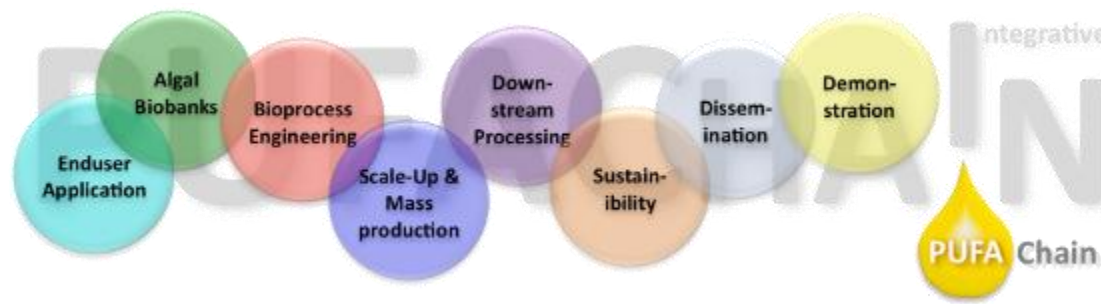


PUFAChain - a value chain from algal biomass to lipid-based products



Thomas Friedl, Stefan Durm, Anastasiia Kryvenda

Congress – Innovations from biomass, Papenburg, Germany,
June 18 2015



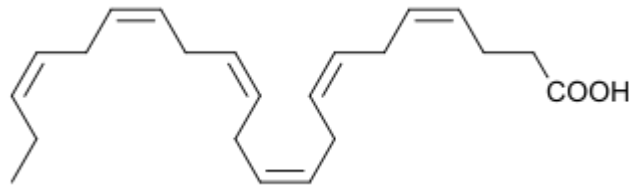
Project Objectives

High-value products from algae: a complete value chain for the industrial development

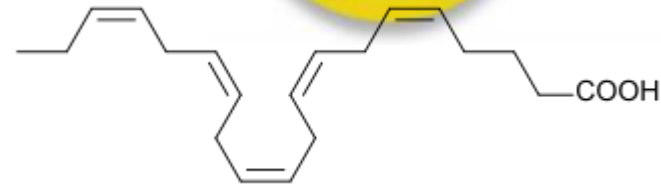
- high purified omega 3 fatty acids (DHA/EPA) for nutrition and pharmaceutical applications
- from selection of algal strains, feedstock production and harvesting to oil extraction and purification

What are PUFAs?

Poly Unsaturated Fatty Acids



all-cis-
4,7,10,13,16,19-docosahexaenoic
acid (**DHA**) or 22:6(n-3)



all-cis-
5,8,11,14,17-eicosapentaenoic
acid (**EPA**) or 20:5(n-3)



Increasing significance of omega-3 polyunsaturated fatty acids

- maintaining heart health
- protective properties against cancer and birth defects
- may offset symptoms of diabetes, arthritis and even neurological diseases

What are PUFAs?



Omega-3 fatty acids: *essential* fatty acids

- cannot be synthesised by the human body, must be supplied in the diet

conventional sources so far

- mainly obtained from cold water fish oil, but ...
- concentration of EPA/DHA in fish oil varies considerably, depending on location, annual season and availability of phytoplankton



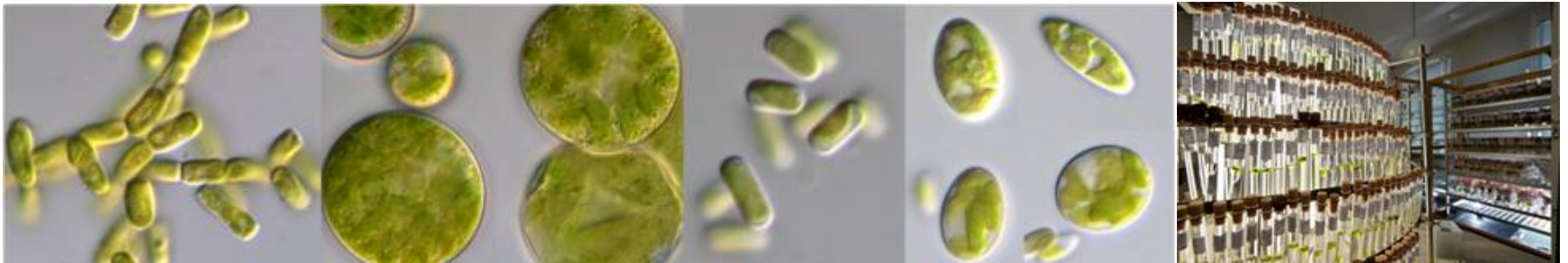
... the better choice: PUFAs from microalgae

- forming feed for other marine life
- sustainability and reliability: culturable
- no competition with agriculture



Designed conditions of cultivation process

- high purity: algal strains provide different acids much more selectively
- facilitates further isolation and purification of target products
- avoiding contaminants like heavy metals and other unwanted by-products



Project Overview

now month **20** out of 48



Project title	PUFACHain – The Value Chain from Microalgae to PUFA
Call	KBBE.2013.3.2-02: The CO ₂ Algae Biorefinery
Grant Agreement No	613303
Duration	48 months
Start	1 st November 2013
End	31 st October 2017
Partners	9 partners / 4 countries
Total costs	7,149,939.60 Euro
EU contribution	5,124,066.00 Euro

Partner Structure



Provision of algal strains, growth experiments; Coordinator



CREMER
Oleo Division

Lipid analysis
Usage of extracted PUFAs



Provision of algal strains, growth experiments



Upscaling and production of algal biomass



Oil extraction from algal biomass

Coordination together with UGOE



Filtering of algal biomass

Sustainability, eg. Life Cycle Assessment



WAGENINGEN UR
For quality of life

10 Work Packages



WP1 Administration:

e.g., Communication and coordination, Financial and administrative management of the project

WP10 Dissemination

e.g., project specific database, web site, newsletter



Work Packages



WP2: Specifications and Scientific Coordination

e.g.,

- Specification of suitable algae species
- accurate quantification of the products of interest: EPA and DHA
- validation of internal methodologies for the determination of
(1) total lipid content and (2) the lipid profile in microalgae samples
- conditions of cultivation, harvesting, relevant by-products



Work Packages

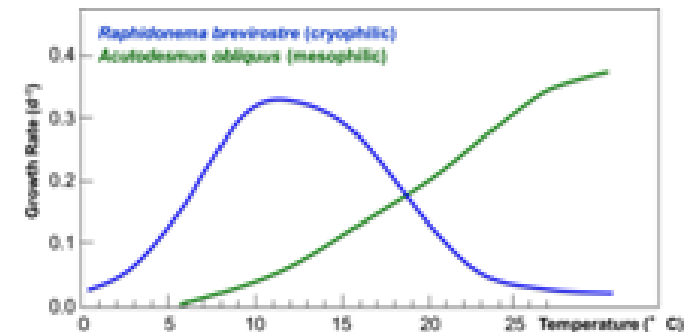


WP3: Biology

Two bioresources, SAG (UGOE) and CCCryo (Fraunhofer)

e.g.,

- Optimization of pre-selected strains from the SAG culture collection (incl. genetic characterization and cryopreservation)
- Optimization of microalgae from Polar regions (Algal Crop Rotation principle)



2278 strains available to the public

1238 algal species, and additional strains:

- ~ 300 strains currently awaiting accession
- ~ 800 unidentified strains obtained through collaborations and own research projects



Fatty Acid Profiles from 2071 strains of SAG culture collection

PUFA preselection of strains



	no. of strains	DHA 22:6n-3	EPA 20:5n-3	ARA 20:4n-6	
Cyanobacteria	223	1.7	0.7	0.3	
Glaucophyta	15		2.5	1.9	
Chlorophyceae	927	38.6	24.1	29.9	
Trebouxiophyceae	253	2.3	6.1	7.6	
Ulvophyceae	70	0.6	0.9	0.8	
prasinophytes	21	1.7	1.8	2.4	
Streptophyta	159	0.6	5.7	5.4	
Rhodophyta	78		14.5	15.1	
Euglenozoa	131	33.0	14.3	18.1	
Bacillariophyceae	18	2.3	1.8	0.5	
Xanthophyceae	81	2.3	14.5	11.6	
Eustigmatophyceae	17		2.7	1.6	
other Stramenopiles	24	1.4	2.6	3.7	
Haptophyta	13	6.3	1.4	0.3	
Cryptophyta	27	3.4	4.3	0.3	
Dinophyta	14	6.3	1.4	0.5	
	2071	8.5 (176)	21.2 (440)	17.9 (371)	47.7 (987)
DHA and EPA		29.7 (616)			
DHA, EPA and/or ARA	47.7 (987)				
only other FAMES	52.3 (1084)				

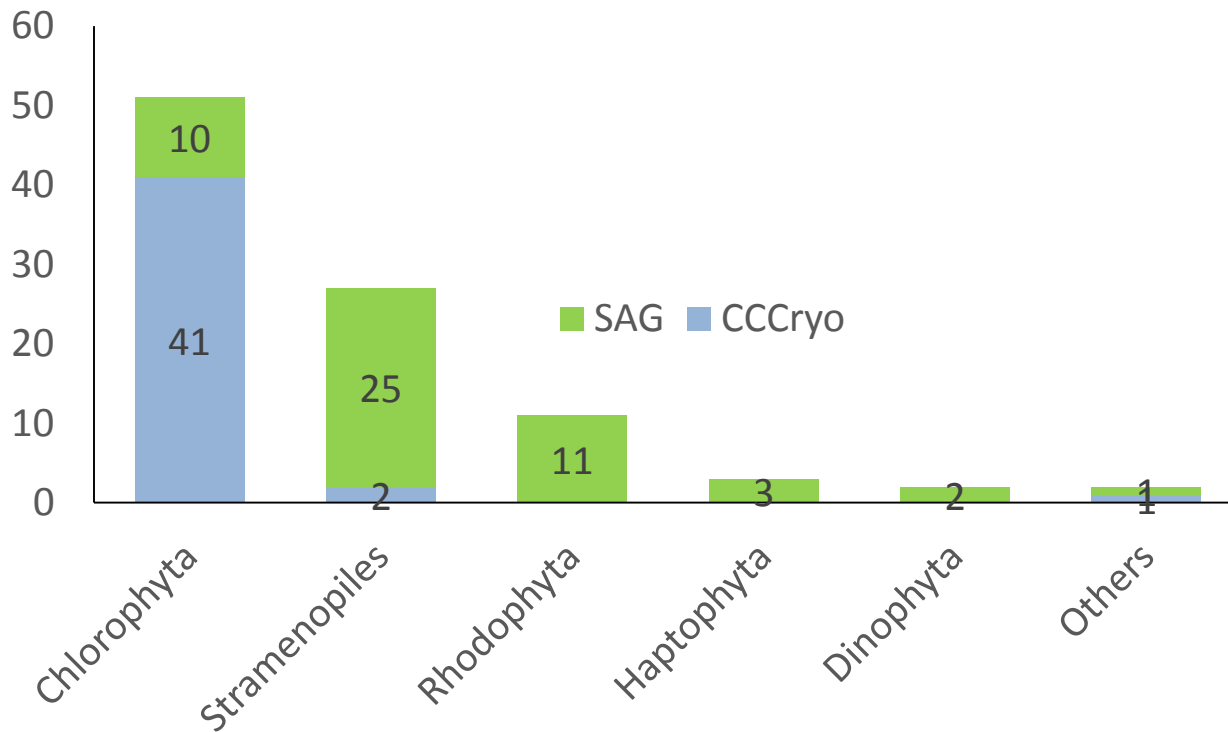
WP 2 and 3:

The initial list of algae strains - 96 strains

(52 strains from SAG, 44 strains from CCCryo)



PUFA preselection of strains



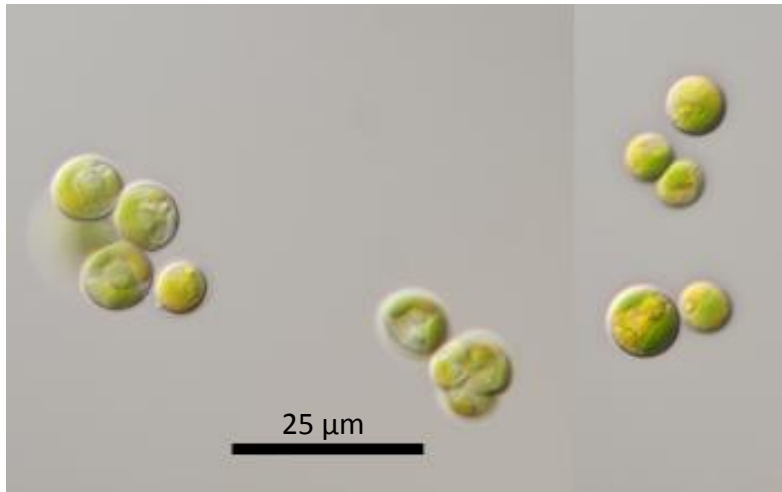
Optimization of PUFA yields



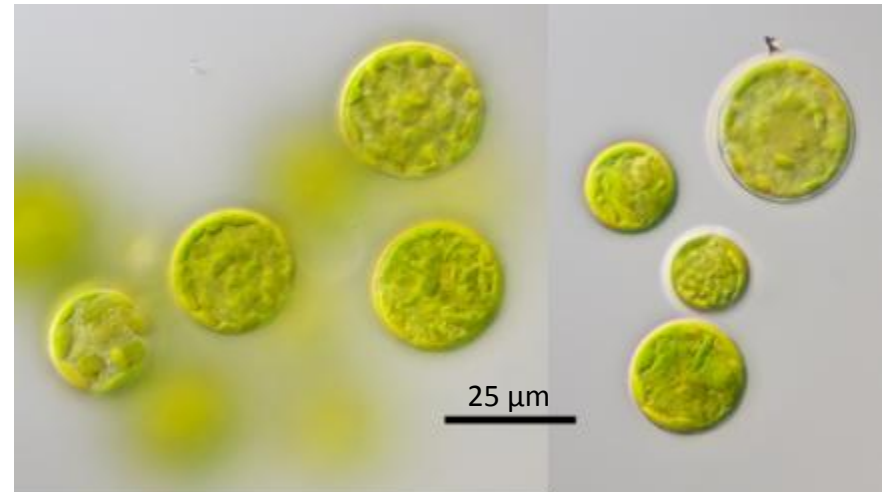
WP 2 and 3: ... and the winners are (so far)



EPA only: various unicellular Eustigmatophyceae (freshwater or terrestrial)
Stramenopiles *incertae sedis* (one strain)
cryptotolerant diatoms (two strains, but with some ARA)



unicellular eustigmatophyte



unicellular Stramenopiles *incertae sedis*

WP 2 and 3: ... and the winners are (so far)



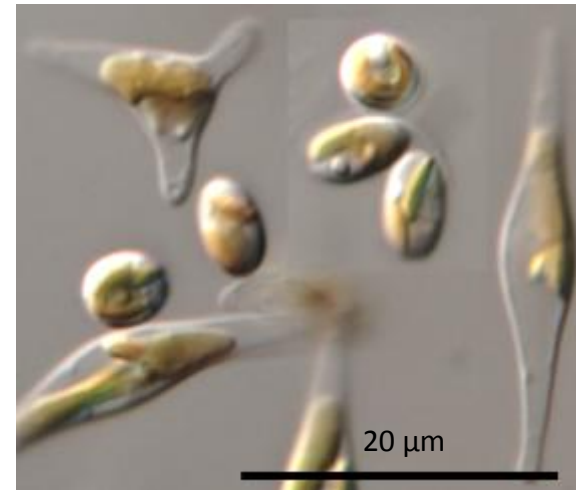
EPA and DHA in almost equal relations:

a Dinoflagellate

Phaeodactylum tricornutum (as control)



Marine dinoflagellate

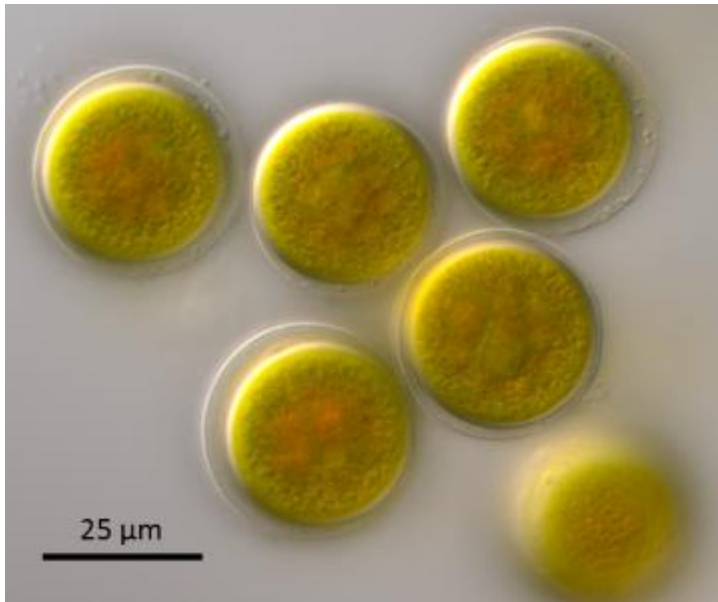


Phaeodactylum tricornutum

WP 2 and 3: ... and the winners are (so far)



DHA only: still missing, but a group of coccoid Chlorophyceae identified as promising; also cryotolerant



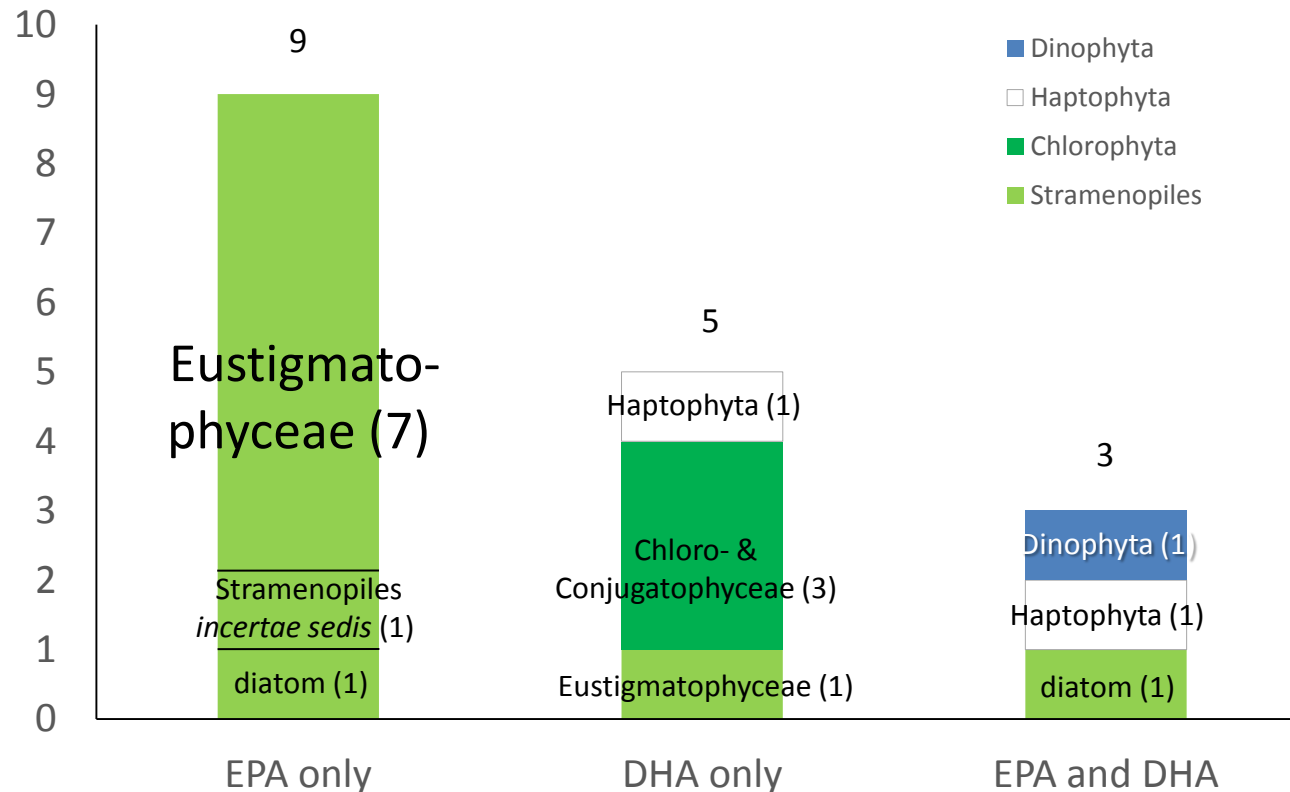
Unicellular chlorophyte,
isolated from soil crust

WP 2 and 3:

...the 22 strains to continue with:



PUFA yield optimization and biomass production

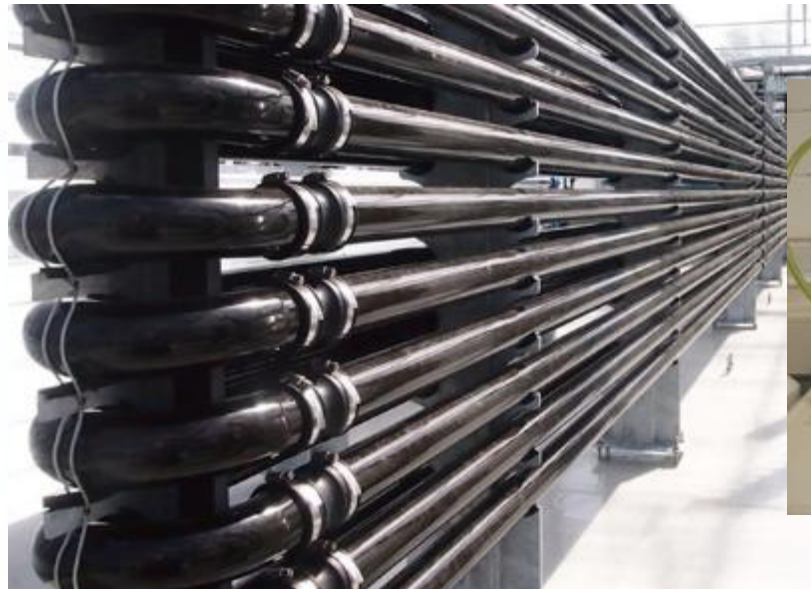
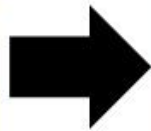


Work Packages



WP4: Bioprocess Engineering

Case studies on three microalgae, now:
upscaling tests with 6 strains from SAG



Upscaling



Phaeodactylum cornutum SAG 1090-6

Filtering Testplant

MAHLE

Work Packages



WP5: Industrial production (month 27)

- Future industrial facility for microalgae biorefining: location, pre-engineering project for its construction, business plan

WP6: Downstream

- **Cell disruption and crude oil extraction**
so far: liquid propane for the crude oil extraction from wet algal biomass

Work Packages



WP7: Product Formulation (month 24)

e.g., Chemical characterization of final crude alga oil,
Separation of DHA and EPA

Work Packages

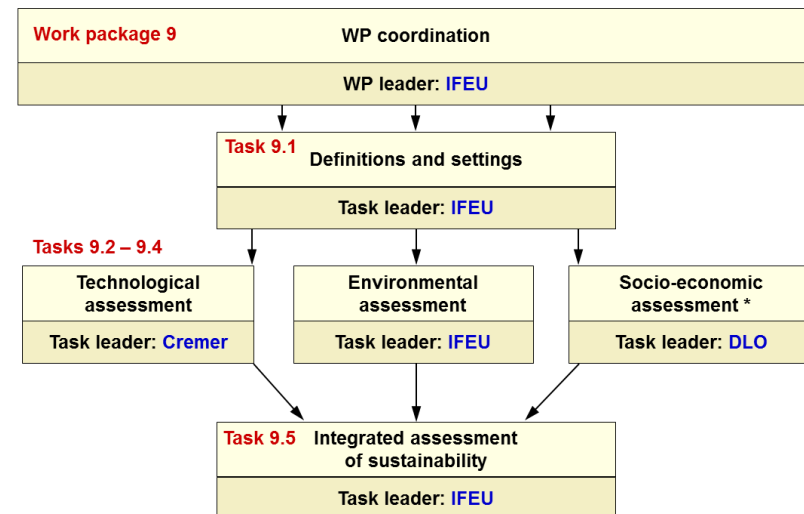
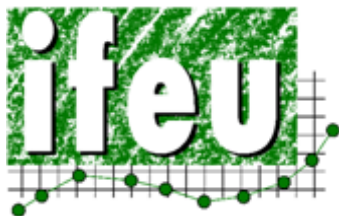


WP8: Demonstration (start in month 24)

e.g., Design, control and arrange modifications of demonstration plant

WP9: Sustainability

e.g., life cycle assessment, technological, environmental and technological assessments





Next Steps

- Optimization of PUFA yield: growth experiments
- Optimization of methodologies for the fatty acid determination
- Additional photobioreactor trials with the samples that had been hard to cultivate
- Provision of more partners with microalgae samples (upscaling, filtering, extraction)
- Filtration trials at pilot scale
- Analysis of various cell disruption processes
- Genetic characterization of strains



PUFA Chain
... is also a lot of fun



Thank you
for your attention !

