Modelling VFA production kinetics from protein-rich industrial wastes

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Mixed-culture fermentations for the production of VFA

- VFA are interesting molecules
- Proteins found in agro-industrial wastes can be appropriate substrates
- Protein fermentation has not received much attention

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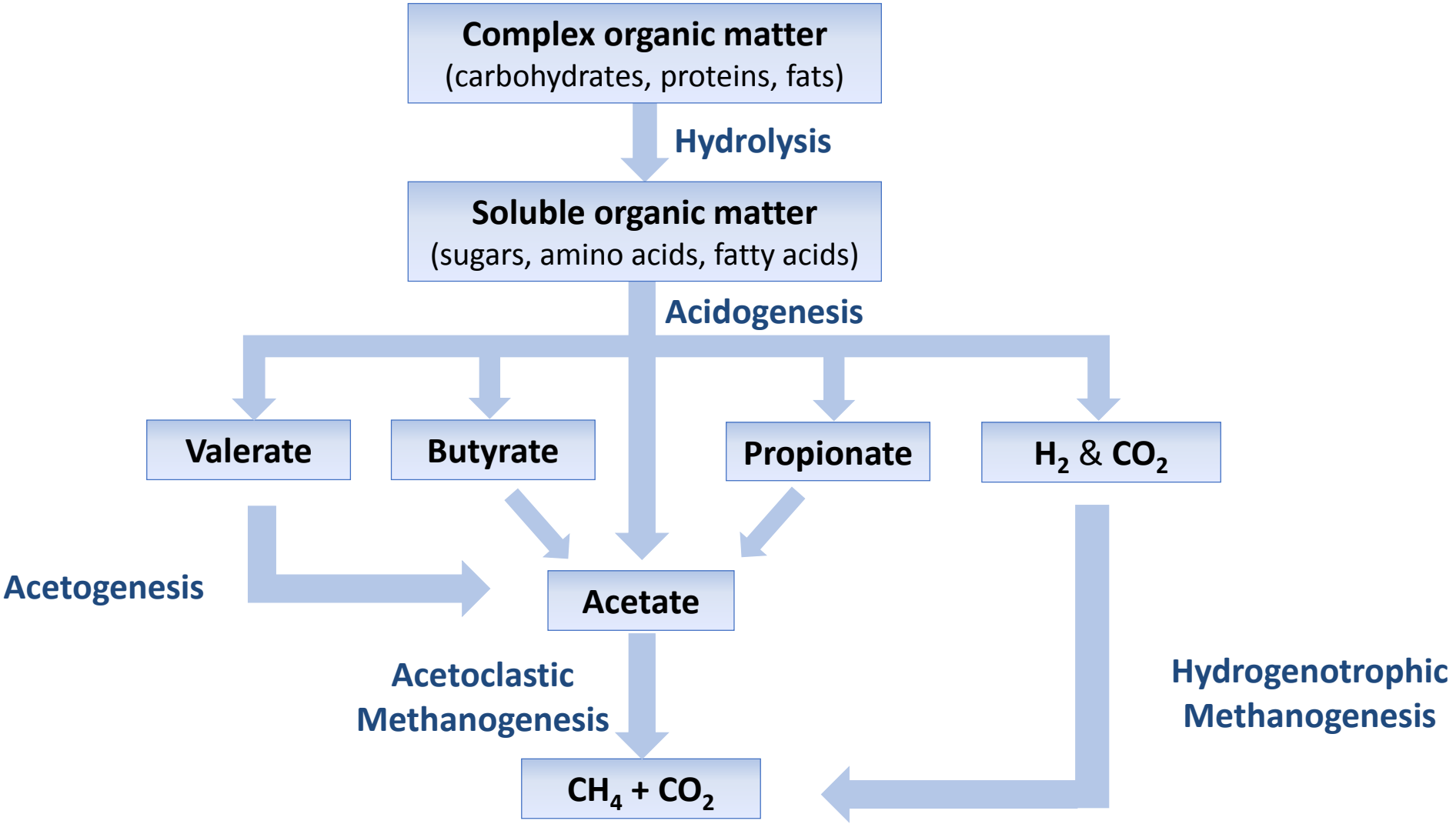
Modelling anaerobic fermentation



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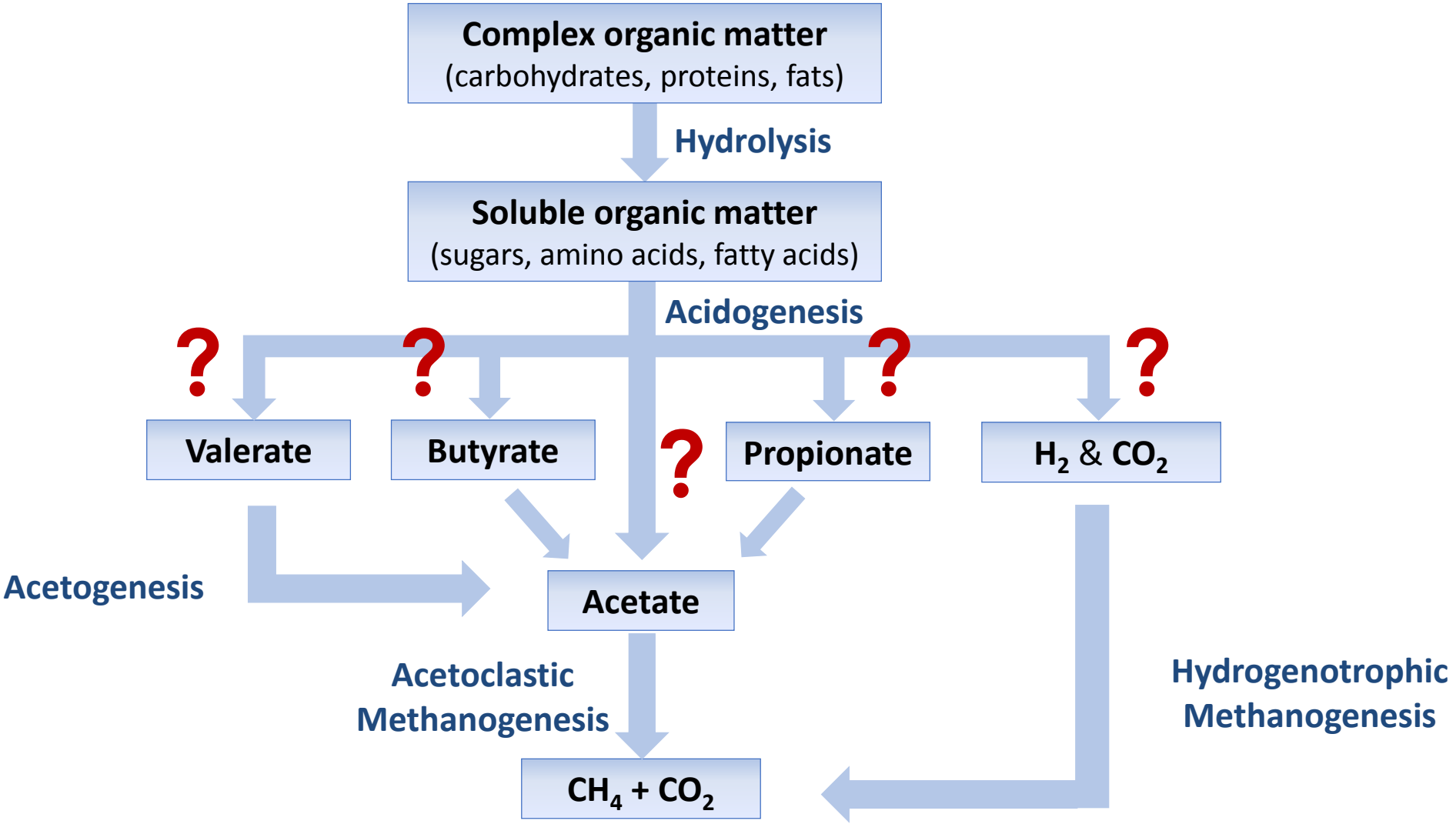

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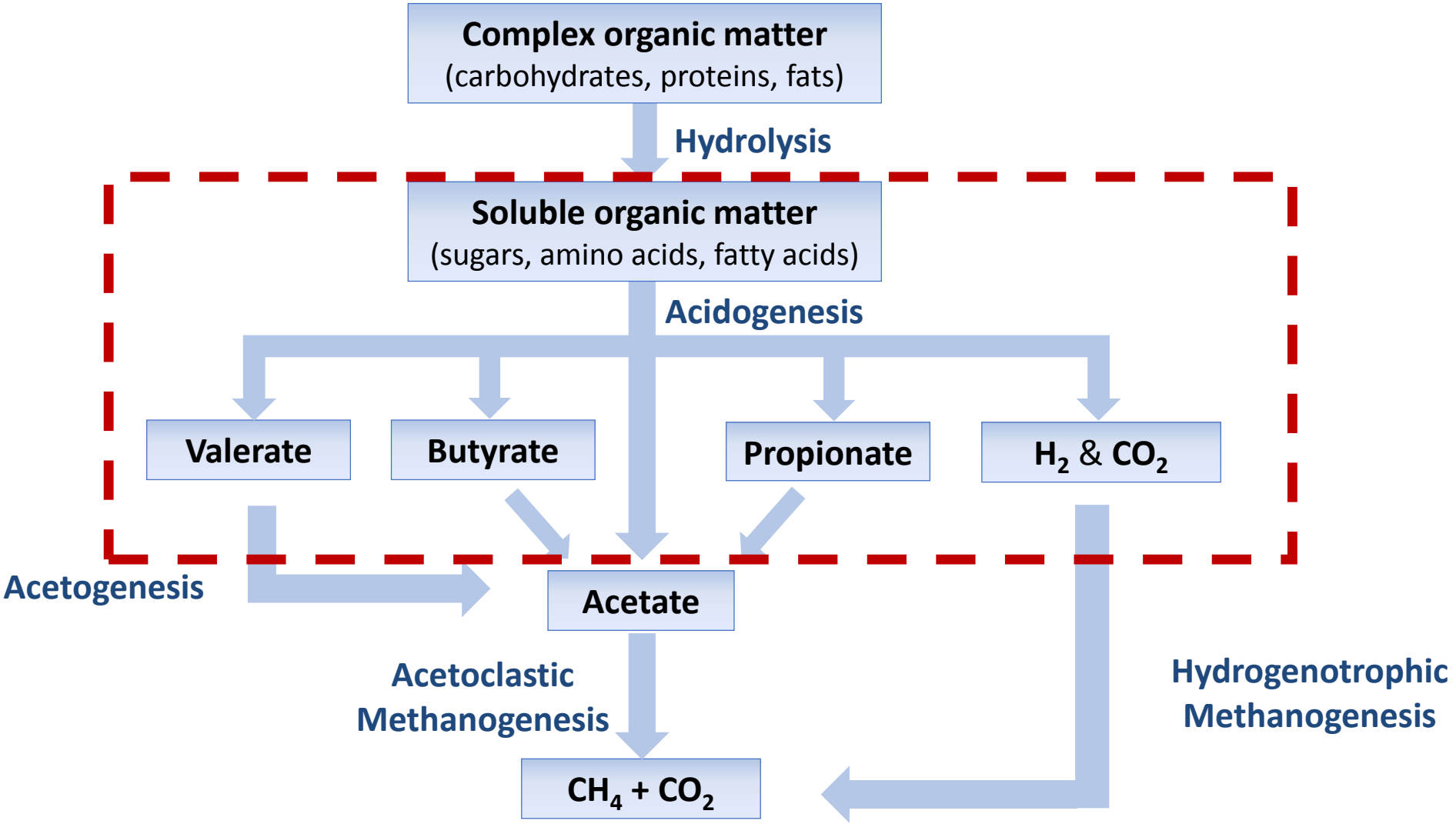

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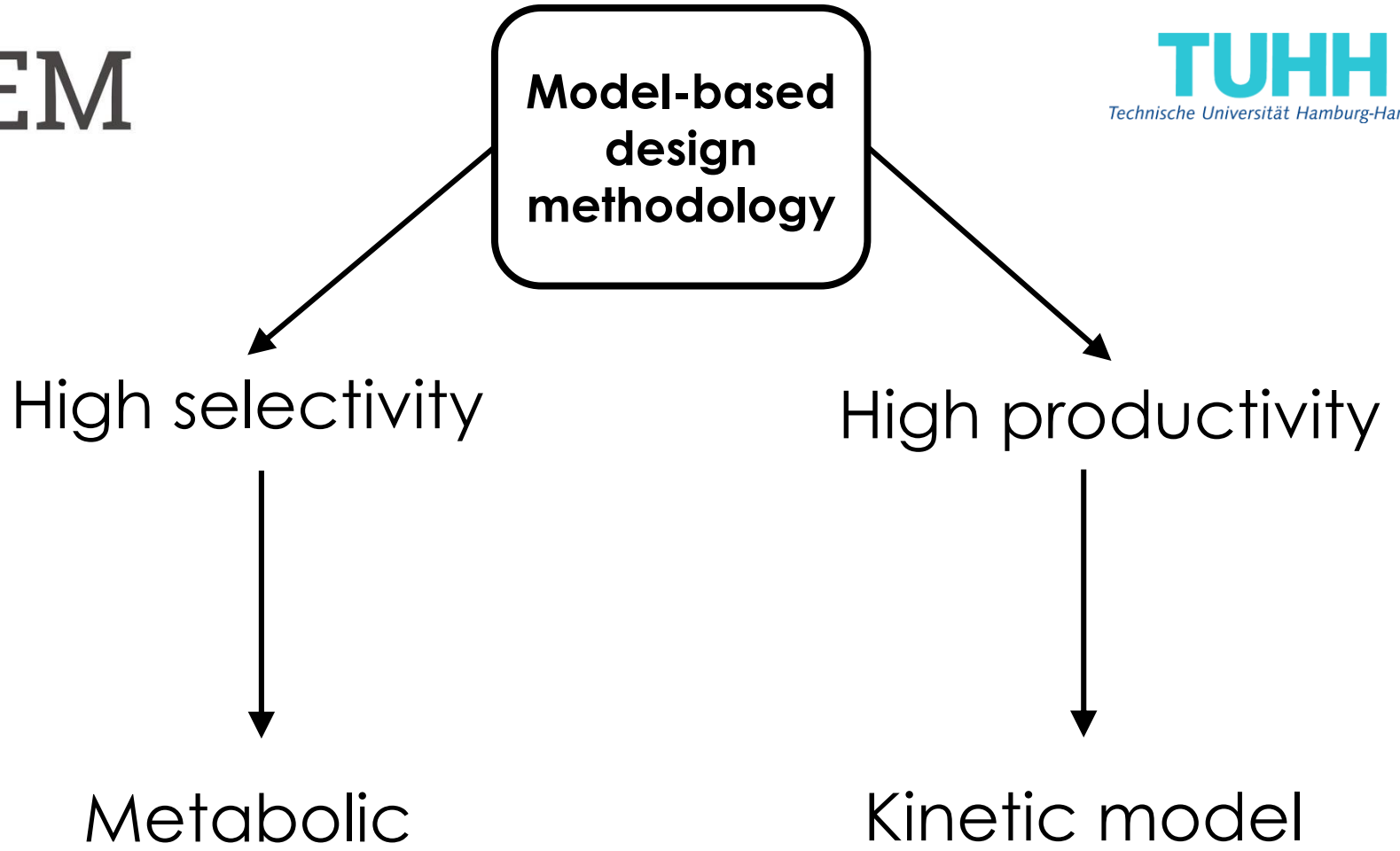
BIOCHEM proposes a design methodology for VFA production



BIOCHEM proposes a design methodology for VFA production

Kinetic parameters →

Hydrolysis	$r_{hyd} = k_{hyd} \cdot [Prot]$
Acidification	$r_{Acid} = k_{Acid} \cdot \frac{[AA]}{K_{S,AA} + [AA]} \cdot X_{AA}$
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VFA stoichiometry

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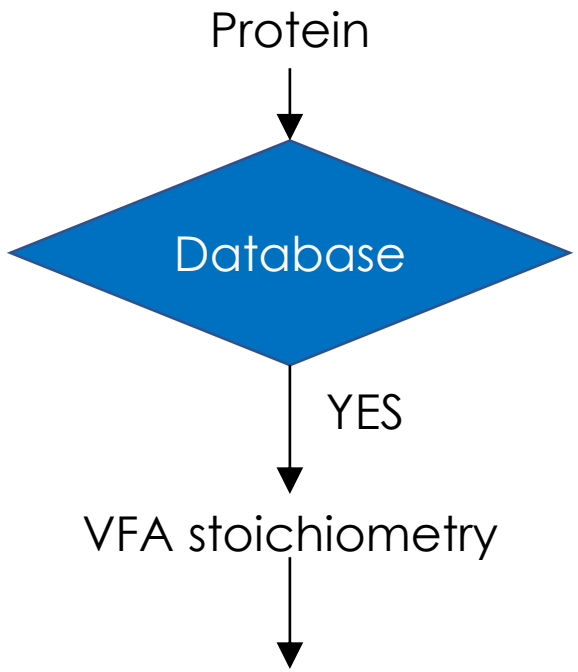

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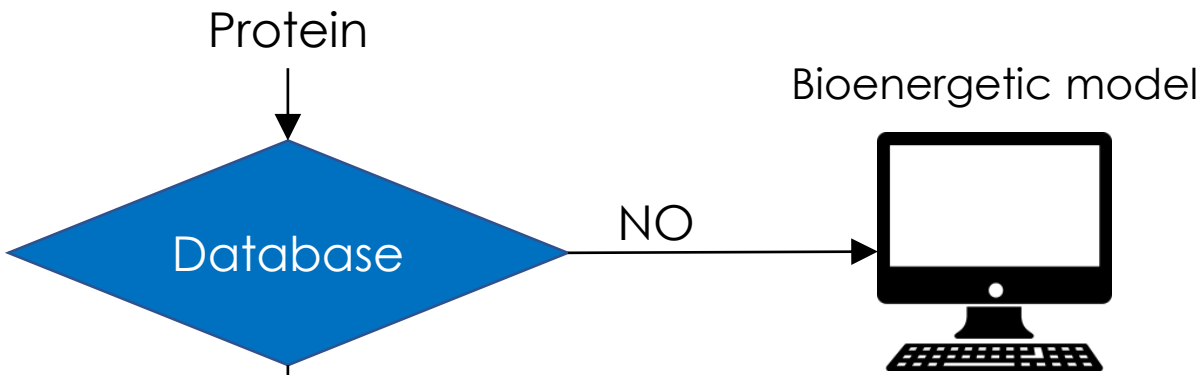

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→ Model results

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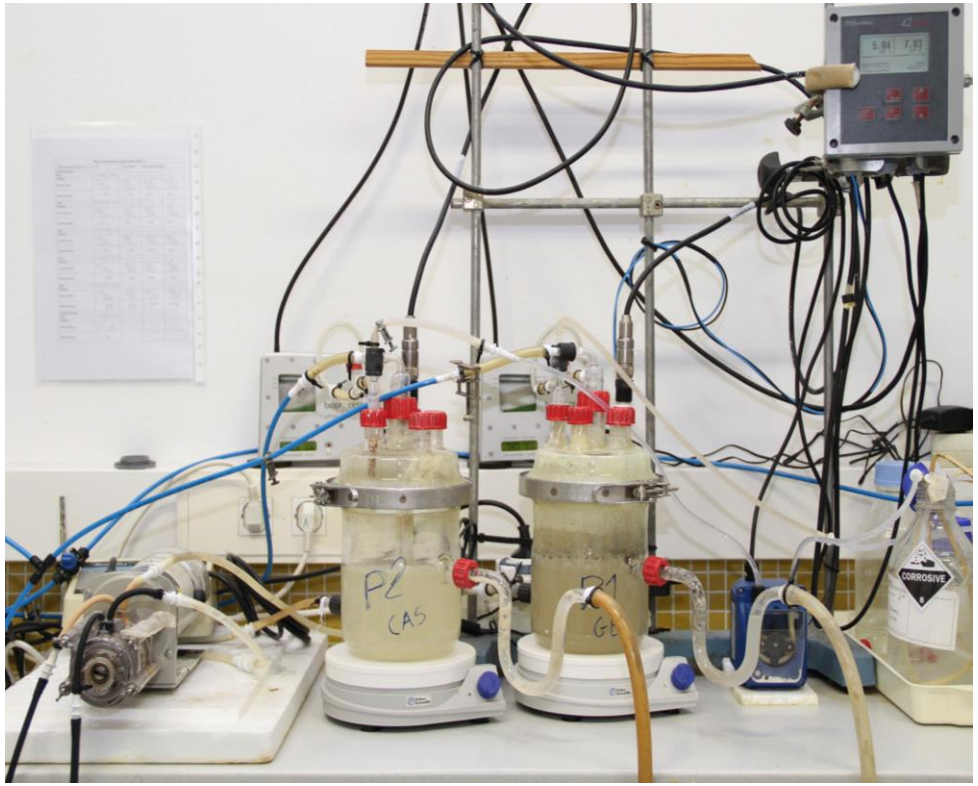
Experiments for parameter estimation

Batch test at different conditions:

- Two substrates: casein and gelatine
- pH: 5, 7 and 9
- Different substrate to inoculum ratio (SIR)
- Inoculum from CSTR reactors at steady state



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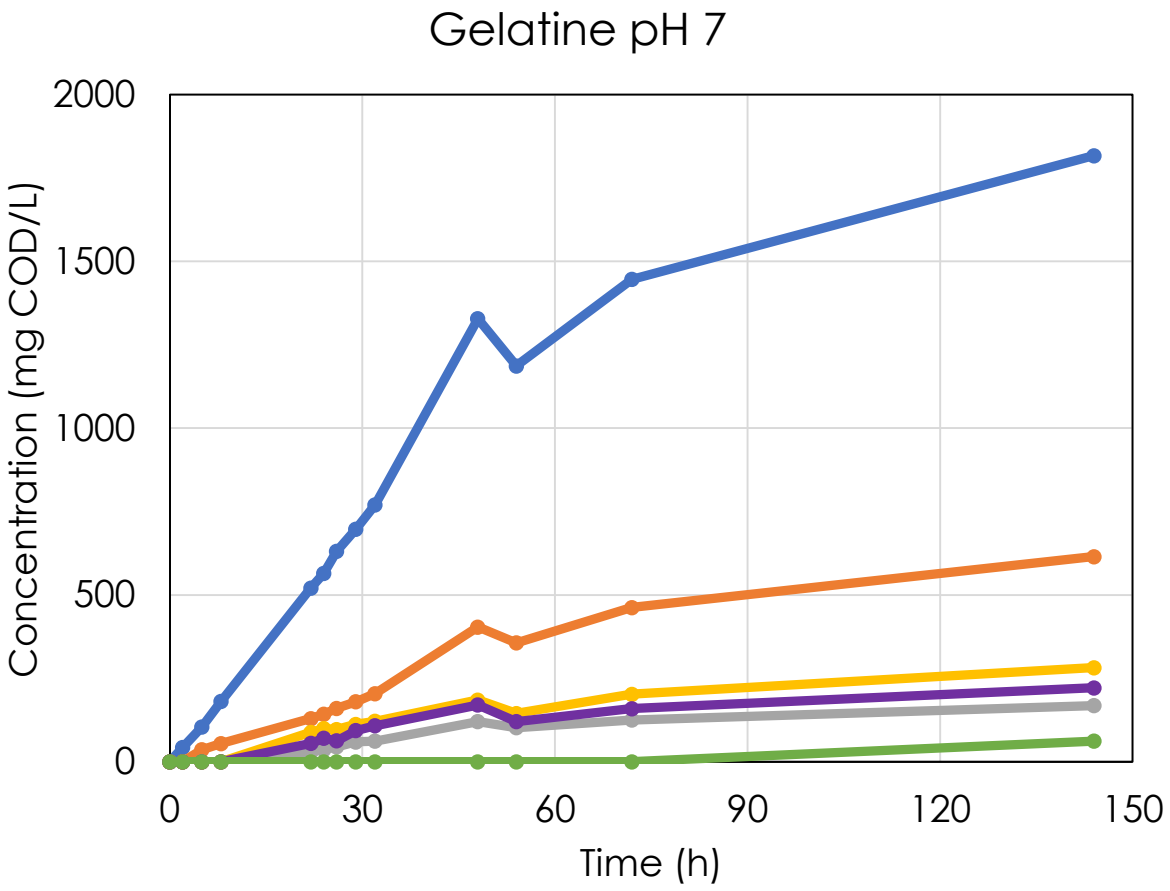
Experimental results have different selectivities

- Different protein at pH 7



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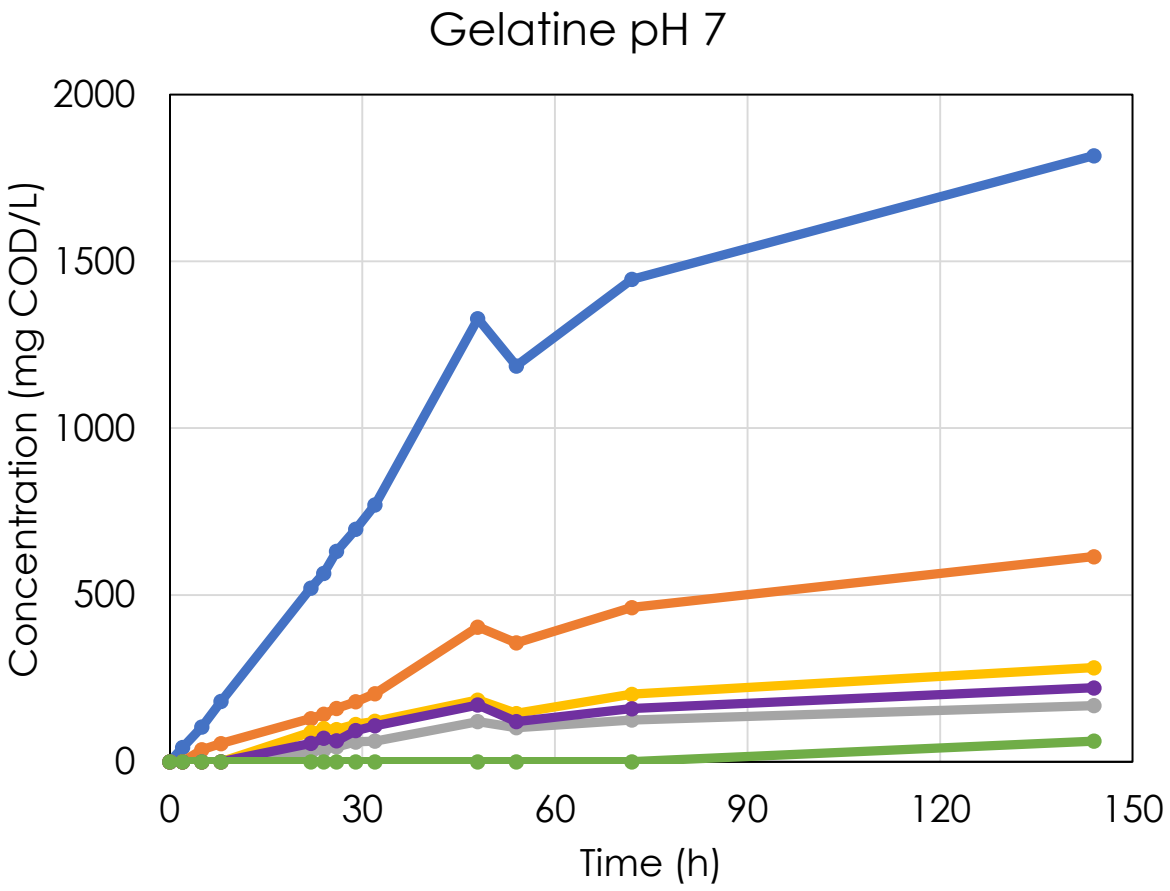

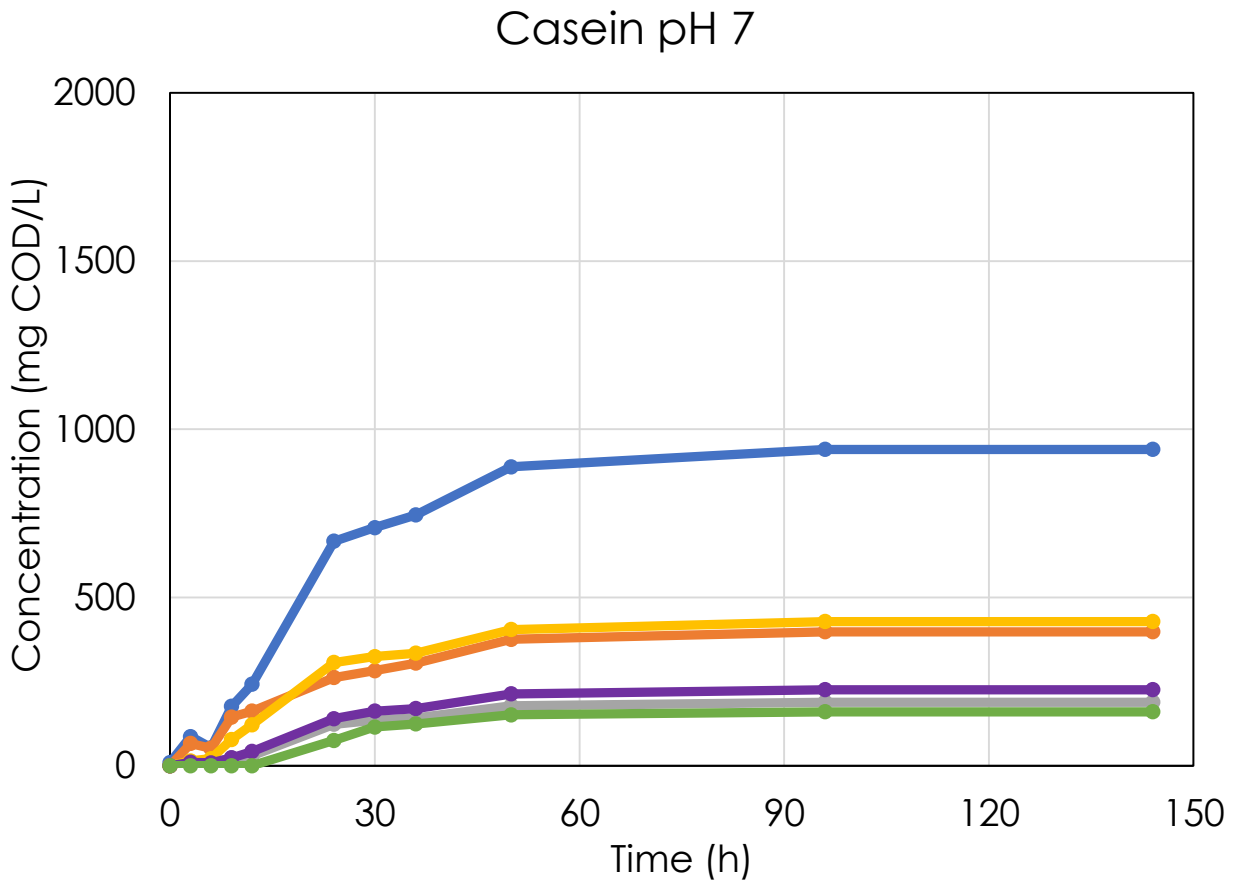

Acetate Propionate n-Butyrate i-Butyrate
n-valerate i-valerate

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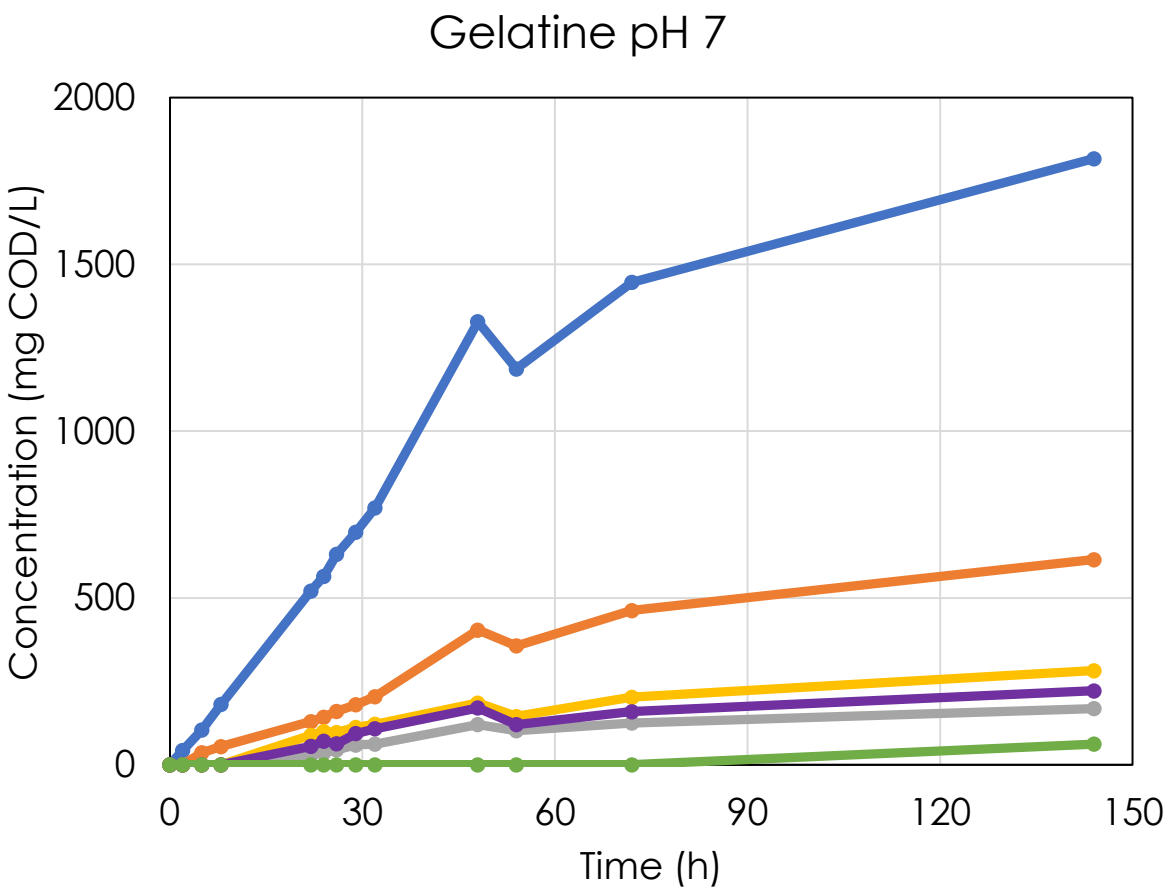
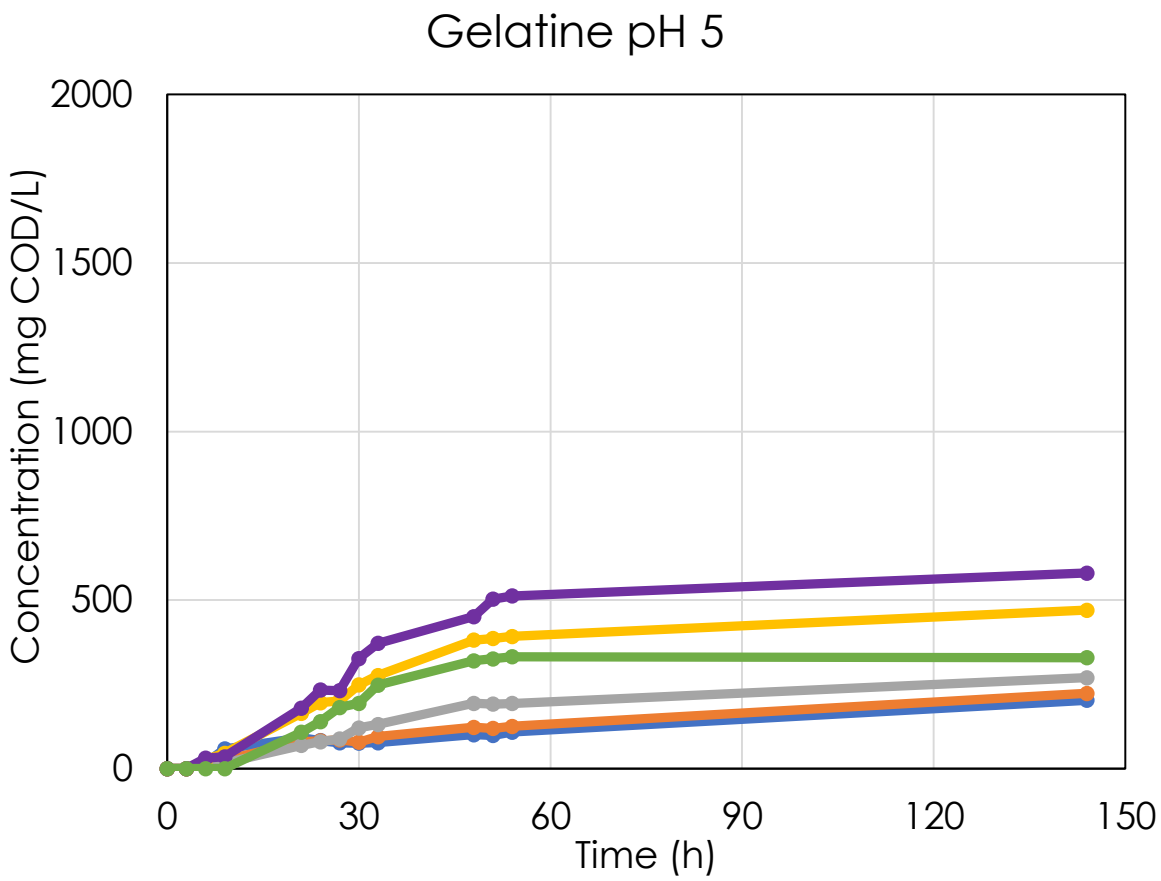
Experimental results have different selectivities

- Different pH in gelatine





Acetate Propionate n-Butyrate i-Butyrate
n-valerate i-valerate

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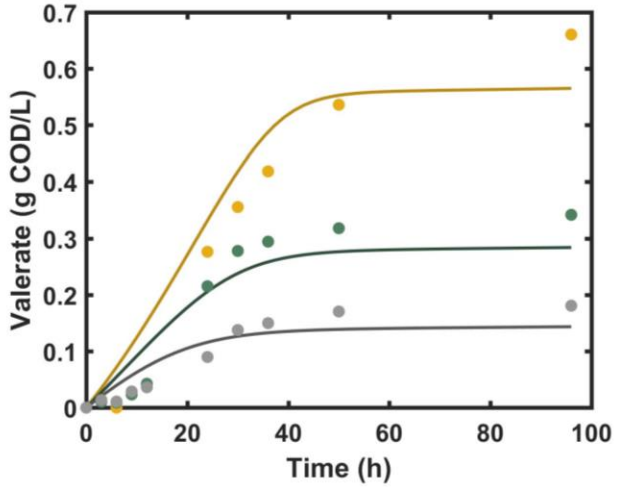
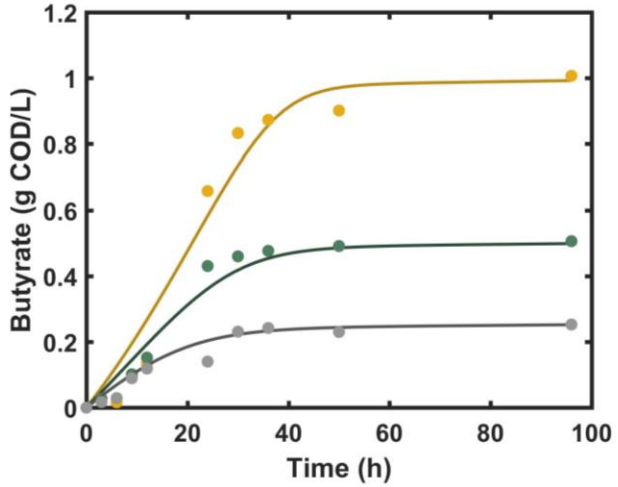
The fit between the model and the experiments is good

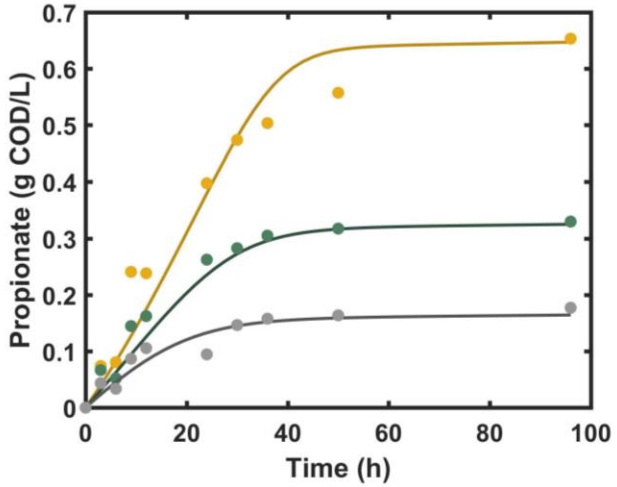
Casein
pH 7
SIR: 5-20

$$\hat{\theta} = \arg\min\left(\sum_k\left(\sum_j\left(\sum_i\left(\frac{y_{j,i}(\theta) - y_{j,i,exp}}{\sigma_{j,i}}\right)^2\right)\right)\right)$$

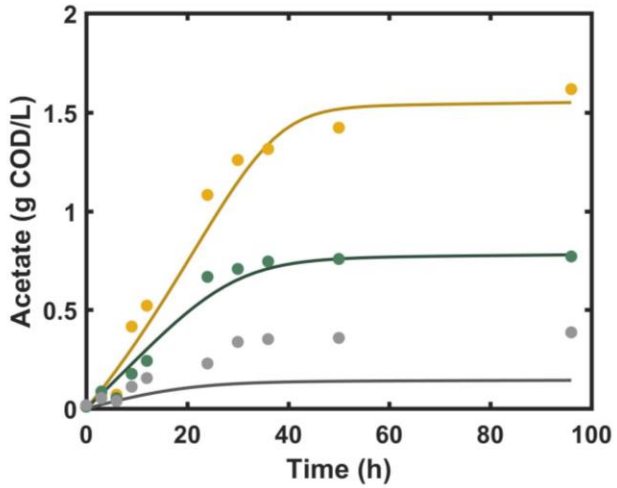
i: compound
j: time
k: Substrate to inoculum ratio

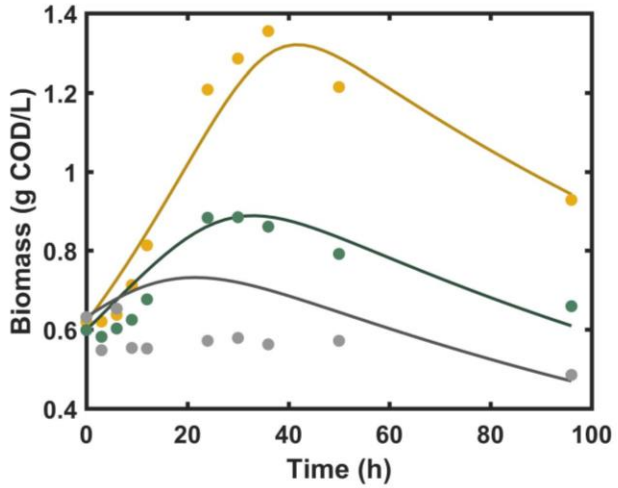


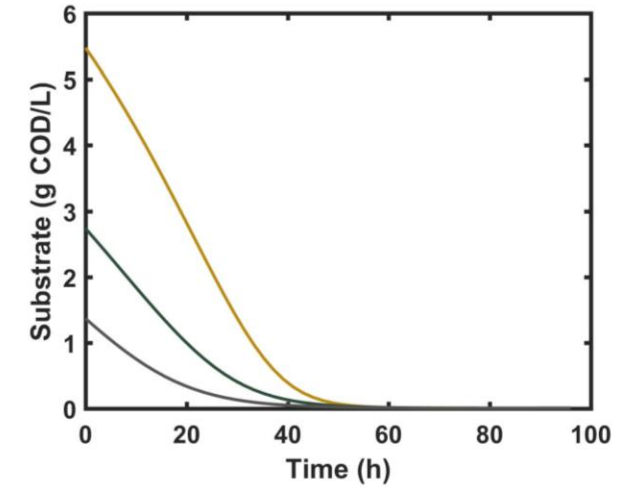




RMSE 7.7 %







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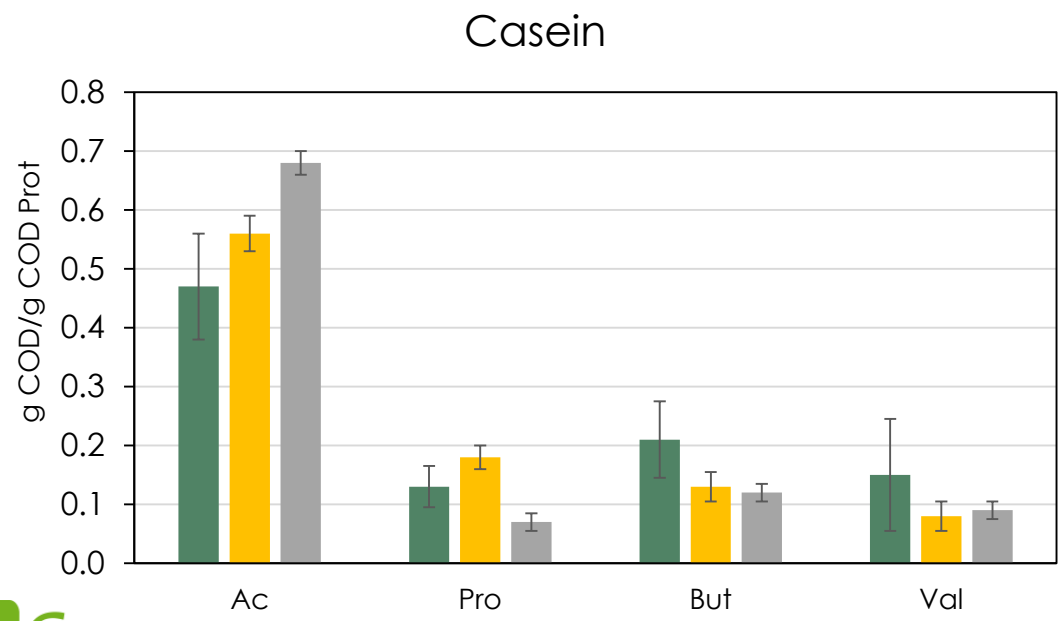
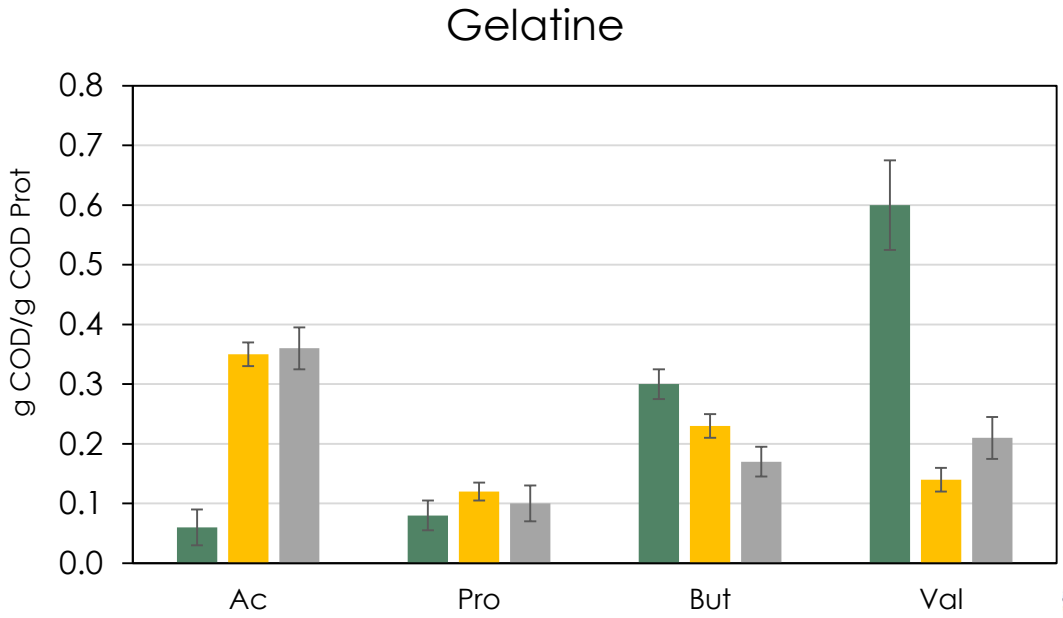
Parameters for protein fermenters

		pH 5	pH 7	pH 9
μ_{max} (d^{-1})	Gelatine	0.54	0.57	0.60
	Casein	0.58	1.44	0.76
Y_{AA} (g_{COD} BM/g_{COD} Prot)	Gelatine	0.22	0.22	0.21
	Casein	0.18	0.18	0.17

Selectivities





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- Compared to glucose:

Values for glucose	pH 7
μ_{max} (d^{-1})	5.28
Y_{Glu} (g_{COD} BM/g_{COD} Prot)	0.22

Source: Rombouts *et al.* (2018) FEMS

Case studies

Cheese whey (CW)	
Sugars (g/L)	4
Casein (g/L)	1

Tuna canning wastewater (TCWW)	
Sugars (g/L)	2.5
Gelatine (g/L)	20

1. Batch conversions with inhibited methanogenesis

2. Optimise VFA productivity: SBR

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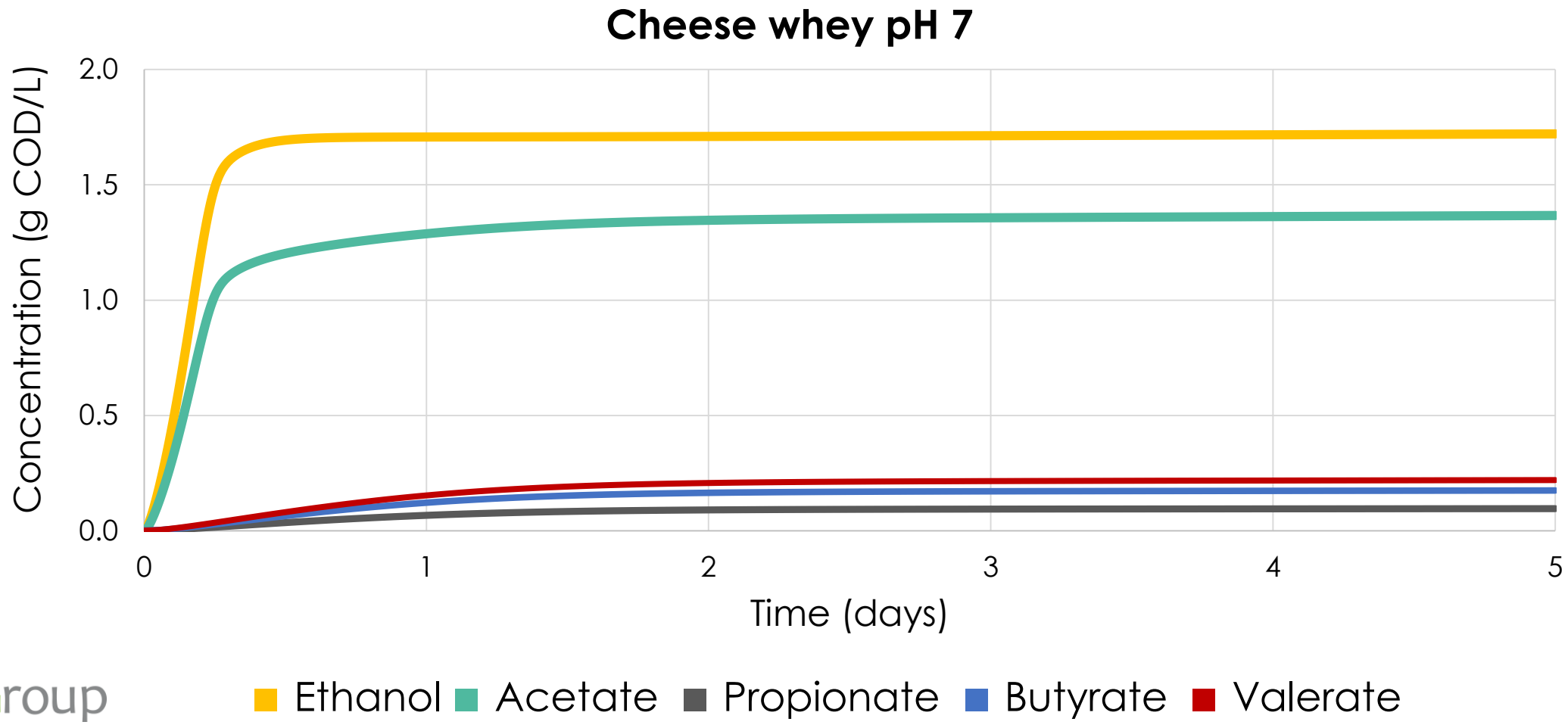
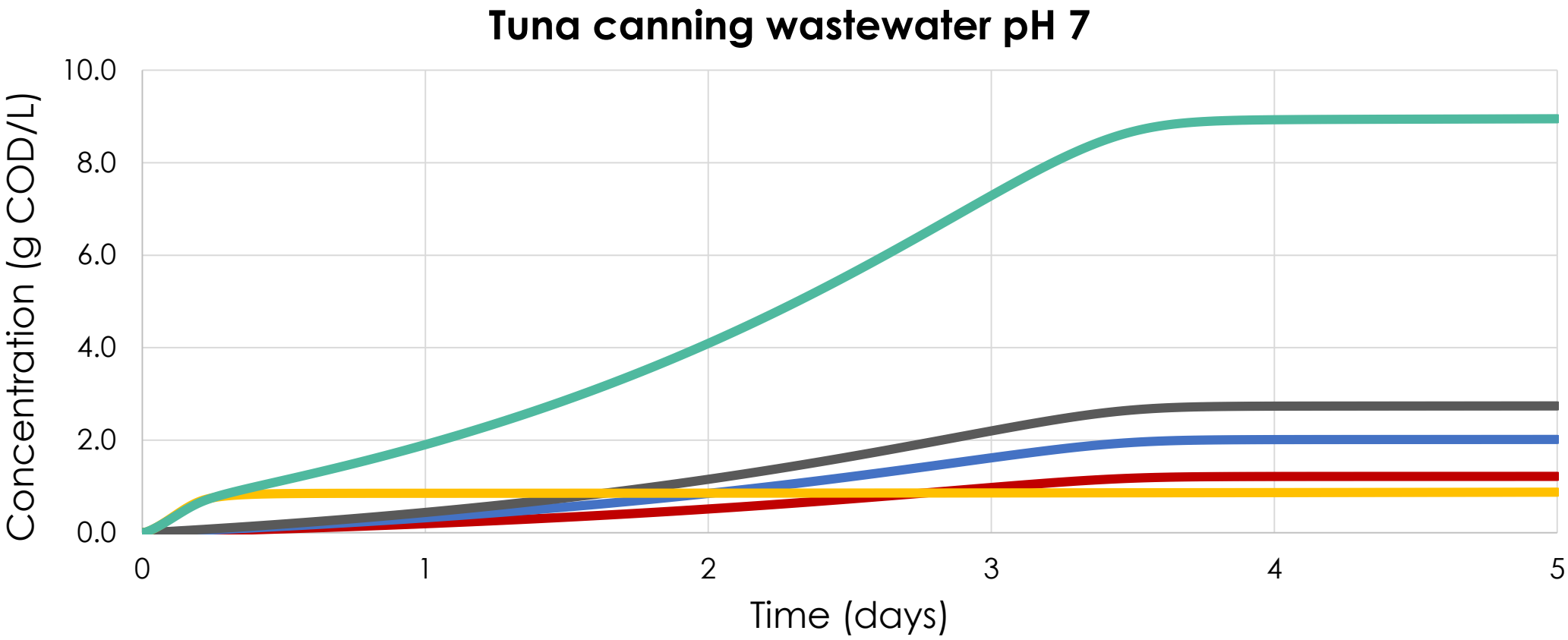
Cheese whey conversion is fast

- Different VFA have different production rates depending on the substrate
- Methanogenesis is assumed to be chemically inhibited



Tuna canning WW needs a longer run

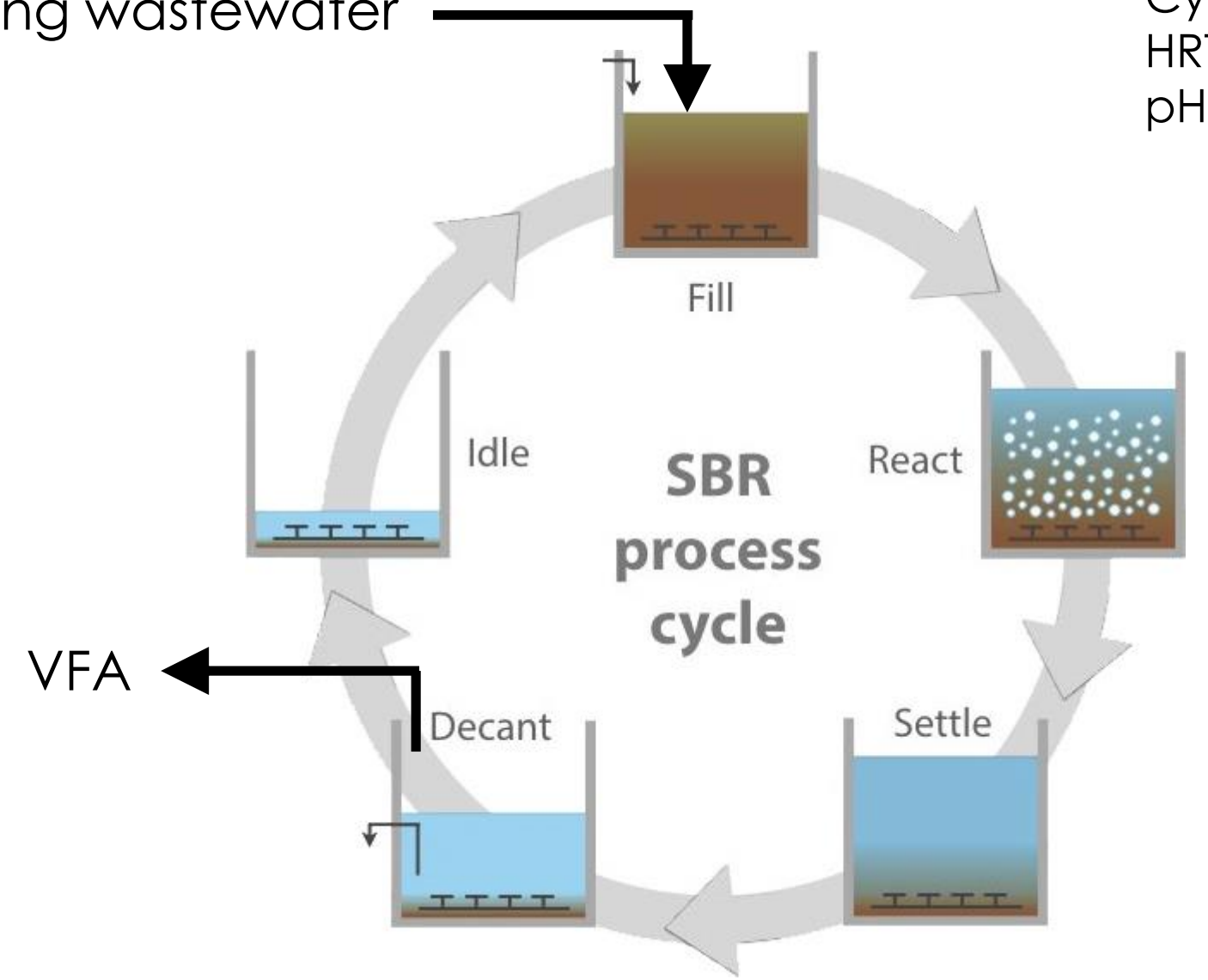
- Different VFA have different production rates depending on the substrate
- Methanogenesis is assumed to be chemically inhibited



Selecting the SRT value in an SBR is a key issue

Tuna canning wastewater

Cycle length: 0.5 days
HRT: 1 day
pH 7



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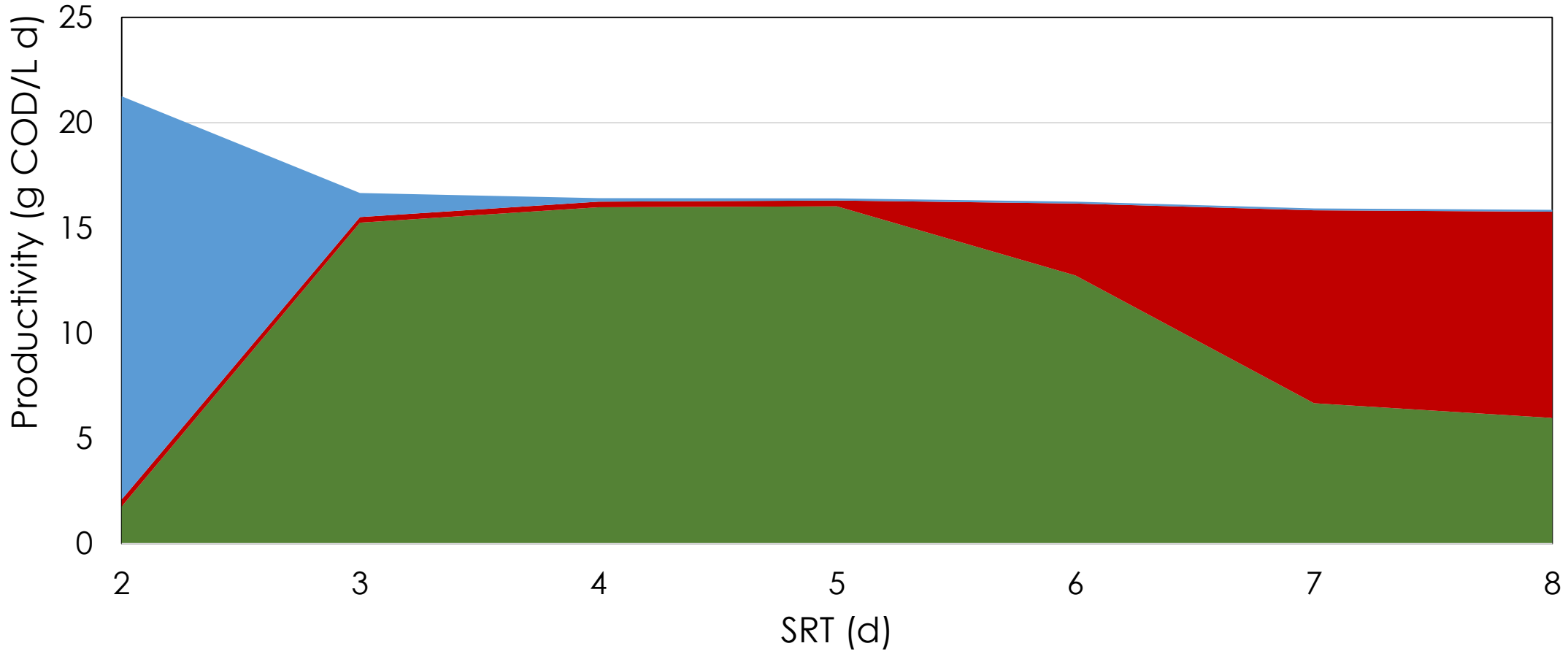
We can find the optimum value with the model

Cycle length: 0.5 days HRT: 1 day pH 7



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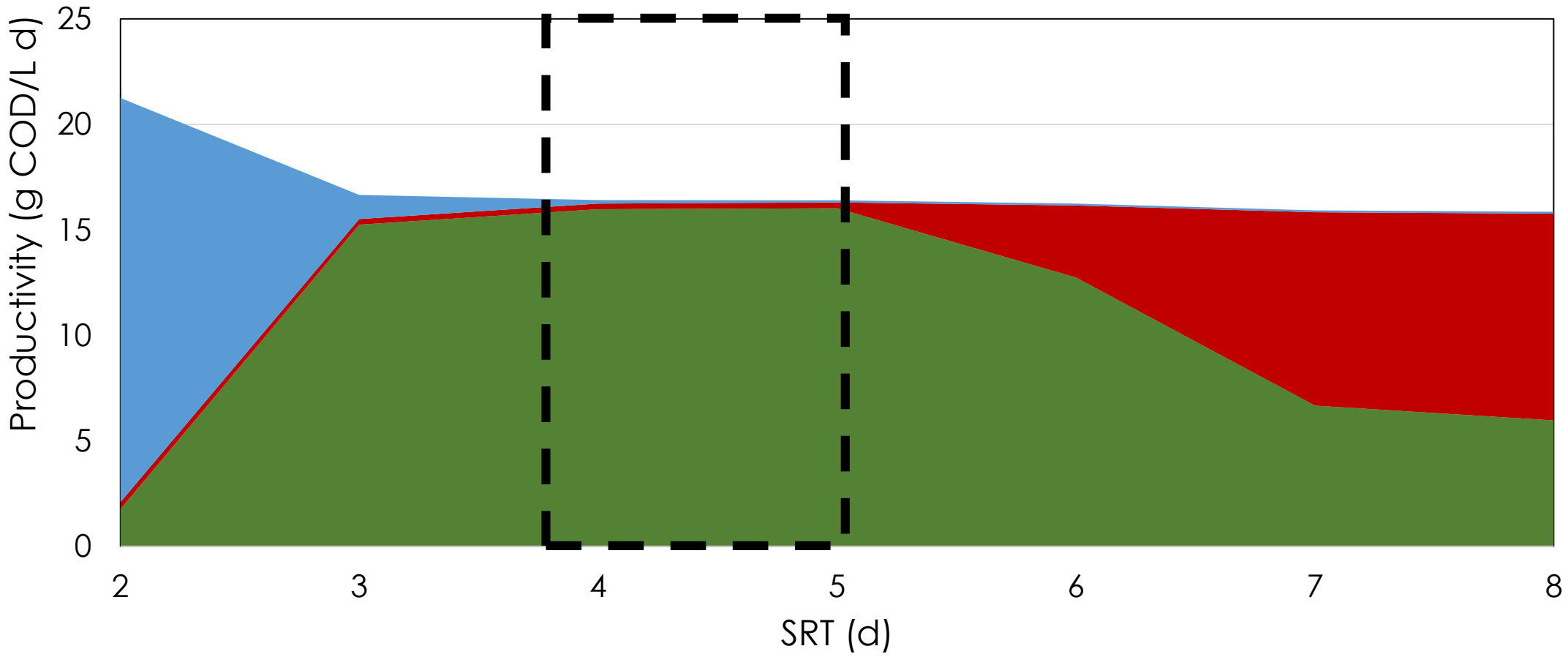

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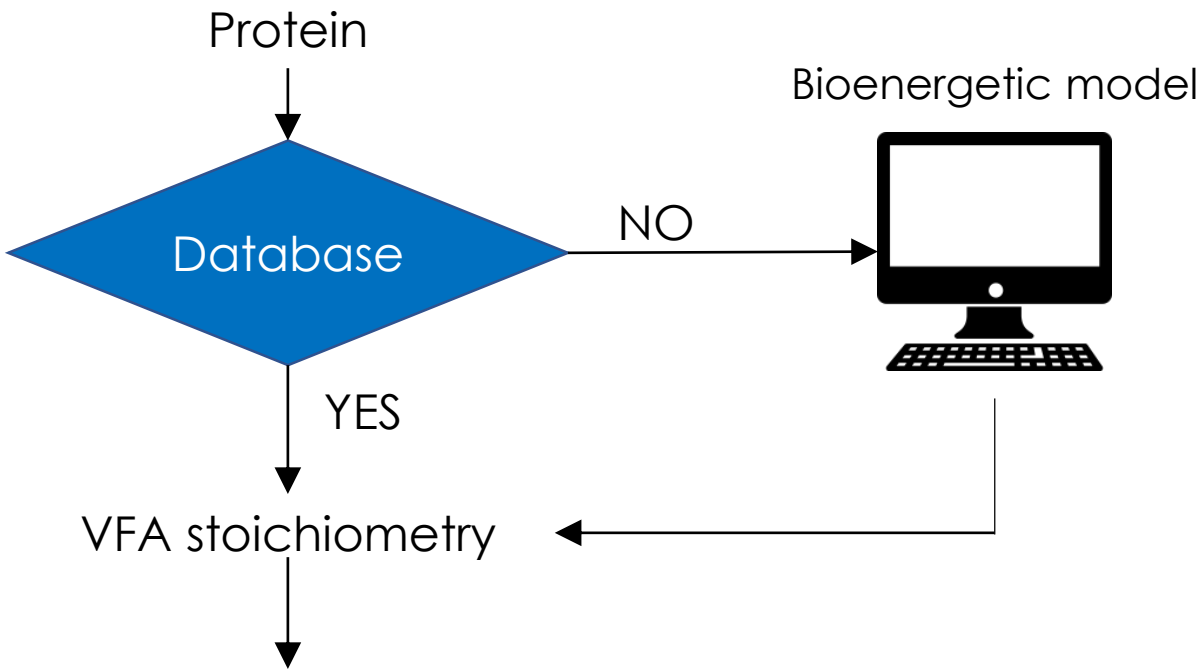
Conclusions



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→ Design parameters
Simulation tool

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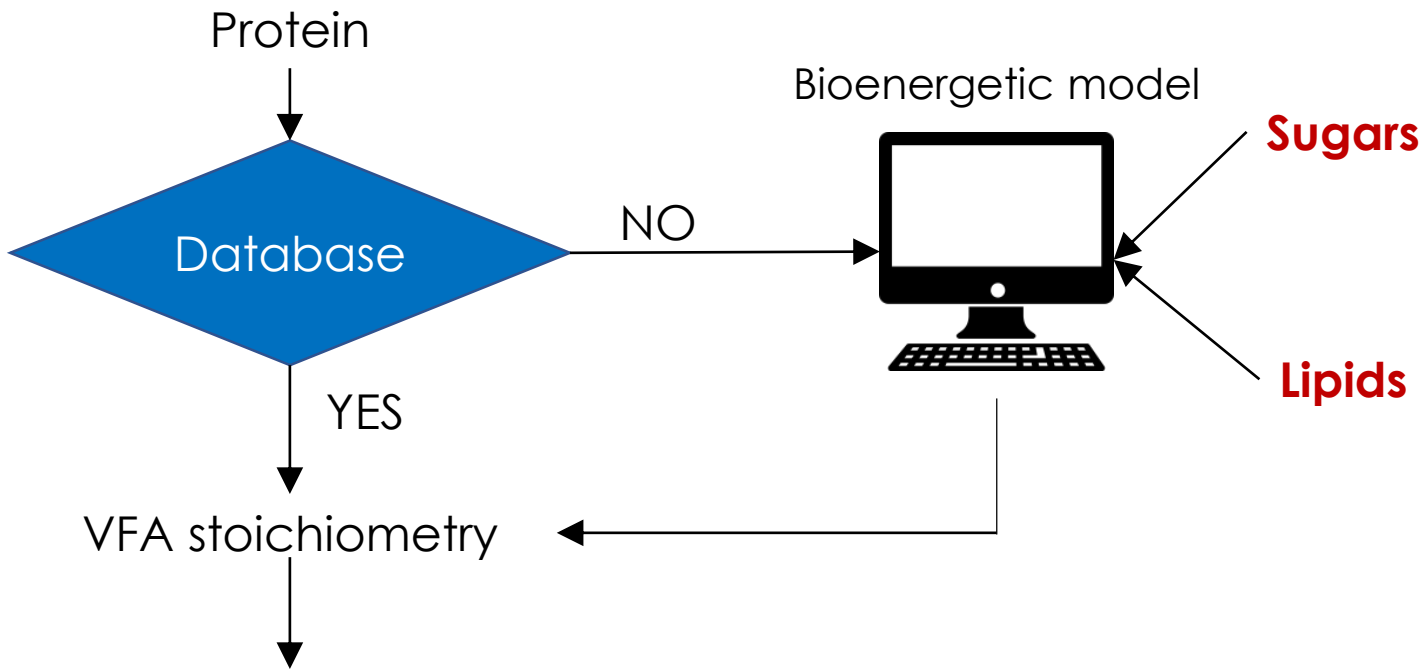

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Acknowledgements

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4th International Conference on Biogas Microbiology

Save the date

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