The PUFAChain Business Case scenarios for PUFA production from solar-driven autotrophic microalgal cultivation and biorefinery

The PUFACHAIN concept

The FP7 project PUFAChain aims at substantiating the industrial development of a sustainable production of purified polar omega-3 polyunsaturated fatty acids (PUFAs), particularly Docosahexaenoic acid (DHA) and Eicosapentanoic acid (EPA), recognized as important to support human health. For this purpose, considering the production methodology and the innovative biorefining strategy developed within the project, an Industrial Facility for microalgae biorefining was designed and optimized, covering production of the selected strains and downstream processing of the biomass.

Most suitable locations

The choice was made based on 3 criteria: (1) the pre-existence of a microalgae farm in the surrounding area so that the industrial facility can be supplied with the required raw material; (2) the existence of knowhow that can be used to create, operate and upgrade the biorefinery; (3) the proximity to possible consumers of the end product, one of the biggest consumers of the biorefinery products are the fish feed factories.

Two different latitudinal belts in terms of annual solar irradiation and annual temperature were considered: one in Southern Europe and the other in Central Europe. Lisbon (SED1 and SEL1) and Munich (SED1M1 and SEM1) regions were the locations considered for the PUFAChain Biorefinery scenarios.

A4F Experimental Unit

The layout used in A4F Experimental Unit in Lisbon was used as the basis to develop the concept and the project for the Demo Plant (table) and afterwards, for the Industrial Facility (tools). The knowhow gathered during the pilot scale trials of the selected strains provided the technology parameters for the design of the biomass production, concentration and drying systems, and all the auxiliary systems. A4F successfully adapted the design, built and tested an optimized reactor: Unilayer Horizontal Tubular Photobioreactor (UHT-PBR). This technology significantly lowers capital expenditures, as well as operational expenditures, when compared with Multilayer Horizontal Tubular Photobioreactors (MHT-PBR). Additionally, the design of the processing system was performed based on data provided by project partners involved in the downstream (A4F, MAHLE, Natex and OI oiles).

Strain selection

The most promising strains were selected and two scenarios were analysed: (1) for EPA and DHA production (SED) through cultivation of a novel strain SAG 40.80 Phacotus centauriaceous throughout the whole year, and (2) for EPA production (SE), applying the Algal Crop Rotation (ACR) principle, with cultivation of a mesophilic strain SAG 51.91 Chlorella simplex and a cryophilic strain CCCC 956-11 Raphidiomonas nivalis.

Business Case

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Biomass produced (ton/year)</th>
<th>PUFA Metal soap (ton/year)</th>
<th>CAPEX (M€)</th>
<th>OPEX (M€/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demo Plant (tons)</td>
<td>165-395</td>
<td>12-24</td>
<td>22-27</td>
<td>4-6</td>
</tr>
<tr>
<td>Industrial Facility (tons)</td>
<td>1836-4343</td>
<td>177-295</td>
<td>195-318</td>
<td>21-36</td>
</tr>
</tbody>
</table>

Systems

- **Inputs**
  - Water treatment and distribution
  - Nutrient media preparation and distribution
  - Carbohydrates

- **Production**
  - Laboratory
  - Photobioreactors (Tubular)
  - Carbonation

- **Outputs**
  - Soil harvesting
  - Processing and biomass storage
  - Effluents treatment and medium recycling

- **Management**
  - Data acquisition and control
  - Offices and social area