

Utilization Potential of Phenolic Lignin Degradation Products by Various Microorganisms

Mioto Uno ¹, Shouyou Takamatsu ¹ and Young-Cheol Chang ^{1*}¹Course of Chemical and Biological Engineering, Division of Sustainable and Environmental Engineering, Muroran Institute of Technology

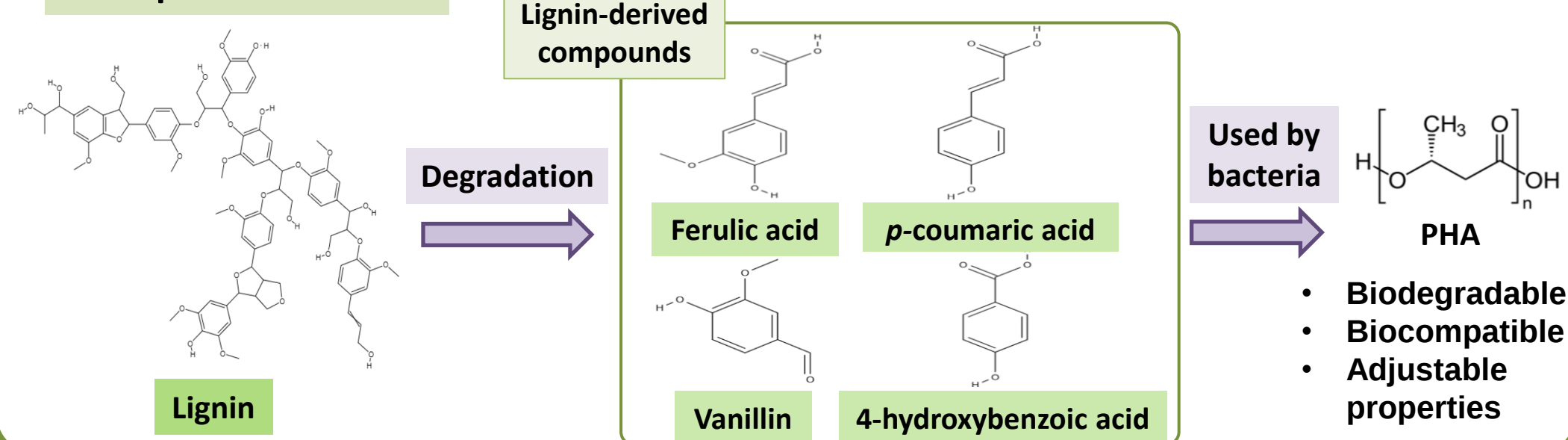
* Correspondence: ychang@muroran-it.ac.jp; Tel: +81-143-46-5757

INTRODUCTION & AIM

Recent research has focused on identifying cost-effective alternatives to conventional substrates used in polyhydroxyalkanoic acid (PHA) production. Among these, lignin—a complex aromatic polymer and the second most abundant organic compound on Earth after cellulose—has gained attention. Lignin is commonly discarded as a byproduct of the paper and agricultural industries, yet its recalcitrant structure makes it difficult to biodegrade. However, during industrial processing, lignin is partially broken down into phenolic compounds such as ferulic acid, which are more amenable to microbial utilization. Despite this, the potential of these phenolic degradation products as substrates for PHA production has not been thoroughly explored.

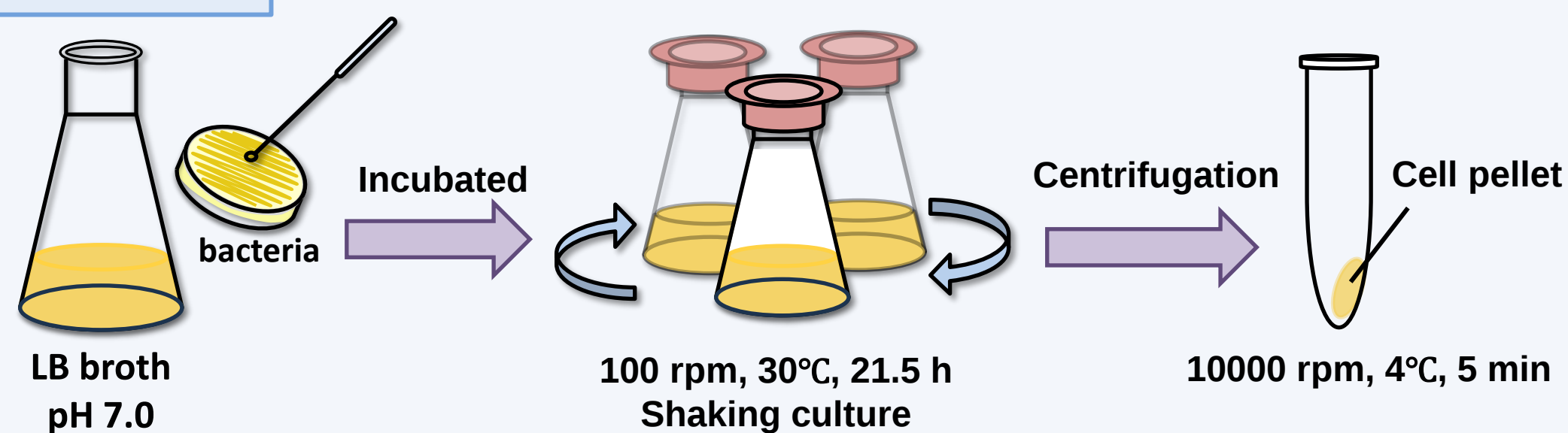
In this study, we assessed the ability of various microorganisms to utilize lignin-derived phenolic compounds, with the ultimate goal of enabling PHA production from lignin waste streams. Strains from the genera *Comamonas*, *Sphingobium*, and *Pseudomonas*, known for both phenolic compound degradation and PHA biosynthesis, were tested. Four representative lignin-derived compounds—ferulic acid, *p*-coumaric acid, vanillin, and 4-hydroxybenzoic acid—were used as sole carbon sources in minimal salts (MS) medium. Each compound was dissolved in ethanol and added at concentrations of 0.1 g/L and 0.5 g/L, reflecting levels typically found in acid hydrolysates and kraft pulp.

Graphical abstract



METHOD

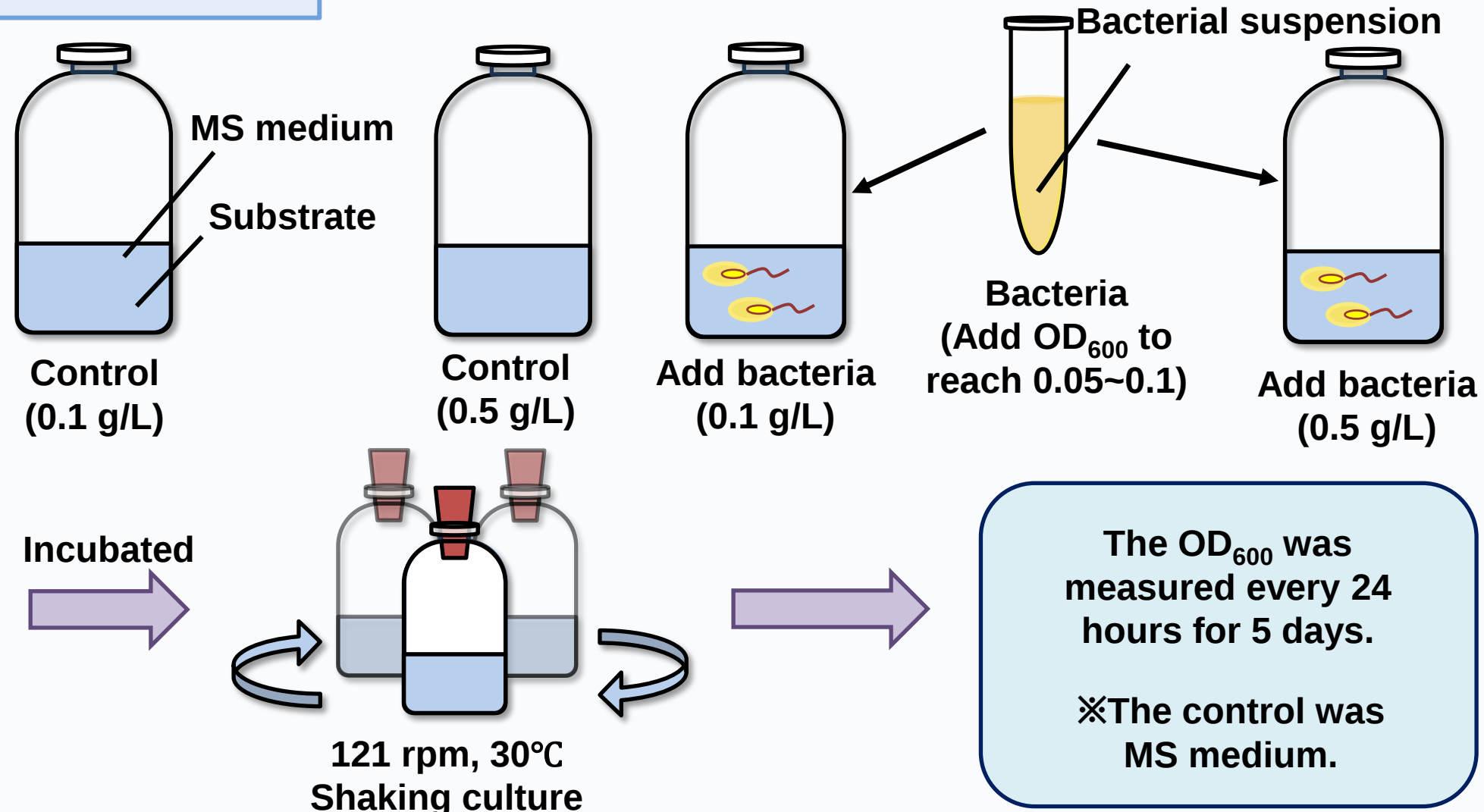
Pre-culture



Test strain

- *Comamonas testosteroni* (NBRC 100989)
- *Comamonas testosteroni* (NBRC 109938)
- *Comamonas testosteroni* (NBRC 110673)
- *Comamonas* TUC-1
- *Sphingobium jiangsuense* (NBRC 112973)
- *Sphingobium* sp. (NBRC 103272)
- *Sphingobium amiense* (NBRC 102518)
- *Sphingobium xenophagum* (NBRC 101067)
- *Pseudomonas putida* (NBRC 100988)

Main-culture



Lignin-derived compounds (Substrate)

- Ferulic acid (FA)
- *p*-coumaric acid (CA)
- Vanillin (VA)
- 4-hydroxybenzoic acid (HA)

RESULTS & DISCUSSION

Pseudomonas putida (NBRC 100988)

A selection of the results is presented below.

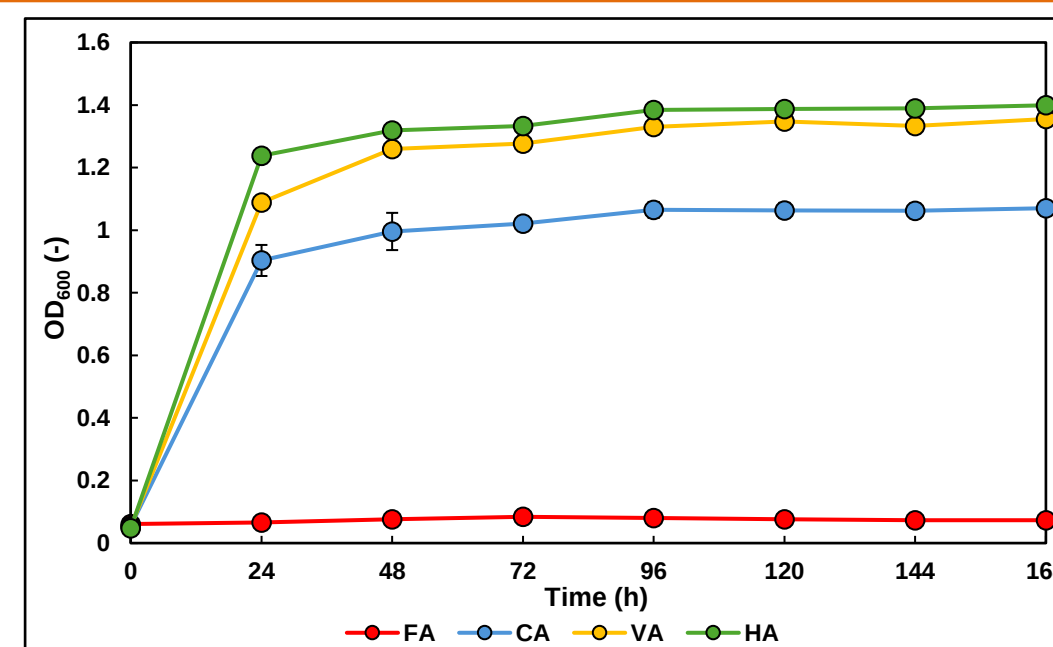


Fig. 1. Time-dependent changes of *Pseudomonas putida* (NBRC 100989) at a substrate concentration of 0.1 g/L

At 0.1 g/L, they grew on substrates other than FA.

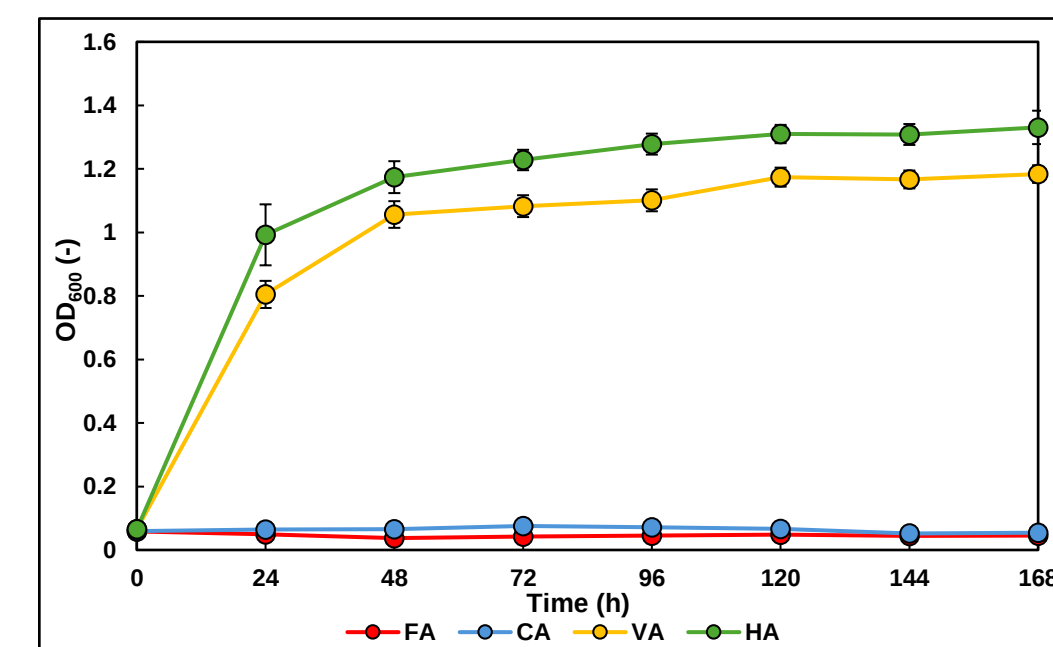


Fig. 2. Time-dependent changes of *Pseudomonas putida* (NBRC 100989) at a substrate concentration of 0.5 g/L

At 0.5 g/L, growth was observed with CA and VA.

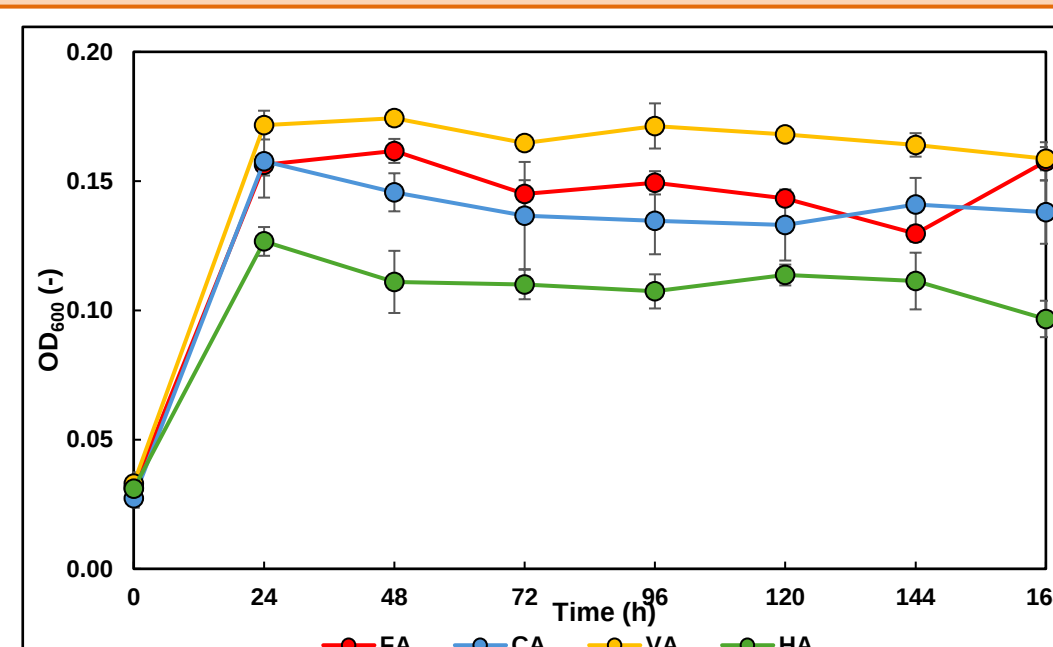
Sphingobium jiangsuense (NBRC 112973)

Fig. 3. Time-dependent changes of *Sphingobium jiangsuense* (NBRC 112973) at a substrate concentration of 0.1 g/L

At 0.1 g/L, slight growth was observed with all substrates.

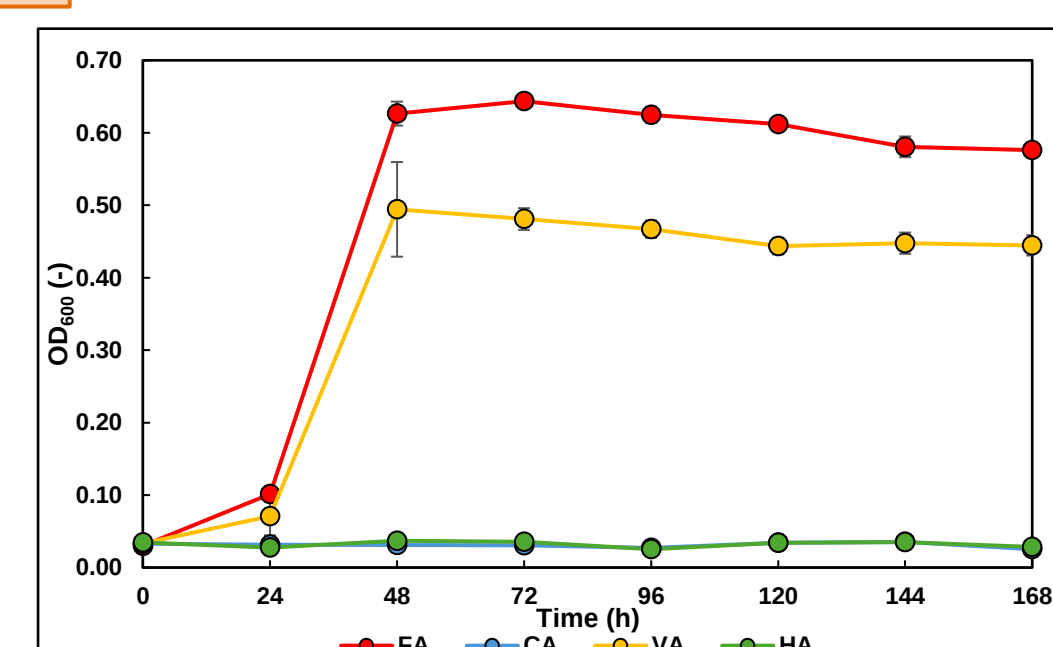


Fig. 4. Time-dependent changes of *Sphingobium jiangsuense* (NBRC 112973) at a substrate concentration of 0.5 g/L

At 0.5 g/L, slight growth was observed with FA and CA.

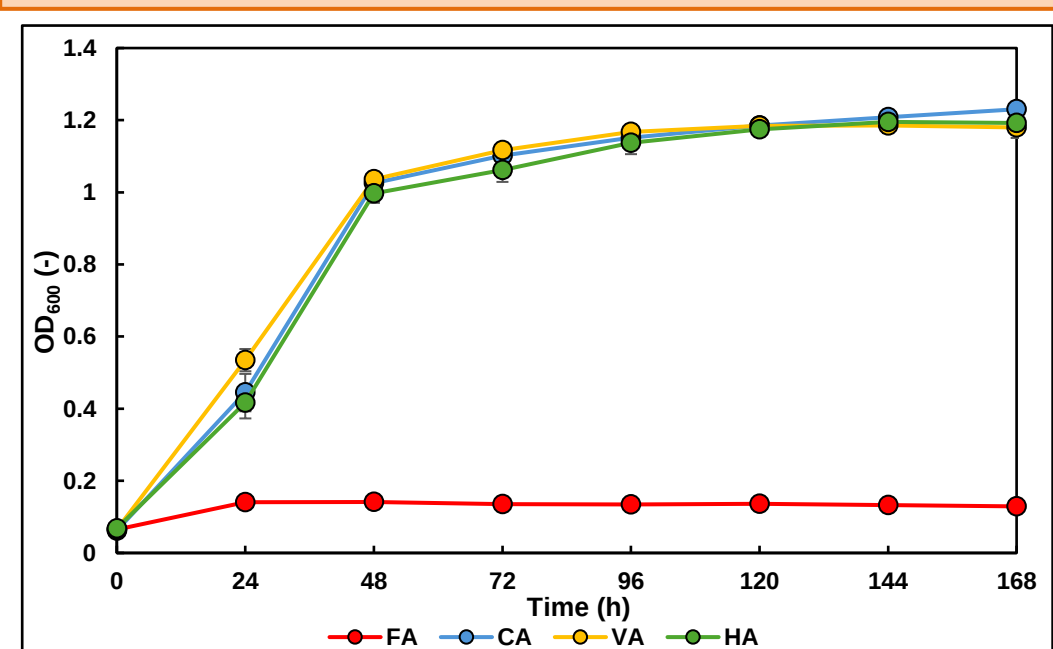
Comamonas testosteroni (NBRC 100989)

Fig. 5. Time-dependent changes of *Comamonas testosteroni* (NBRC 112973) at a substrate concentration of 0.1 g/L

At 0.1 g/L, they grew on substrates other than FA.

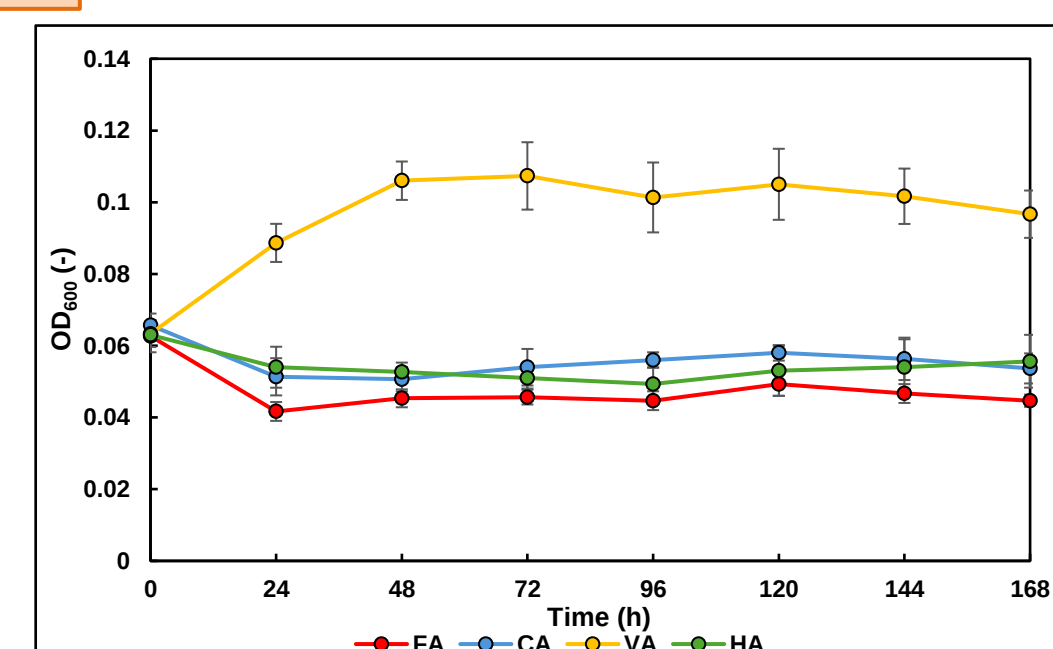


Fig. 6. Time-dependent changes of *Comamonas testosteroni* (NBRC 112973) at a substrate concentration of 0.5 g/L

At 0.5 g/L, slight growth was observed with VA.

CONCLUSION

- *Pseudomonas putida* (NBRC 100988) grew on all substrates except FA at 0.1 g/L, and grew on CA and VA at 0.5 g/L.
- *Sphingobium jiangsuense* (NBRC 112973) showed slight growth on all substrates at 0.1 g/L, and slight growth was also observed with FA and CA at 0.5 g/L.
- *Comamonas testosteroni* (NBRC 100989) grew on all substrates except FA at 0.1 g/L, and slight growth was observed with VA at 0.5 g/L.
- The lack of growth may be due to the complex structure of the aromatic compounds and the possible absence of metabolic pathways.

FUTURE WORK / REFERENCES

- These results demonstrate that the tested strains can metabolize a range of lignin-derived phenolics.
- Based on these findings, we aim to further evaluate PHA production using these strains with individual or mixed phenolic substrates to assess production yields and overall feasibility.