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Dipartimento di Ingegneria
Civile, Edile e Ambientale

Fermentative hydrogen and PHAs production by microbial community selection and enrichment via bioaugmentation

Grazia Policastro, University of Naples *Federico II*

Thessaloniki (Greece), June 23-26, 2021

Outlines

Biorefinery and Fermentation framework

- *Introduction*
- *Dark fermentation and Photo Fermentation*
- *Energy and value added by-products*

Experimental activities

- *Experimental set-up*
- *Results*

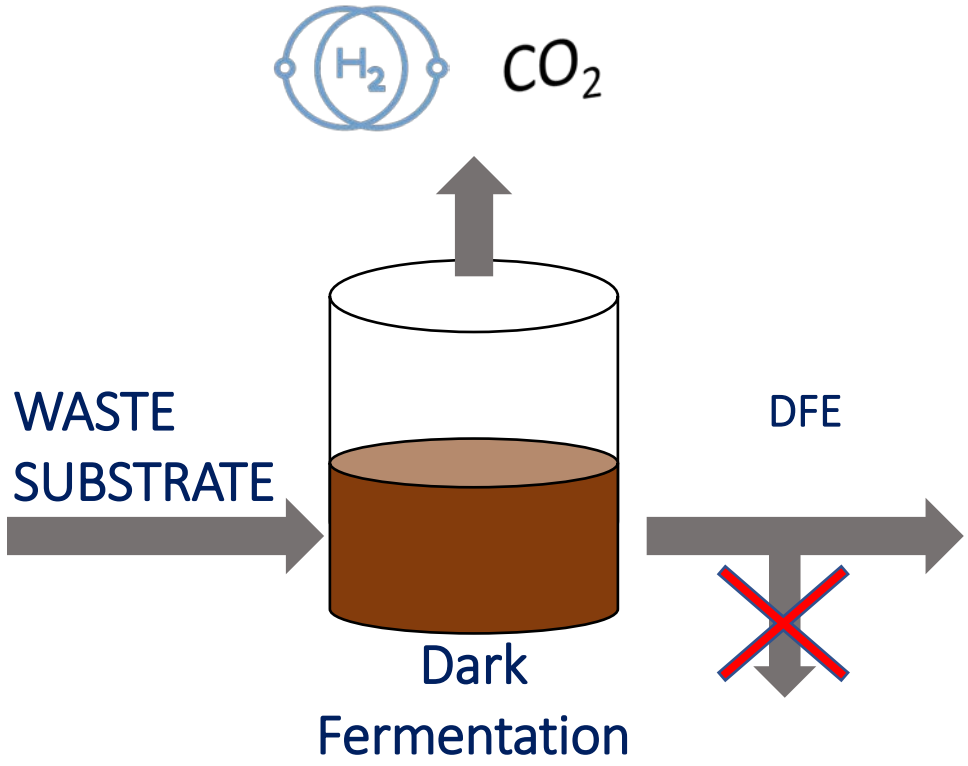
Conclusions & Future Perspectives

What is a biorefining system

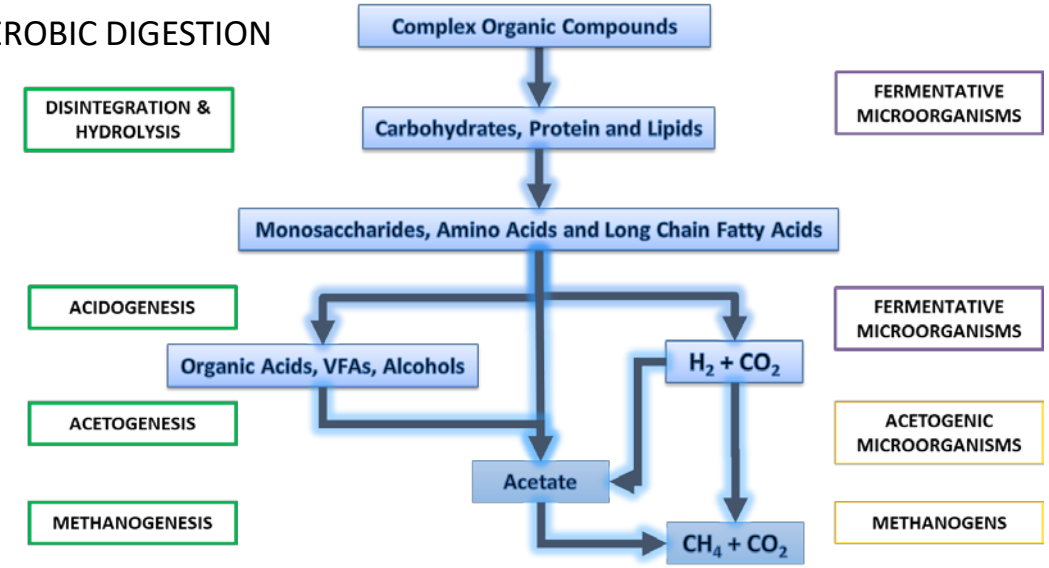
Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, materials) and bioenergy (biofuels, power and/or heat)… facility that integrates biomass conversion processes and equipment to produce fuels, power, heat, and value-added chemicals from biomass.

- Anaerobic processes?
  - Costs (O_2 not used as electron acceptor)
  - Energy/Value-added chemicals
  - GHG emission mitigation

DARK AND PHOTO FERMENTATION



ANAEROBIC DIGESTION



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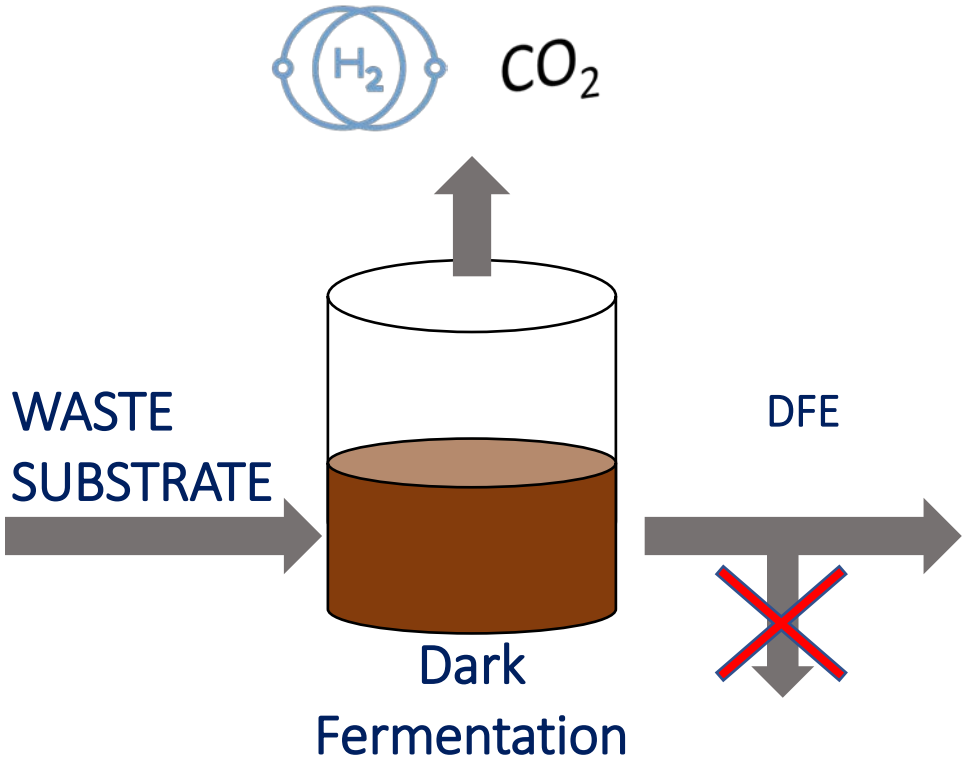

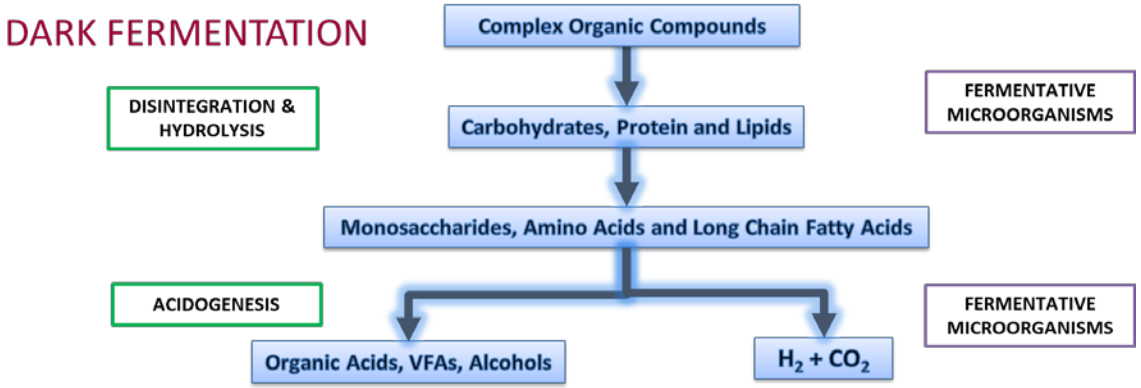

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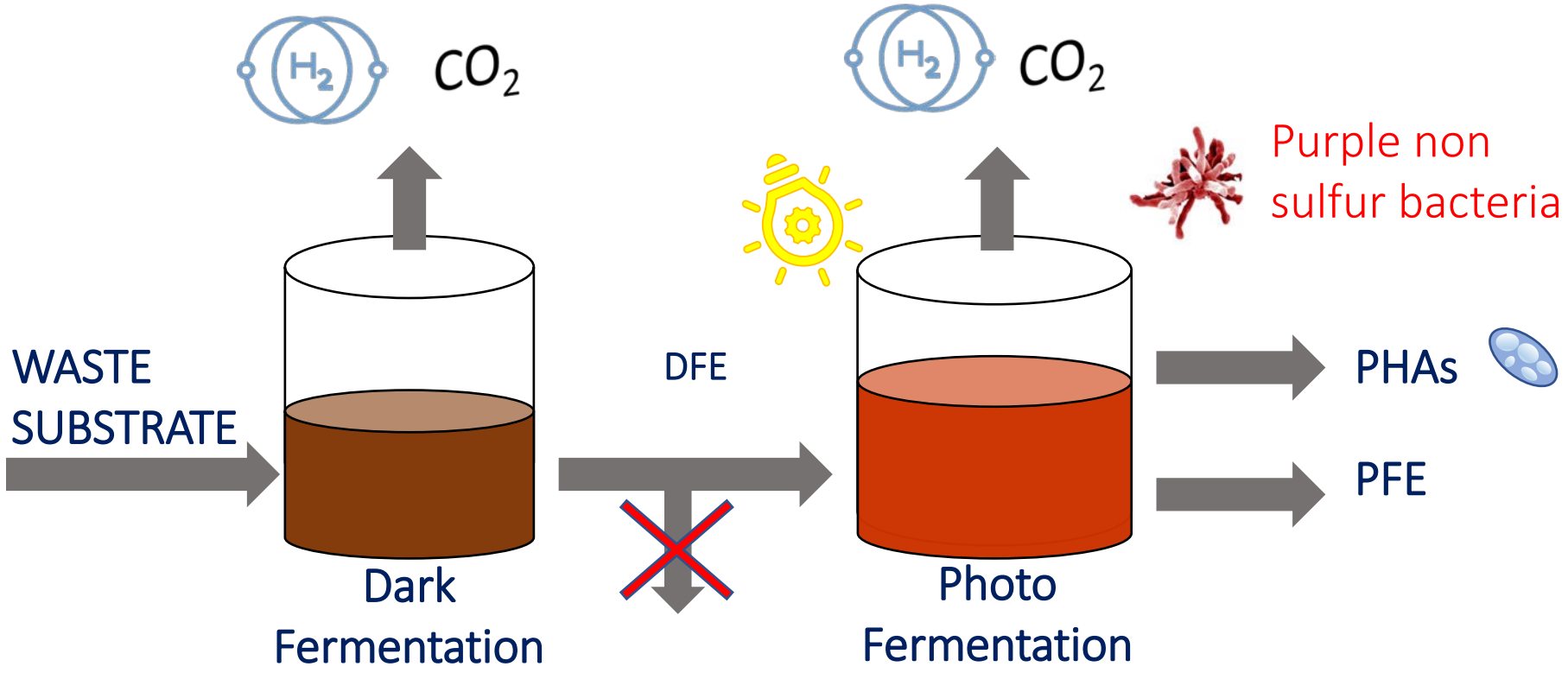
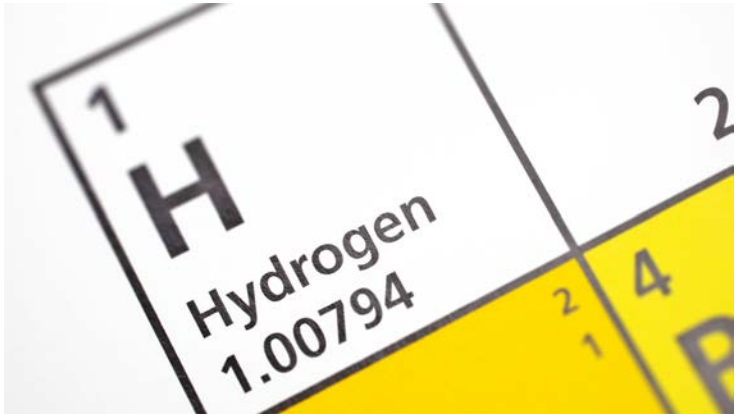


ENERGY AND VALUE ADDED BY-PRODUCTS

H_2 production



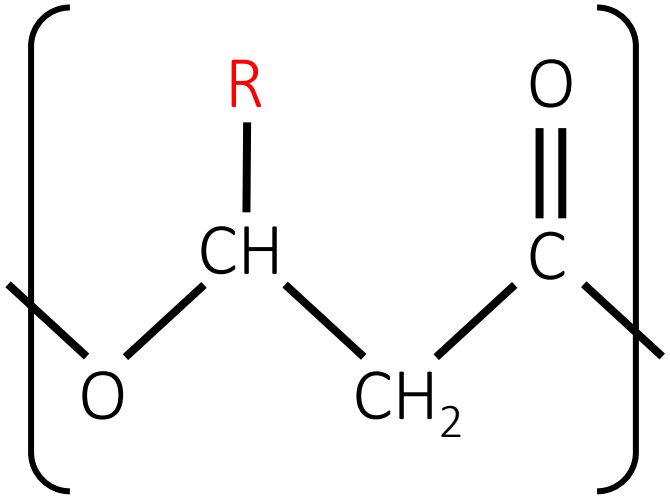
PCI 119.90 MJ/Kg

$2H_2 + O_2 \rightarrow H_2O$

- *Efficiency conversion in internal combustion engines 50-60%*
- *Efficiency conversion (fossil fuels) ~25%*

ENERGY AND VALUE ADDED BY-PRODUCTS

Polyhydroxyalacanoates

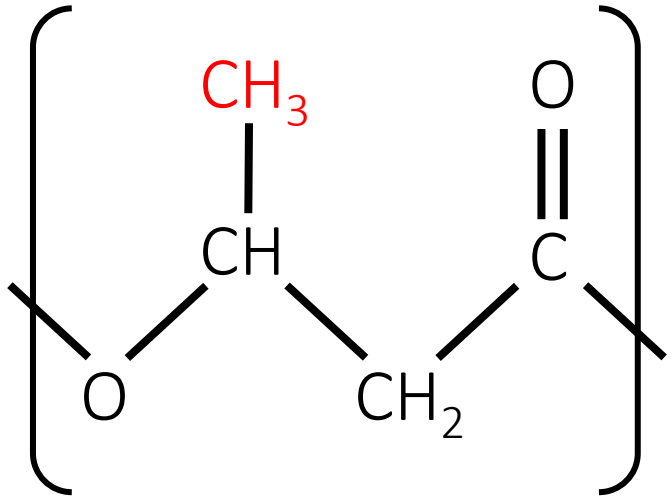


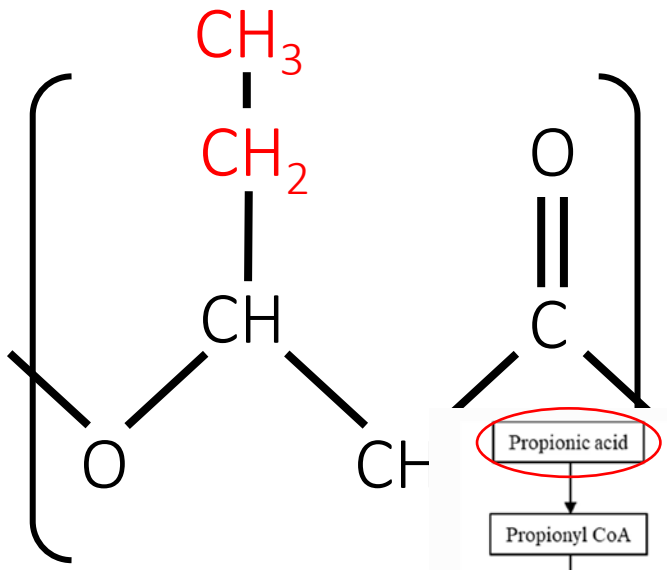
3-hydroxyalcanoate

R alcaly group

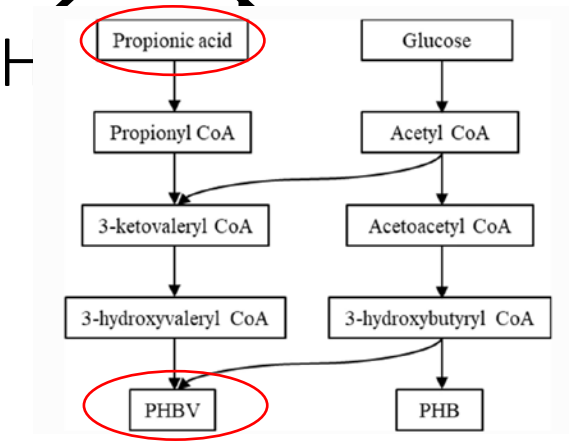
ENERGY AND VALUE ADDED BY-PRODUCTS

Polyhydroxyalacanoates





Co-polymers



Policastro et al., 2021

EXPERIMENTAL SET-UP

Aims

- Hydrogen and PHAs production via two stage Dark and Photo Fermentation
- Propionic acid production via Dark Fermentation
- Microbial community enrichment

EXPERIMENTAL SET-UP

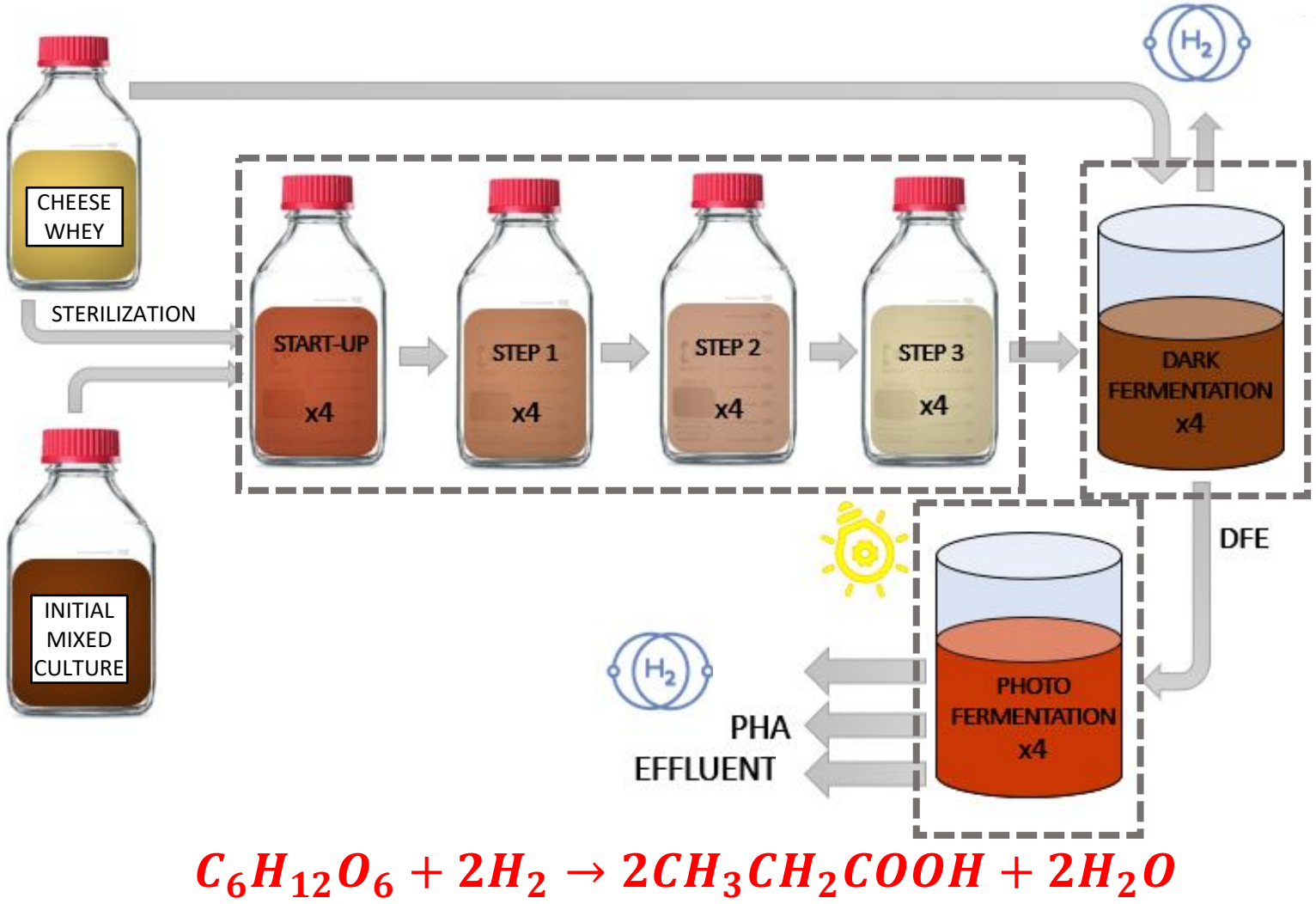
	CHEESE WHEY	INOCULUM
Total Solids [g/L]	64,29	4,67
Volatile Solids [g/L]	60,23	2,79
COD [g/L]	89,28	26,87
Carbohydrates [g/L]	39,08	
Proteins [g/L]	15,80	
Lipids [g/L]	4,12	

Cheese whey

- COD 50-102 mg/L
- 180-190×10^6 t/YEAR
- Only the 50% is used for further processes!

→ VALORIZATION

EXPERIMENTAL SET-UP



$$C_6H_{12}O_6 + 2H_2 \rightarrow 2CH_3CH_2COOH + 2H_2O$$

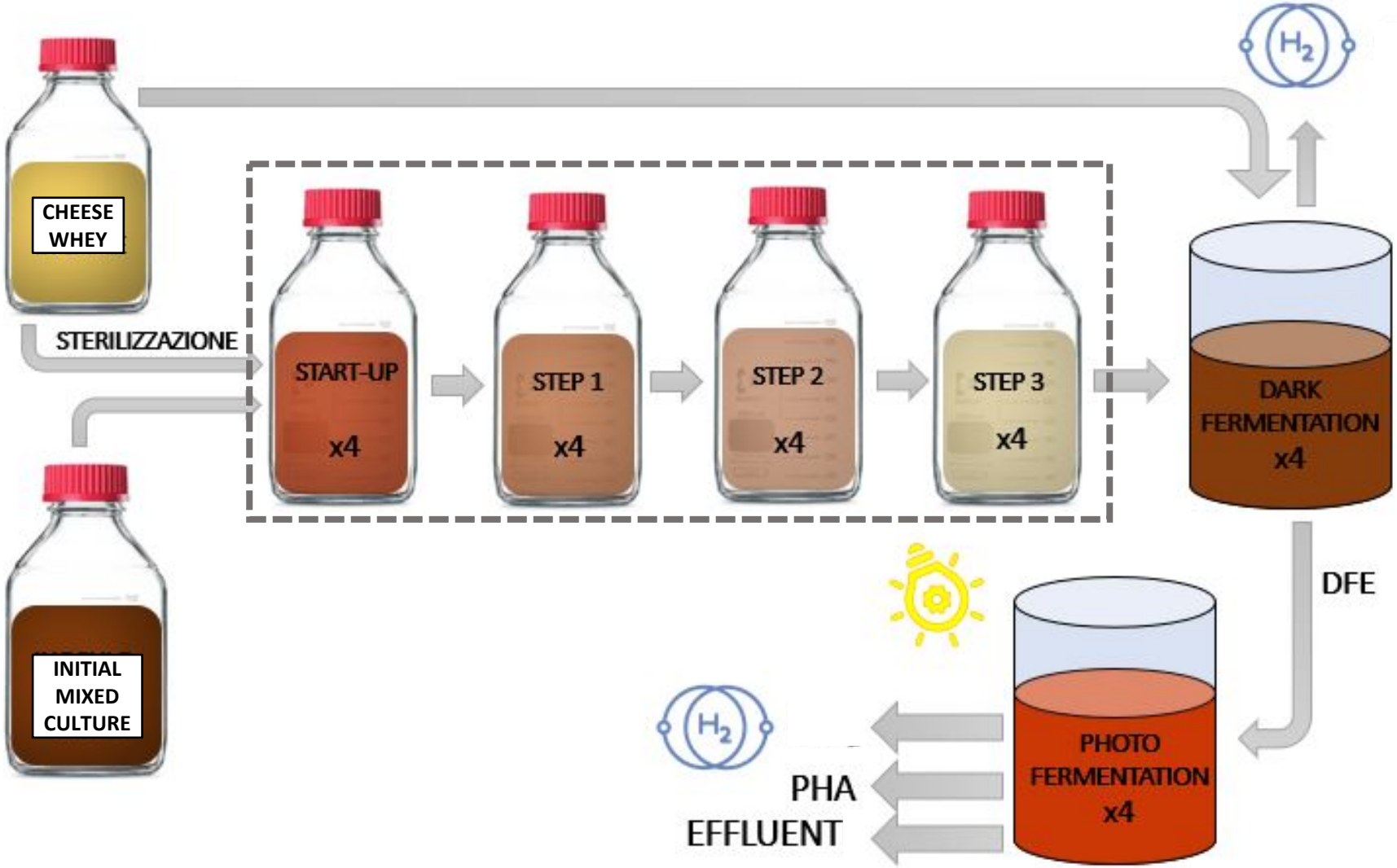
DF OPERATIONAL PARAMETERS:

- V_R = 500mL
- V_W = 400mL
- T= 35±1°C
- pH= 6,8-7,2
- F/M= $1\frac{g_{VS,sub}}{g_{VS,in}}$

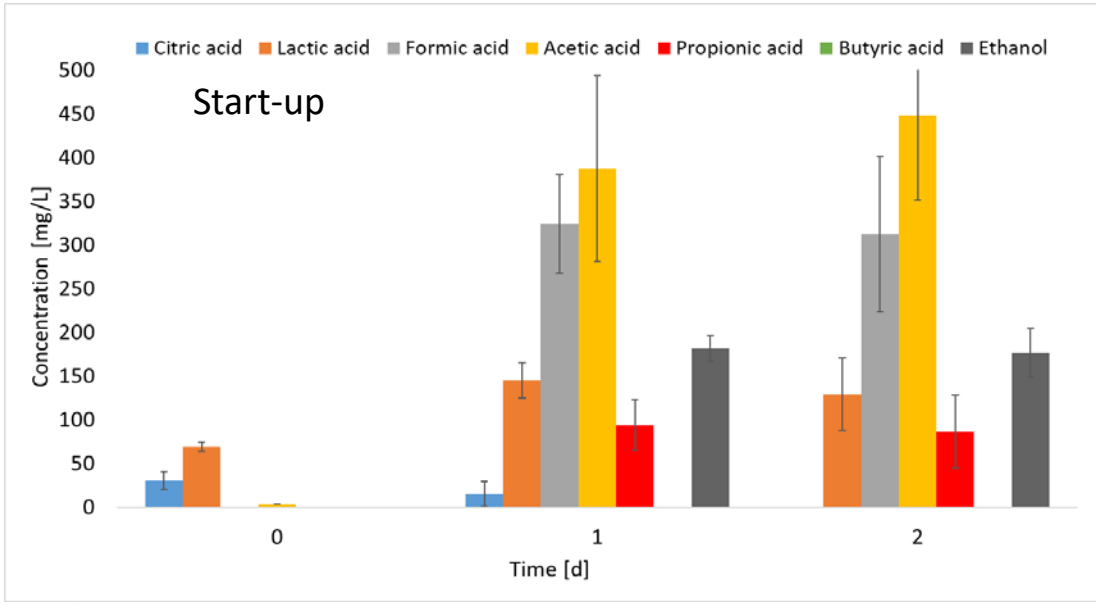
PF OPERATIONAL PARAMETERS:

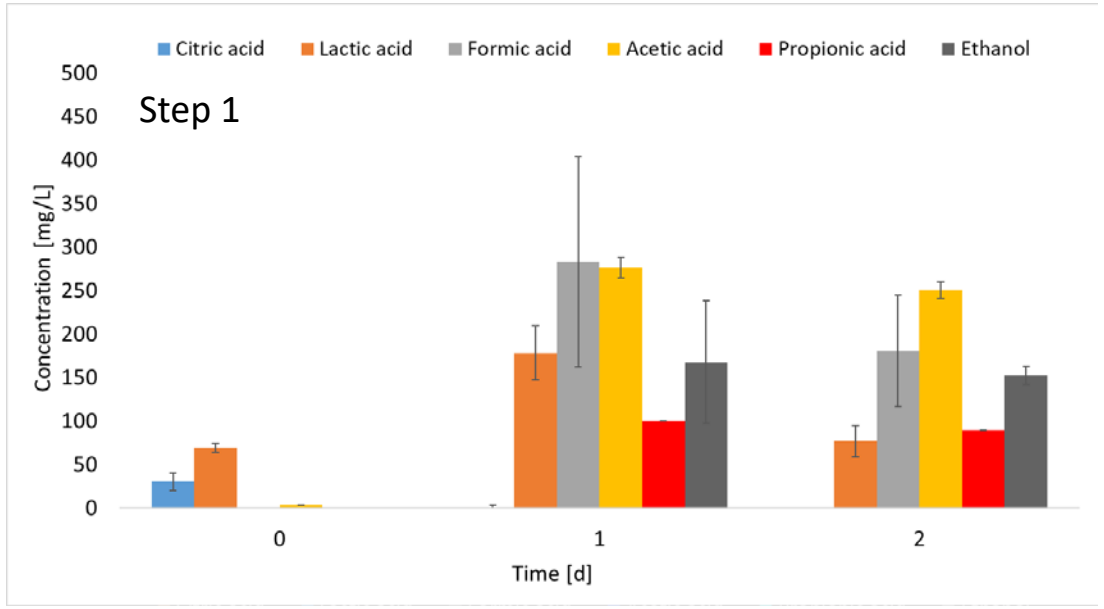
- T= 23±2°C
- Agitation= 250 rpm
- I= 3000 lux
- CODIN= $1\frac{g_{COD}}{L}$

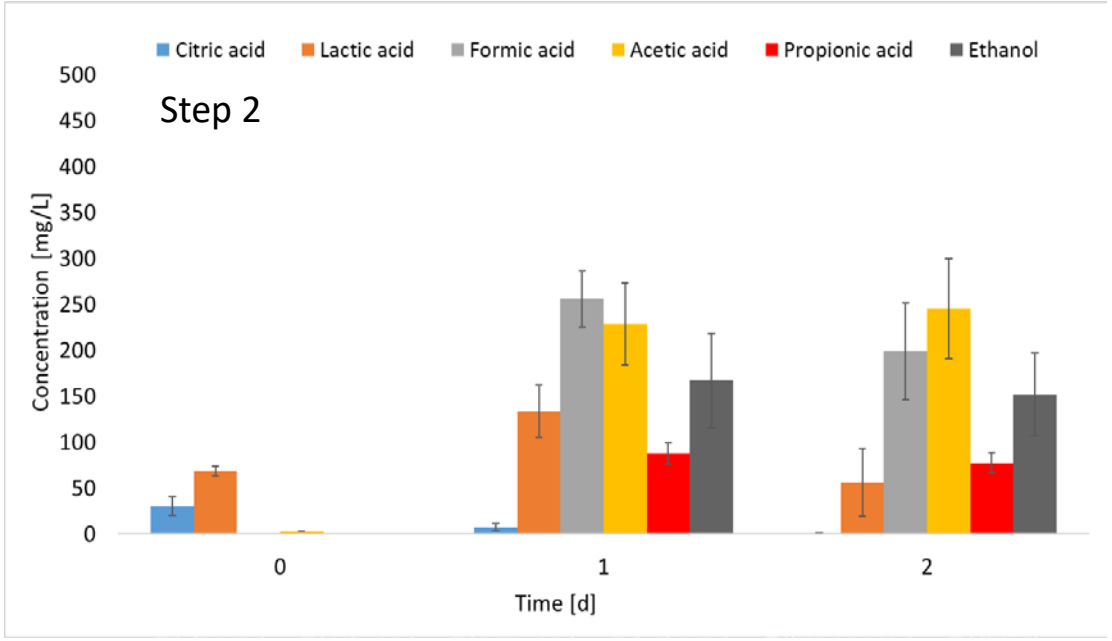
RESULTS: Bioaugmentation cycle

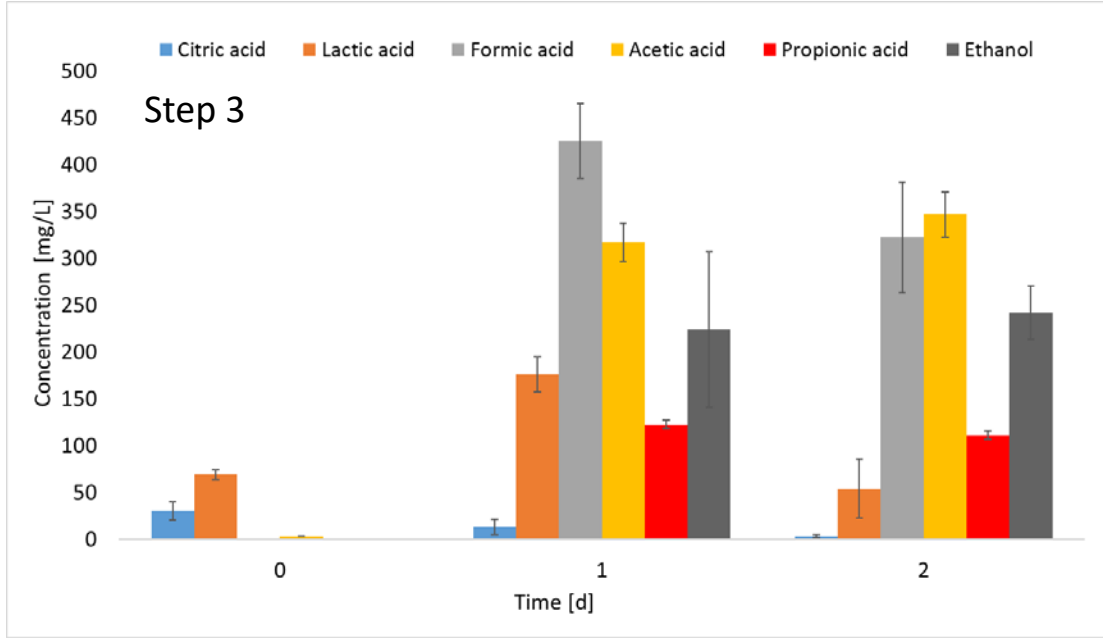


RESULTS: Bioaugmentation cycle

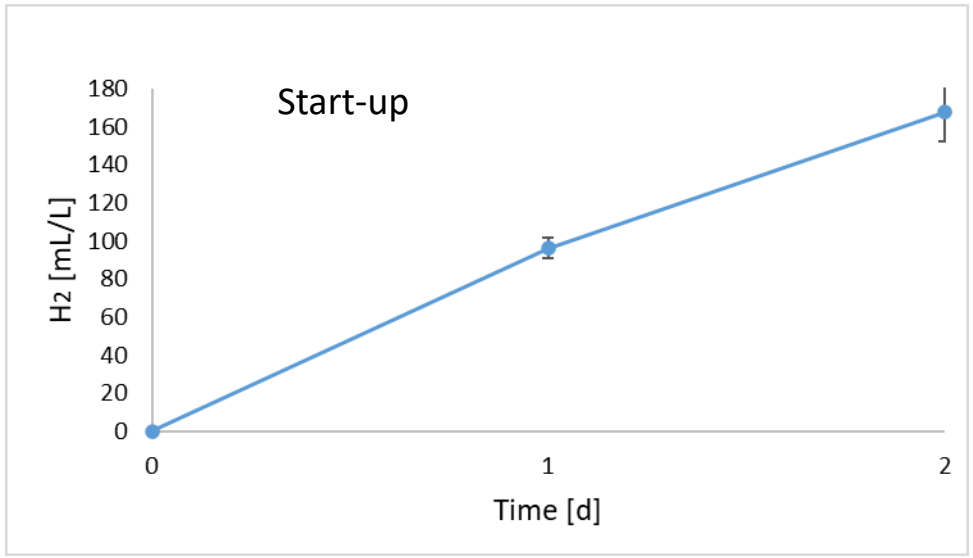


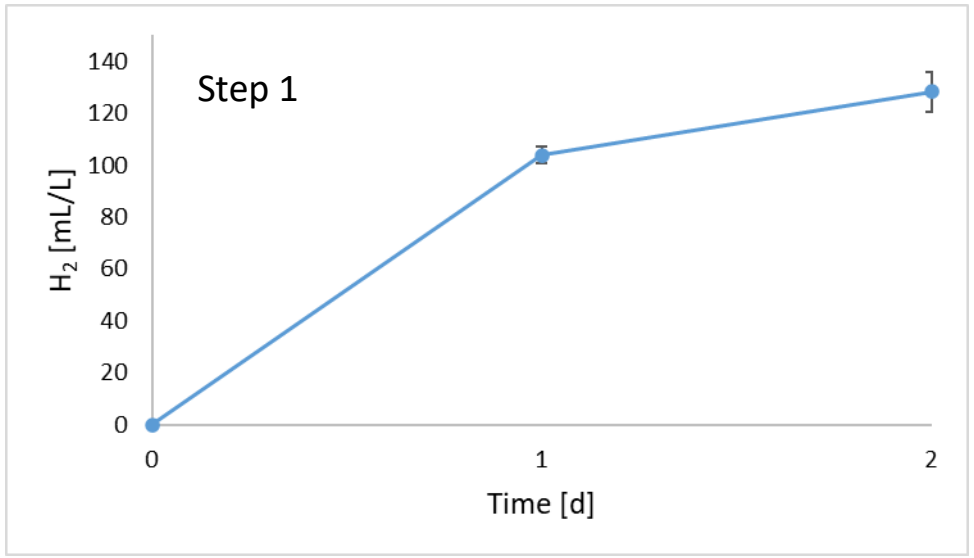


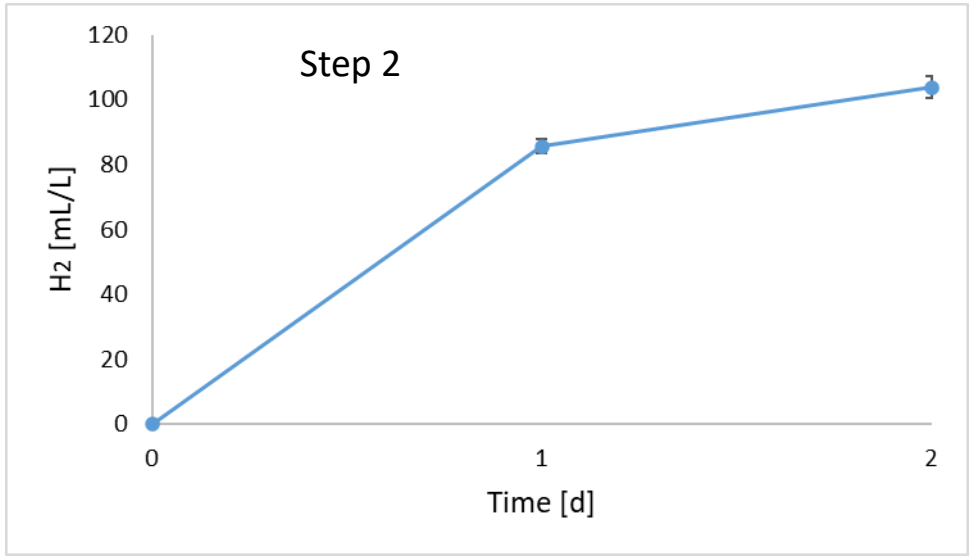


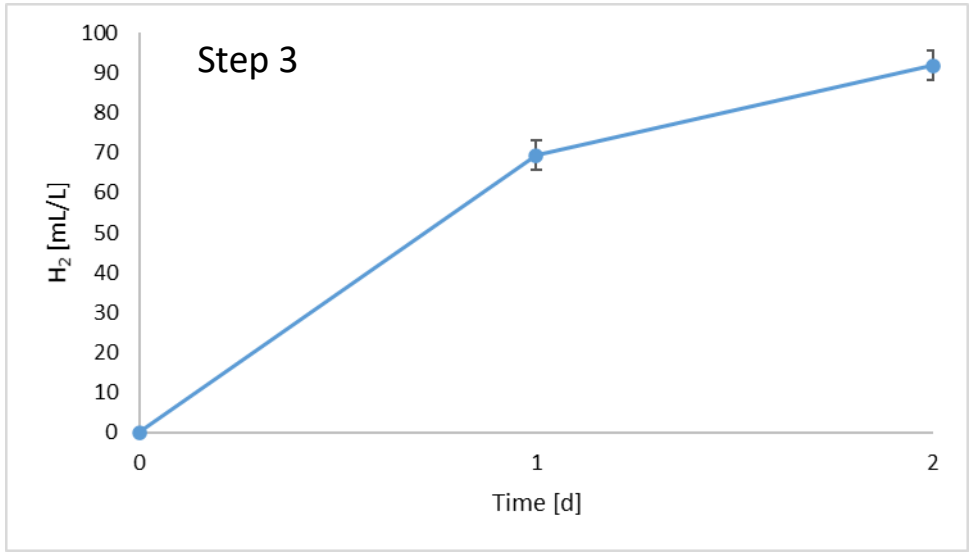


RESULTS: Bioaugmentation cycle

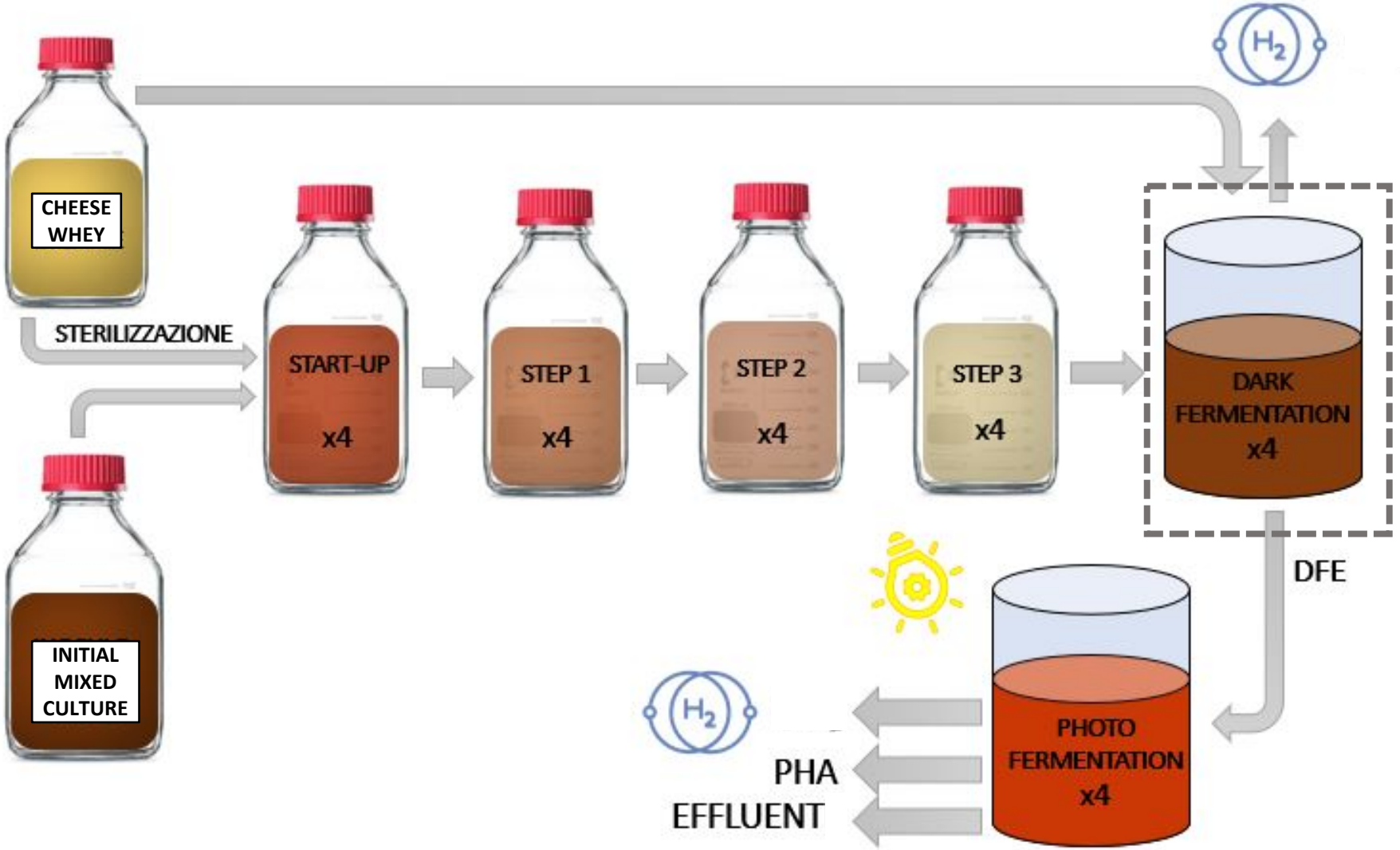




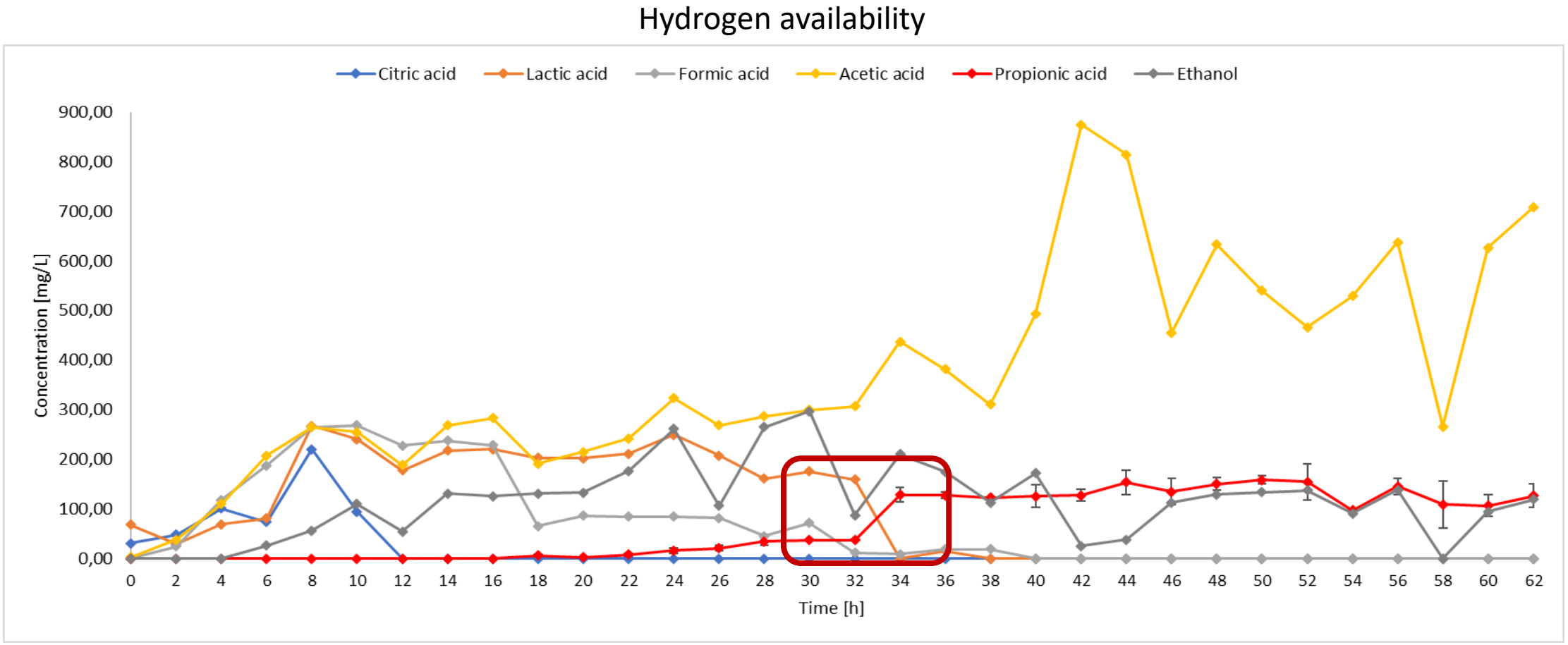




RESULTS: Dark Fermentation

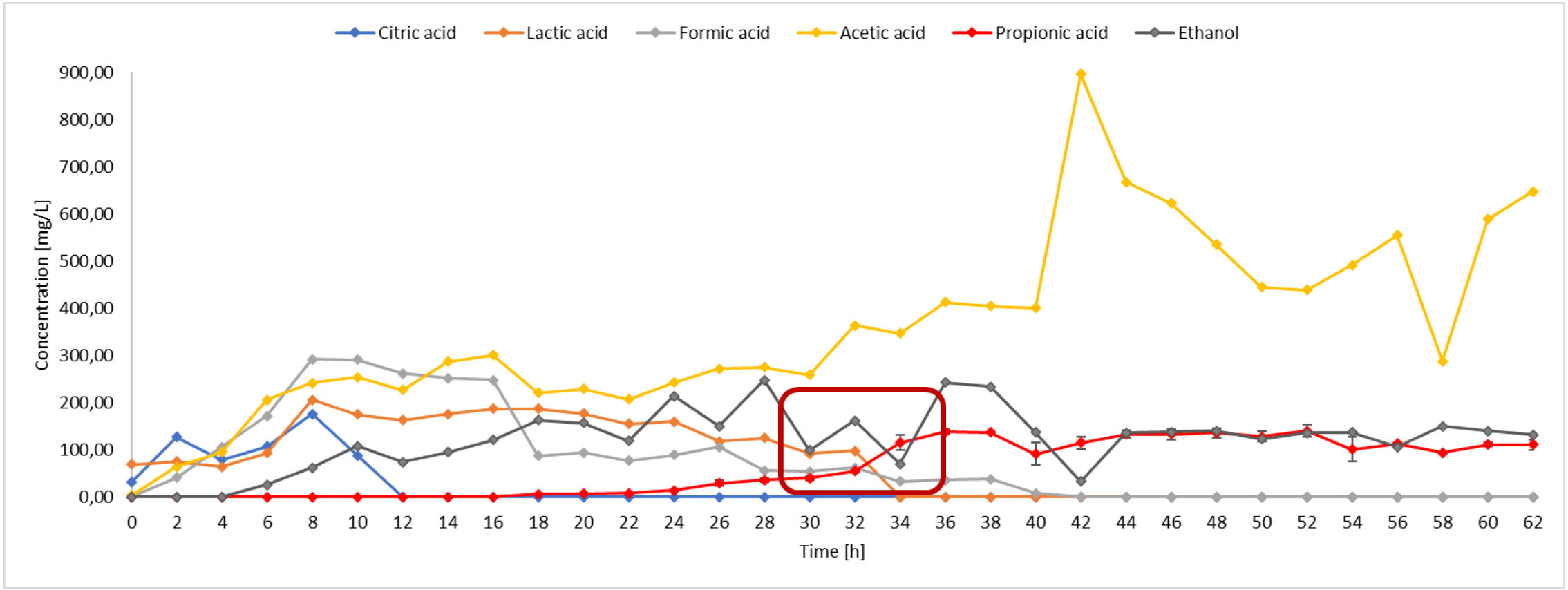


RESULTS: Dark Fermentation



RESULTS: Dark Fermentation

Hydrogen limiting conditions

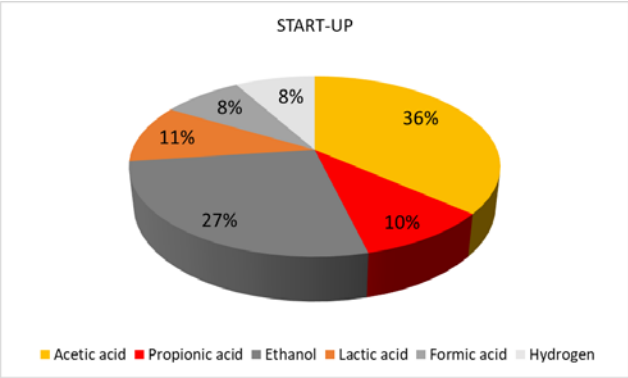


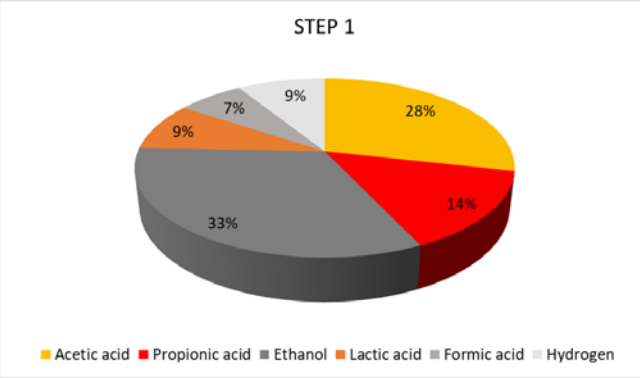
$$C_6H_{12}O_6 + 2H_2 \rightarrow 2CH_3CH_2COOH + 2H_2O$$

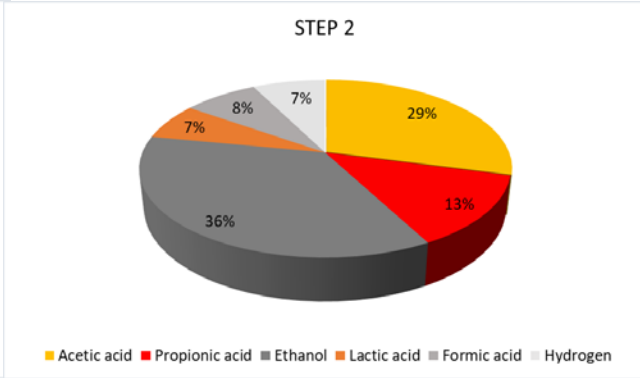
$$3CH_3CHOHCOOH \rightarrow 2CH_3CH_2COOH + CH_3COOH + CO_2 + H_2O$$

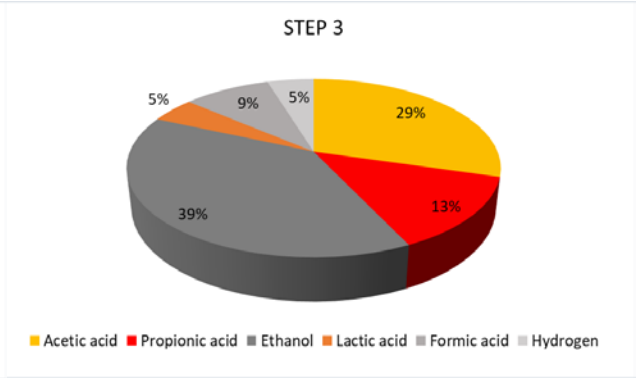
RESULTS: Dark Fermentation

Bioaugmentation cycle

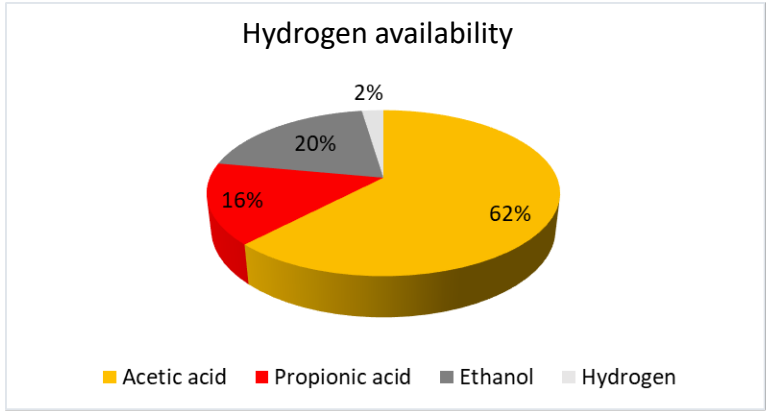


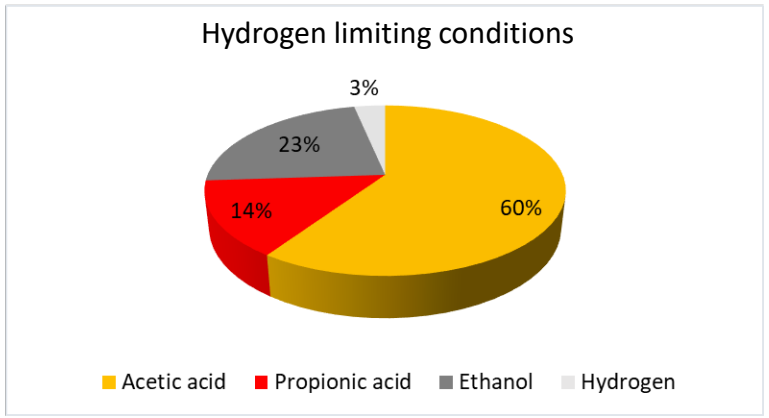






Final Dark Fermentation



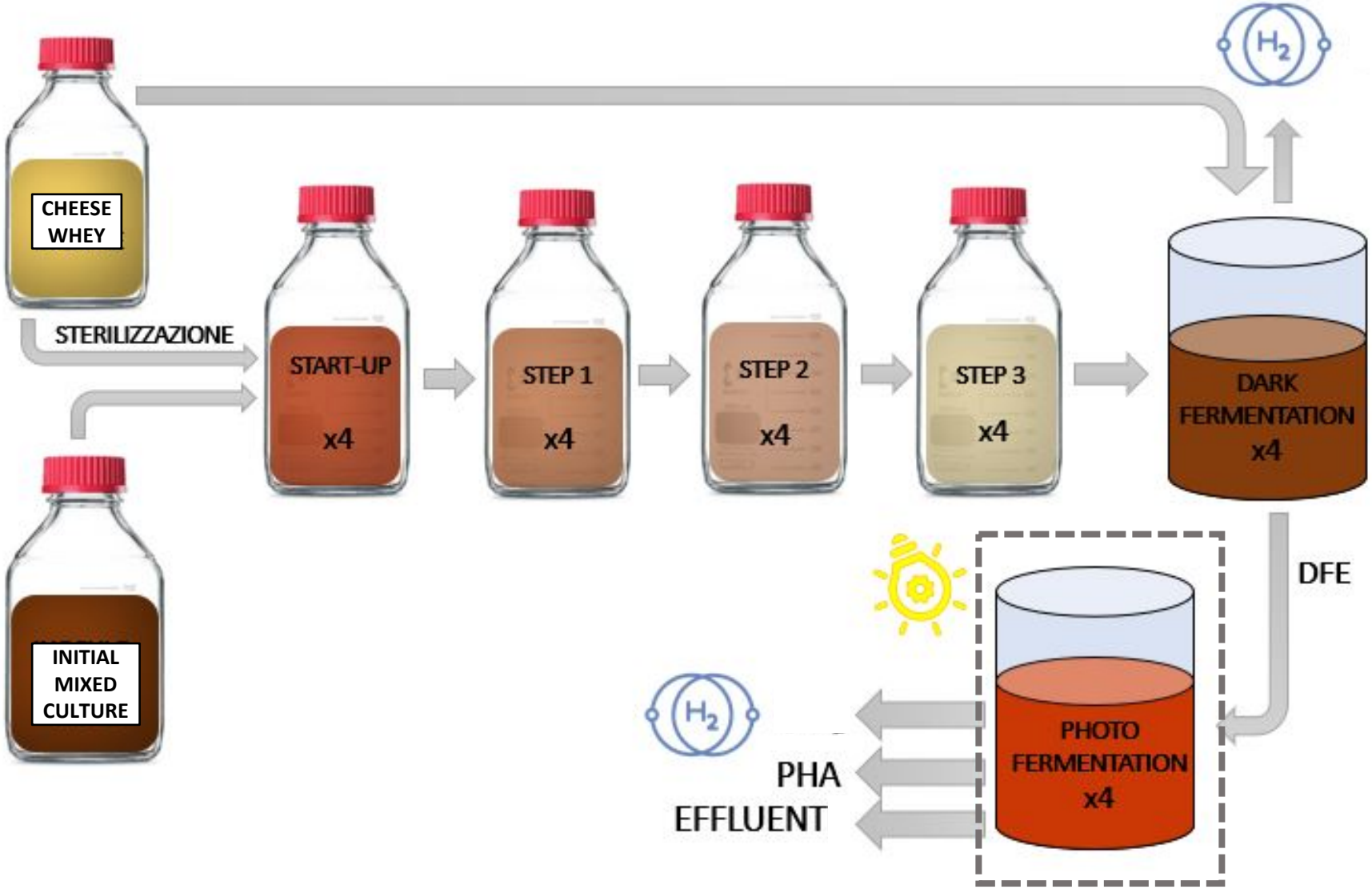


Optimal propionic acid range for high performance PHAs production:

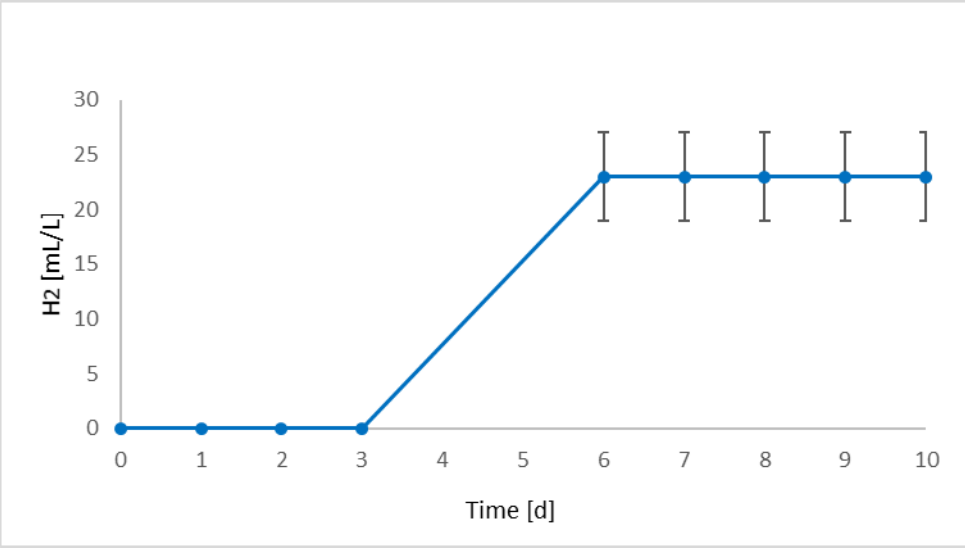
10-30%

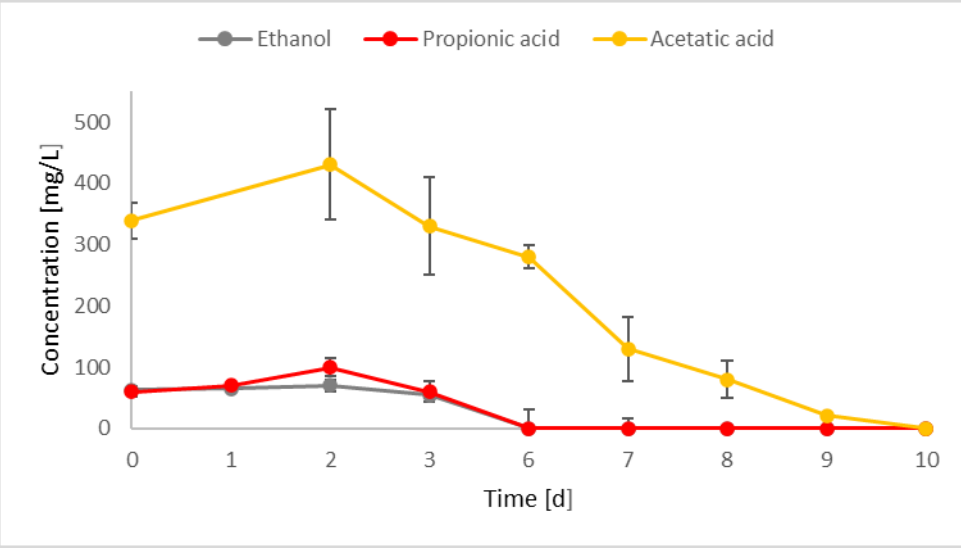
Kim et al., 1994

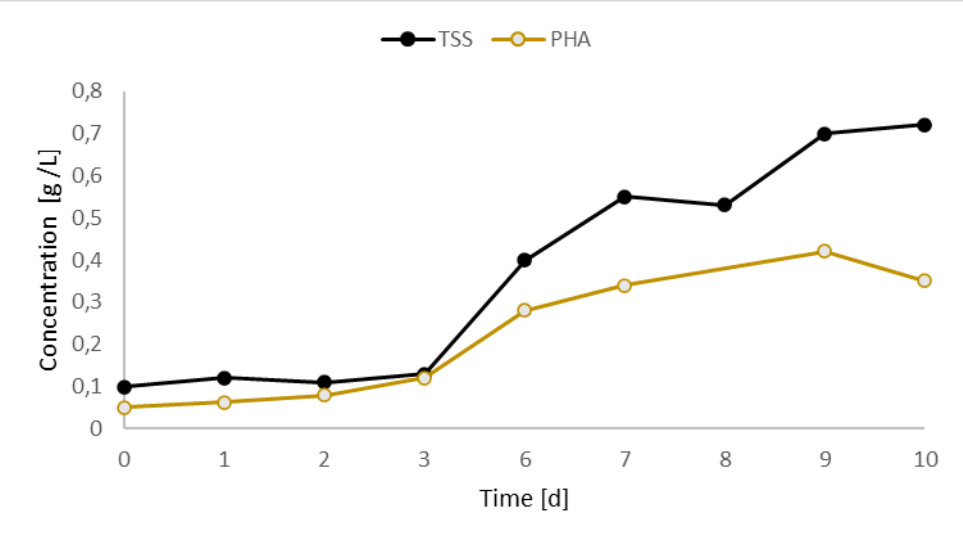
RESULTS: Photo Fermentation



RESULTS: Photo Fermentation







CONCLUSIONS

- DF of cheese whey was effective for the production of DFEs containing propionic acid.
- Mixed cultures were effective both for the DF stage and the PF one.
- PHAs production was satisfactory

FUTURE PERSPECTIVES

- Further enhancement of the propionic acid percentage

$$3CH_3CHOHCOOH \rightarrow 2CH_3CH_2COOH + CH_3COOH + CO_2 + H_2O$$

- Analysis of the PHA structure and properties

- Analysis of microbial communities

ACKNOWLEDGMENTS:

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