Supplementary Information

Deciphering the role of biochar type and particle size in anaerobic co-digestion of food waste and waste activated sludge under thermophilic condition

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Table S1 Treatment conditions applied in this study

Treatments [a]	Biochar			Substrate [b]	Temperature (℃)
Different biochar types (biochar particles size: 0.6-1.25 mm)					
	BC ($g\ L^{-1}$)	HMK ($g\ L^{-1}$)	HSC ($g\ L^{-1}$)		
CK	0	0	0	FW+WAS	55
BC	15	0	0	FW+WAS	55
HMC	0	15	0	FW+WAS	55
HSC	0	0	15	FW+WAS	55
Different biochar particles sizes (biochar type: HSC)					
	Small <0.6 mm ($g\ L^{-1}$)	Medium 0.6-1.25 mm ($g\ L^{-1}$)	Large 1.25-1.6 mm ($g\ L^{-1}$)		
CK	0	0	0	FW+WAS	55
Small	15	0	0	FW+WAS	55
Medium	0	15	0	FW+WAS	55
Large	0	0	15	FW+WAS	55

[a] CK: control; BC: bamboo charcoal; HMC: hog manure charcoal; HSC: hickory shell charcoal.

[b] FW: food waste; WAS: waste activated sludge.

Table S2 Specific surface area and pore size distribution of biochar measured by BET method

Biochar	Specific surface (DFT, $m^2 g^{-1}$)	Total pore volume (DFT, $cm^3 g^{-1}$)	Micropore volume (DR, $cm^3 g^{-1}$)	Main pore size (DFT, nm)
BC	**58.01**	**0.084**	**0.021**	**4.077**
HMC	**43.66**	**0.092**	**0.017**	**4.220**
HSC	**17.82**	**0.016**	**0.005**	**3.433**

Nitrogen adsorption-desorption measurements revealed significant feedstock-dependent differences in the characteristics of the tested biochar. BC exhibited the largest specific surface area and the largest micropore volume, consistent with a high abundance of microporous structures that are conducive to microbial attachment. HMC showed a moderate surface area but the highest total pore volume, indicating a substantial contribution of mesopores or macropores that may enhance solute transport and adsorption capacity. HSC had the smallest surface area and pore volume. These differences might be associated with their distinct functional roles. BC provides a high contact area for microbial colonization; HMC provides a larger pore volume to facilitate mass transfer and the adsorption of inhibitory molecules; and HSC, despite its limited surface area, may be enriched in surface-bound redox-active sites within pore structure.

Table S3 α diversity index in the digester at the end of anaerobic digestion

	Group	Shannon	Simpson	ACE	Chao	Coverage
Archaea	CK	1.292	0.384	110.908	97.143	0.999
	BC	1.42	0.34	187.476	181.13	0.999
	HMC	1.801	0. 302	221.883	207.588	0.999
	HSC	1.563	0.302	229.11	206.553	0.999
Bacteria	CK	5.127	0.017	1936.873	1850.439	0.991
	BC	4.994	0.019	1957.254	1876.795	0.99
	HMC	4.778	0.032	1814.118	1773.943	0.991
	HSC	4.883	0.024	1736.926	1719.619	0.992

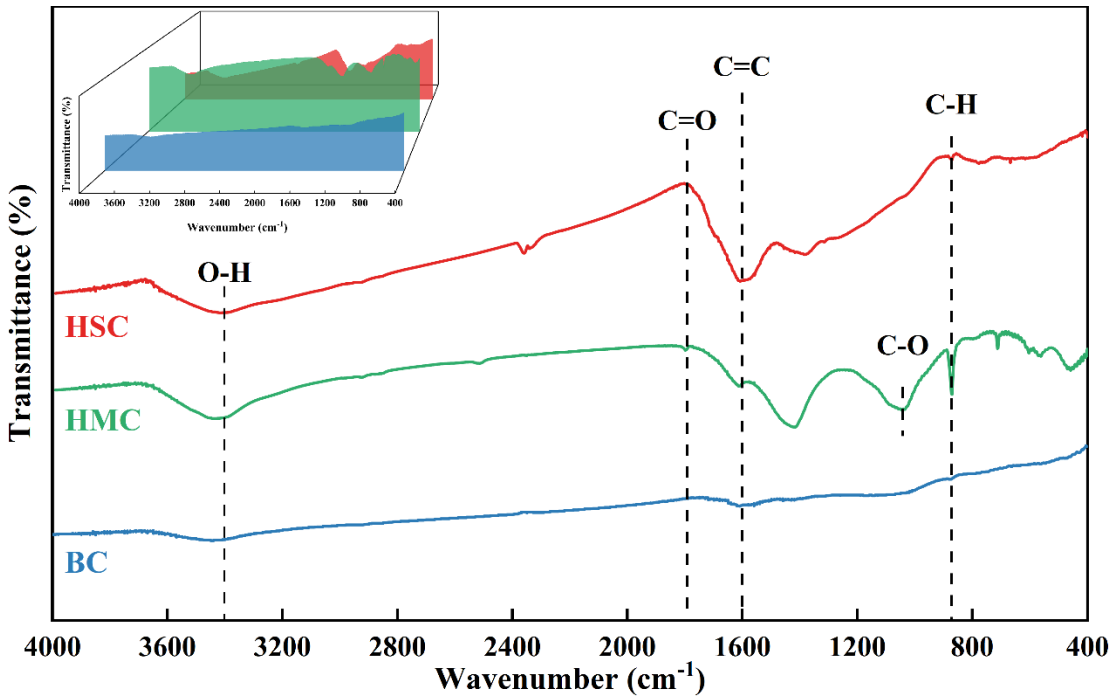

Fig. S1 The Fourier-transform infrared (FTIR) spectra of the three types of biochar (BC: bamboo charcoal; HMC: hog manure charcoal; HSC: hickory shell charcoal).