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Methanosarcina sp. as key archaea to avoid acidification in dry anaerobic digestion of food waste

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INTRODUCTION

- Food waste (FW) is a highly biodegradable substrate rich in nitrogen [1]. These characteristics often lead to accumulation of volatile fatty acids (VFAs) and free ammonia nitrogen (FAN), causing low methane yields and even AD failure [2,3]. It is then critical to have well-adapted resilient **archaeal communities** in the reactors, resistant to these common inhibitors (such as mixotrophic archaea [4])
- Objective:** assess influence of the composition of the archaeal communities of different inocula on the methane production from FW and cardboard (CB) at different working conditions (*i.e.* **total solid (TS)** contents, **co-digestion proportions** and **substrate loads**)

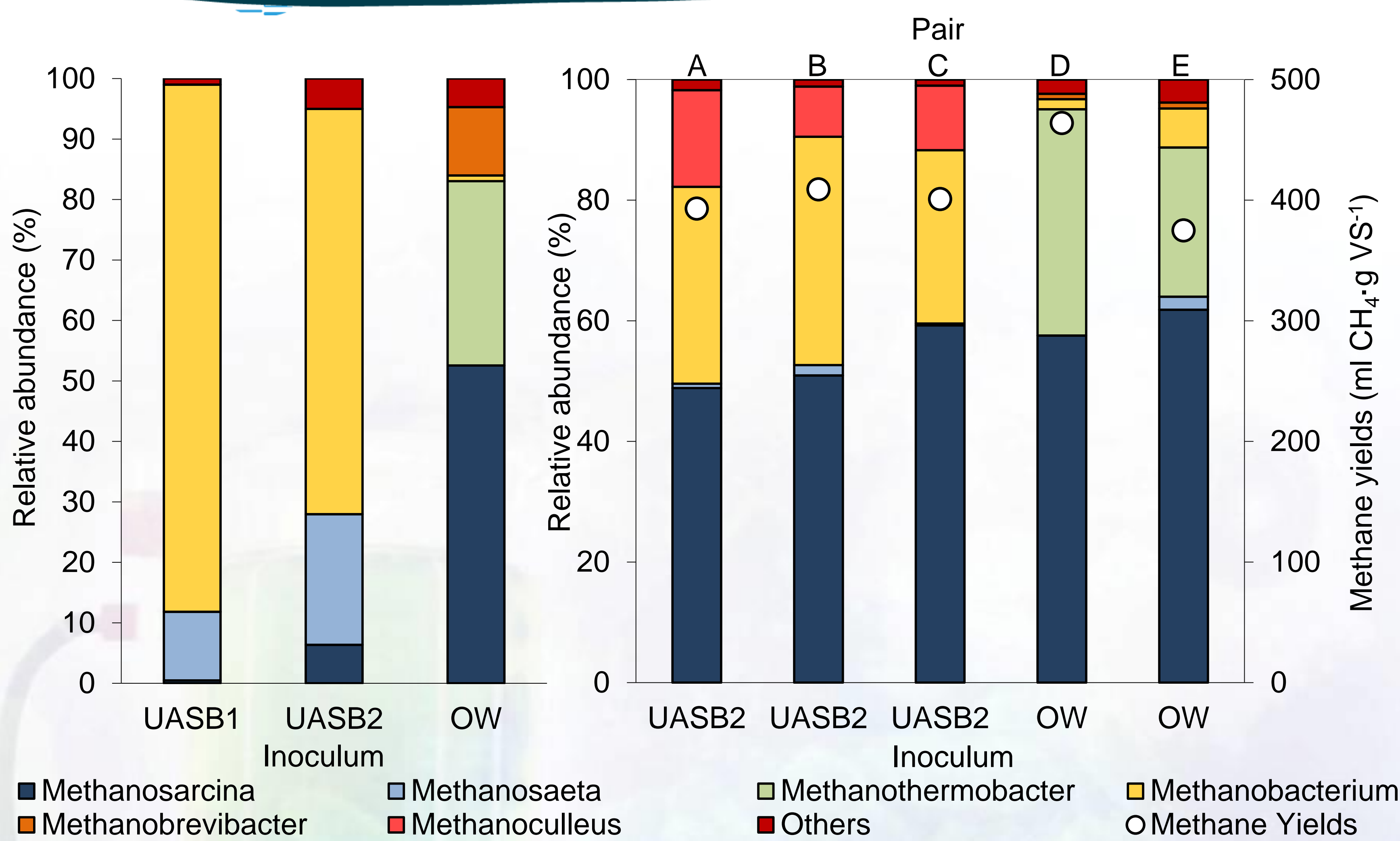
MATERIALS & METHODS

- Model FW (VALORGAS report [5]) and compact CB as substrates
- Three different inocula: UASB1 (high TS, low TAN), UASB2 (high TS, low TAN), OW (low TS, high TAN)
- 5 pairs of comparable experiments at different co-digestion proportions (1.00-4.00), substrate to inoculum (S/X) ratios (0.25-1.00 g VS-g VS⁻¹) and initial TS contents (20-30 %)
- Follow-up of methane production and analysis of concentration of TAN, VFAs and archaeal composition in inocula and digestates

Operational conditions of the batch experiments and obtained methane yields

Pair	Inoculum	Substrate	S/X (g VS-g VS ⁻¹)	Co-dig. ratio (g TS FW-g TS CB ⁻¹)	Initial TS (%)	Methane yield (ml CH ₄ -g VS ⁻¹)
A	UASB2	FW+CB	0.25	1.00	27.5	393±9.0
	UASB1	FW+CB	0.25	1.00	30.0	7.9±1.9
B	UASB2	FW+CB	0.25	1.86	27.5	409±11
	UASB1	FW+CB	0.25	1.75	30.0	11±2.7
C	UASB2	FW+CB	0.25	1.00	35.0	401±16
	UASB1	FW+CB	0.25	1.00	35.0	17±2.3
D	OW	FW	0.25	-	20.0	464±14
	UASB1	FW	0.25	-	20.0	0.7±0.9*
E	OW	FW	1.00	-	20.0	375±17
	UASB2	FW+CB	1.00	4.00	27.5	0±0

MAIN RESULTS



Composition of the archaeal communities in the inocula (left) and the digestates (right)

- High TAN and transient VFA concentrations in the reactors (up to 5 g·l⁻¹ and 23 g COD·l⁻¹, respectively)
- One reactor of each pair produced methane efficiently and the other was acidified due to VFA accumulation at the beginning of the batch AD process
- No methane with UASB1; with UASB2, only at an S/X ratio of 0.25 g VS-g VS⁻¹; OW worked at high loads
- In UASB1: no **Methanosarcina** sp. initially; in UASB2, minority initially; in OW: predominant methanogen
- In all reactors producing methane: **Methanosarcina** sp. as main methanogen
- No **Methanosaeta** sp. in digestates due to inhibition

Take-Home Message

- While the tests started with inocula rich in **Methanosarcina** sp. led to efficient methane production, VFAs accumulated in the reactors when inocula were poor in this archaea and no methane was produced
- Higher proportions of **Methanosarcina** sp. in the inocula allowed greater substrate loads
- Regardless of the inoculum used, **Methanosarcina** sp. was the dominant methanogen in the **methane-producing** reactors
- The initial archaeal composition of the inoculum is crucial during reactor start-up to achieve stable anaerobic digestion

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