Dynamic sensitivity analysis of a mathematical model describing the effect of the macroalgae *Asparagopsis taxiformis* on methane production under *in vitro* continuous conditions

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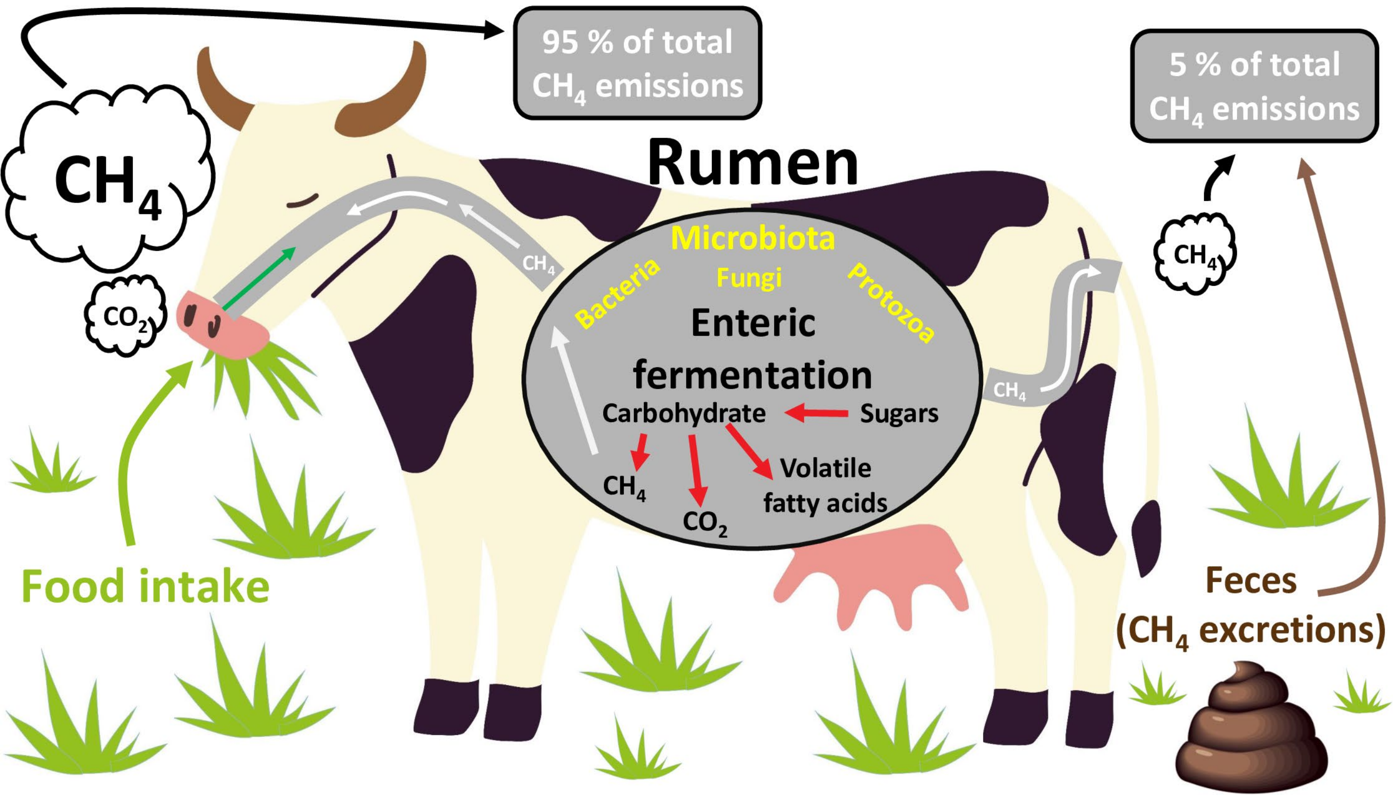
Context

Enteric CH_4 emissions produced from the **rumen fermentation** contribute the most to the greenhouse gases (GHG) emitted from ruminants

→ 66% of total GHG emissions from agricultural sector in 2019 (CITEPA, 2021)



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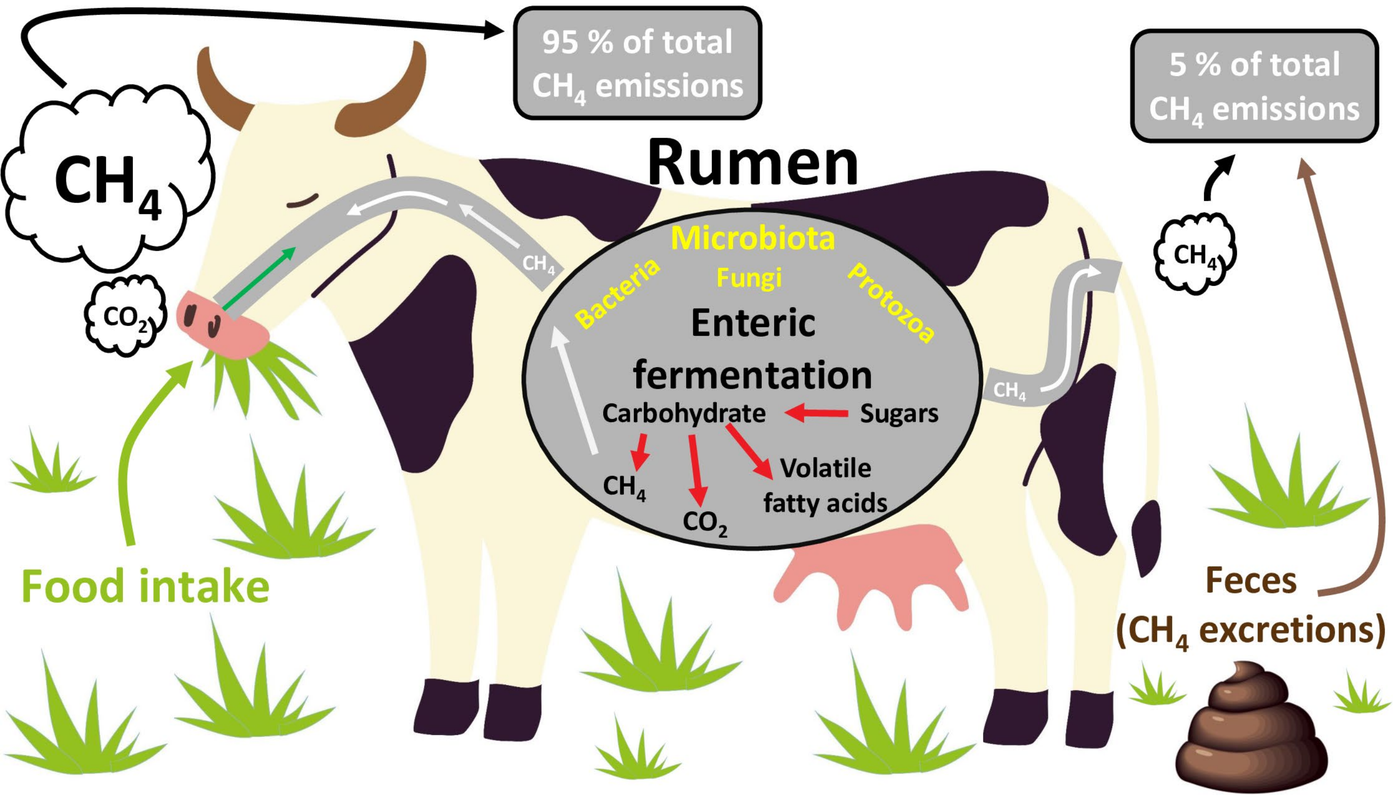

Mechanistic models are used to:

- estimate CH_4 emissions from ruminants
- better understand the complex mechanism of the rumen fermentation
- Assess the effect of dietary mitigation strategies

Aim of the study

SA is commonly implemented on mechanistic models of the rumen fermentation to:

1. Identify the key factors driving CH_4 production

2. Reduce the uncertainty of output variables

3. Reduce model complexity

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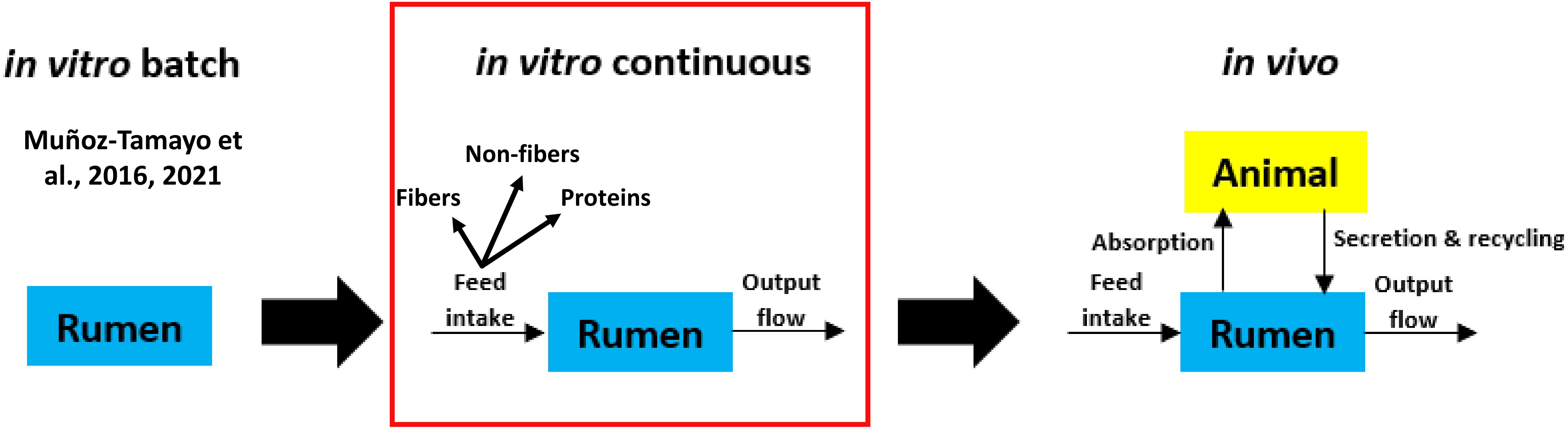
Gaps → **Capturing the dynamic characteristic of the rumen fermentation**

Aim: to conduct a **dynamic SA** of a mechanistic model under ***in vitro* continuous** conditions accounting for the effect of ***Asparagopsis taxiformis* (AT)** on CH_4 production (Muñoz-Tamayo et al. (2016, 2021))

Assumption → **Integrate the dynamic aspect can allow to better understand rumen function and provide relevant information for *in vitro* experimentation**

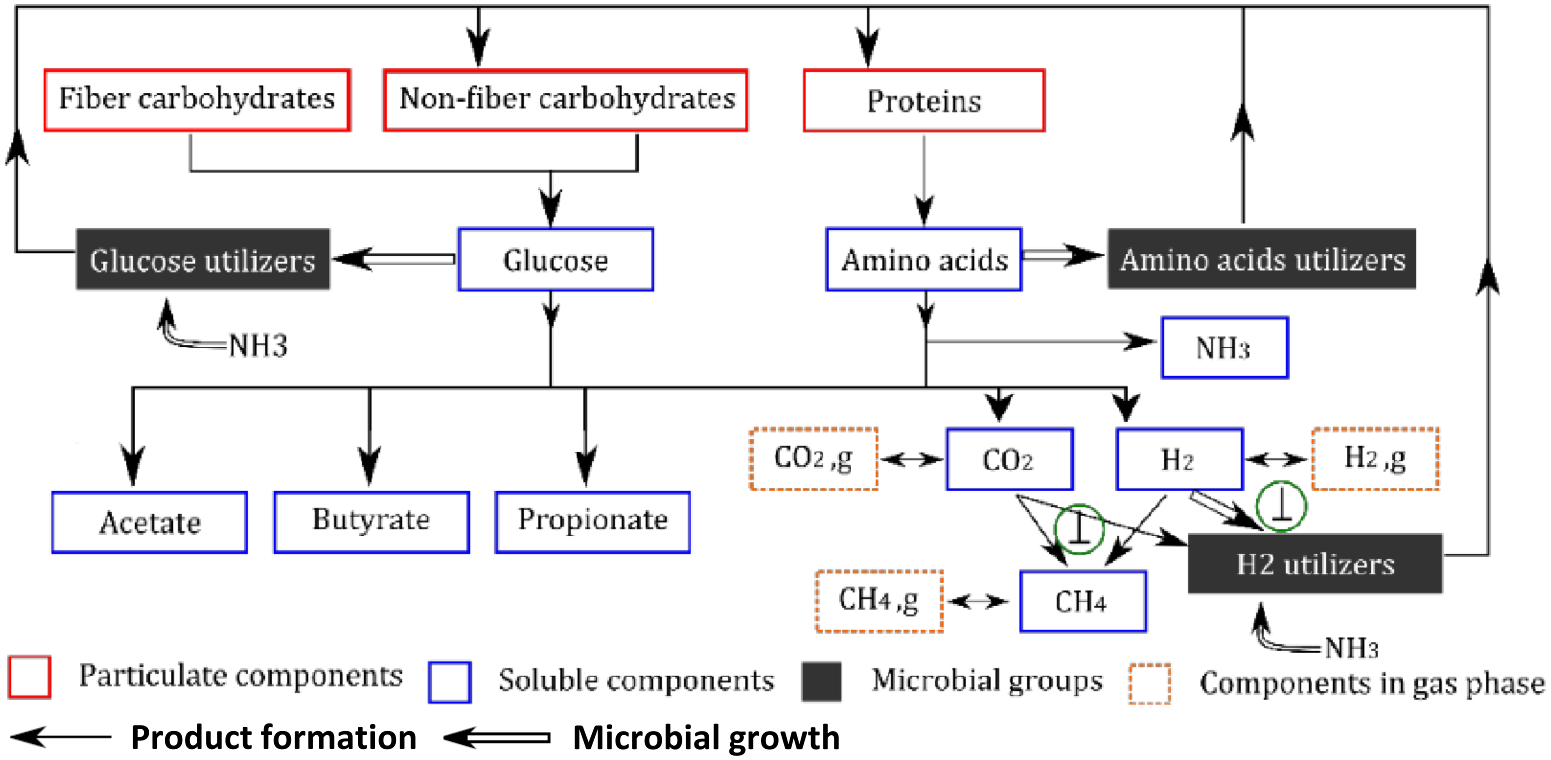
Representation of the *in vitro* continuous system



Representation of the rumen fermentation

18 output variables and 32 input parameters

Muñoz-Tamayo et al., 2016



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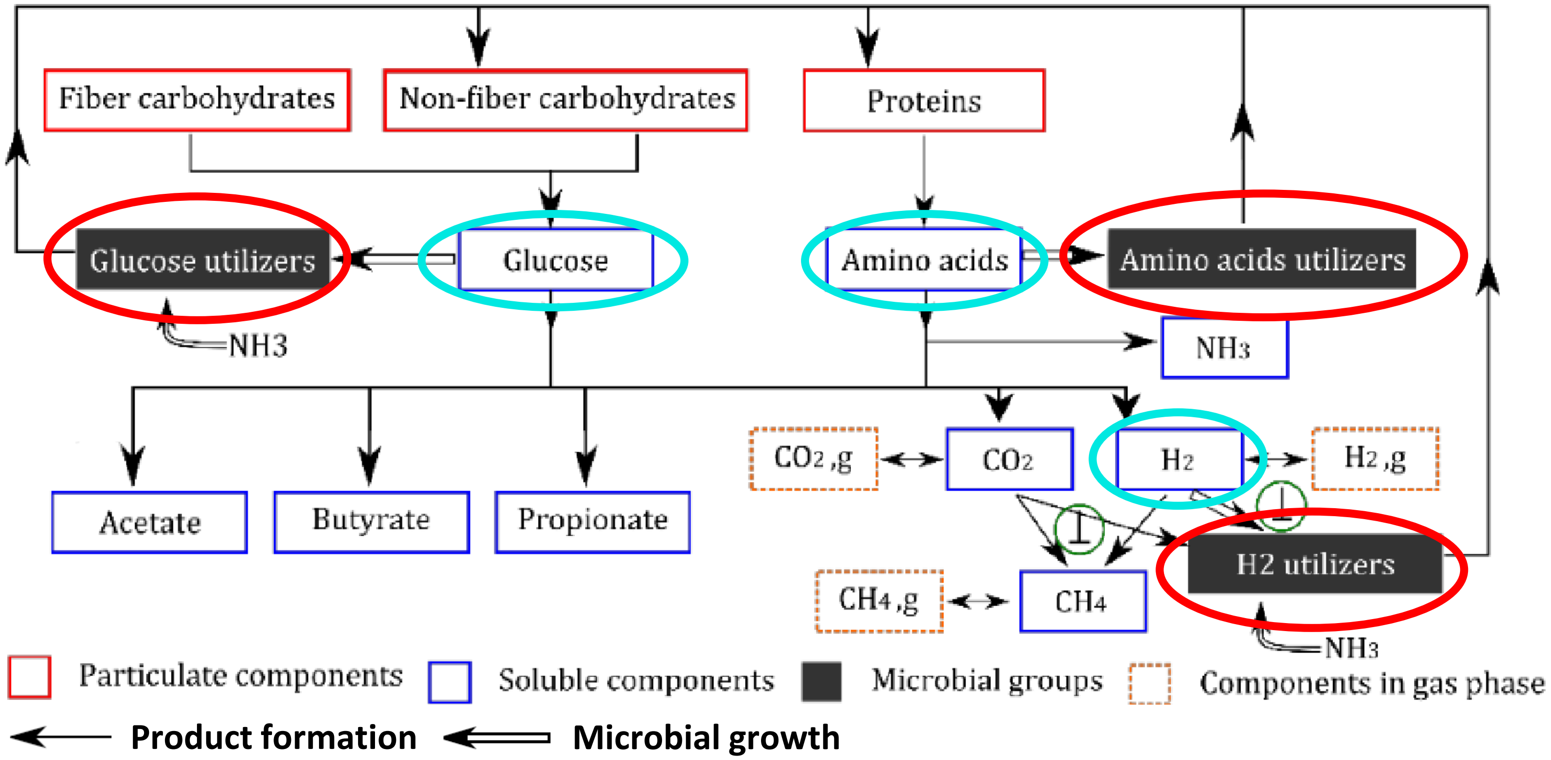

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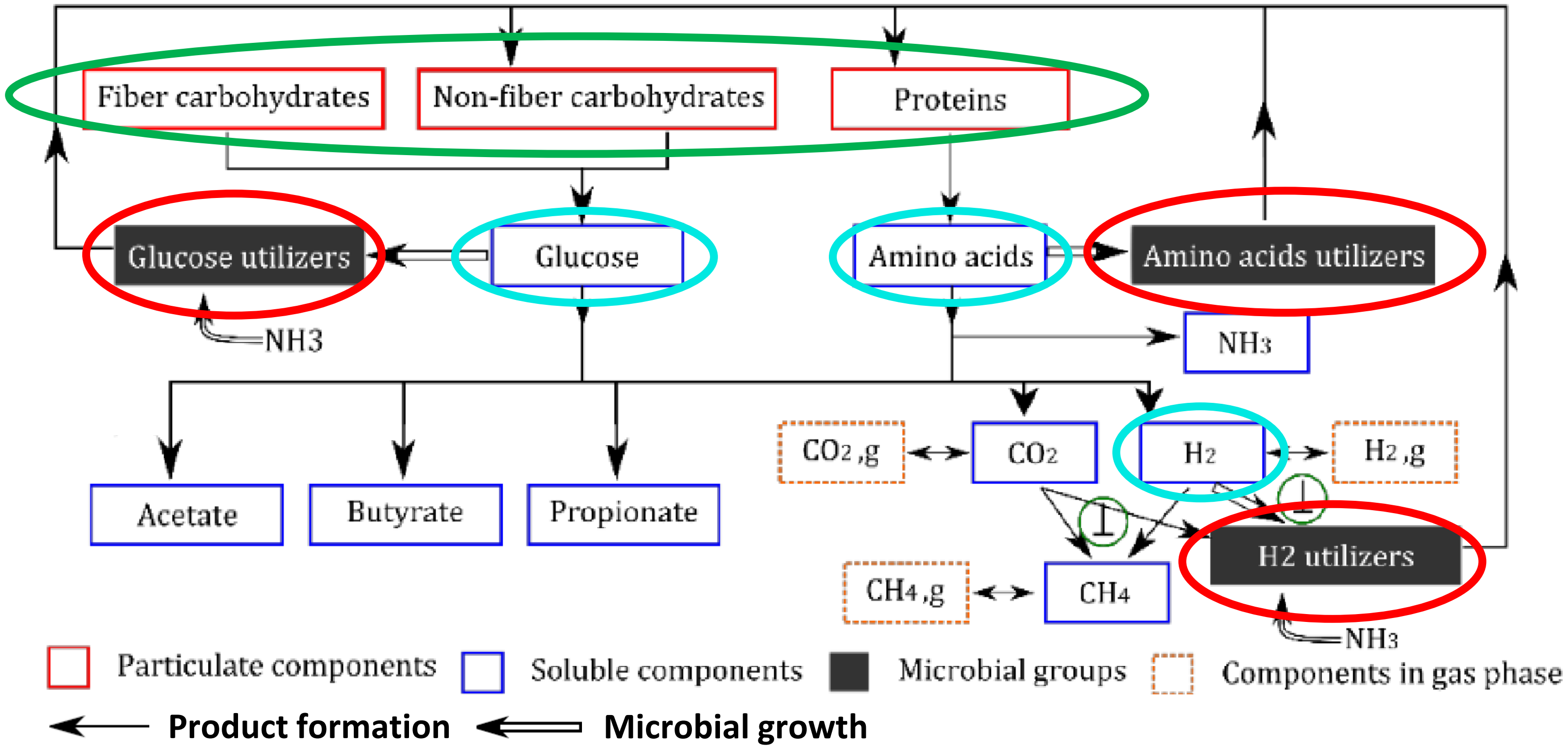
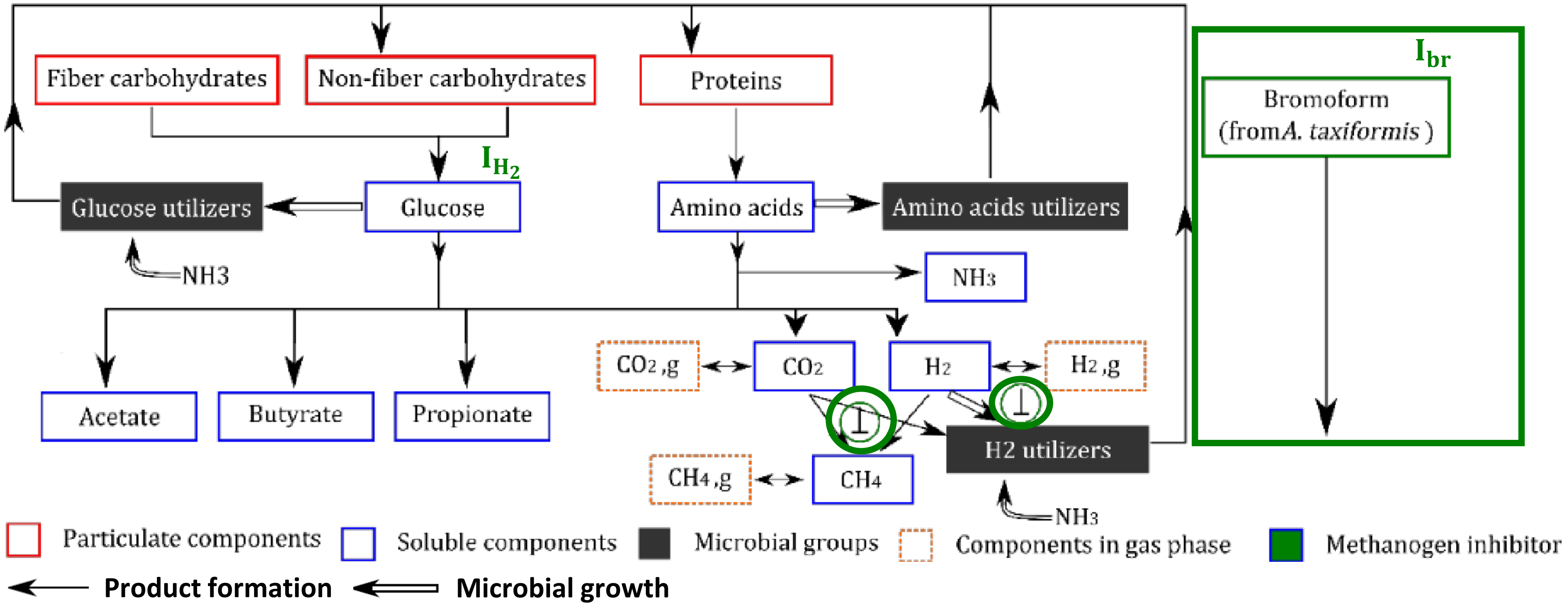


Representation of the rumen fermentation

Integration of the effect of AT (Muñoz-Tamayo et al., 2021)

19 output variables and 32 input parameters



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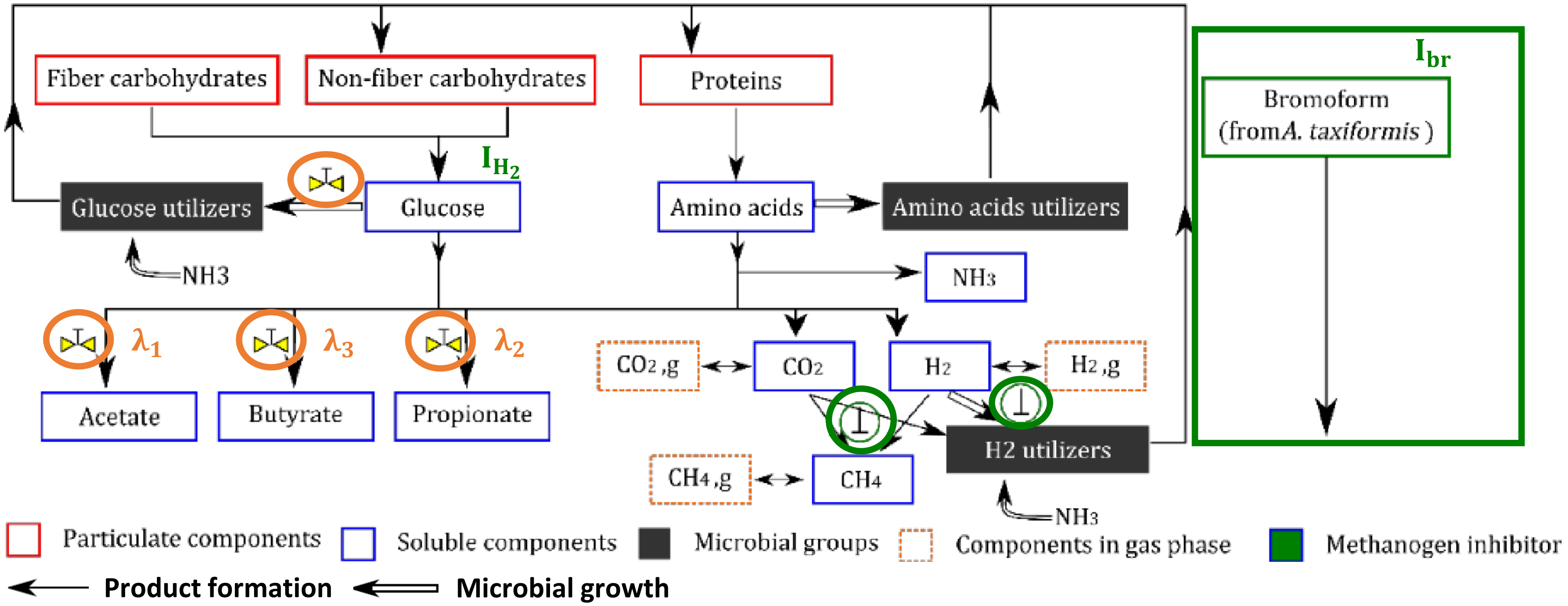

$$\lambda_1 = p_3 - p_4 \times \rho_{H_2}$$

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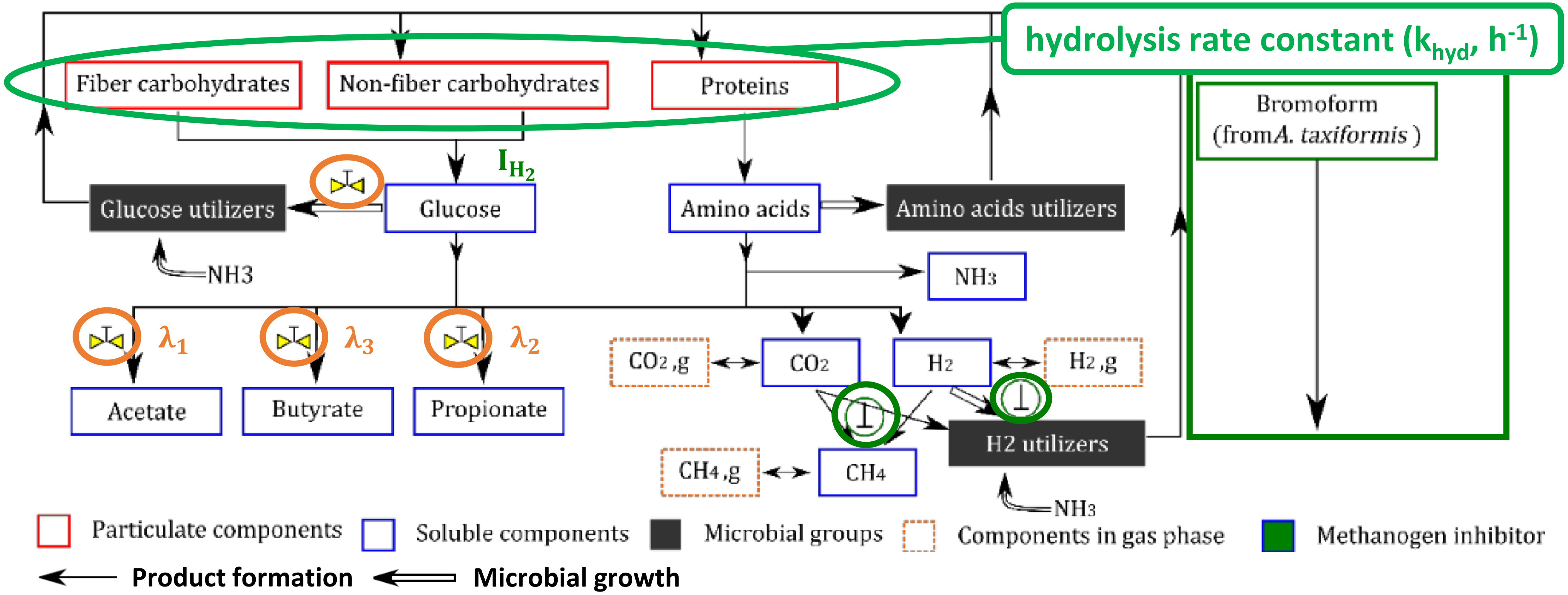

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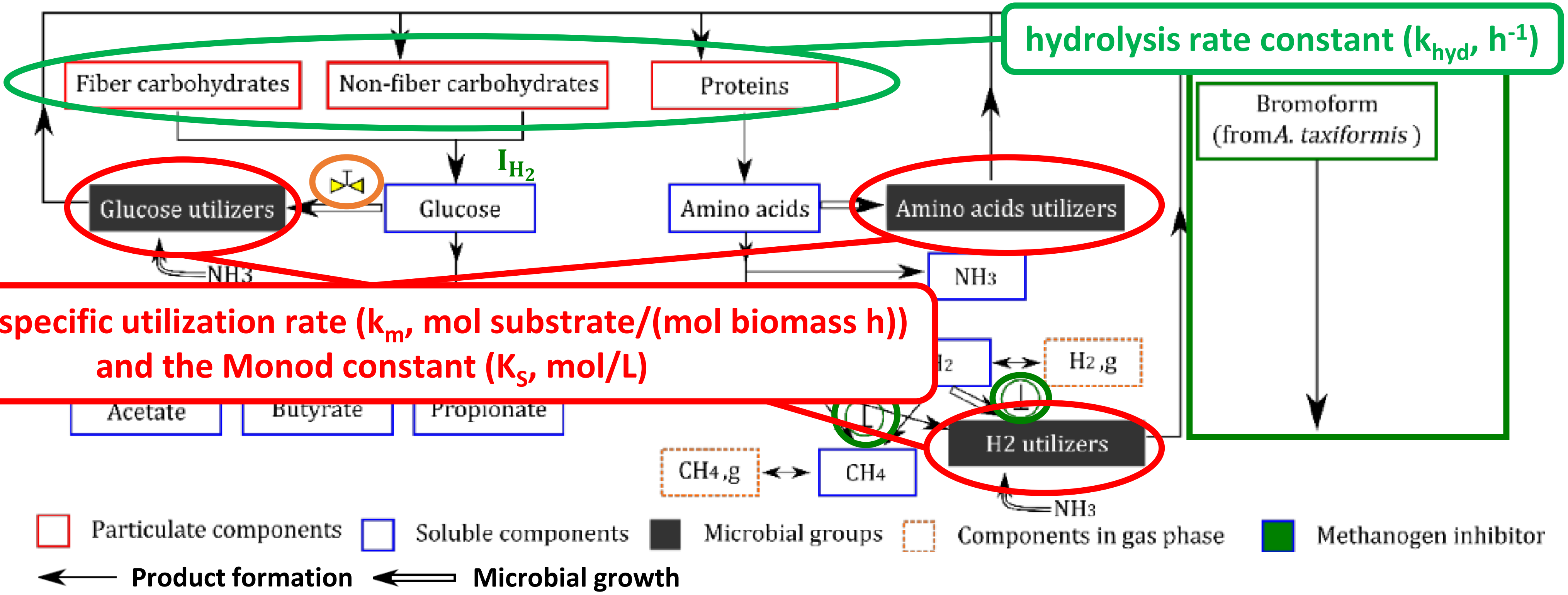

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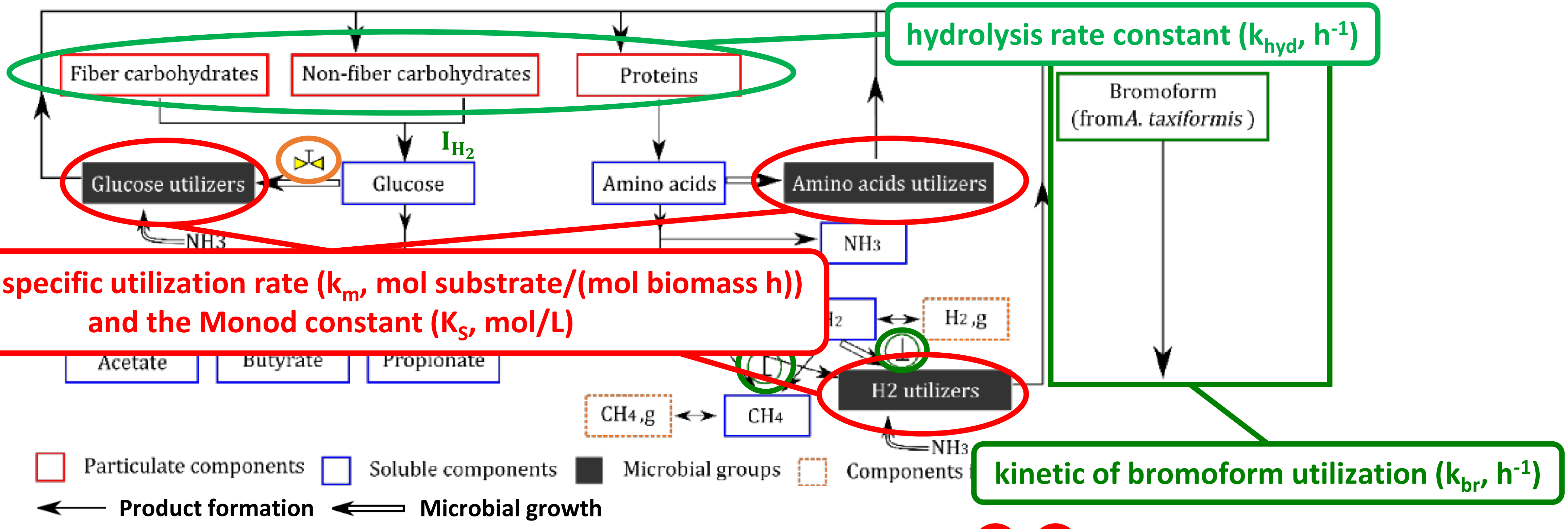

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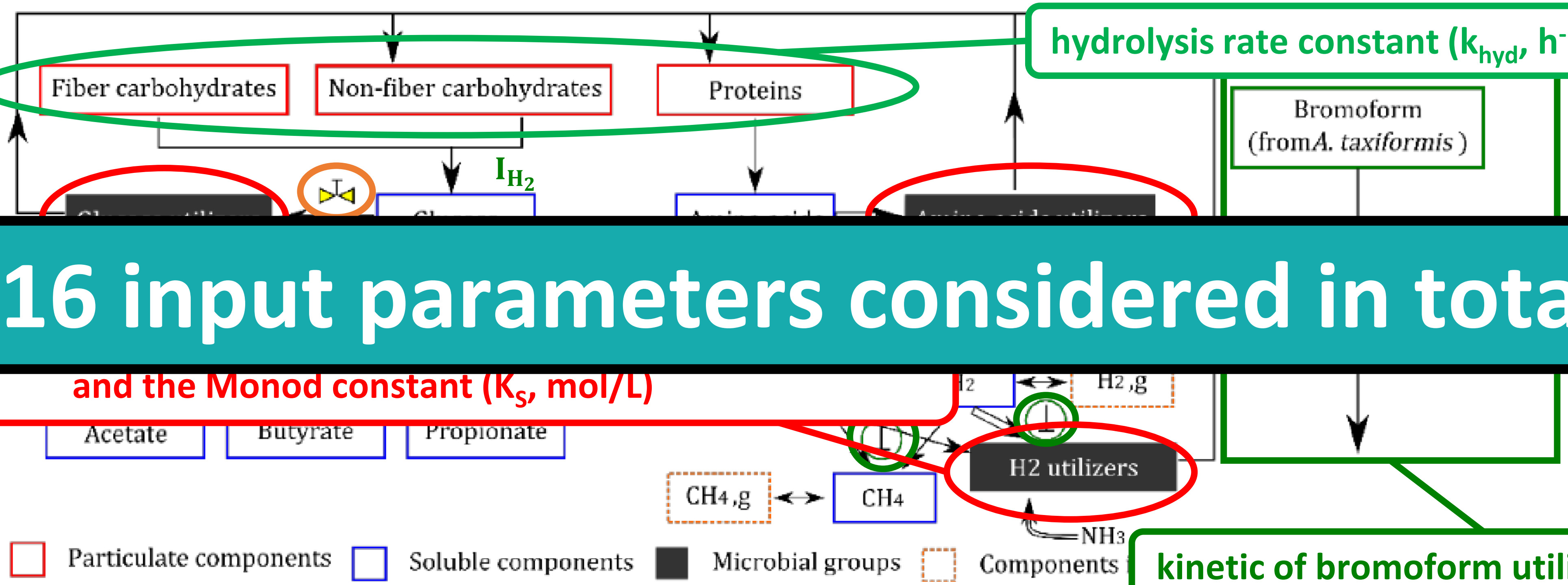

16 input parameters considered in total

maximum

and the Monod constant (K_S, mol/L)

kinetic of bromoform utilization (k_{br}, h^{-1})

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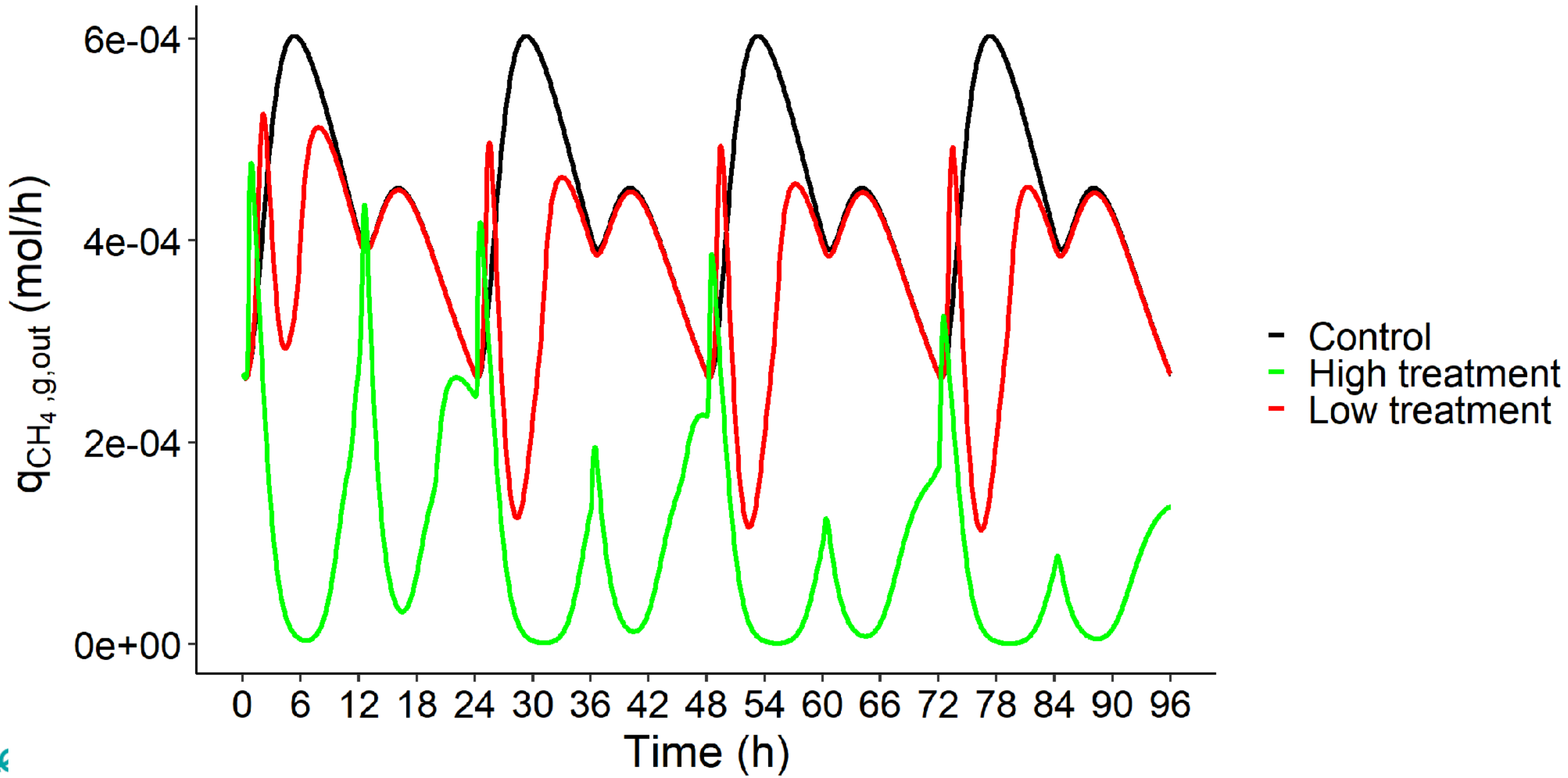
CH_4 (mol/h) for a 4 days simulation

<u>3 dietary scenarios were studied</u>: Control (0% of AT), Low AT treatment (0.25% of AT) and High AT treatment (0.50% of AT)



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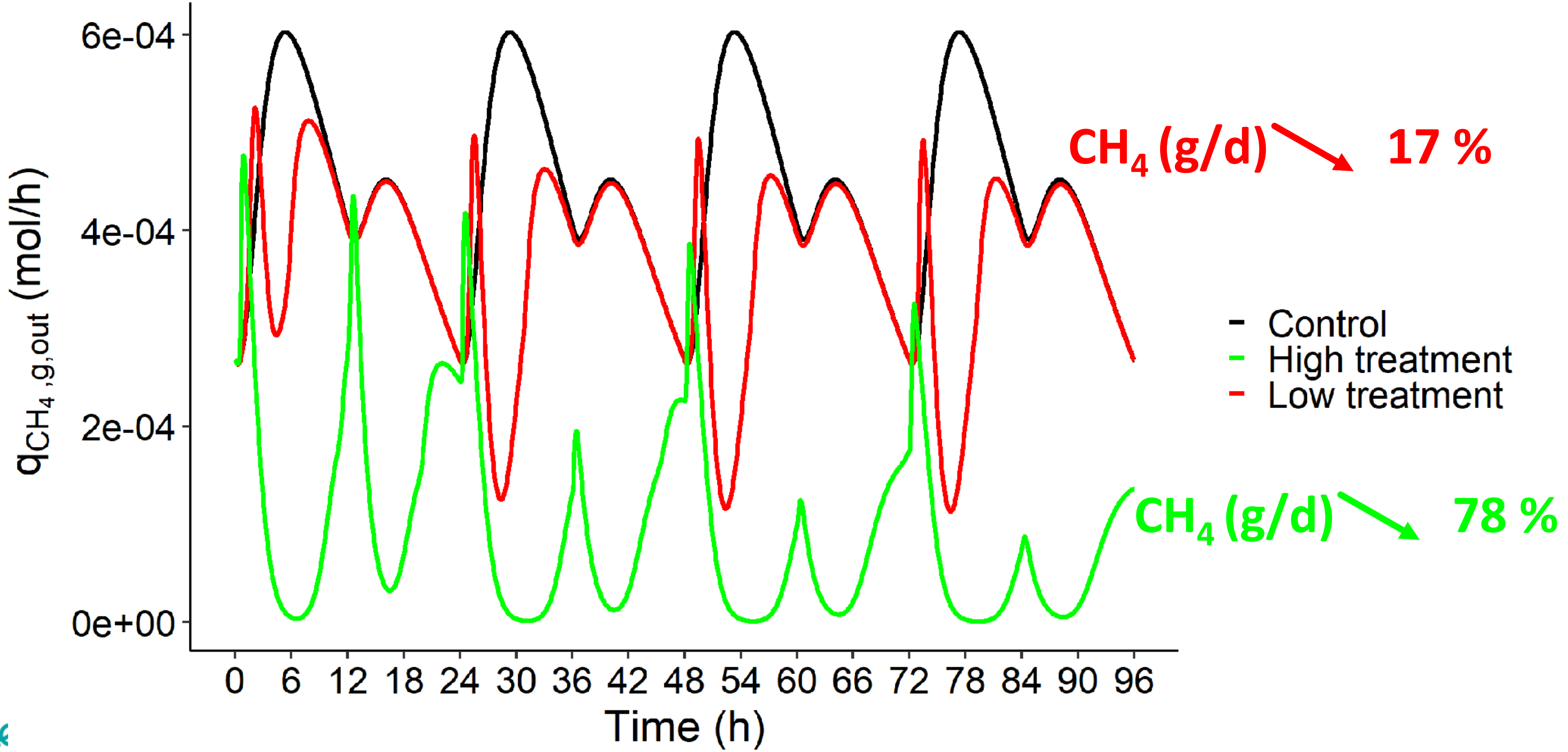

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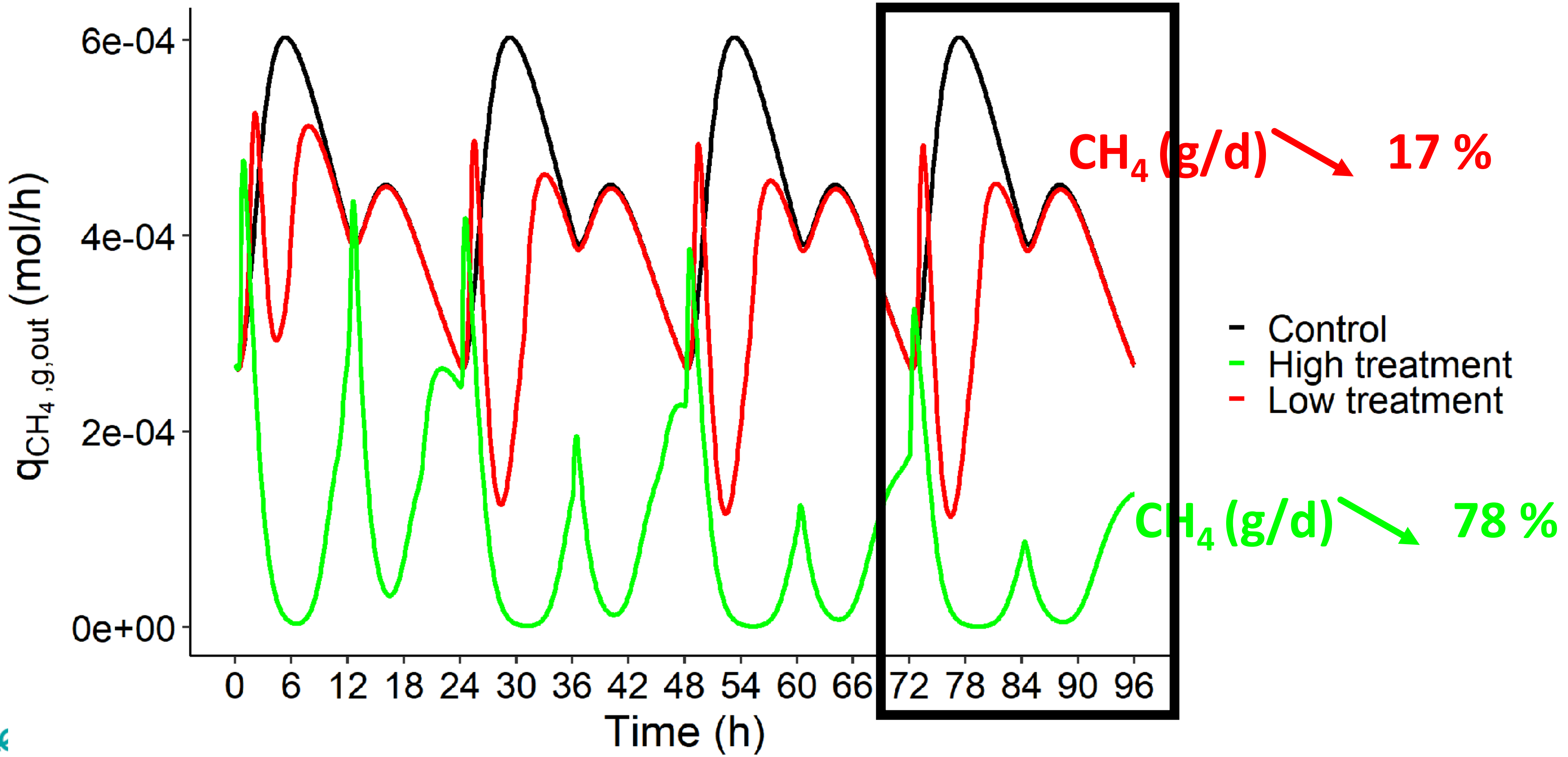

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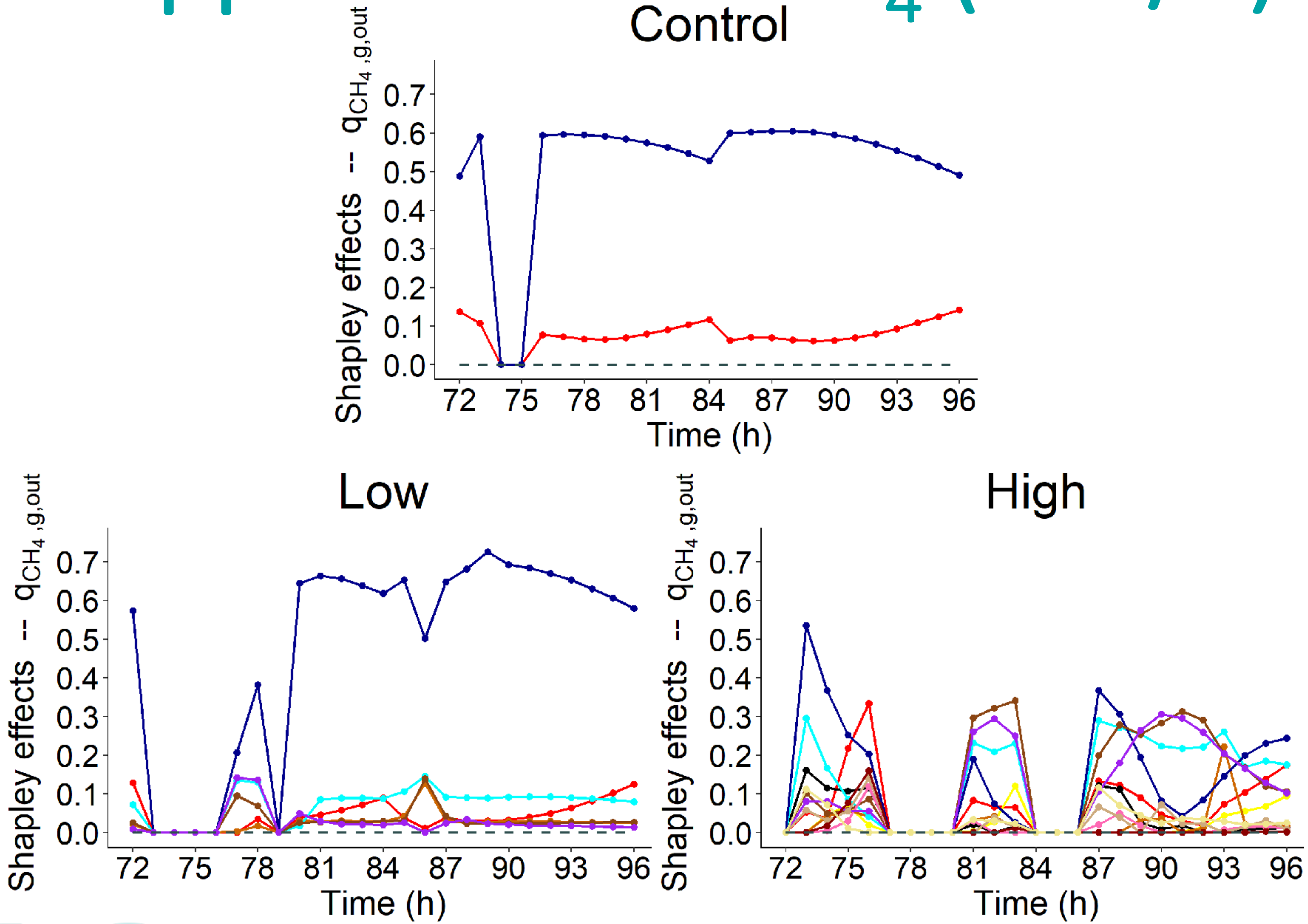
Advantage: condensed and easy-to-interpret (sum equal to 1)

Estimation: Random permutation method (Song et al., 2016)

→ Cost: $C = N_\upsilon + m(n-1)N_0N_i$, with $N_0 = 1$, $N_i = 3$ and $m = 10{,}000$ as recommended by Song et al., 2016

Application on CH_4 (mol/h) – Shapley effects



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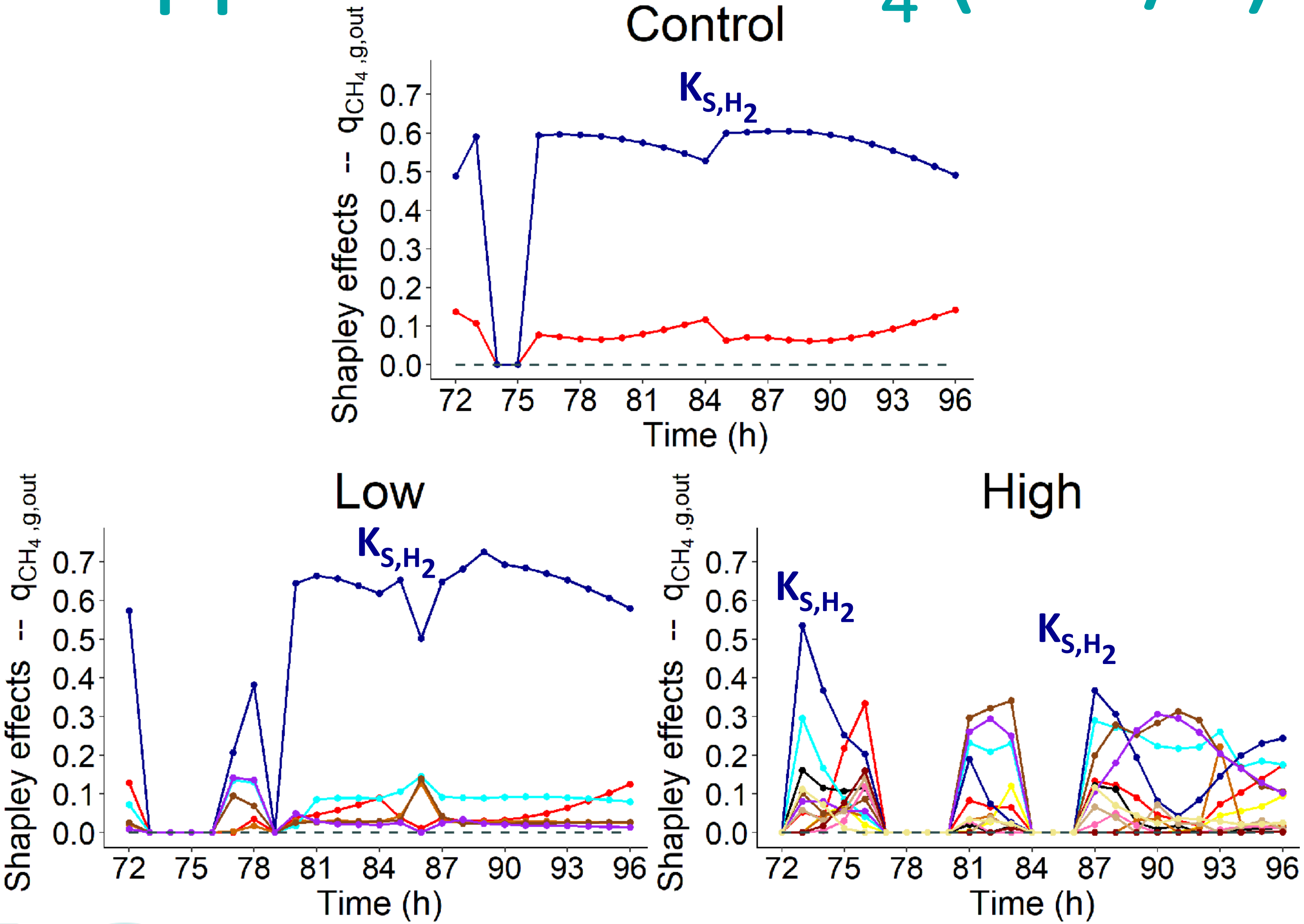

- ❖ H_2 utilizers microbial group (**K_{S,H_2}**) contributed largely the most (> 50%) to $q_{CH_4,g,out}$ variability over time for Control and Low with a constant dynamic, and showed an important contribution for High at the beginning and end of the fermentation

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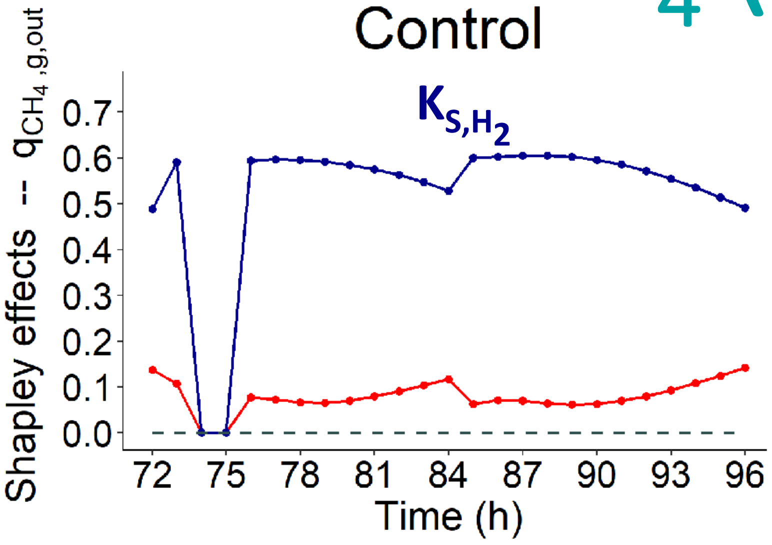

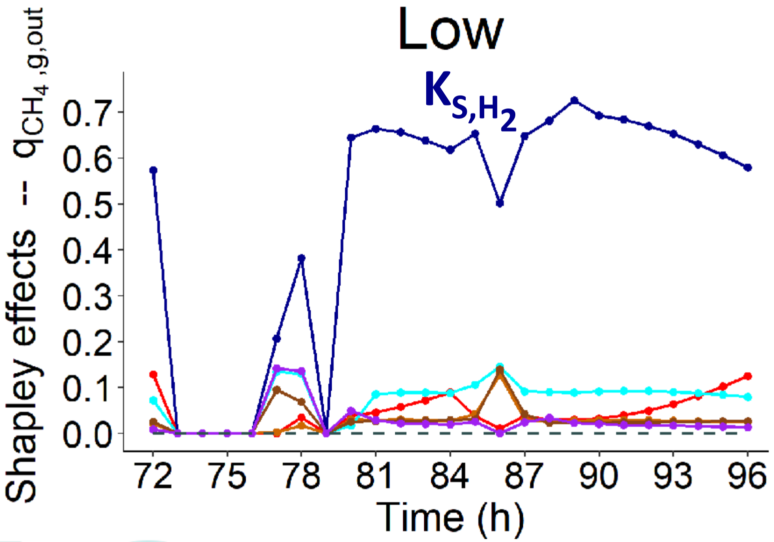

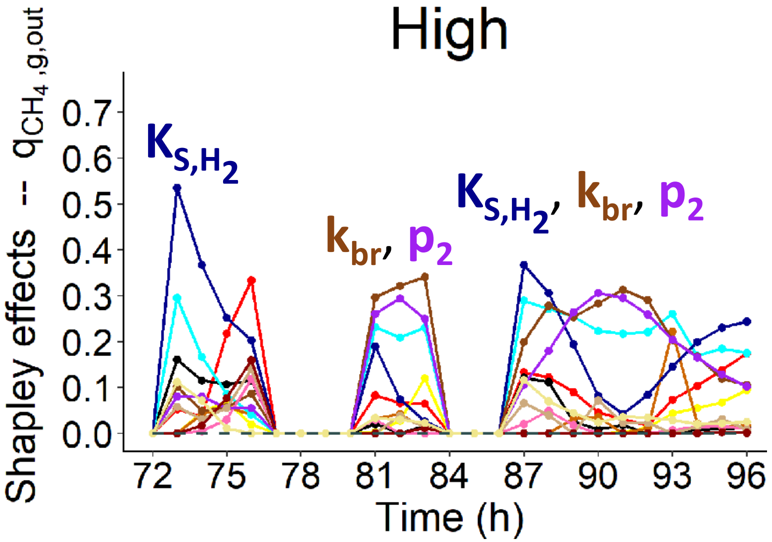

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- A shift of IPs explaining $q_{CH_4,g,out}$ variability was highlighted for High

  → **k_{br}** and **p_2** (I_{br}) explained most of $q_{CH_4,g,out}$ variation in the middle of the fermentation, replacing a part of the variability explained by **K_{S,H_2}**

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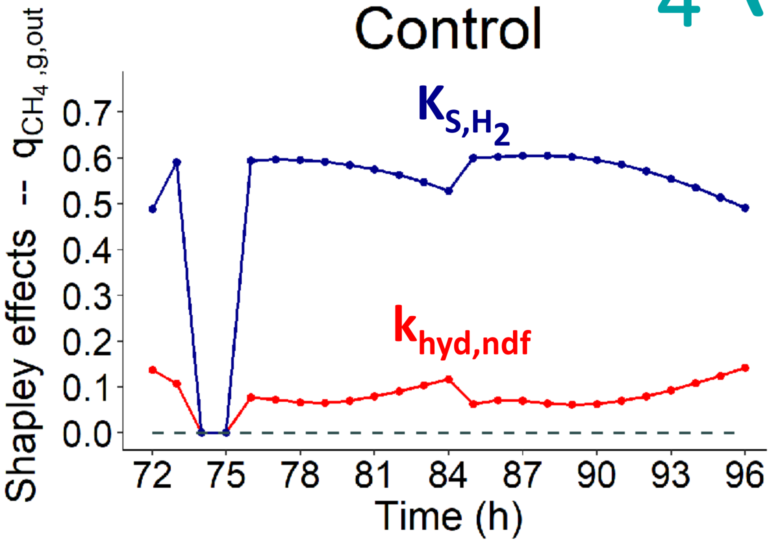

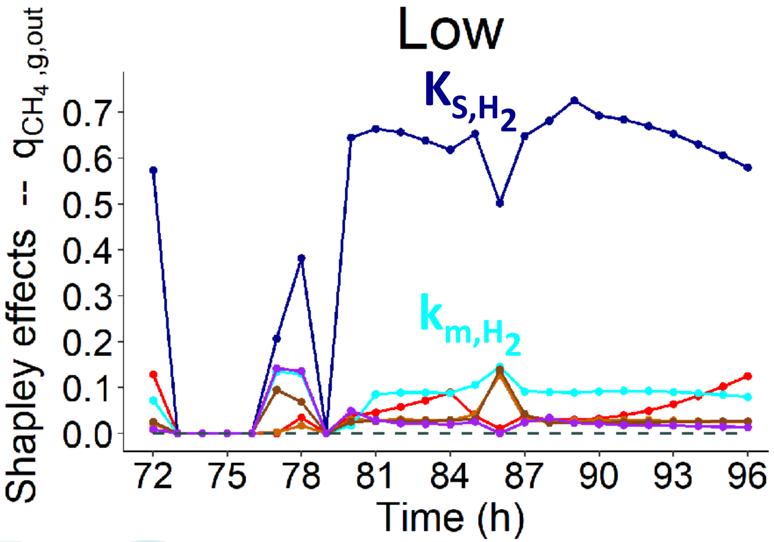

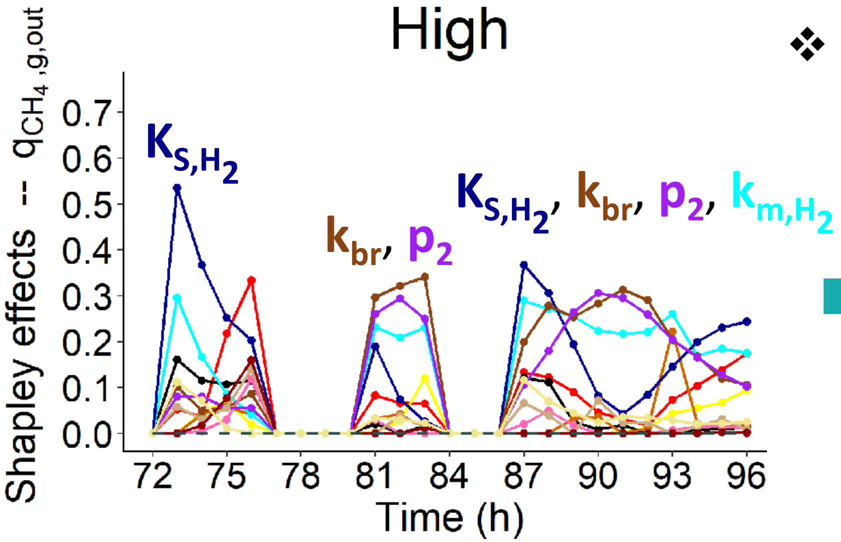

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Next step

Our SA framework could be used to optimize experimental conditions involving CH_4 inhibitor, such as identifying optimal sampling times or inhibitor doses

Thank you for your attention!

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