PROAGRO LECTORIUM

A priming effect in anaerobic digestion of swine manure

Prof. Qiang Lin

Chengdu Institute of Biology,

Chinese Academy of Sciences

A solution to the global energy crises and environmental pollution

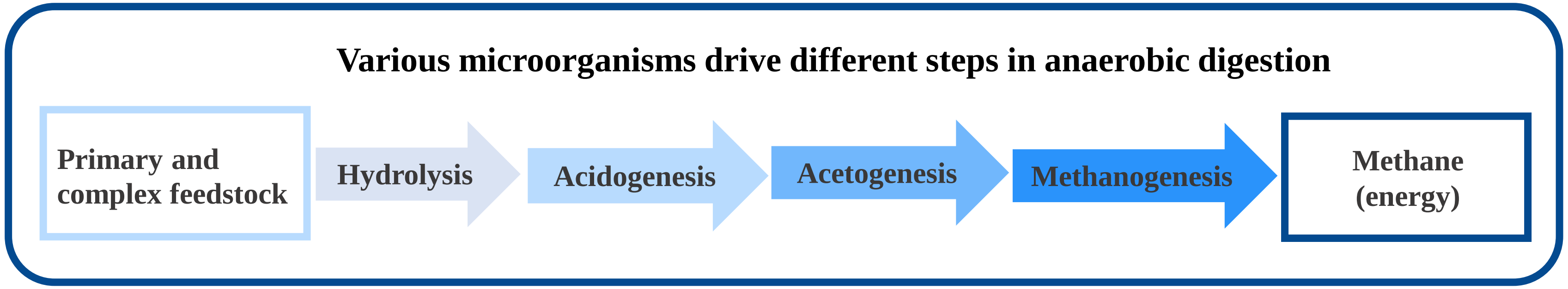
- As the development of livestock farming, numerous manure have been generated and released, causing a serious threat and pollution to environment.
- Natural gas crisis in 2022 highlights the global energy issue.
- What is a solution to the two problems above?

Anaerobic digestion

Anaerobic digestion

Anaerobic digestion represents an effective treatment for animal manure, fruit waste…

- To address these pollution
- To recover energy from these pollution



Water Research 2022, Q. Lin et al.

Anaerobic digestion performance

Operational parameters (abiotic factors)

- Temperature
- pH
- Substrate characteristics
- Hydraulic retention time
- Organic loading rate
- …..

Microbial community (biotic factors)

- Microbial activity
- Microbial community composition
- Microbial assembly
- Microbial interactions
- Microbial life strategies
- …..

Priming effect

- Priming effect priorly describes a process in soil that the degradation of other organic materials is promoted after the input of a labile substrate.

- Whether there is a priming effect in anaerobic digestion: whether and how the addition of a substrate promotes the degradation of the other substrates in anaerobic digestion, **by activating microorganisms**.

Setup of anaerobic co-digestion

Anaerobic co-digestion of swine manure and straw

To explore microorganism-driven priming effect in anaerobic co-digestion:

- Add labile substrate such as **apple waste** and **fructose** in the co-digestion, separately.
- Monitor dynamics of present microorganisms and potentially active microorganisms, by amplicon sequencing of the 16S rRNA gene and 16S rRNA.
- Investigate transcriptional profiles of microbial communities by metatranscriptomic sequencing.

Improved performance in anaerobic digestion

Daily CH_4 production

Compared to without addition of labile feedstocks (0.9 ± 0.2 L L^{-1} d^{-1})

the addition of apple waste significantly promoted daily CH_4 production to 1.5 ± 0.6 L L^{-1} d^{-1} , $P = 0.003$

the addition of fructose significantly promoted daily CH_4 production to 1.6 ± 0.7 L L^{-1} d^{-1} , $P = 0.002$

However, need to confirm these promotion is attributed to the promoted digestion of manure

Bioresource Technology 2022, Q. Lin et al.

Improved performance in anaerobic digestion

In each feeding cycle, the cumulative CH_4 production is

- In the control: 4.3 ± 0.2 L

- with the addition of apple waste:

detected 6.6 ± 0.4 L > expected 5.6 L

$$\text{The expected } CH_4 \text{ production } (L) = (\text{Carbohydrate } (g\ VS) \times 415 + \text{Lipid } (g\ VS) \times 1014 + \text{Protein } (g\ VS) \times 496 + \text{Lignin } (g\ VS) \times 727 + \text{VFA } (g\ VS) \times 373) \times 0.001$$

- With the addition of fructose:

detected 7.0 ± 0.3 L > expected 5.3 L

$$C_xH_yO_z + \left(x - \frac{y}{4} - \frac{z}{2}\right)H_2O \rightarrow \left(\frac{x}{2} + \frac{y}{8} - \frac{z}{4}\right)CH_4 + \left(\frac{x}{2} - \frac{y}{8} + \frac{z}{4}\right)H_2O$$

Expected values are its contribution to methane production by assuming completely digestion of labile substrate. Even though, the detected values are higher than expected, indicating the promoted digestion of manure by adding labile substrate.

Improved performance in anaerobic digestion

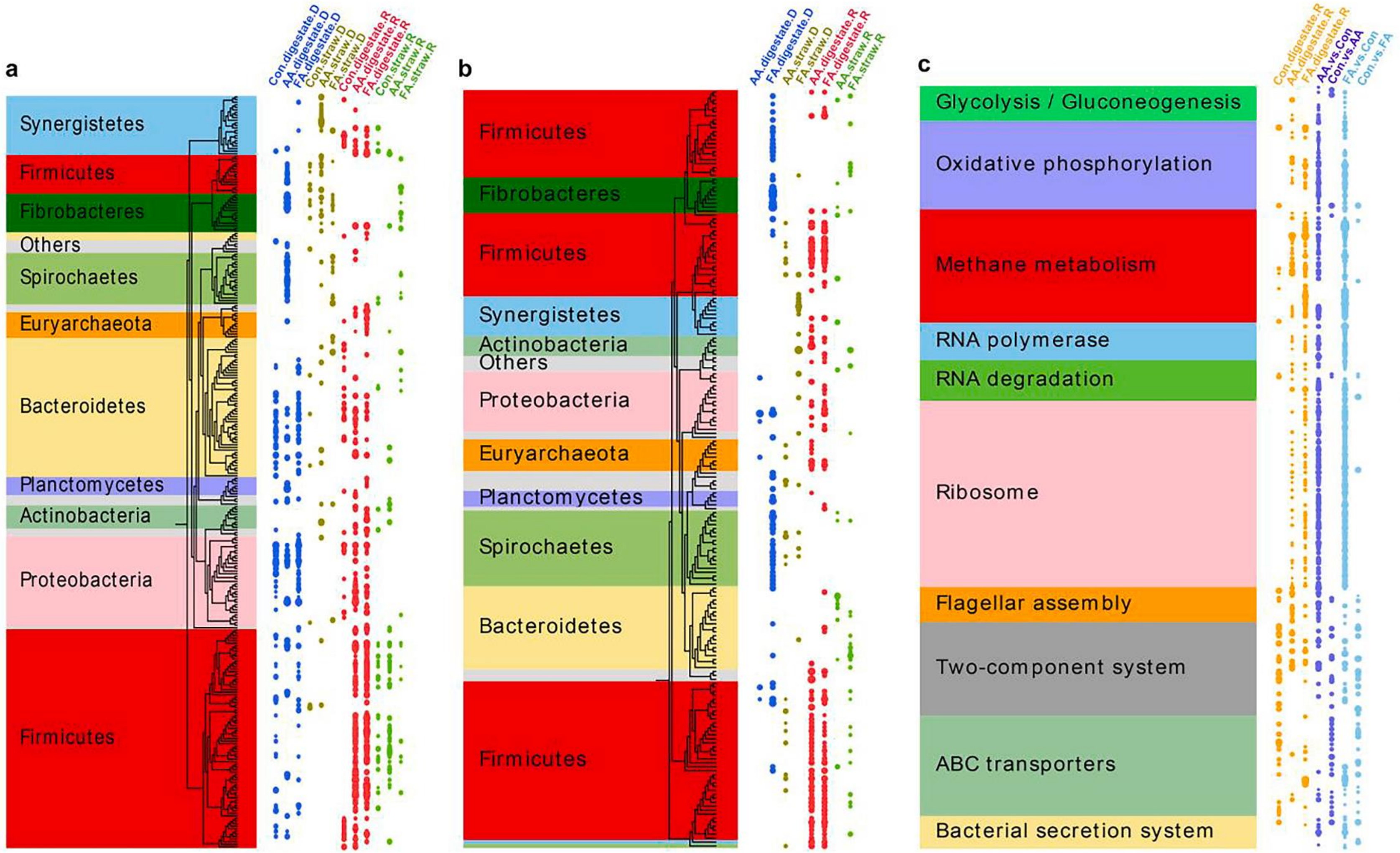
Compared to the control, the transformation efficiencies of swine manure to CH_4 were significantly ($P < 0.001$) promoted by 39 ± 13% and 65 ± 14% with the addition of apple waste and fructose, respectively.

Reveal the positive priming effect in anaerobic digestion by adding labile substrate.

What is the microbial mechanisms behind?

Microbial mechanisms underlying priming effect

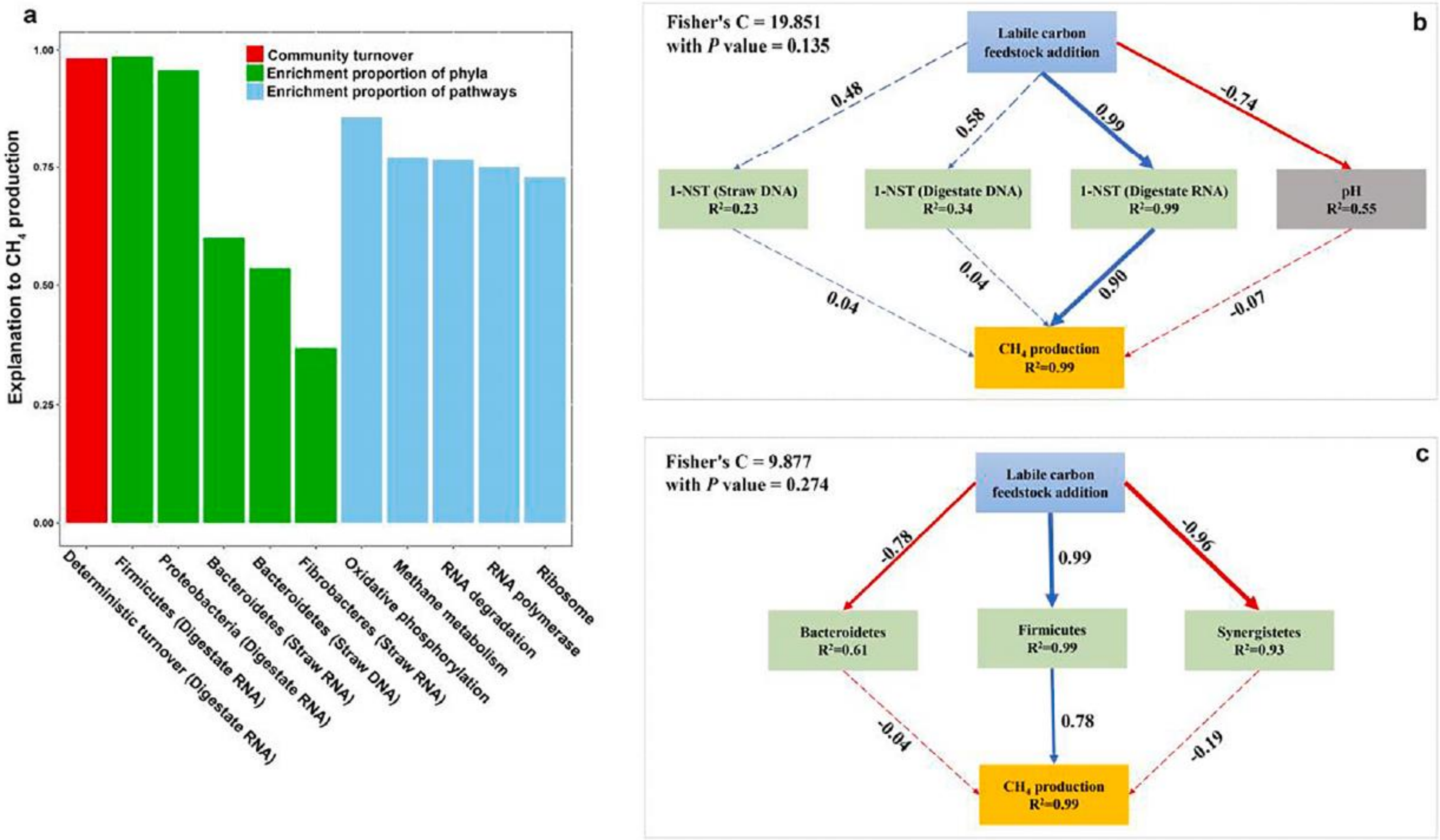
The phylogenetic distributions of enriched microorganisms, and enriched metabolic pathways by adding labile substrate



Bioresource Technology 2022, Q. Lin et al.

Microbial mechanisms underlying priming effect

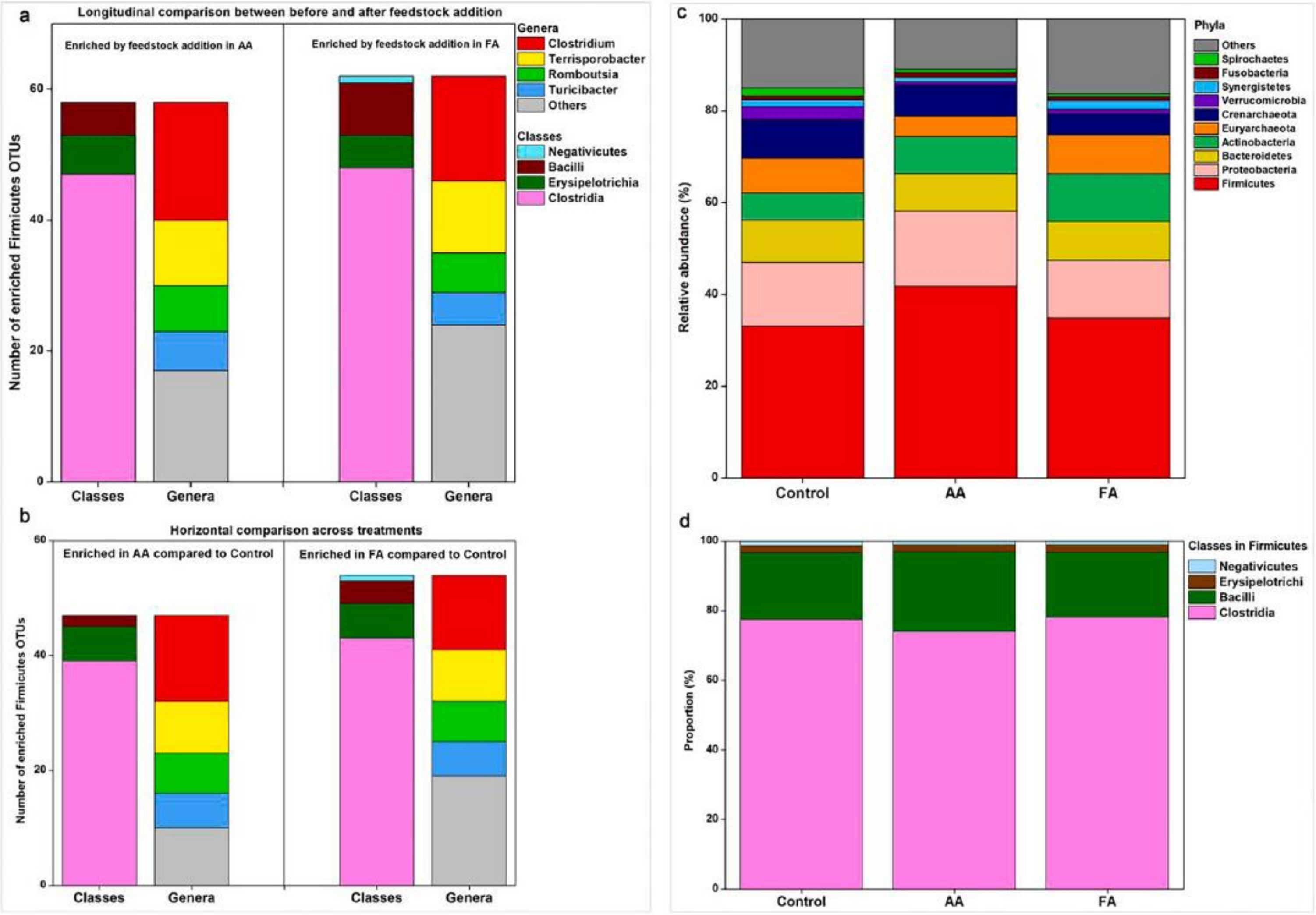
- Deterministic turnover of microbial communities
- Firmicutes
- Proteobacteria
- Bacteroidetes
- Oxidative phosphorylation
- Methane production



Bioresource Technology 2022, Q. Lin et al.

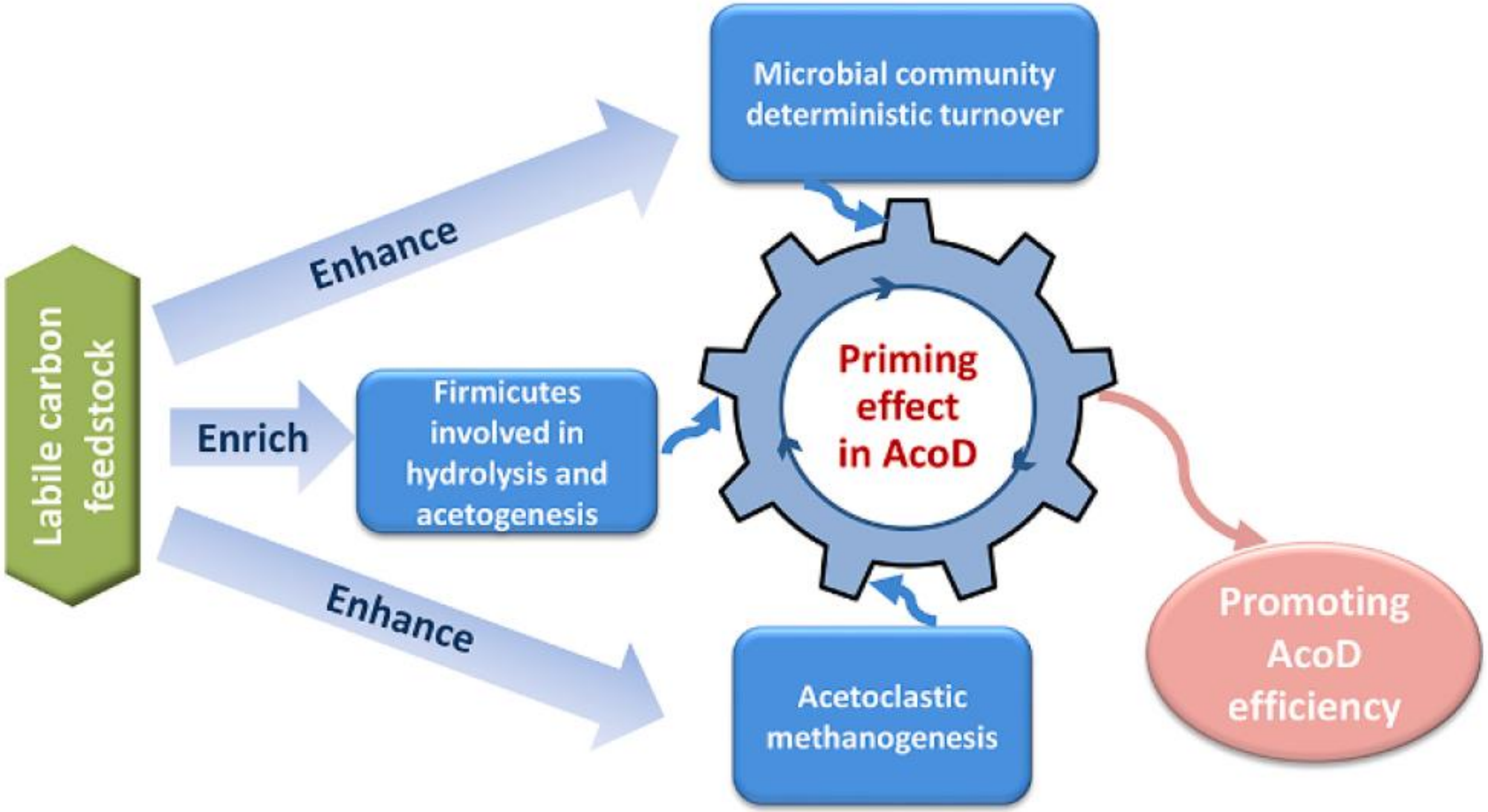
Microbial mechanisms underlying priming effect

Enriched Firmicutes OTUs



Bioresource Technology 2022, Q. Lin et al.

Microbial mechanisms underlying priming effect



Bioresource Technology 2022, Q. Lin et al.

PROAGRO LECTORIUM

Thank you