Improving anaerobic fermentative performance of food waste by Fe-modified biochar: FeBC synthesis and application in fermentation system

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The biological conversion of food waste through anaerobic fermentation has attracted wide attention, and the positive effects of biochar on enhancing fermentative performance have been documented (Fagbohungbe, 2017). However, limited research has been conducted on the retention of microbial functionality and the recovery of biochar in fermentation system. Magnetic biochar presents a promising avenue for addressing this issue. In this study, we synthesized Fe-modified biochar (FeBC) and examined its impact as an additive on the anaerobic fermentation of food waste. The results of this study lay the foundation for optimizing the application of modified biochar in fermentation systems and closing the loop on waste management.

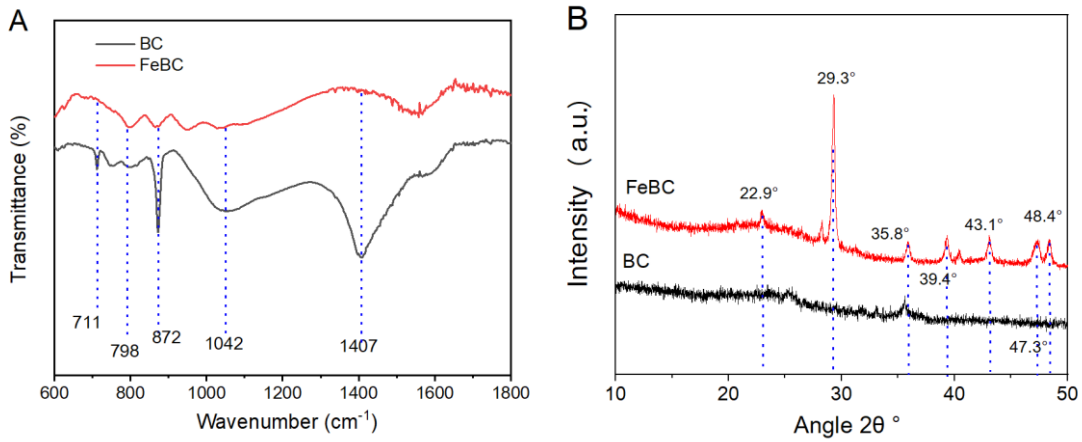

Figure 1. Characterization of raw biochar and FeBC. (A) Fourier transform infrared spectra and (B) XRD spectra.

FeBC was prepared using the iron-impregnated method (He, 2018). As shown in Figure 1, the FT-IR analysis indicated that various basic functional groups were formed on the surface of FeBC, which could improve the pH buffering ability of the biochar. Additionally, the XRD results suggested that Fe-modified biochar carries more iron-containing compounds after modification.

Table 1. Gompertz kinetic parameters of hydrogen production in system without biochar and system with FeBC.

Groups	P (mM)	R_{max} (mM/h)	λ (h)	R^2
Control	25.50	2.93	4.15	0.98
FeBC-treated	33.73	37.10	5.84	0.99

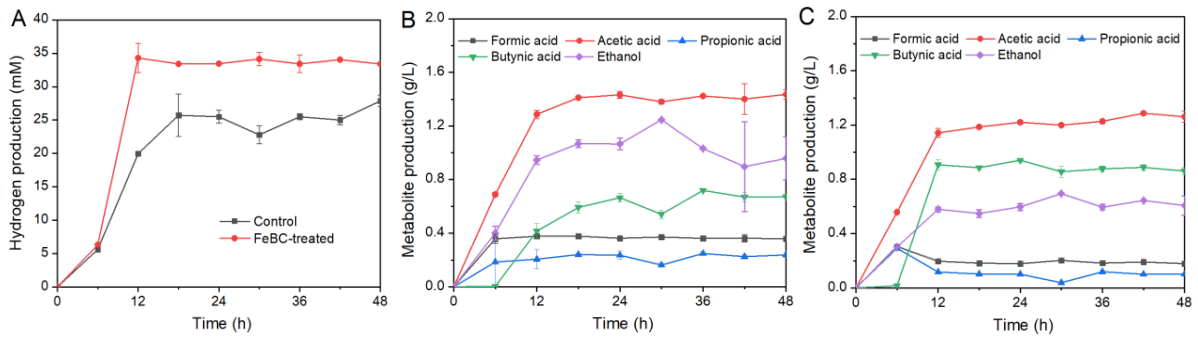

Figure 2. Effect of FeBC amendment on dark fermentation performance. (A) hydrogen production; (B) metabolite production of control group; (C) metabolite production of FeBC-treated group.

Figure 2 demonstrates that FeBC significantly enhanced the yield and rate of hydrogen fermentation, resulting in a 33.3% increase in final hydrogen production (as shown in Table 1). Notably, FeBC exerted a regulatory effect on the metabolic pathways of microbial communities by promoting the conversion of substrates to butyric acid while concurrently reducing the conversion to formic and propionic acid. This pathway shift is more favorable for hydrogen production.

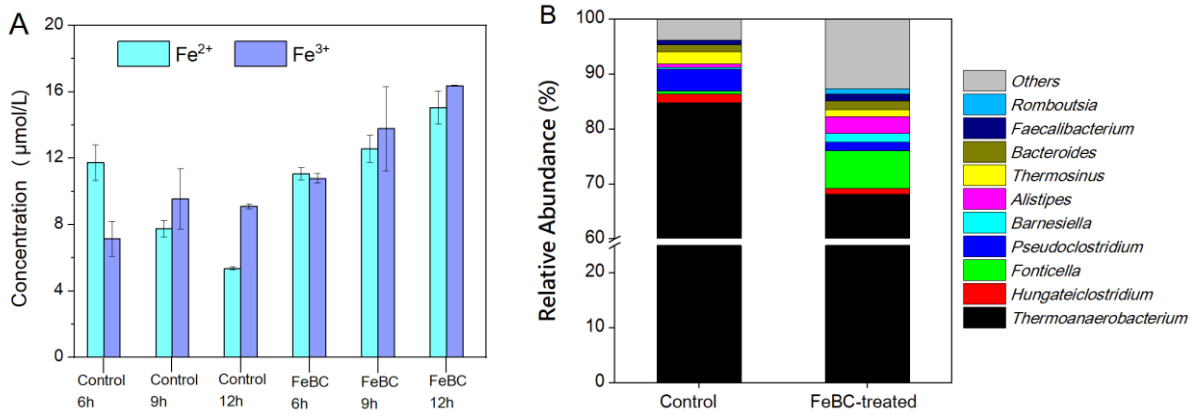

Figure 3. Release of Fe^{2+} and Fe^{2+} during fermentation (A) and effect of FeBC on microbial community (B).

Figure 3A indicates that FeBC can gradually release Fe^{2+} and Fe^{3+} during fermentation, which may improve the activities of ferric reduction oxidase and hydrogenase (Mo, 2023). Moreover, from Figure 3B, *Fonticella* was significantly enriched in the FeBC system. *Fonticella* is an important genus involved in using various organic substances for metabolism and is a key contributor to bacterial exoelectrogenesis during fermentation (Luo, 2022).

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