UPCYCLING MICROALGAE SIDE STREAMS FOR BIOPOLYMERS PRODUCTION

C.L. Duarte, J. Fradinho, B.S. Ferreira, J.F.B. Pereira, M.A.M. Reis

NOVA SCHOOL OF SCIENCE & TECHNOLOGY
biotrend experts in bioprocessing
UNIVERSIDADE D COIMBRA
i4HB
UCIBIO @REQUIMTE

10th International Conference on Sustainable Solid Waste Management

21-24 June

Introduction

Materials and methods

Results

Conclusions

- Introduction
- Materials and methods
- Results
- Conclusions

INTRODUCTION

 + CO_2 + Nutrients → 

↓

Lipids

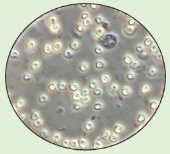
Proteins

Carbohydrates

Pigments

←  ←

Treatment and/or valorization



INTRODUCTION

Polyhydroxyalkanoates (PHAs) → Biocompatible, Biodegradable, Biopolyester

↓

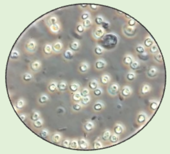
Similar properties to petrochemical plastics (e.g. melting temperature, flexibility, cristallinity)

↓

Used as a substitute for conventional plastic

↓

In line with the context of a circular economy, and EU guidelines for a sustainable bioeconomy for Europe



GOAL

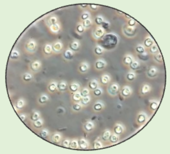
PHA production process:
1. Fermentation of algae based side streams into volatile fatty acids (VFAs)
2. Enrichment of the mixed microbial culture (MMC) with the fermented stream and PHA accumulating organisms
3. PHA accumulation

↓

Valorization of algae-based side streams into PHAs

↓

Acidogenic fermentation batch tests



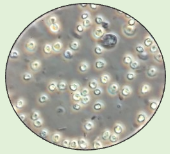
- Introduction
- Materials and methods
- Results
- Conclusions

EXPERIMENTAL SET-UP: BATCH TESTS

Microalgae side streams (A4F – Algae for Future) + Anaerobic sludge inoculum (Mutela WWTP, Portugal) → 2 gVS/gVS (Substrate/inoculum)

Batch test conditions:
pH 5.5
30 ^{o}C
180 rpm
32 days
100 mL serum flasks
Aerated with nitrogen gas

→ pH controlled with a phosphate buffer



EXPERIMENTAL SET-UP: BATCH TESTS

Nannochloropsis

Chlorella

Phototrophic consortium

Organic load: 2.9 gC/L
Strong buffer solution: 1 M

Nannochloropsis

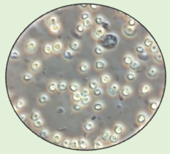
Haematococcus

Organic load: 1.2 gC/L
Weak buffer solution: 0.1 M

↓

Batch tests preformed in triplicate
Control for each algae (no inoculum added)
Control for inoculum (no microalgae added)

Gas phase analysed with GC
Liquid phase analysed with HPLC



Introduction

Materials and methods

Results

Conclusions

RESULTS- FEEDSTOCK CHARACTERIZATION

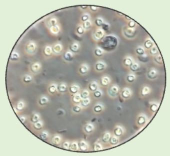
Table 1: Characterization of each microalgae side stream

Feedstock	% Ash	% Protein	% Carbohydrates	% Lipids
Nannochloropsis	8.7 %	26.2 %	13.7 %	51.4 %
Chlorella	10.4 %	22.8 %	25.2 %	41.6 %
Phototrophic consortium	9.9 %	25.9 %	30.3 %	33.9 %
Haematococcus	3.1 %	17.5 %	N/A	N/A

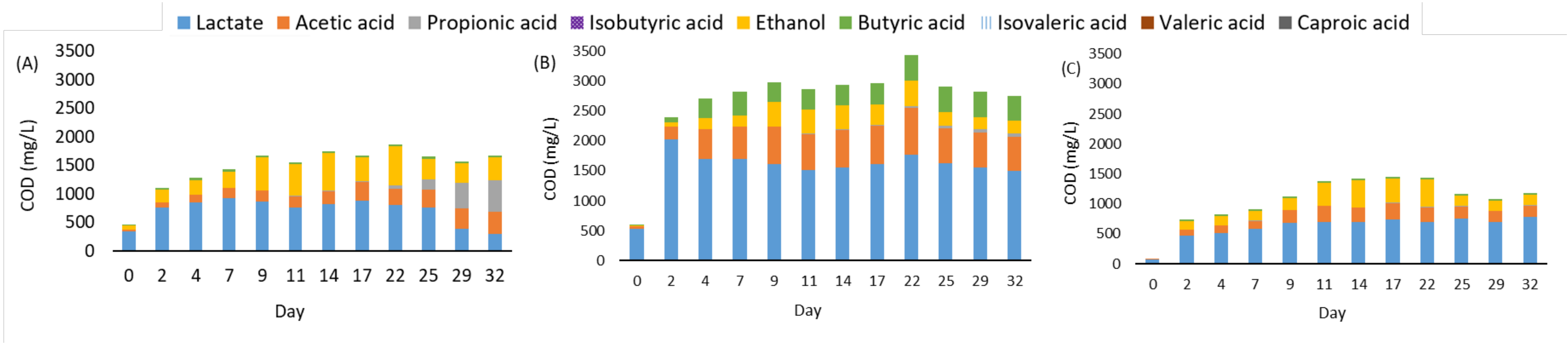
Note: N/A- Not Available

Rich in lipids

Rich in carbohydrates

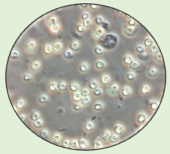


RESULTS- BATCH TEST SET A

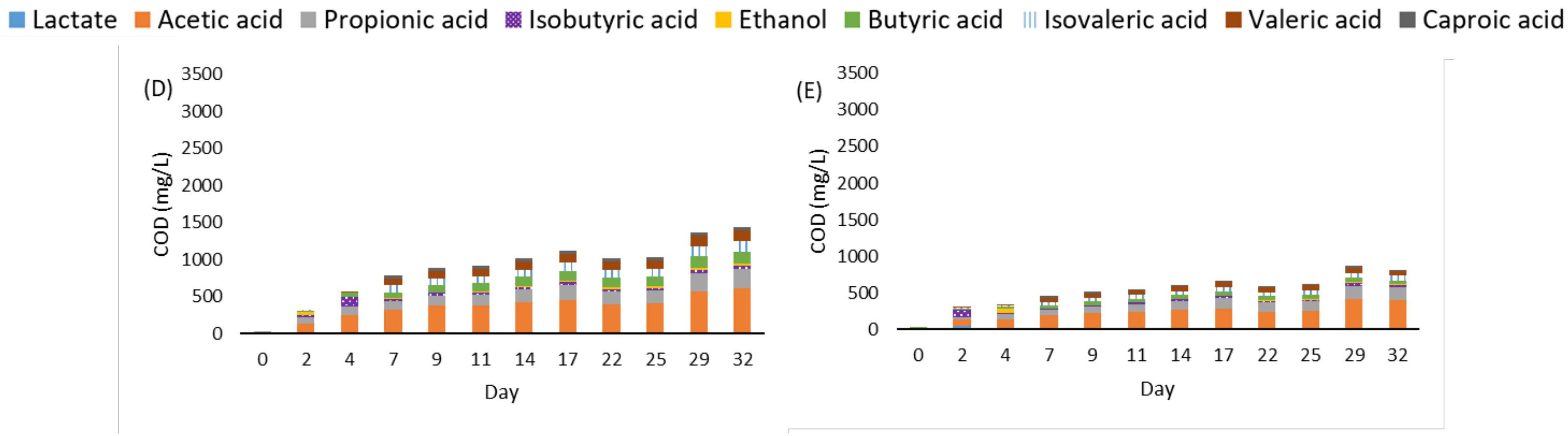


Nannochloropsis *Chlorella* Phototrophic consortium

Figure 1: Results of fermentation products shown as mgCOD/L throughout the experiment. (A). Average results for triplicate experiment of *Nannochloropsis* (set A). (B) Average results for triplicate experiment of *Chlorella*. (C) Average results for triplicate experiment of phototrophic consortium.



RESULTS- BATCH TEST SET B



Nannochloropsis   *Haematococcus*

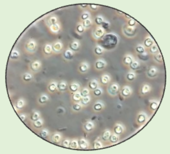


Figure 2: Results of fermentation products shown as mgCOD/L throughout the experiment. (A). Average results for triplicate experiment of *Nannochloropsis* (set B). (B). Average results for triplicate experiment of *Haematococcus*.

RESULTS- BATCH TEST CONTROL

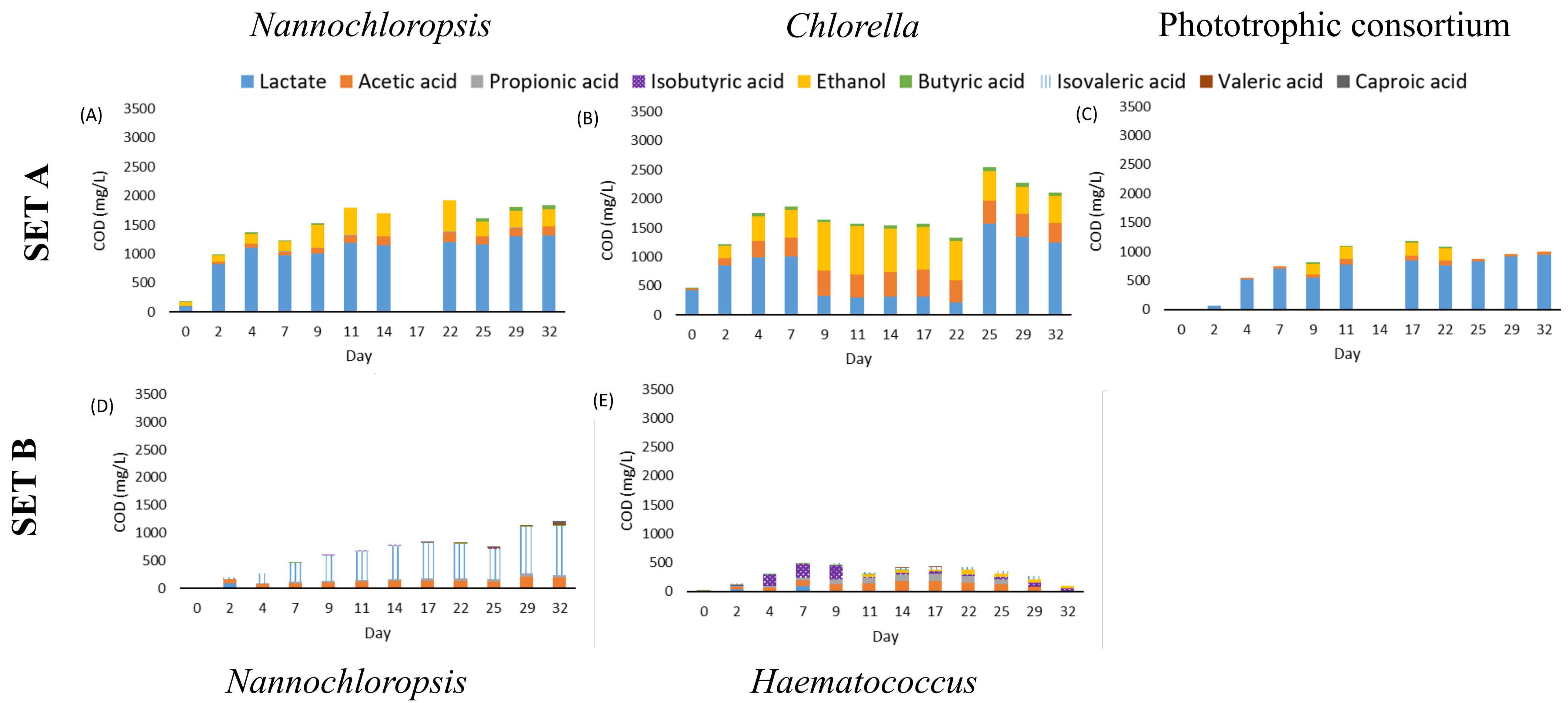
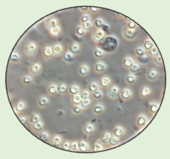


Figure 3: Results of fermentation products of controls shown as mgCOD/L throughout the experiment. (A). Results of *Nannochloropsis* control experiment, results of day 17 not available (set A). (B) Results of *Chlorella* control experiment. (C) Results of phototrophic consortium control experiment, results of day 14 not available. (D) Results of *Nannochloropsis* control experiment (set B). (E) Results of *Haematococcus* control experiment.



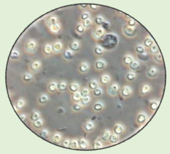
RESULTS- BATCH TESTS

SET A- Overall yield
$gC_{produced}/gC_{in}$

Nannochloropsis: 17.7 %
Chlorella: 37.7 %
Phototrophic Consortium: 13.9%

SET B- Overall yield
$gC_{produced}/gC_{in}$

Nannochloropsis: 42.5 %
Haematococcus: 21.0 %



Introduction

Materials and methods

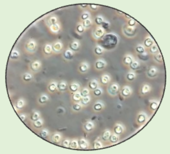
Results

Conclusions

CONCLUSIONS

Fermentation batch tests:

- *Nannochloropsis* with low organic load showed highest yield of 42.5 % ($gC_{produced}/gC_{in}$)
- Best production with the feedstock with lower content in carbohydrates and higher content in lipids
- Lower organic load and lower phosphate buffer solution favours a higher production and variety of VFAs
- Pre-treatments are being assessed



Thank you for your attention

ANY QUESTIONS?

PACTO DA BIOECONOMIA AZUL

PRR Plano de Recuperação e Resiliência

REPÚBLICA PORTUGUESA

Financiado pela União Europeia NextGenerationEU

PROJETO Nº C644915664-00000026

The authors acknowledge FCT for PhD Grant PRT/BD/152855/2021 and UCIBIO and i4HB. This work was financially supported by Project Pacto da Bioeconomia Azul – PBA, Ref. C644915664-00000026 –financed under Invitation Notice n.º 02/C05-i01/2022 regarding the development of projects within the scope of the Mobilizing Agendas for Business Innovation, framed and financed under component n.º 5 - Capitalization and Business Innovation of the Recovery and Resilience in Portugal.