ecoduna

Overview

- Ecoduna – who we are
- Microalgae production systems
- The ecoduna technology
- Building a 1ha industrial pilot plant
- The harvesting system
- 365 days – data and experiences
- Downstream processing
- Outlook

Wo we are

ecoduna AG / eparella GmbH

- Team of 25 people
- 700 owners

- proprietary technology
- R&D and pre-industrial algae production
- Expertise in all relevant areas
- Since 2010

History

- 2007: the idea – ‘the hanging gardens’
- 2010: PHOBIOR (EC ECO-Innovation project)
  - Ecoduna founded & First financing by a group of 13 enthusiasts
- 2011 & 2013 selling of plants in DK and DE
- 2012 R&D facility operational
- 2015 Technology change & change of goal
- 2017 Start of construction of industrial pilot plant
- 2018 Start of industrial production

Microalgae production systems

- Open ponds
- Raceway ponds
- Raceway cascades
- Plastic V-bags[c]
- Green wall technology[c]
- Horizontal closed stems [c]
  - Plastic tubing
  - Glass tubes
- Flat panel
- Bubble column

other providers of PBR Technology:

- [c] closed: IGV, Subitec, GF, A4F, Novagreen, Phytolutions;
- open: various developments

Evolution

- First idea 2007

- first concepts 2008

- First industrial pilot 2018

USP

Proprietary technology

- Upright flowing algae
- Glass & Steel (food safe)
- No cell stress by pumps
- 6m high
- 230km glass tubes in 32 units
- Fully automated
- 100t of dry biomass p.a.

- https://www.youtube.com/channel/UC3Ko941azXbb58-hNQMKoDA

Low OPEX – fully automated

- Optimal growth due to:
  - No Oxygen ‚poisoning‘
  - No CO_2 depletion
  - Good Light penetration
  - Good Culture stability
  - Reduced Biofilm
- Continuous harvesting by cell density
- Water recycling
- Cleaning in place – no mechanical cleaning

- Closed system – controlled culture quality

Process chain @ ecoduna

Lab
Seed & culture collection

Inokulum production

Algae Production

Daily harvest

Harvesting Process

Water Recycling

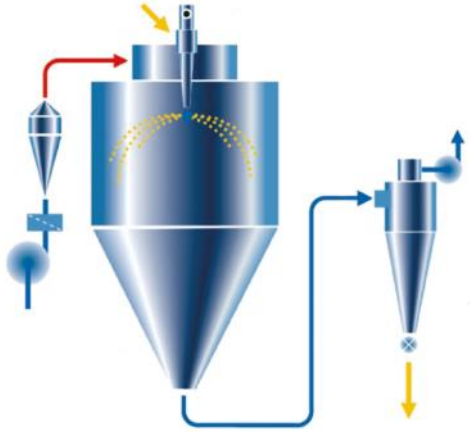
Crossflow Filtration

1:10

Disc stack centrifuge

1:20

Spray Dryer

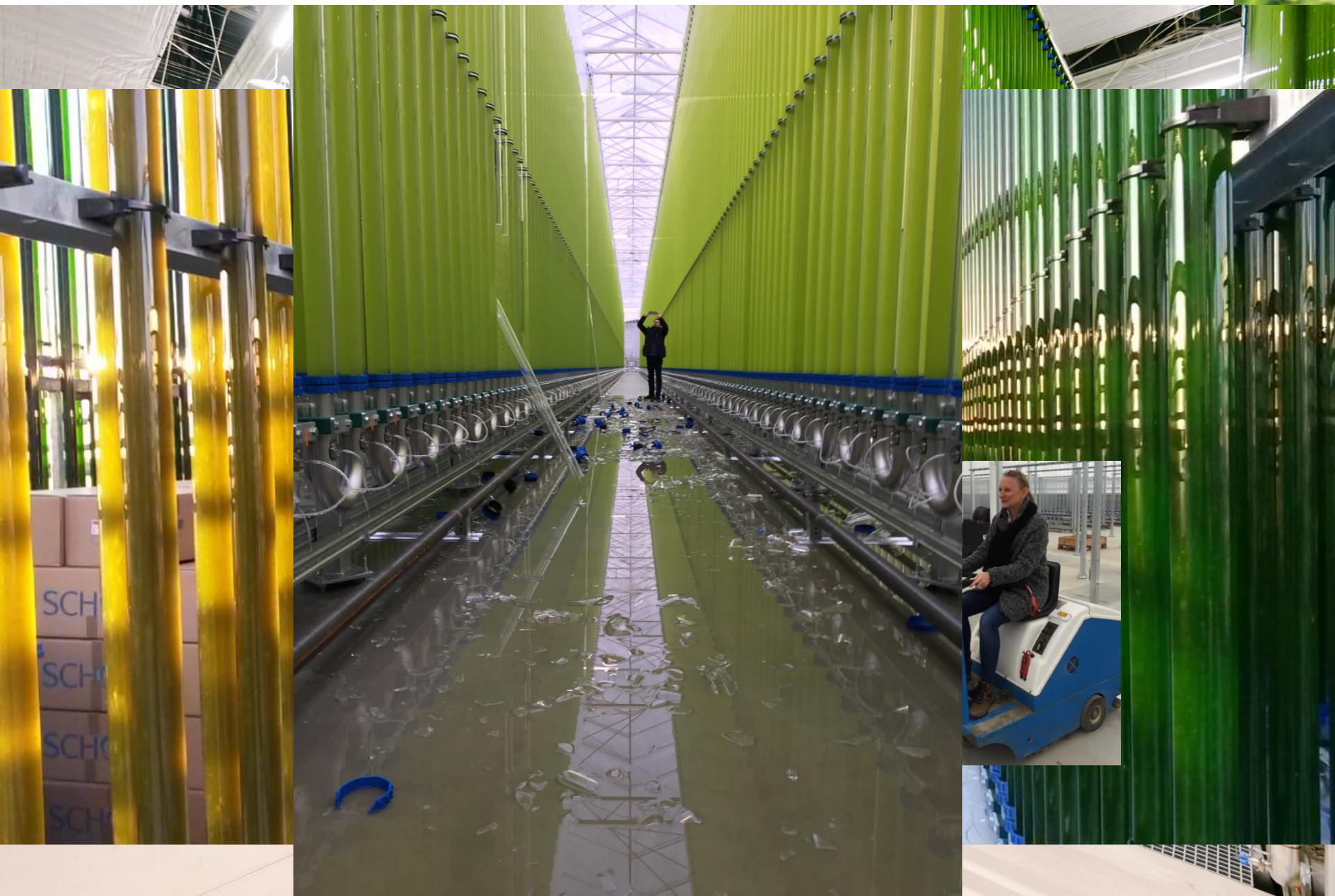


Final Product

Technical Data

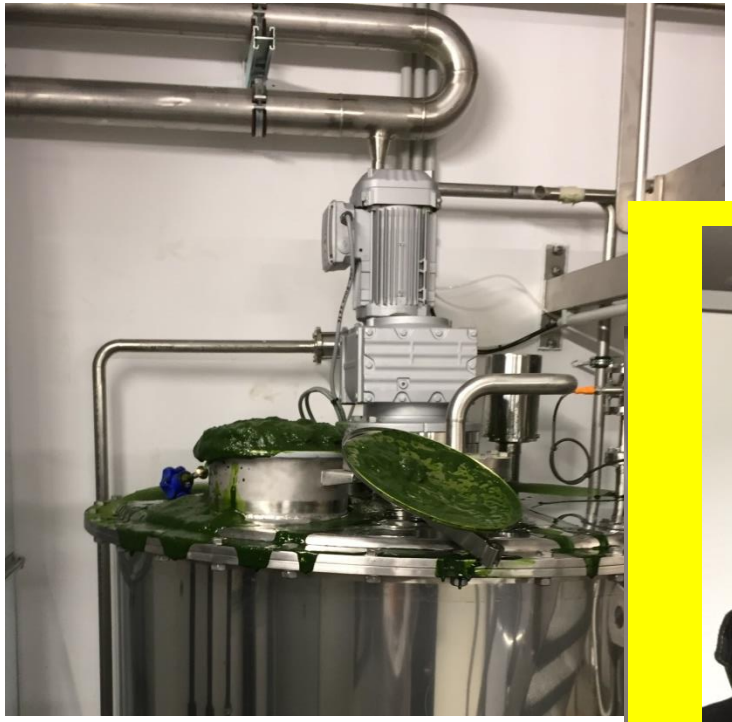
- 1ha plant
- 32 independent growth vessels
- 800 m^3 photoactive volume
- 43.000 glass tubes (6cm diameter, 6m height)
- 230 km pipe length
- Up to 80% Water recycling
- Fixation of 2 kg CO2 for 1 kg algae biomass, up tp 5kg in total
- Amount of Valves/sensors: 1.200
- Dry biomass 50-300kg/day (seasonal)

One year of industrial pilot - PBR



One year of industrial pilot - Downstream

One year of industrial pilot - Drying



Product qualities

- Fresh
- Fresh/Frozen
- Powder
- Capsules/Tablets
- Extracts
  - Phycocyanin
  - EPA

Omega 3 Fatty Acid extraction

EPA - essential Omega3 FA

- Mostly from fish and krill oil
- Health claims
  - Brain development of babies
  - Reduces heart attac risk
    - (Daily recommended intake 0,5g)

Open points

- Biomass pre-treatment
  - Particle size
  - Extracibility of FA
  - Cell wall treatment
- Solvent/technology
- Yield - efficiency

Requirements on algae biomass for successful CO_2 extraction

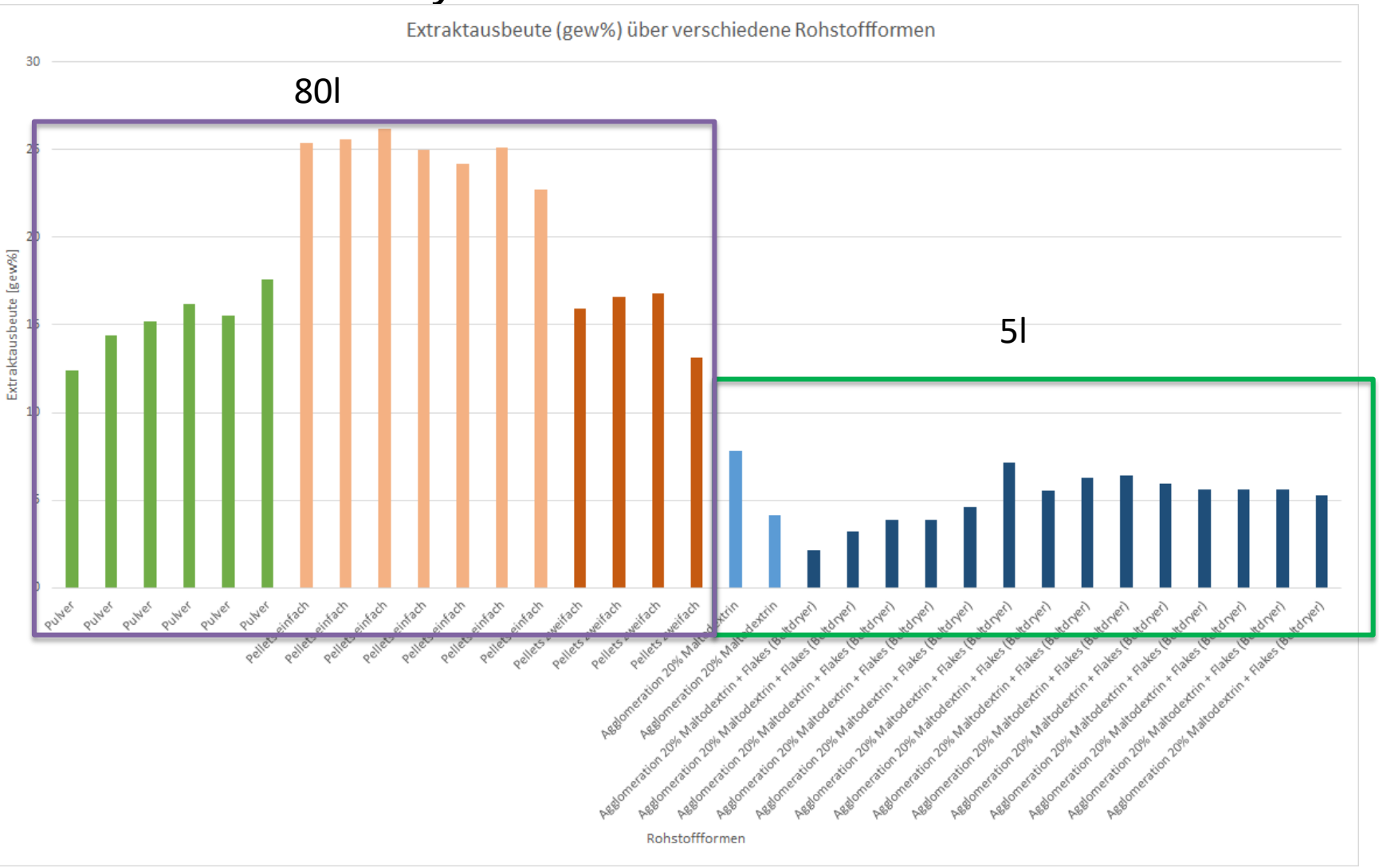
- Prompt inactivation of enzymes after harvesting
- Proper cell disruption – methods are strains specific
- Particle size in the range of 300 – 800µm – pelletizing, agglomeration recommended
- Water content - 8 – 12 % – optimum

Difficulties of CO_2 extraction

- Different algae strains require different pre-treatment strategies
- Most of the algae biomass is dried by spray drying – other drying techniques required (belt drying, drum drying)
- Fatty acids are distributed over 3 lipid classes – neutral lipids, phospholipids and glycolipids – only neutral lipids are easily extractable by CO_2, PL&GL having limited solubility in CO_2

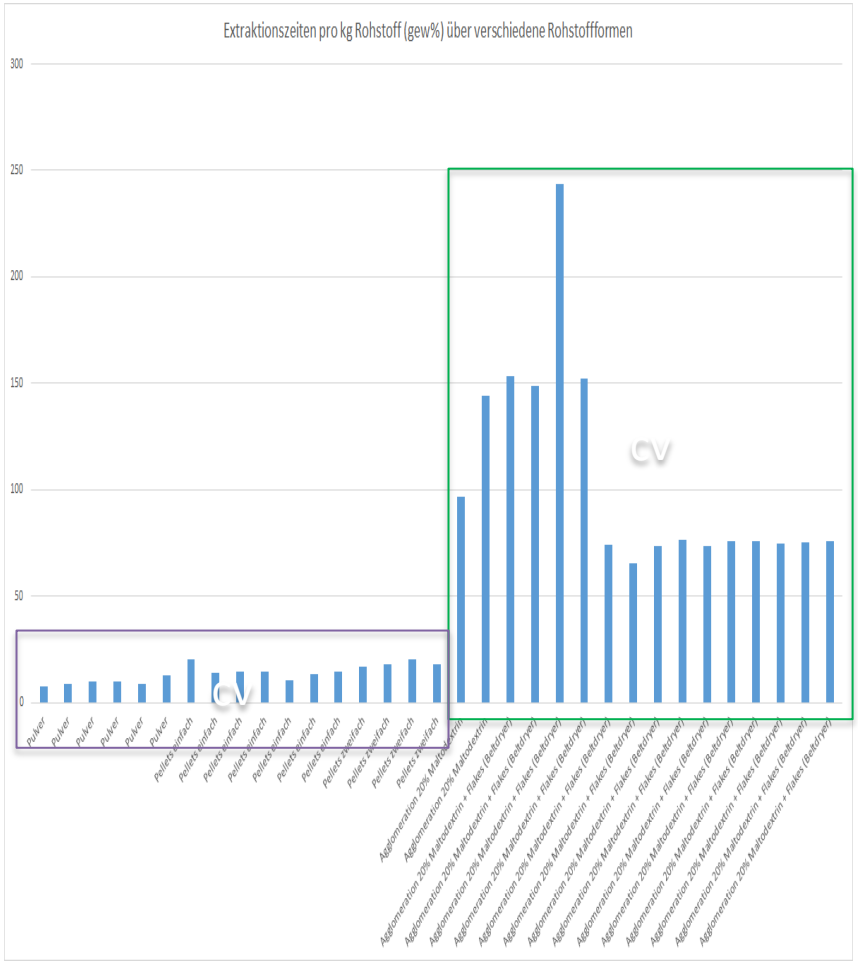
Extraction – process development

Yield - Extractability

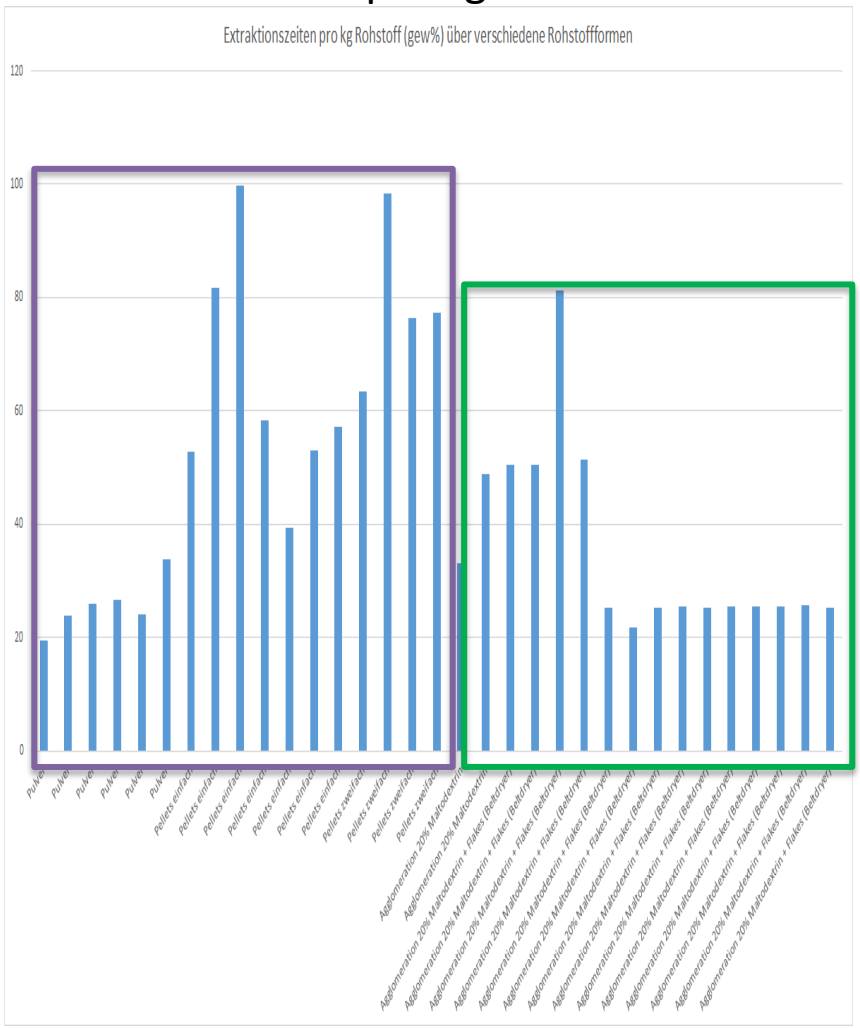


Process parameters ssCO$_2$

Extraction time per kg biomass



Amount of CO2 per kg biomass



Novel compounds from algae

Compound	Source	Application	Reference
Auxins, cytokinins, polyphenols	Supercritical CO2 extract; macroalgae; Baltic sea	Promotion of plant growth	Michalak et al., 2015
Heteropolysaccharids	Ulva sp.	Defense against plant pathogens	Burketová et al., 2015
Sulfated polysaccharids	Pressurized liquid extract; Saccharina japonica	Food: oil emulsification	Saravana et al., 2016
Acidic polysaccharide	Nostoc flagelliforme	Pharmaceutic: Anti-viral	Nowruzi et al., 2018
Polyphenols	Ecklonia cava	Pharmaceutic: Anti-inflammation	Kim et al., 2014
Fucoidan (sulfated polysaccharid)	Undaria pinnatifida	Cosmetics: skin protection, anti-aging	Majee et al., 2017

Food regulation: Novel Food!!

Summary

- Big market potential for microalgae
- High value products (FA, Amino Acids, Pigements) for Nutraceuticals and Pharma
- Ingredients for speciality products
- Standards need to be defined
- Customer education – away from legends
- Process knowledge still needs to be developed
  - - > high amounts of biomass needed

Strong need for cooperation between industry (SME) and academia

Grazie!

Ecoduna – Algae at it´s best!