MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

Terrestrial valorization of a MELiSSA compartment: Photoheterotrophic production of purple microbial protein on brewery water

Dr. Abbas Alloul
Prof. Siegfried Vlaeminck

TU Delft

Microbial protein, renaissance in the food chain?

N:100
P:100

Fertilizers

N:14
P:14

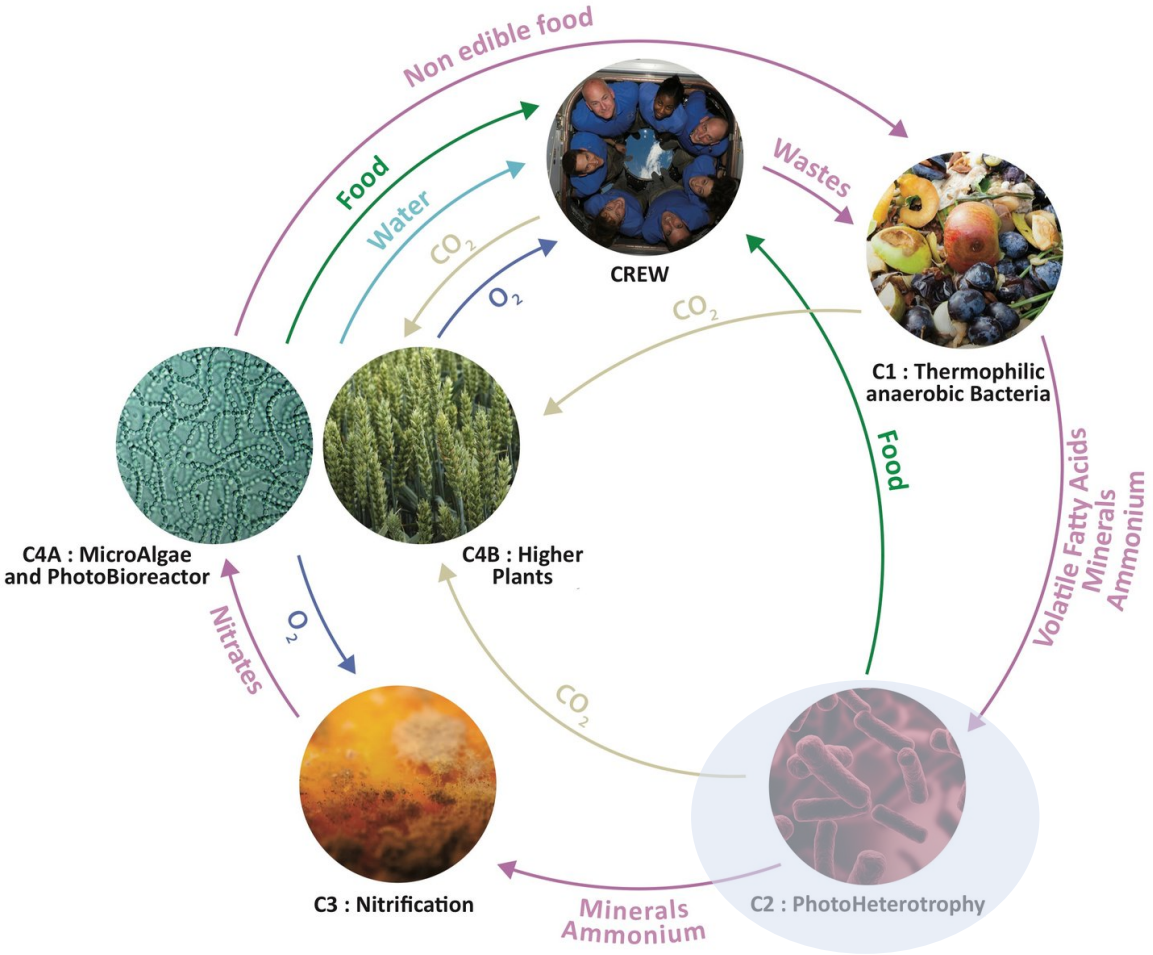
Consumption

Microbial protein
Use of microorganisms for feed or food applications

→ Classical food chain

(Coppens et al., 2016)

C2 MELiSSA


Non edible food
Food
Water
CO_2
O_2
CREW
Wastes
CO_2
C1 : Thermophilic anaerobic Bacteria
Food
Volatile Fatty Acids
Minerals
Ammonium
C4A : MicroAlgae and PhotoBioreactor
C4B : Higher Plants
Nitrates
O_2
CO_2
C3 : Nitrification
Minerals
Ammonium
C2 : PhotoHeterotrophy

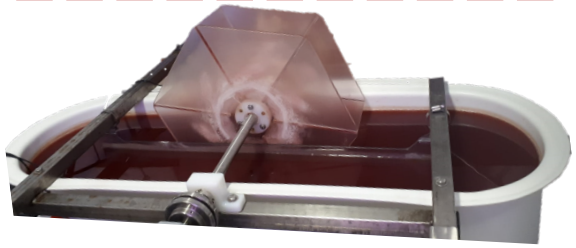
Purple non-sulfur bacteria (PNSB)

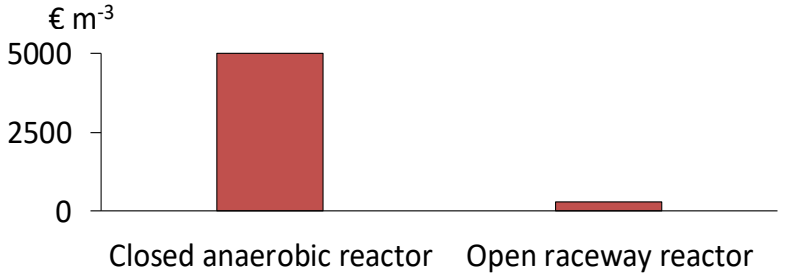
Versatile microbes!

	Photo	Chemo
Auto	Microalgae	Hydrogen oxidizing bacteria
Hetero		Aerobic bacteria Anaerobic bacteria

Closed anaerobic reactor

Open raceway reactor
(limited O_2 entry)





(Acién et al., 2012)

Feeding regime and age as tool

Inoculum
Rhodobacter capsulatus

Medium
Synthetic volatile fatty acid based wastewater

Reactor operation
Sequencing batch

Volumetric loading rate
2.4 vs 4.8 g COD L^{-1} d^{-1}

Age
1.25, 2 and 3 d sludge retention time

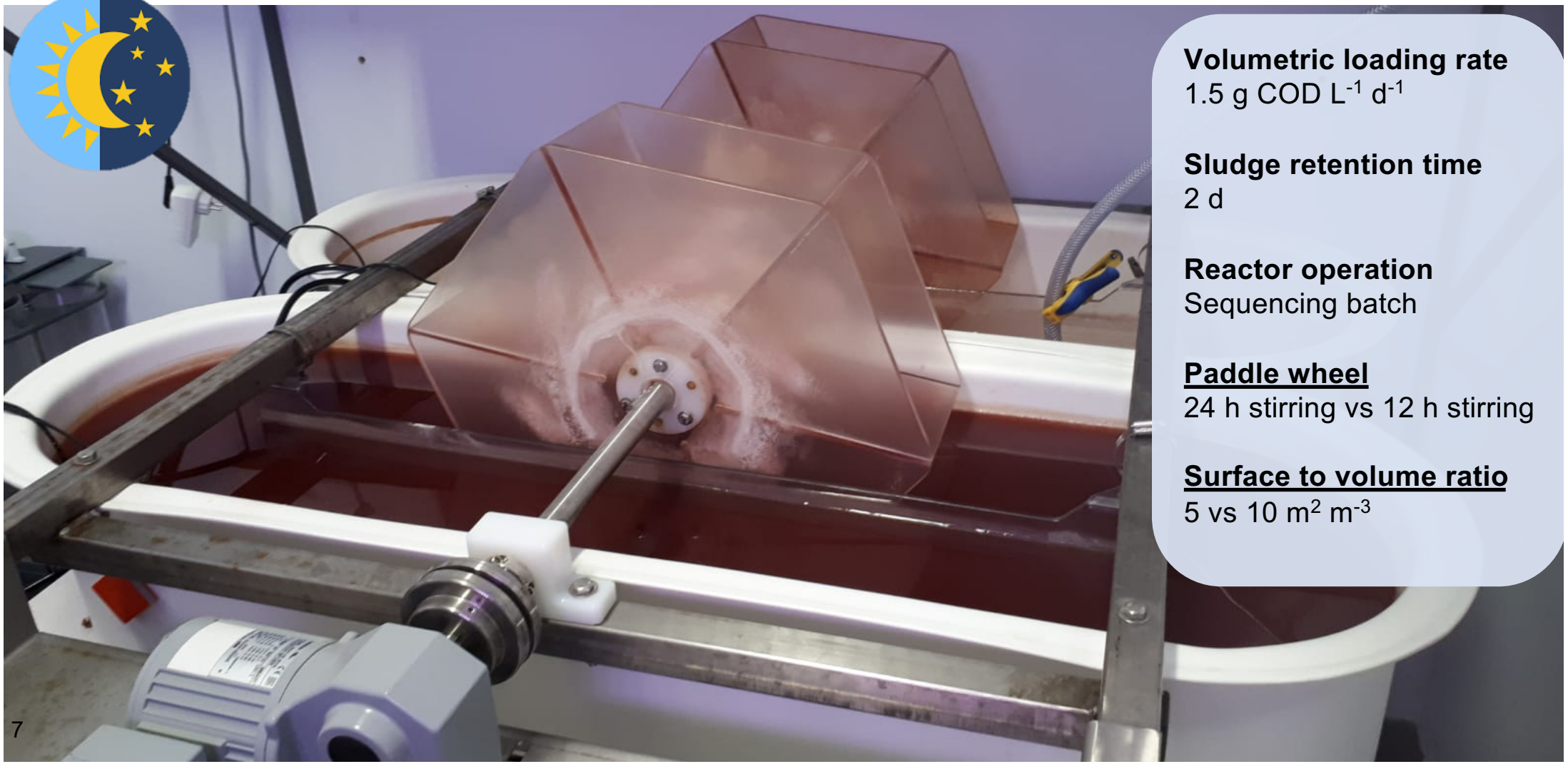
Feeding regime and age as tool

Tool	Rel. abundance PNSB*	Shannon diversity index
Feed bacteria day + night (4.8 gCOD L^{-1} d^{-1})	50%	1.1
Feed bacteria day (2.4 gCOD L^{-1} d^{-1})	88%	0.6
↓ Age (SRT: 2 d)	94%	0.3
↑ Age (SRT: 3 d)	91%	0.4

* 16S rRNA gene sequencing

Alloul et al., 2020 BioRxiv

Oxygen supply and light availability as tool



Volumetric loading rate
1.5 g COD L^{-1} d^{-1}

Sludge retention time
2 d

Reactor operation
Sequencing batch

Paddle wheel
24 h stirring vs 12 h stirring

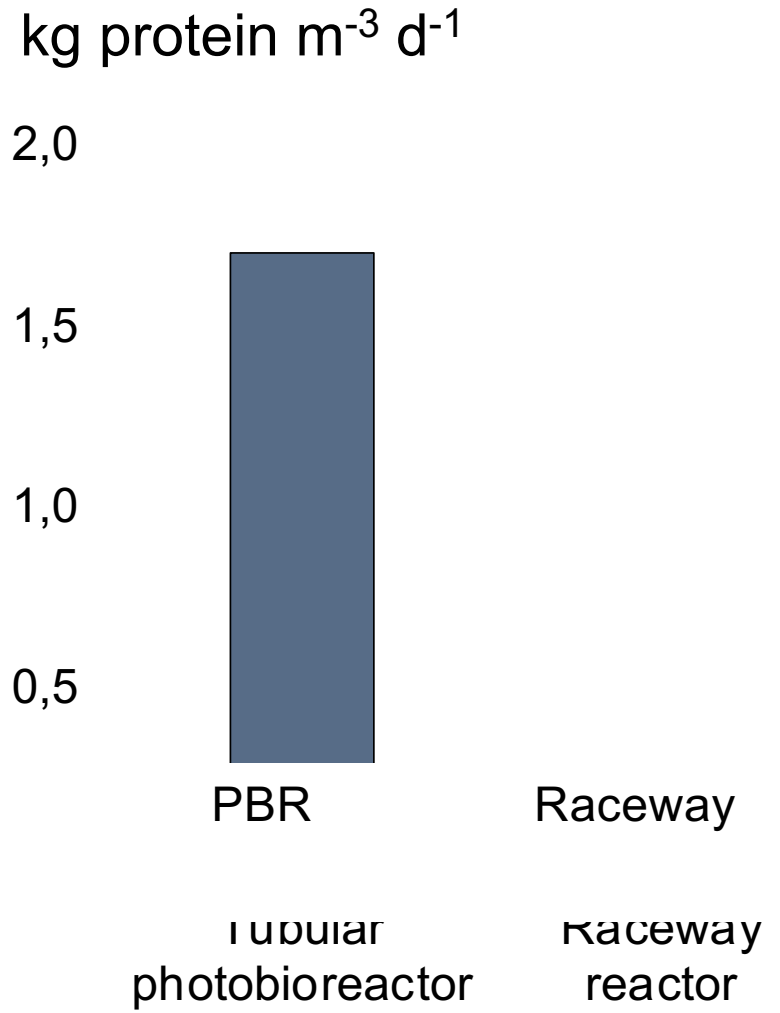
Surface to volume ratio
5 vs 10 m^2 m^{-3}

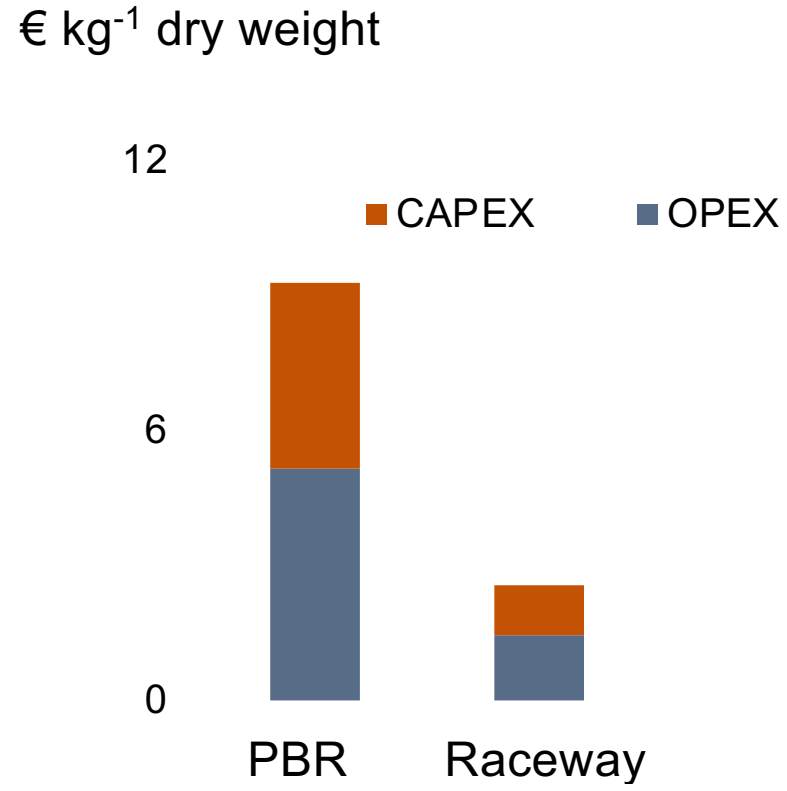
Oxygen supply and light availability as tool

Stirring (on:off)	S:V (m^2 m^{-3})	Rel. abundance PNSB*	Shannon diversity index
24h:0h	5	14%	1.5
12h:12h	5	56%	1.3
24h:0h	10	75%	0.9

* 16S rRNA gene sequencing

Protein productivity & production cost





Take home

Optimal conditions

- Manage loading rate by preventing COD availability during the dark
- Prevent oxygen supply during the night => stop paddle wheel
- Maximize light availability by increasing surface:volume ratio

Performance

- PBR 8 times higher protein productivity than raceway (0.2 kg m^{-3} d^{-1})
- Production cost raceway € 2500 $tonne^{-1}$

- Alloul, A. et al. (2020). Control tools to selectively produce purple bacteria for microbial protein in raceway reactors. *bioRxiv*.
- Alloul, A. et al. (2021). Cocultivating aerobic heterotrophs and purple bacteria for microbial protein in sequential photo-and chemotrophic reactors. *Bioresource Technology*, 124192.
- Alloul, A. et al. (2021). Purple bacteria as added-value protein ingredient in shrimp feed: Penaeus vannamei growth performance, and tolerance against Vibrio and ammonia stress. *Aquaculture*, 735788.

Abbas.Alloul@UAntwerpen.be
A.Alloul@tudelft.nl

Siegfried.Vlaeminck@UAntwerpen.be

Sustainable Energy, Air & Water Technology
University of Antwerp

fwo

Radu Giurgiu

Marta Cerruti

David Weissbrodt