Whitepaper
“European Roadmap for an Algae-Based Industry”

René Wijffels, Olaf Kruse, Olivier Lepine, Gabriel Acien, Liliana Rodolfi, Carlos Unamunzaga, Mario Tredici, Tom Bradley, Vitor Verdelho, Maria Barbosa
European Roadmap for an Algae-Based Industry

• Conference Olhão, Portugal, 6-7 April 2016

• six Consortia of EU-funded projects:
  • AlgaeCLuster (InteSusAI, ALLGAS and BIOFAT)
  • MIRACLES, FUEL4ME and SPLASH

• Develop a white paper on industrial algae production for the European Economy

• Give a state of the art of algae production in Europe

• Identify and discuss common challenges and report the highlights from the different projects

• Discuss the European innovation agenda needed to stimulate the development of the algae industry in Europe
Algae Innovation Agenda for 2020 and 2030

• The global challenges (2050)
  • To combat hunger, malnutrition and contribute to welfare: 70 % more food needed
  • 100 % more energy consumed
• Are we on the end of the cliff?
Challenge: make microalgae biomass “cheap”

• Fish feed industry can make use of this oil source
• Food industry can replace functional proteins from soy
• Edible oil from sources like soy and palm oil are replaced by algae oil
What has been reached?

• Operational pilot and demonstration scale production facilities of up to 1 ha have been realized
• Knowledge on fundamental biology develops rapidly
• Technology for production matures
• Biorefineries to process algal biomass into multiple high quality products are being implemented
Future research priorities

• Markets
• Production technology
• Industrial strains
• Biorefinery
Markets

• Better connect to industry
• From technology push to market pull
  • Gradual replacement of products (drop in)
  • New and unique products (performance)
• Perspective for food and feed commodities
  • Biomass production costs <1 €/kg dry biomass
  • Regulatory and standardization issues
• Wastewater treatment becomes competitive
  • Valorisation of biomass; e.g. as biofertilizer
  • Attention to product residues
• Market supply by local producers
  • Co-operations, alliances, auctions
Production technology (1)

• Proof sustainability at large scale (compared to...)
• Development of new reactor concepts
  • High productivity, low energy, high biomass, low CAPEX
• Stand-alone production
  • CO₂ capture, temperature, off the grid, recycling
  • Use of agro-food waste
• Demonstration projects for specific markets
  • Simulating outdoors in lab, pilots, demonstration
  • GMP for food/feed grade commercial production
  • Outdoor facilities for production of GM algae
Production technology (2)

• Solving technological bottlenecks
  • Stability: seasonality, fouling, contamination

• Biomass concentration > 20 g/L

• Biomass characteristics
  • Maximize product concentration
  • Excretion
  • Customize biomass composition

• Robotics in large scale microalgae production
  • Automatic cleaning, artificial intelligence for automatic production decisions, data acquisition, process control
Industrial strains

• Targets
  • Robust strains
    • Productivity, contamination, fouling, temperatures, light
  • Improved photon conversion efficiencies
  • Synthesis and secretion of products
  • Accumulation of products in high concentrations
  • Design of specific composition of e.g. lipids and terpenoids

• Construction and discovery of new strains and metabolic engineering (by both GMO and non-GMO approaches)
  • Bioprospecting and mutations
    • High throughput screening techniques
  • Breeding
  • Laboratory evolution
  • Genetic modification
  • Implementation of CRISPR/CAS9
Biorefinery

- Biorefinery research should be product driven
- Reduce length and complexity of the biorefinery chain
  - Integration of different unit operations
  - Focus on the isolation of 1 or 2 high value products and valorisation of rest biomass

- Functionality of algal extracts
- Basic research
  - Cell and cell wall properties in different cultivation stages
  - Mild disruption techniques
  - Extraction techniques with high yield and reuse of solvents
  - Integration of unit operations
Perspective

• Use production infrastructure to develop markets (5 years)
  • 5 commercial products with algae inside

• Multiple producers to cover market demands (5-10 years)

• Chemical products and biofuels on the longer term (10 years)