Biomeet Sessions
Inovação Biotecnológica ao serviço da Agricultura

LAURA MONTEIRO
Senior R&D Project Manager

CONFIDENCE BUILT ON EXPERIENCE

7 June 2023
A4F is specialized in the process of design–build–operate–transfer (DBOT) of commercial scale algae production facilities.
Similar to agriculture

---

**No need...**
- Arable land;
- Compete with food crops;
- Much water (>90% recycled)

**But need...**
- CO₂ (Lots...!!)
- Daily harvest, ≈ 330 Days!
- Water (fresh or seawater)
- Technology (several...)

---

Microalgae on industrial scale: 5.0 g/m²/day of protein
Seaweed on industrial scale: 4.10 g/m²/day of protein
Soya on industrial scale: 0.11 g/m²/day of protein

---

30-100 ton/ha/year
(autotrophic/mixotrophic)
more efficient than any other crop
**Microalgae & Seaweed**

- **Protein**
  Essential amino acids (profile similar to food)

- **Polysaccharides**
  Starch, glucose, alginates, agar, carragenan

- **Pigments**
  Chlorophyll, carotenoids, astaxanthin, phycobilins

- **Lipids**
  PUFAs (ARA, EPA, DHA), TAGs, Polar Lipids

- **Essential vitamins**
  A, B1, B2, B6, B12, C, E, nicotinate, biotin, folic acid and pantothenic acid
APPLICATIONS & FRAMEWORKS

Current applications

- Food ingredients
- Healthy foods

Food

- Premix feeds
- Specialty feeds

Feed

- Nutraceuticals
- Pharmaceuticals

Health

- Cosmeceuticals
- Thalassotherapy

Cosmetics

- Biofertilizer
- Soil remediation

Fertilizers

Emerging applications

- Biofuels
- CO₂ mitigation

Fuels

- N&P removal
- Bioremediation

Wastewater

- Biofibers
- Bioplastics

Chemicals
**Founded in 2008**

### People
- **50+** highly educated
  - > 50 % PhD & MSc
- Highly trained people: **20 years of accumulated experience** in microalgae industrial production

### Co-funded Projects
- **29+** R&D projects with
  - >250 M€ funding
- Involved in **11** projects: **biorefining** for added value products and energy

### # Units Operated
- **5 units**, from R&D to Commercial Scale
- **Currently** building **4 units** in Europe and Africa
- Currently involved in other projects abroad: South America, Africa, Europe and Middle East
WHAT WE DO

APPLIED R&D

CONTRACT R&D TECHNOLOGY SUPPLY

INDUSTRIAL PRODUCTION

CONFIDENCE BUILT ON EXPERIENCE
### R&D TRACK RECORD

#### Applied R&D in Biotechnology

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIAVA (FP7)</td>
<td>Jan 2011</td>
<td>36 months</td>
</tr>
<tr>
<td>BIOFAT (FP7)</td>
<td>Apr 2011</td>
<td>60 months</td>
</tr>
<tr>
<td>PHOTO.COMM (FP7)</td>
<td>Oct 2012</td>
<td>48 months</td>
</tr>
<tr>
<td>DEMA (FP7)</td>
<td>Dec 2012</td>
<td>54 months</td>
</tr>
<tr>
<td>PUFACHAIN (FP7)</td>
<td>Nov 2013</td>
<td>48 months</td>
</tr>
<tr>
<td>D-FACTORY (FP7)</td>
<td>Dec 2013</td>
<td>48 months</td>
</tr>
<tr>
<td>ALFF (H2020)</td>
<td>Dec 2014</td>
<td>48 months</td>
</tr>
<tr>
<td>PHOTOFUEL (H2020)</td>
<td>Jul 2015</td>
<td>48 months</td>
</tr>
<tr>
<td>DEMA (FP7)</td>
<td>Dec 2020</td>
<td>54 months</td>
</tr>
<tr>
<td>MULTI-STREAM (EU-BBI-JU)</td>
<td>May 2020</td>
<td>48 months</td>
</tr>
<tr>
<td>ALGAREF (P2020)</td>
<td>Apr 2020</td>
<td>24 months</td>
</tr>
<tr>
<td>EXTRATOTECA (P2020)</td>
<td>May 2019</td>
<td>36 months</td>
</tr>
<tr>
<td>ARAFARM (P2020)</td>
<td>Nov 2017</td>
<td>48 months</td>
</tr>
<tr>
<td>EnhanceMicroalgae (Interreg Atlantic Area)</td>
<td>Nov 2017</td>
<td>71 months</td>
</tr>
<tr>
<td>ABACUS (P2020)</td>
<td>Mar 2017</td>
<td>48 months</td>
</tr>
<tr>
<td>REDWine (EU-BBI-JU)</td>
<td>May 2021</td>
<td>48 months</td>
</tr>
<tr>
<td>CIRCALGAE (HorizonEU)</td>
<td>Oct 2022</td>
<td>48 months</td>
</tr>
<tr>
<td>ALIGNED (HorizonEU)</td>
<td>Oct 2022</td>
<td>36 months</td>
</tr>
<tr>
<td>Pacto Bioeconomia Azul (PRR)</td>
<td>Oct 2022</td>
<td>38 months</td>
</tr>
<tr>
<td>ASTEASIER (EIC Transition)</td>
<td>Jan 2023</td>
<td>24 months</td>
</tr>
<tr>
<td>INNOAQUA (HorizonEU)</td>
<td>Jun 2023</td>
<td>48 months</td>
</tr>
<tr>
<td>InnoProtein (CBE-JU)</td>
<td>Jun 2023</td>
<td>48 months</td>
</tr>
</tbody>
</table>

**CONFIDENCE BUILT ON EXPERIENCE**
Microalgae production expertise at pilot and industrial scale

- Arthrosira sp. (Spirulina)
- Chlamydomonas sp.
- Chlorella sp.
- Dunaliella salina
- Haematococcus pluvialis
- Lobosphaera incisa
- Nannochloropsis sp.
- Phaeodactylum tricornutum
- Raphidonea sp.
- Scenedesmus sp.
- Synechococcus sp. PCC 7002
- Synechocystis sp. PCC 6803
- Thalassiosira weissflogii
- Tisochrysis lutea
- Prorocentrum Cassubicum
- Scotiellopsis sp.
- Tetroselmis sp.
- Odontella sp.
- Porphyridium cruentum
- Euglena gracilis
- Galdieria sulphuraria
Macroalgae production expertise at pilot and industrial scale

Fucus Vesiculosus
Ulva spp.
Gracilaria spp.
Porphyra spp.
A4F BIOREFINERY TRACK RECORD

Extracts production expertise at industrial scale

- **Carotenoids**
  - > 3.5% Carotenoids

- **Phycocyanin**
  - > 85% Protein
  - > 25% Phycocyanin

- **Protein**
  - > 60% Protein

- **Omega-3**
  - > 14% EPA

- **Bulk**
  - 50:50 Protein and Carbohydrate

CONFIDENCE BUILT ON EXPERIENCE
INDUSTRIAL PRODUCTION
LARGE INDUSTRIAL PROJECTS

- Tubular PBRs, 1.300 m³
- Pataias, Portugal
- Designed, built, operated by A4F

ALGAFARM
SECIL/ALLMICROALGAE
CONFIDENCE BUILT ON EXPERIENCE

LARGE INDUSTRIAL PROJECTS

BIOFAT
FP7 PROJECT

• Cascade raceways, 3,000 m²
• Pataias, Portugal
• Designed, built, operated by A4F

2009
2011
2015
2016
CONFIDENCE BUILT ON EXPERIENCE

ALGATEC
ECO BUSINESS PARK

- Multi-technology production, 14 ha
- Biorefinery
- Póvoa de Santa Iria, Portugal
- Commissioning stage

LARGE INDUSTRIAL PROJECTS

2009 - 2015
2011 - 2016
2017 - Present
Industrial Symbiosis in a Co-location Approach

New bio-based products and circular economy

Recycling industrial effluents through microalgae production, improving the environmental performance of the whole industrial site and decreasing the costs of microalgae production.
ALGAE-BASED BIOFERTILIZERS AND BIOSTIMULANTS

- Versatile resources for agriculture
- Input of organic carbon
- Improve soil aggregation and stabilization
- Positive influence on soil microbial populations
- Promote plant growth and health
- Help fixating $\text{N}_2$

Source: Alvarez et al 2021
Algae-based fertilisers present many advantages

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Traditional Fertilizers</th>
<th>Biofertilizers</th>
<th>Bacteria</th>
<th>Fungi</th>
<th>Microalgae/Cyanobacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental damage by degrading the soil, water contamination, and eutrophication induction.</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Creation of symbiotic bonds with the plant roots and microorganisms within the soil.</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Role in the nitrogen cycle making it available to the plant.</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Promotion of the solubilization of phosphorus.</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Soil fertility improvement.</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>The slow rate of nutrient release for the consumption of the plant.</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N fixation by individual strains, P solubilization, and hormone production for promoting the growth of the plant.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>CO₂ capture and greenhouse emissions reduction capability during the addition of organic carbon to the soil.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Industrial production and widespread used in the agriculture field.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Source: Osorio-Reyes 2023
Algae can act as biostimulant promoting plant growth

Algae can enhance soil fertility and microbiome properties

Original Article

*Bacillus* and microalgae biofertilizers improved quality and biomass of *Salvia miltiorrhiza* by altering microbial communities

Xuemin Wei¹, Xuanjiao Bai¹, Pei Cao, Gang Wang. Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China.

*Algal Research*

Volume 59, November 2021, 102434

Plant growth biostimulant activity of the green microalga *Desmodesmus subspicatus*

ALGAE FOR WASTE STREAMS VALORIZATION (AND BIOFERTILIZERS PRODUCTION)
Algae can be cultivated using **agricultural** wastewaters.
"Chlorella vulgaris and Scenedesmus obliquus suspensions, grown in maize drainage water, can be used on-farm, as low cost slow-release organic fertilizers, doubling lettuce fresh biomass and improving soil health"
Combination of wastewater treatment, biofuel and biofertilizer production

- *Scenedesmus* sp. was cultivated using **domestic wastewater** and **coal-fired flue gas**
- Use of de-oiled microalgal biomass was efficient biofertilizer for rice crop
- Microalgae increased available nutrients in soil
- Microalga supplementation reduced chemical fertilizer

*Source: Nayak et al 2019*
Biostimulant and biopesticide potential of microalgae growing in piggery wastewater

Source: Ferreira et al 2022
Microalgae Cultivation for Bioremediation

➢ Ongoing work: characterization of the microalgal biomass for biofertilizer and biostimulant potential on vegetables and fruit trees by ADP Fertilizantes. The valorization of the biomass will boost the economic viability of the overall process.

➢ Future work: evaluate feasibility of using onsite available flue gas as CO₂ source.
REDwine aims to:

- implement a new business model for wine producers, where they will become microalgae producers by valorising their effluents.
- incentivise the transition of the wine production industry to an innovative, circular and sustainable model that will increase and diversify revenues for its stakeholders.
Thank You!