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Influence of the addition of dairy cow manure as cosubstrate during the energetic valorization of cheese whey by psychrophilic anaerobic digestion

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Introduction

Cheese Whey - CW

50% is used

2019: **2,16e+9** t/year

- pH:4-6
- Alkalinity < 2.5 $gCaCO_3/L$

2018: **6,4e+7** t/year

- COD: 50-102 g/L
- Carbohydrates, lipids and proteins

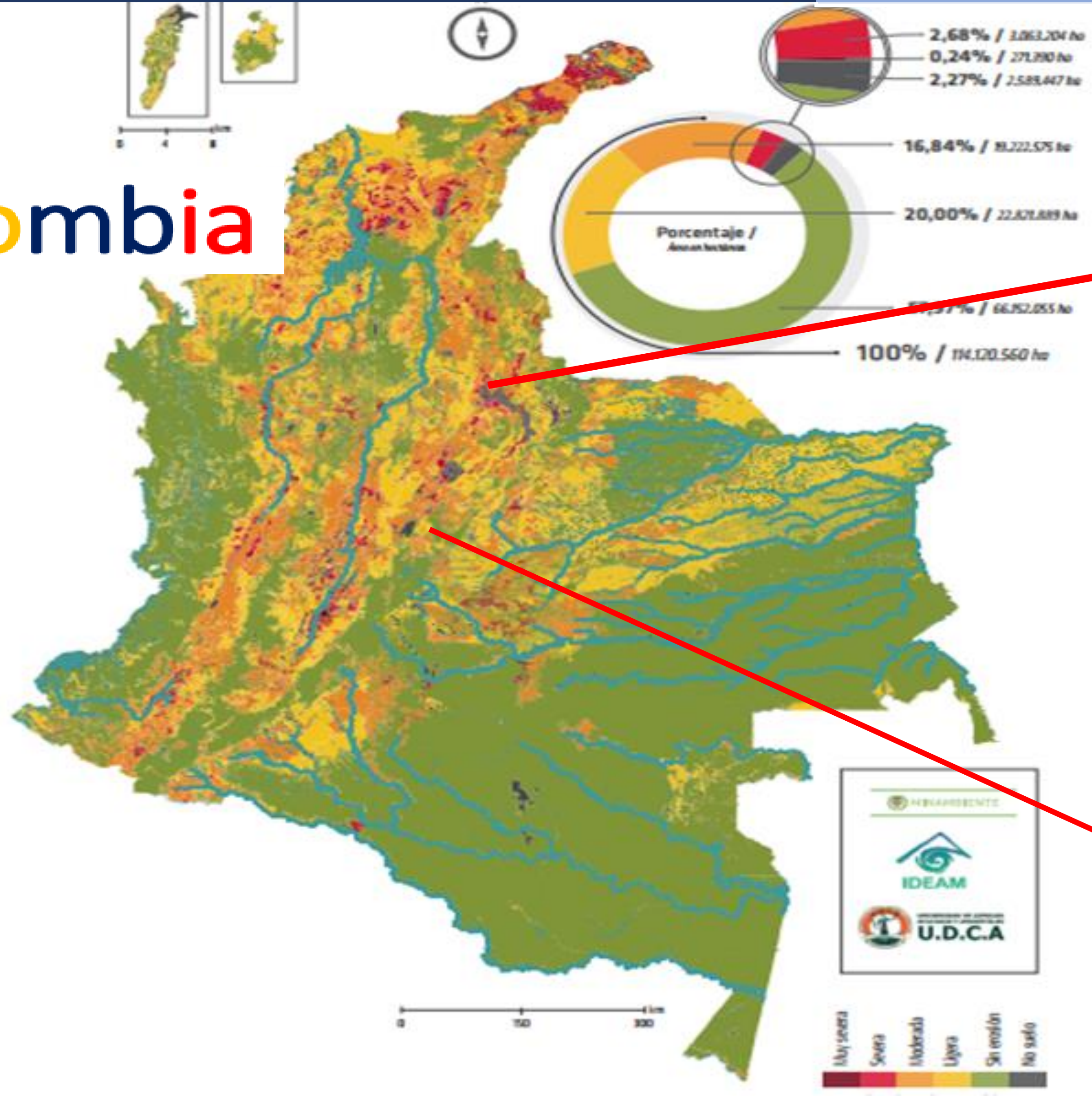
2018: **8,3e+5** t/year

Cow Manure: CM

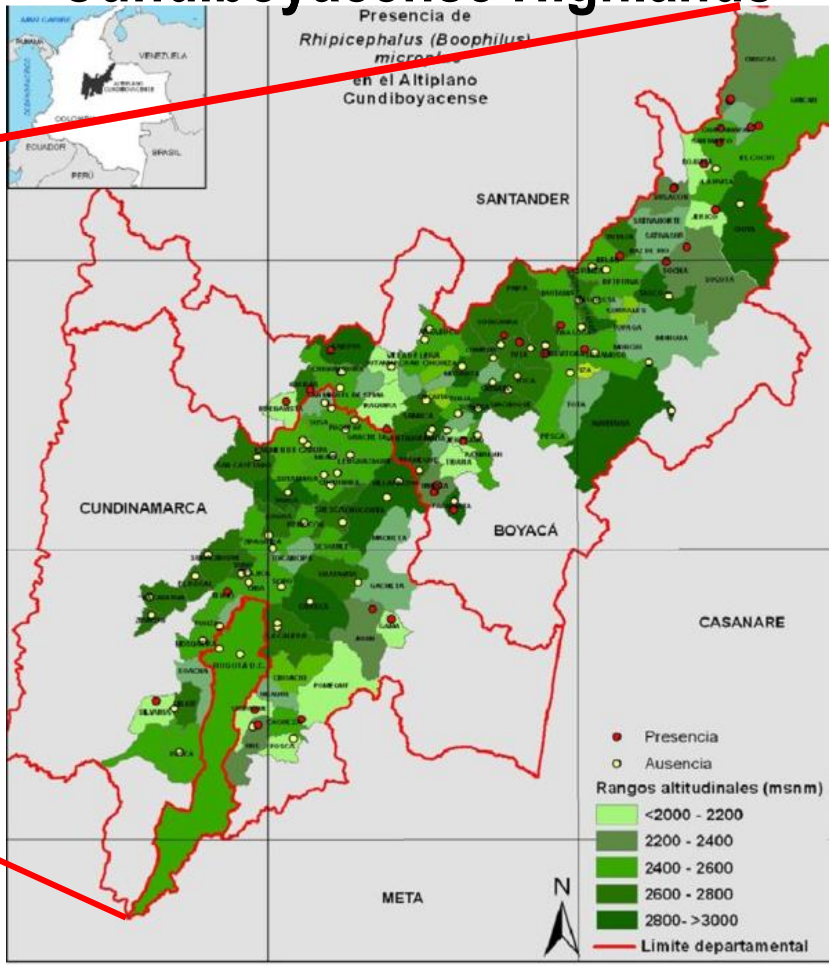
2018: **4,9e+9** t/year

2018: 1,1**e+8** t/year

Source: Mata-Álvarez, (2014); ONU, (2018); UPME-UNAL, (2018); INECOL, (2018); WWF, (2020) Colombia



Cundiboyacense Highlands



Average Temperature: 14 °C

Main Activities: Cattle raising and Farming

Source: Cortes-Vecino, (2010); IDEAM and UDCA, (2018)

Objective

To evaluate the AcoD between CW and CM under 20°C at different mixing proportions and inoculum substrate ratios (ISR) but represented from the point of view of organic load; in order to identify the treatment capacity of AcoD in a psychrophilic regime.

Methodology

Table 1. Physicochemical Characterization of residues

Parameter	Method	CW	CM	Inoculum
pH		5,63 ± 0.02	6,63 ± 0.02	7.25 ± 0.03
Sólidos Totales - ST (%)	2450G	65.22 ± 0.45	94.12 ± 0.15	27.41 ± 0,18
Sólidos Volátiles – SV (%)	2450G	60.16 ± 0.27	87.15 ± 0.14	23.90 ± 0.30
SV/ST	- -	92.94	87.17	87.15
Alcalinidad (mg $CaCO_3$/L)	2320B	0	400 ± 12	1121 ± 20
% Nitrógeno Total	4500-NH3D	1.14 ± 0.2	2.78	2.26
Total COD	5520B	31146 ± 47	108000 ± 56	6970 ± 38
Soluble COD	5520B	26600 ± 58	2630 ± 42	52200 ± 45

Methods according with: APHA, (2017)

Methodology

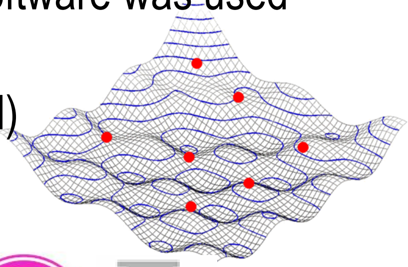
Duran® 250 mL Bottles
Chlorobutyl Septum
Purge with N_2

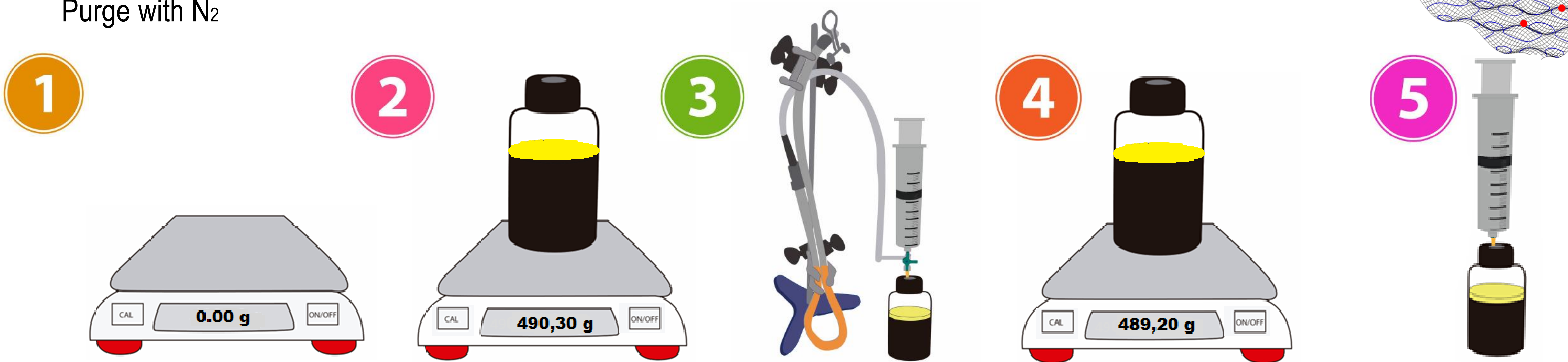
Table 2. Experimental Design

ID	X_1	X_2	Mix CW:CM (%)	OL (gVS/L)	ID	X_1	X_2	Mix CW:CM (%)	OL (gVS/L)
A	1	1	15:85	0.53	F	0	0	50:50	0.75
B	1	-1	15:85	1.26	G	$\sqrt{2}$	0	00:100	0.75
C	0	$-\sqrt{2}$	50:50	0.47	H	-1	-1	85:15	1.26
D	-1	1	85:15	0.53	I	$-\sqrt{2}$	0	100:00	0.75
E	0	$-\sqrt{2}$	50:50	1.80					

Method: Gas Density (Justensen et al., 2019), in addition OBA® software was used (Hafner et al., 2018).

The results was analysed by response surface methodology (RSM)





Methodology

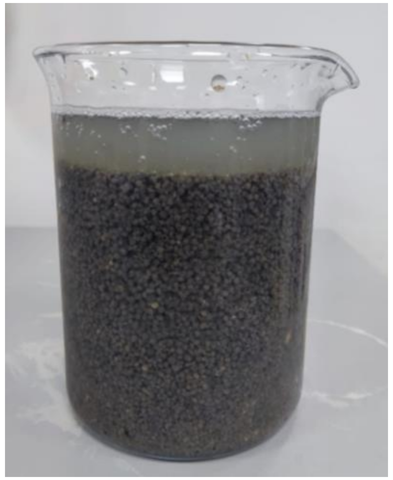
CW and CM

Rancho Los Álamos (Ubaté, Colombia)

350 dairy cows
Process: 1000 and 1200 L of milk/day
Produce: 800 and 1000 L/day of CW.

Average weight of a cow: 500 kg
CM: ≈ 14 ton/ day

Inoculum



Wastewater treatment plant of a dairy company

Storage of samples: 4 °C (Astals et al., 2020)

Results

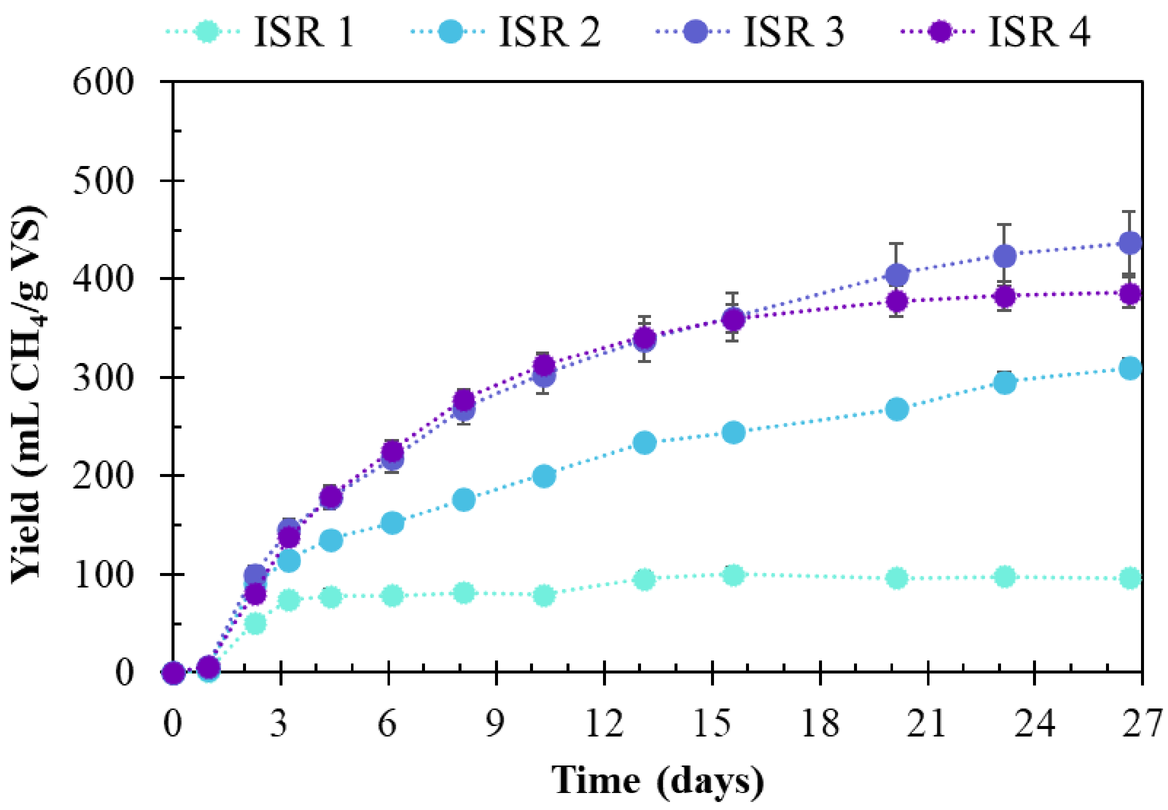


Figure 1. Acccumulated biogas production
of CW (different ISR) psycrophilic conditions

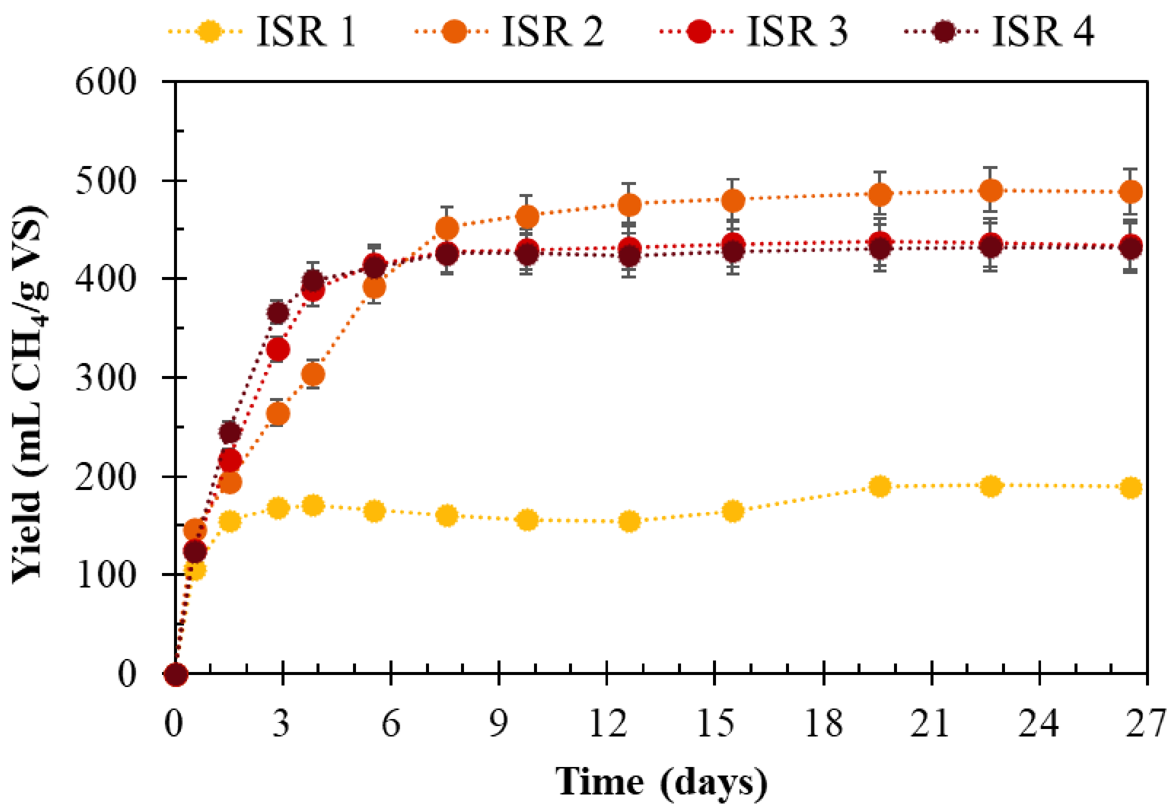


Figure 2. Biogas production CW mesophilic conditions

Results

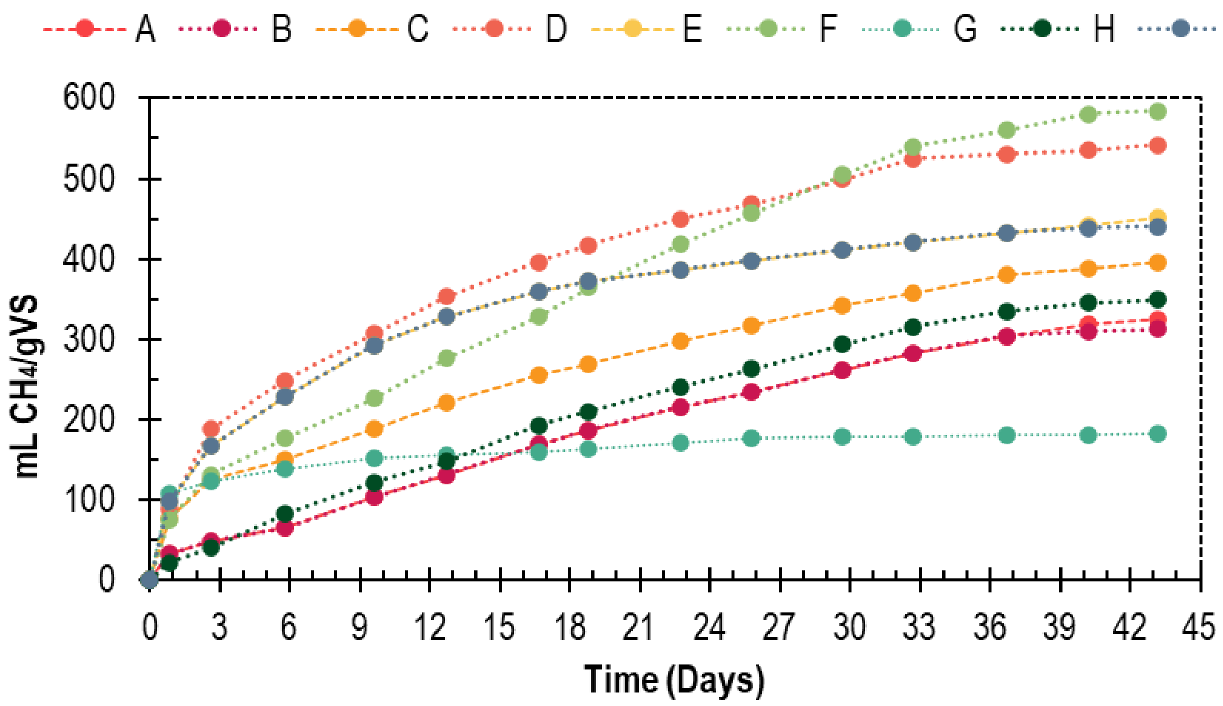


Figure 1. Acccumulated biogas production during codigestion

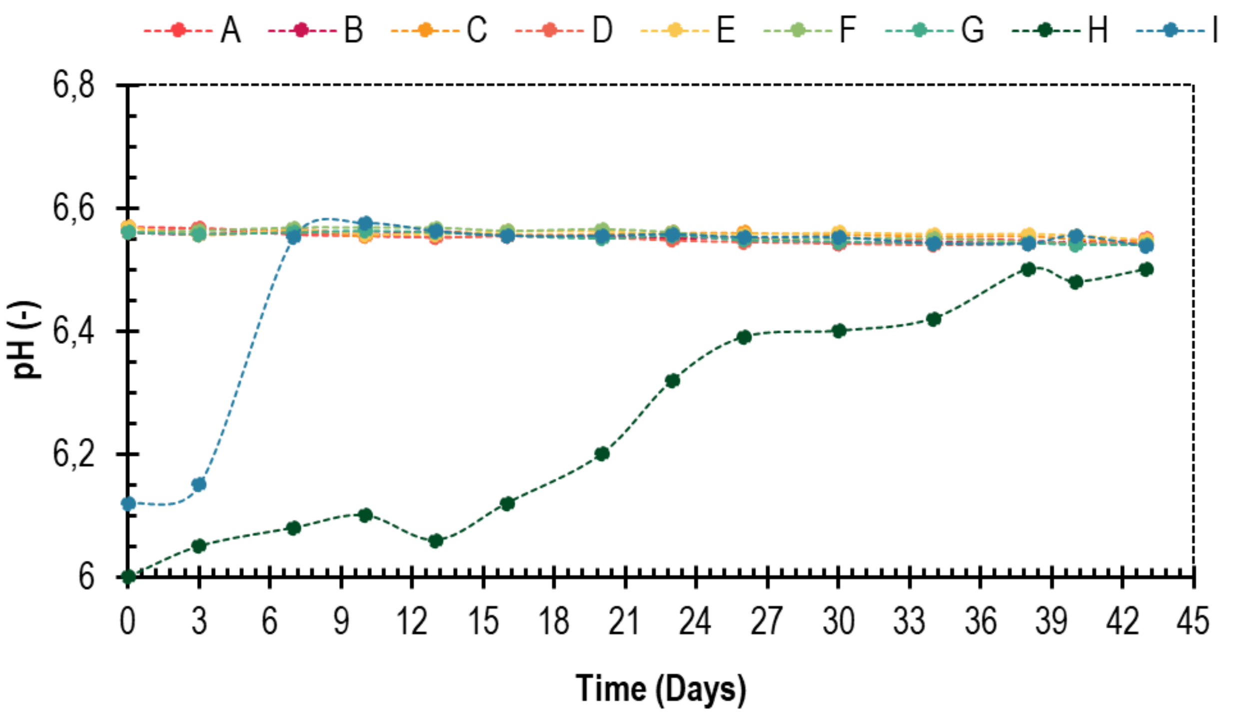
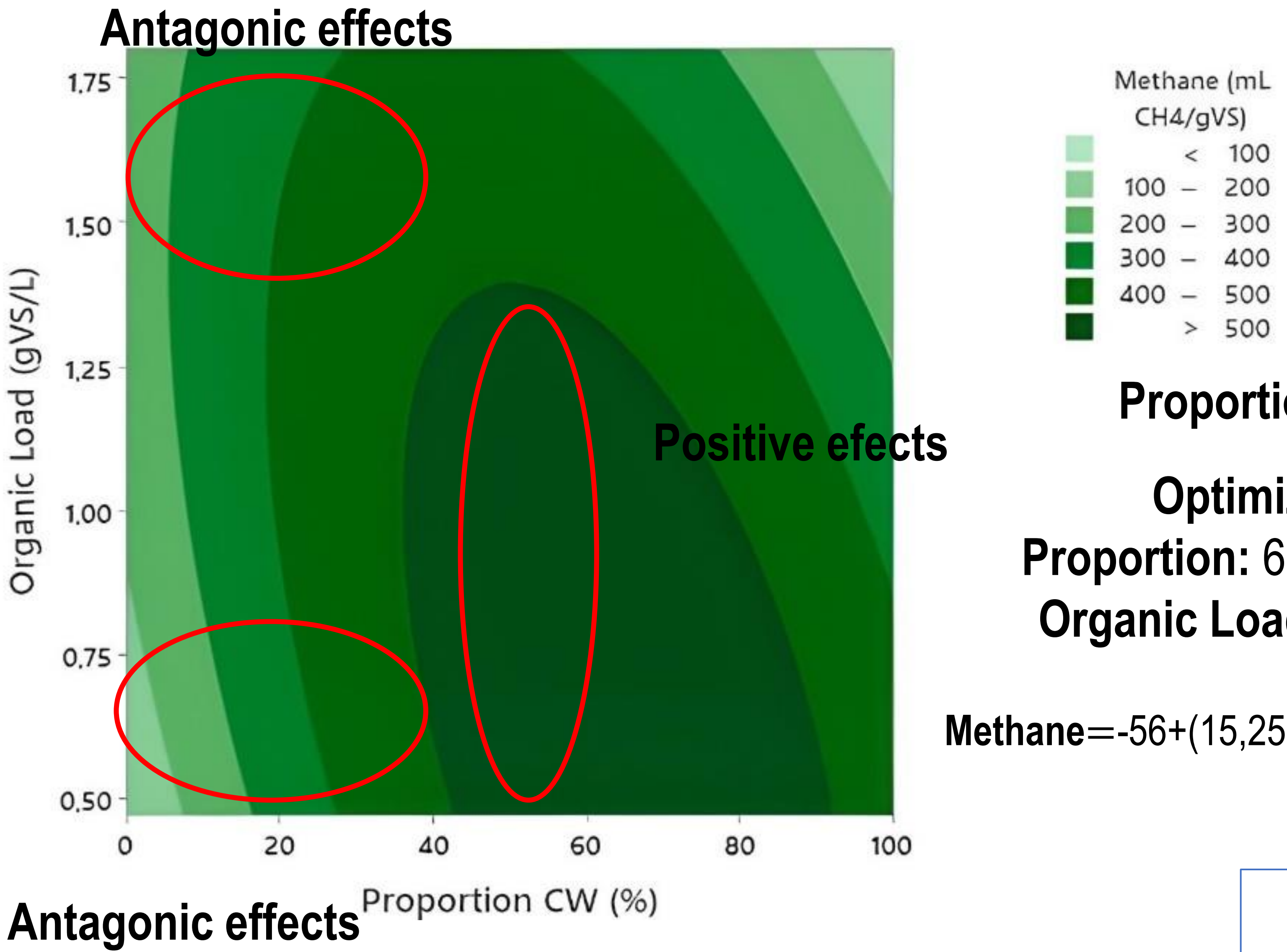


Figure 2. pH during the experiment

ID	Mix CW:CM (%)	OL (gVS/L)	mL CH_4/gVS	ID	Mix CW:CM (%)	OL (gVS/L)	mL CH_4/gVS
A	15:85	0.53	325	F	50:50	0.75	584
B	15:85	1.26	313	G	00:100	0.75	182
C	50:50	0.47	395	H	85:15	1.26	349
D	85:15	0.53	542	I	100:00	0.75	440
E	50:50	1.80	450				

Results



Antagonic effects

Proportion: 0 and 40% CW

Organic load: 1,4 and 1,75 gVS/L

Proportion *p*:0,002 **Organic Load** *p*:0,287

Optimization

Proportion: 65:35 CW: CM

Organic Load: 0,6 gVS/L

BMP: 562 mLCH4/gSV.

Methane=-56+(15,25*Proportion)+(406*OL)-(0,09*Proportion^2)-(OL^2)-(3,73*Proportion*OL)

70: 30 CW: CM

BMP: 420 mLCH4/gSV.

Source: Usman Khan and Kiaer Ahring, (2021); Jaimes-Estevés, (2022)

Conclusions

- The best mixing ratio is 65:35 (CW:DM) using a load of 0.6 gVS/L, under these conditions the process is more stable due to the contribution of alkalinity that the CM makes to the VFAs that may occur due to the high degradability that CW presents.

- Psychrophilic temperatures are adequate to develop digestion processes with low organic loads and high substrate inoculum ratios, since metabolic activity is slower, and this leads to no accumulation of intermediate products that affect the process.

- These results are also useful for making decisions regarding the availability of substrates, for example, if the objective is to treat larger quantities of substrate or to prioritise the production of biomethane.

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