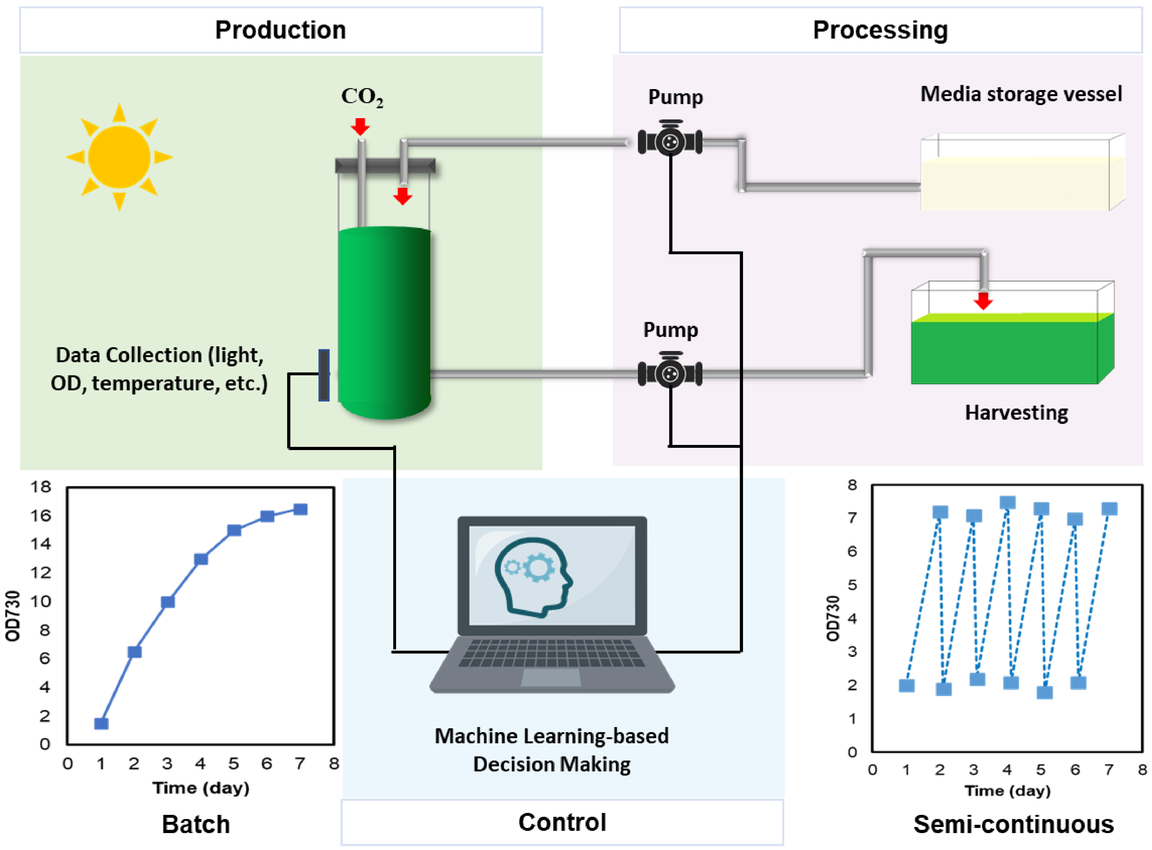
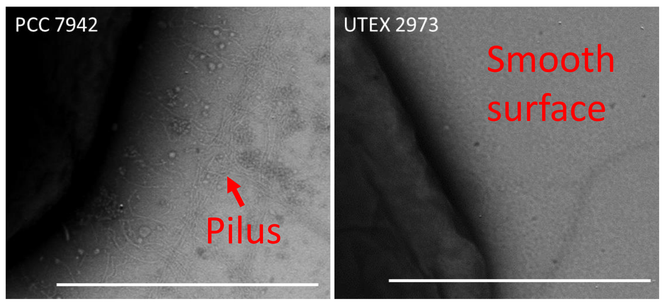
Background

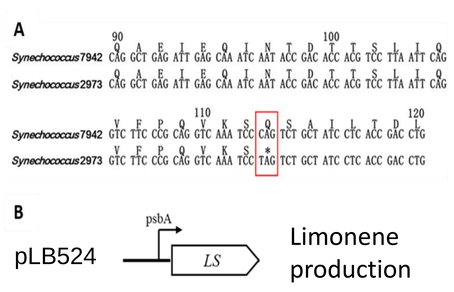
Growth limitation by mutual shading and costly harvesting are two major technical challenges in algal biofuel production. In order to overcome the mutual shading, we developed a machine learning-informed semi-continuous cultivation system (MISC). However, the MISC requires frequent harvesting, so it is economically infeasible unless a low-cost harvesting method is developed.



Material and Methods

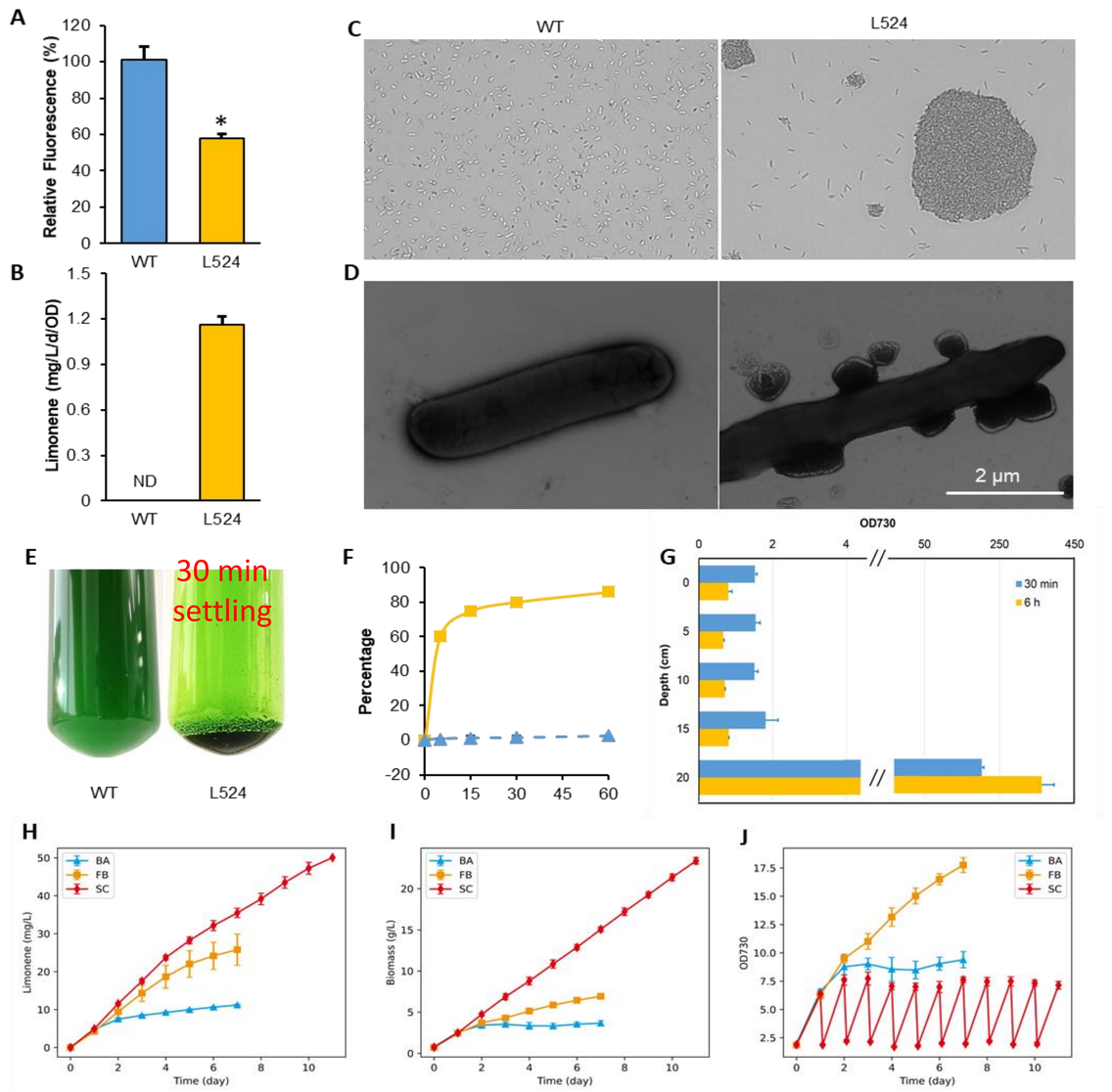
Synechococcus elongatus UTEX 2973 (UTEX 2973) was selected as the model strain due to its relatively smooth cell surface (pilN mutation). Limonene, a strong hydrophobic hydrocarbon was chosen to alter cell hydrophobicity.





Results

- Limonene production increases cell hydrophobicity;
- Increased cell hydrophobicity drives cell aggregation;
- Cell aggregation enables sedimentation (AES);
- AES is a simple, fast, and low-cost harvesting method with high recovery rate and high solid content in its output.



Conclusion

We developed a simple, fast, and low-cost biomass harvesting method, the AES, by altering cyanobacterial cell surface hydrophobicity with a synthetic biology design. The AES economically enabled the implementation of the MISC, which ultimately addressed the technical barriers in algal cultivation and achieved sustainable biofuel production.