Maximum fucoxanthin and lipid production by *Tisochrysis lutea* at lab and pilot scale

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WAGENINGEN UNIVERSITY & RESEARCH

Bioprocess Engineering

ALGAEBIOMASS SUMMIT 2020
VIRTUAL CONFERENCE · AUG 12 - OCT 2

AlgaePARC™

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Maximum fucoxanthin and lipid production by *Tisochrysis lutea* at lab and pilot scale

1. **MAGNIFICENT fucoxanthin and lipid production**

2. **Fucoxanthin and lipid production at lab and pilot scale**

MAGNIFICENT

Microalgae As a Green source for Nutritional Ingredients for Food/Feed and Ingredients for Cosmetics by cost-Effective New Technologies

Coordinator

Prof. Maria Barbosa

Project Manager

Hans Reith

Grant agreement ID: 745754
Budget: 5.89 M€
Project duration: 1-6-2017 | 31-11-2021

https://magnificent-algae.eu/

Context and Objectives

- MAGNIFICENT overview
- MAGNIFICENT fucoxanthin and lipid production

WP 1
Algae cultivation and harvesting

WP 2
Ingredient production, chain integration and validation

WP 3
Product development and formulation, regulatory framework

WP 4
Value chain techno-economic assessment, socio-economic assessment and LCA

+ all partners

WP5
Market and business assessment, IPR management, exploitation, communication and dissemination

+ all partners

WP 6 Project management

+ all partners

WP 7 Ethics Requirements

+ all partners

MAGNIFICENT Consortium

NO.	Participants	Country
1	WU	Netherlands
2	WFBR	Netherlands
3	FRAUNHOFER	Germany
4	NECTON	Portugal
5	Allmicroalgae	Portugal
6	SPAROS	Portugal
7	ERDYN	France
8	ALGADES	Spain
9	MadeBiotech	Portugal
10	NAREC	United Kingdom
11	AST	France
12	IMENZ	Netherlands
13	N-ZYME	Deutschland
14	NATAC	Spain
15	TRC	France

Context and objectives

Expand the range of algae-based commercial products

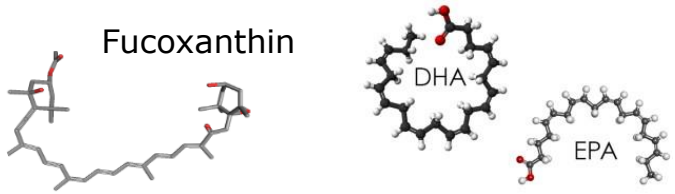
and their market volume in a sustainable manner

Cultivation and Harvesting

Sustainable Ingredients production

End-product formulation & Applications

❖ Fucoxanthin and omega-3 fatty acids (EPA/DHA)



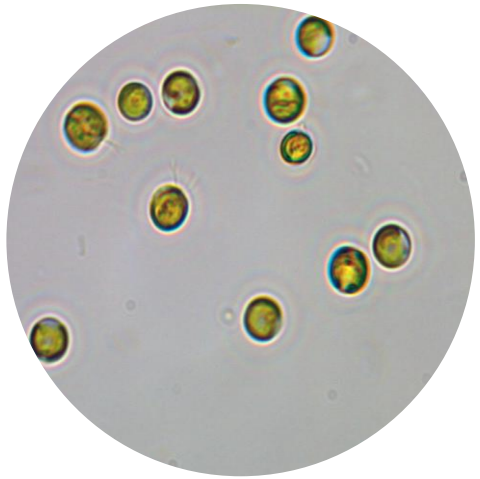
- Food
- Feed
- Cosmetic
- Pharmaceuticals

The global fucoxanthin market is projected to be nearly **700 tons** annually by 2022.
The global EPA/DHA (Omega 3) ingredients market is expected to exceed USD **5.7 billion** by 2026.

Nannochloropsis oceanica (***EPA*** , ***Phospholipids***)

Phaeodactylum tricornutum (***EPA***, ***Fucoxanthin***)

Tisochrysis lutea (***DHA***, ***fucoxanthin***)



❖ From laboratory to industry

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Tisochrysis lutea: **current max. fucoxanthin 2.7% DW; total lipids 33.9% DW; DHA 4.9% DW.**

WP 1
Algae cultivation
and harvesting

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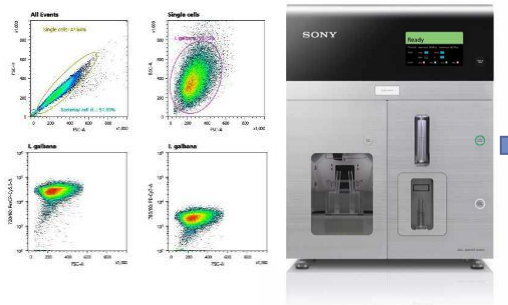
FOOD & BIOBASED RESEARCH WAGENINGEN UR

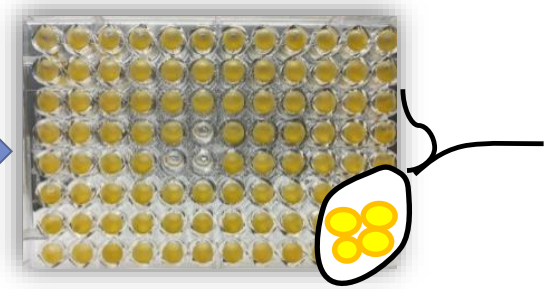
Allmicroalgae

Tisochrysis lutea

1. Process optimization



2. Fluorescence-activated cell sorting (FACS)



3 Robust cell with high yield of fucoxanthin

AlgaePARC

Netherlands

4. Outdoor cultivation at pilot scale (AlgaePARC)

necton

Portugal

5. Industrial fucoxanthin production

WP 2
Ingredient production, chain integration and validation

AlgoSource · IMENZ · Fraunhofer IGB · NATUREXTRACTS · WAGENINGEN UR · madebiotech

WP2

Antioxidants
Fucoxanthin *
β-glucans
PUFA & Phospholipids*
Bioactive peptides
Residual biomass

- Biomass Refining
- Comparison wet and dry routes
- Provide fractions for formulation

NATUREXTRACTS · madebiotech — Portugal

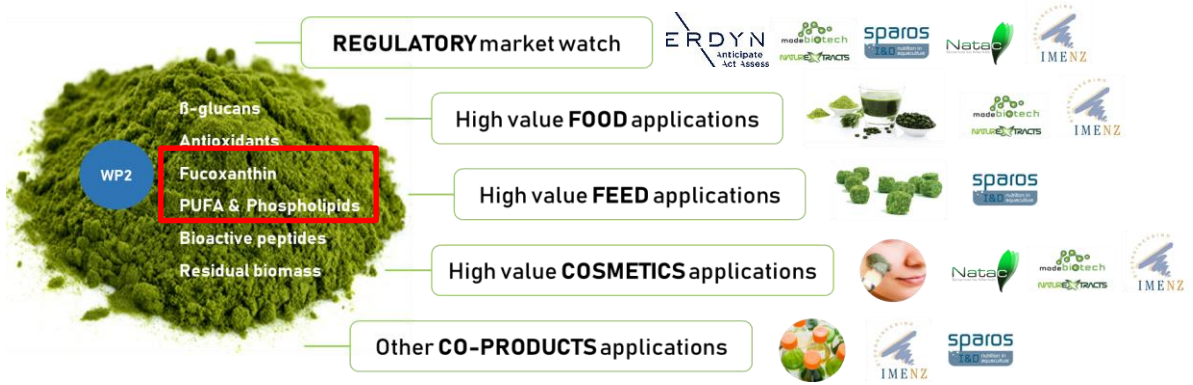
Supercritical CO_2 Extraction

WP3

WP 3
Product development and formulation, regulatory framework

sparos I&D nutrition in aquaculture · madebiotech · NATUREXTRACTS · Natac · IMENZ

- Formulation for different applications
- Product development



sparos I&D nutrition in aquaculture

Microalgal feed

sole larvae

In vivo nutrition trials

WP 4
Value chain techno-economic assessment, socio-economic assessment and LCA

algades

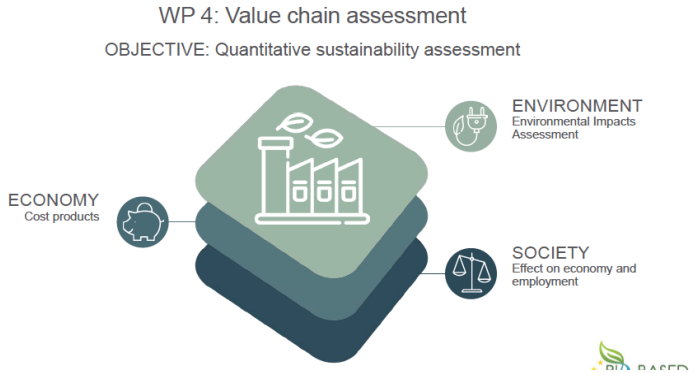
narec distributed energy

TOTAL

+ all partners

WP4

- Quantitative evaluation of new process on:
  - Economics
  - Environment
  - Social
- Comparison with existing processes
- Projections



WP5

- Support and ensure commercial implementation
- Safety and quality of product in line with EU legislation
- Exploitation: IPR management, communication and dissemination

Market and business assessment, IPR management, exploitation, communication and dissemination

ERDYN Anticipate Act Assess

WAGENINGEN UR For quality of life

+ all partners

Fucoxanthin and lipid production at lab and pilot scale

❖ Process optimization at lab scale

Parameters: Light, temperature, dilution rate

Cultivation mode: batch and continuous chemostat

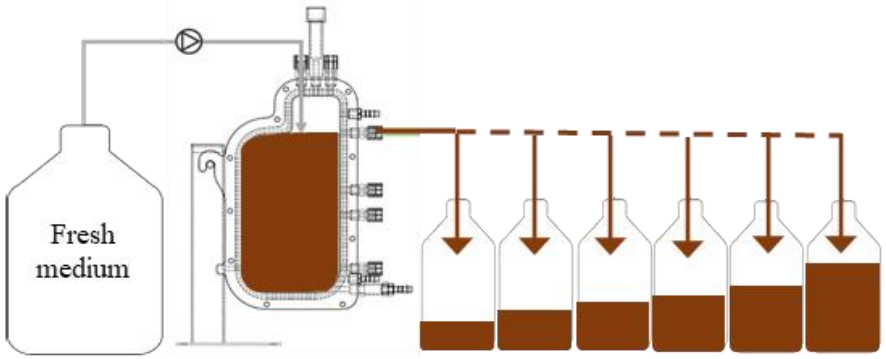
Max. fucoxanthin content: 16.39 mg/g (50 µmol m^{-2} s^{-1}, dilution rate 0.47 d^{-1}, 30 °C)

Max. productivity: 9.81 mg L^{-1} d^{-1} (300 µmol m^{-2} s^{-1}, dilution rate 0.80 d^{-1}, 30 °C)

Batch light & temperature optimization

16.5-30 °C 50-500 µmol m^{-2} s^{-1}

Continuous chemostat dilution rate optimization
Highest ever reported fucoxanthin productivity 9.81 mg L^{-1} d^{-1}



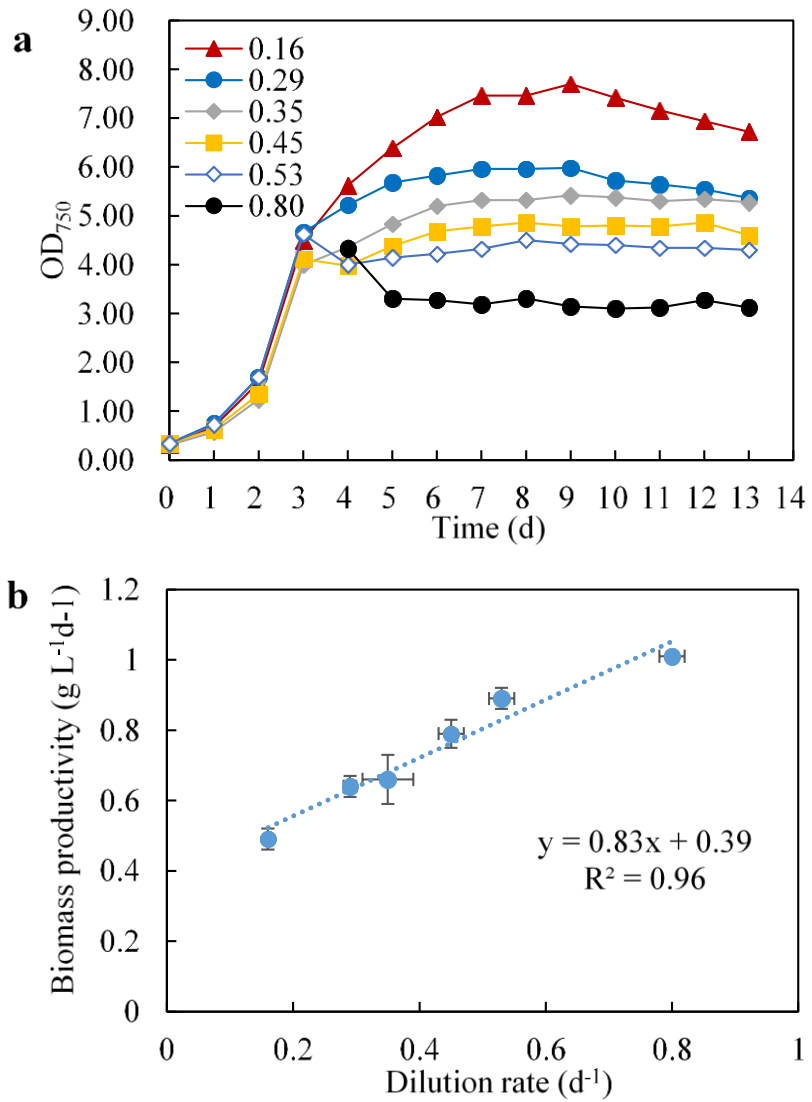
Algaemist Dilution rate 0.16-0.8 d^{-1}

Continuous chemostat light optimization
Highest fucoxanthin content 16.39 mg/g

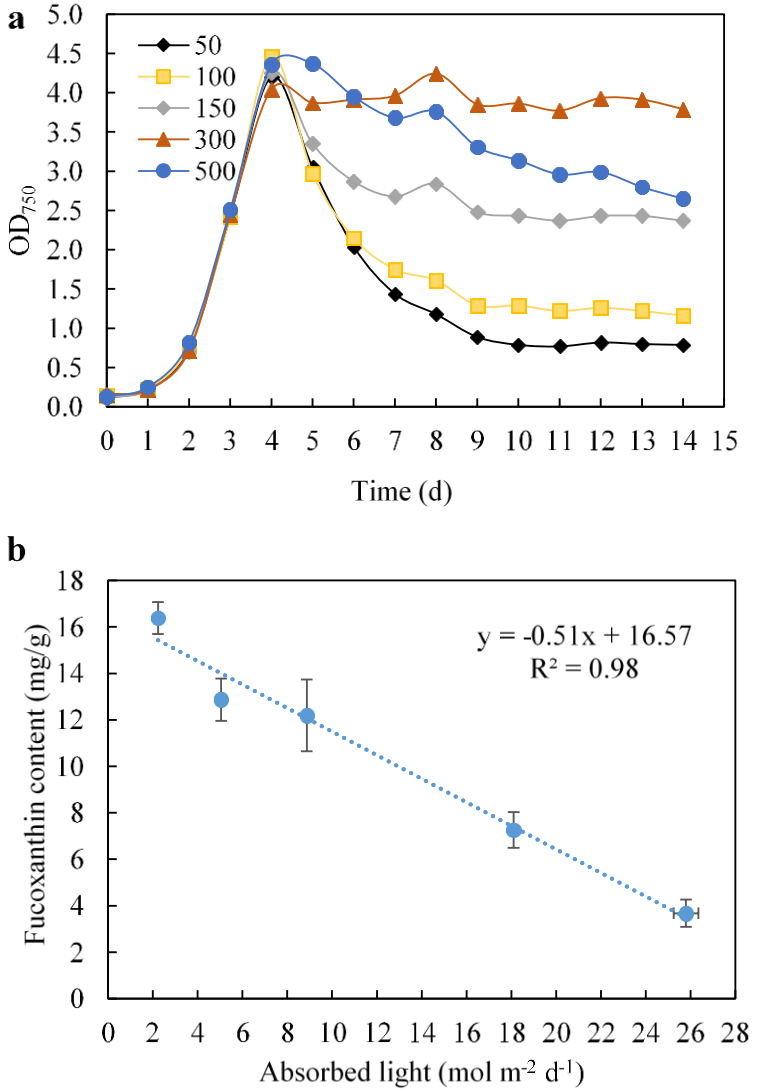
Light intensity 50-500 µmol m^{-2} s^{-1}

Gao, F., Teles, I., Wijffels, R. H., & Barbosa, M. J. (2020). Process optimization of fucoxanthin production with *Tisochrysis lutea*. Bioresource Technology, 123894.

Process optimization using continuous chemostat experiments



Dilution rate from 0.16-0.80 d^{-1}



Light intensity from 50-500 µmol m^{-2} s^{-1}

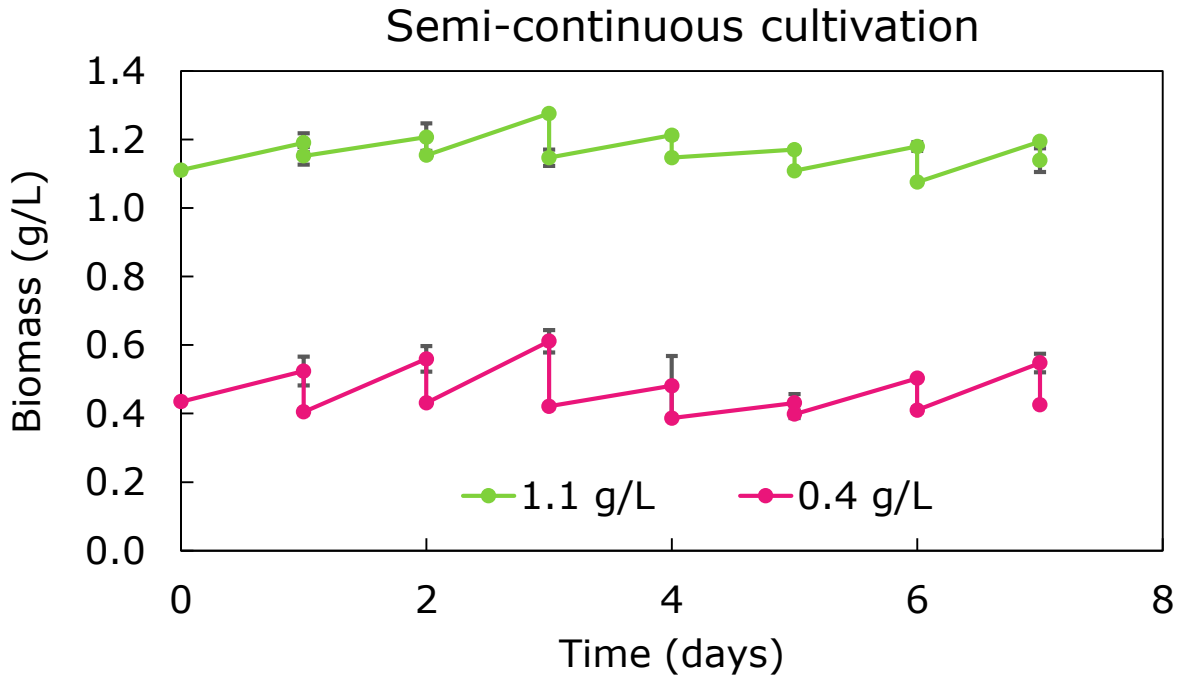
❖ Outdoor fucoxanthin and lipid production at pilot scale

Reactors (biomass 1.1 g/L)
Fx content 18 mg/g DW
Fx productivity 2 mg L^{-1} d^{-1}
Lipid productivity 17 mg L^{-1} d^{-1}
DHA productivity 3.2 mg L^{-1} d^{-1}

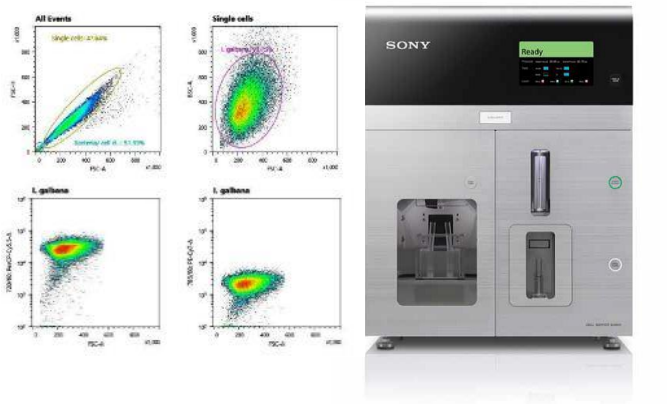
Reactors (biomass 0.4 g/L)
Fx content 14 mg/g DW
Fx productivity 2.4 mg L^{-1} d^{-1}
Lipid productivity 32 mg L^{-1} d^{-1}
DHA productivity 5.7 mg L^{-1} d^{-1}

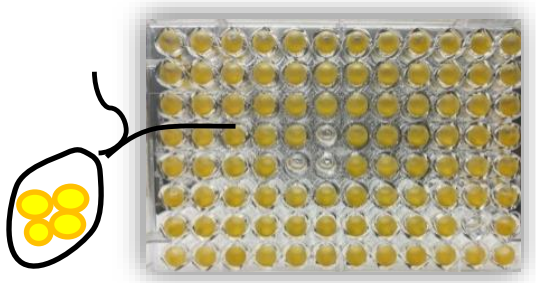
AlgaePARC™

- ✓ High biomass concentration results in high fucoxanthin content.
- ✓ Low biomass concentration results in high fucoxanthin, lipid and DHA productivities.



❖ Strain improvement for fucoxanthin and lipid production using fluorescence-activated cell sorting (FACS)





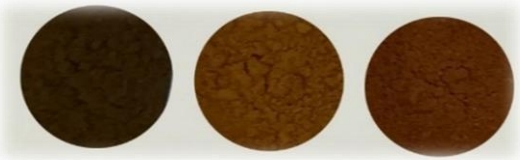
AlgaePARC™

necton

FACS ➡ Single-cell ➡ Lab/pilot/industrial cultivation

Conclusions

- ***Tisochrysis lutea*** **is a promising microalgal species for fucoxanthin and lipid production.**
- **Fucoxanthin and lipid productivity can be improved by process optimization.**
- **FACS opens new possibilities for high-fucoxanthin/lipid cells selection.**



We, MAGNIFICENT team, are working together for expanding the range of algae-based commercial products and their market volume.

Acknowledgement

MAGNIFICENT

https://magnificent-algae.eu/

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Magnificent Algae

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Thank you very much for your attention!

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