Evaluating the technical, economic and environmental performance of micro-algae biorefineries

PM Slegers, F Fasaei, JH Bitter, AJB van Boxtel

Background

Micro-algae biomass contains many valuable components such as a variety of lipids, proteins, sugars, and pigments. To ensure economic and environmental sustainability the biomass should be processed in a biorefinery chain to obtain the best performance. The best design of these biorefineries is yet unknown.

The processing of micro-algae for the lipid fraction has been widely studied. However, for biorefineries it is essential to consider all biomass components and especially the interaction between these components during processing.

In our research <u>we develop simulation models to predict and analyse the feasibility of the proposed biorefinery chains</u> with respect to their products, economics, and environmental sustainability performance.

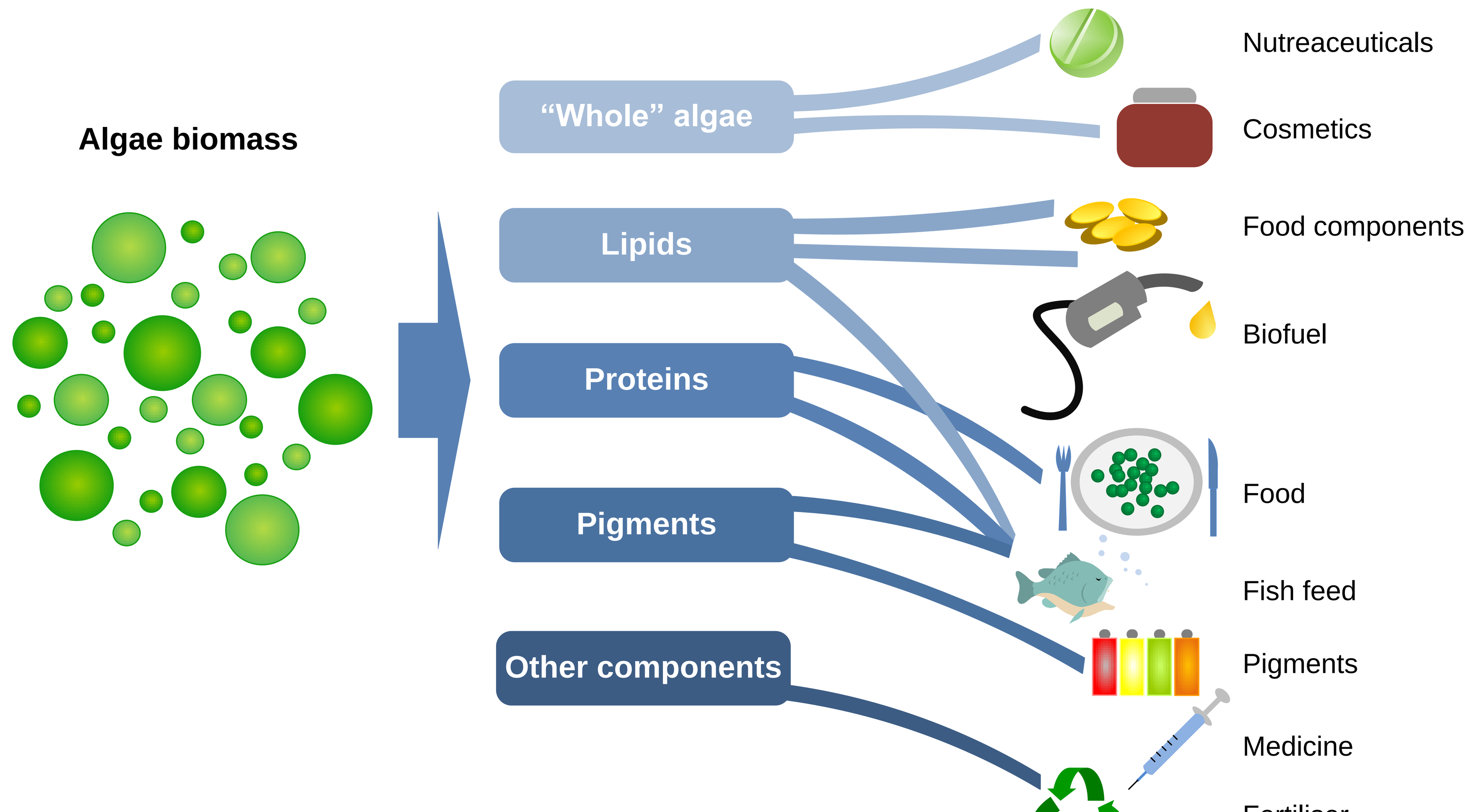

Figure 1. Algae biorefinery

Simulation models

We develop simulation models on the basis of mass and energy balances for each process unit. These are connected to simulate the performance of a processing chain. Scenarios are applied to get insight in the effect of selecting process units, operating conditions, and products on the overall chain performance. As a result, the performance depends on the choices for process units and operating conditions in the integral biorefinery chain.

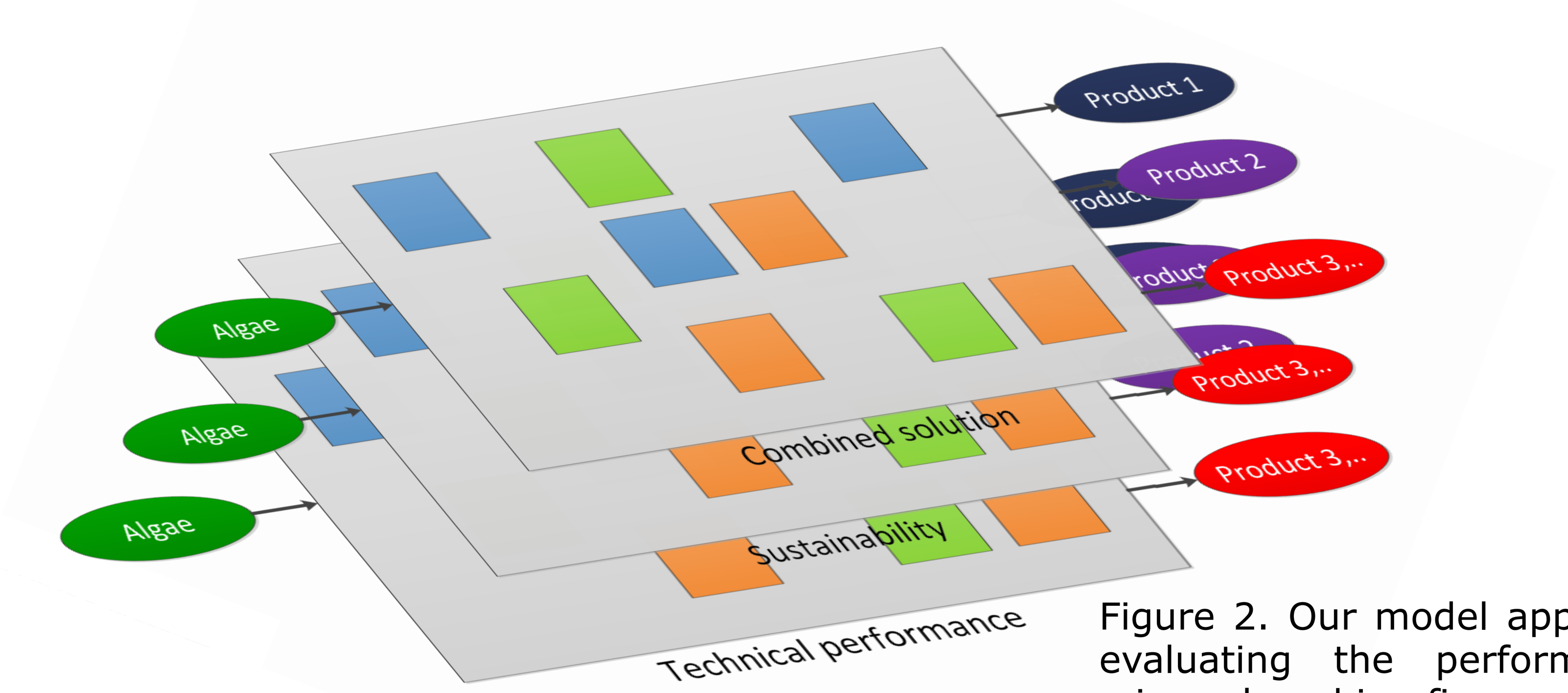

Figure 2. Our model approach for evaluating the performance of micro-algae biorefinery chains.

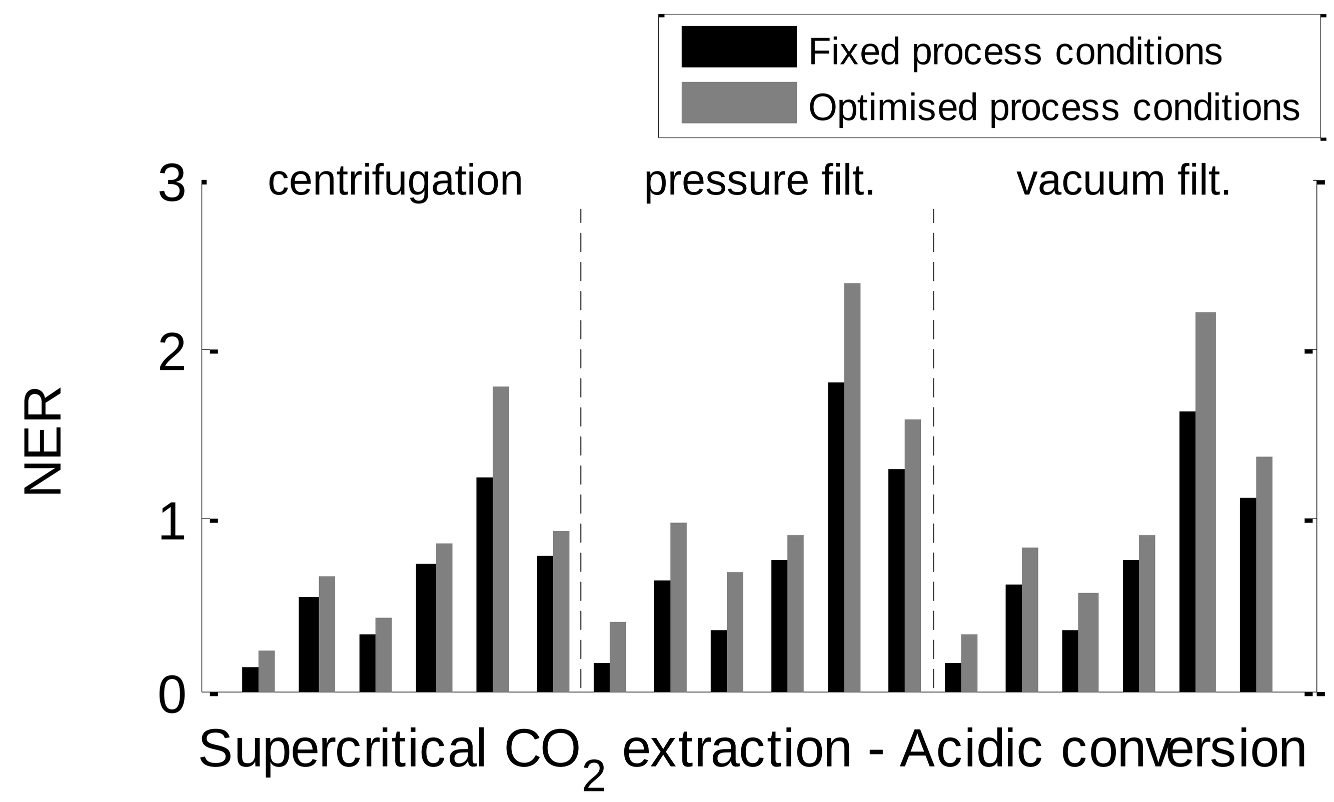

Figure 3. Net Energy Ratio (NER: ration between energy yield from biodiesel and the energy inputs) for processing micro-algae into biodiesel. The results are shown for 12 processing options, with fixed (black) or optimised (grey) process conditions. Simultaneously optimising the process conditions of all the process units in each chain (grey) always leads to higher NER values compared to 'fixed' conditions that are based on separate unit optimisation (black). So separate optimisation of each processing step should be avoided and that the best performance is achieved when optimising the full biorefinery chain.

For more information see Slegers (2014).

Current work

Processing of algae biomass to biodiesel is strongly affected by flow and biomass concentration during cultivation (Slegers, 2014). Several biorefinery chains are currently studied in more detail.

In MIRACLES the aim is to translate experimental data from project partners to larger production scales. For each biorefinery chain the simulation models provide quantitative information on the chain performance. The product yields, energy consumption, required scale and lumped total material input are an estimate for the economic performance. The energy and water consumption, and waste flows are a proxy for the environmental performance.

A similar approach is taken in AlgaePARC Biorefinery, with focus on lipids and proteins.

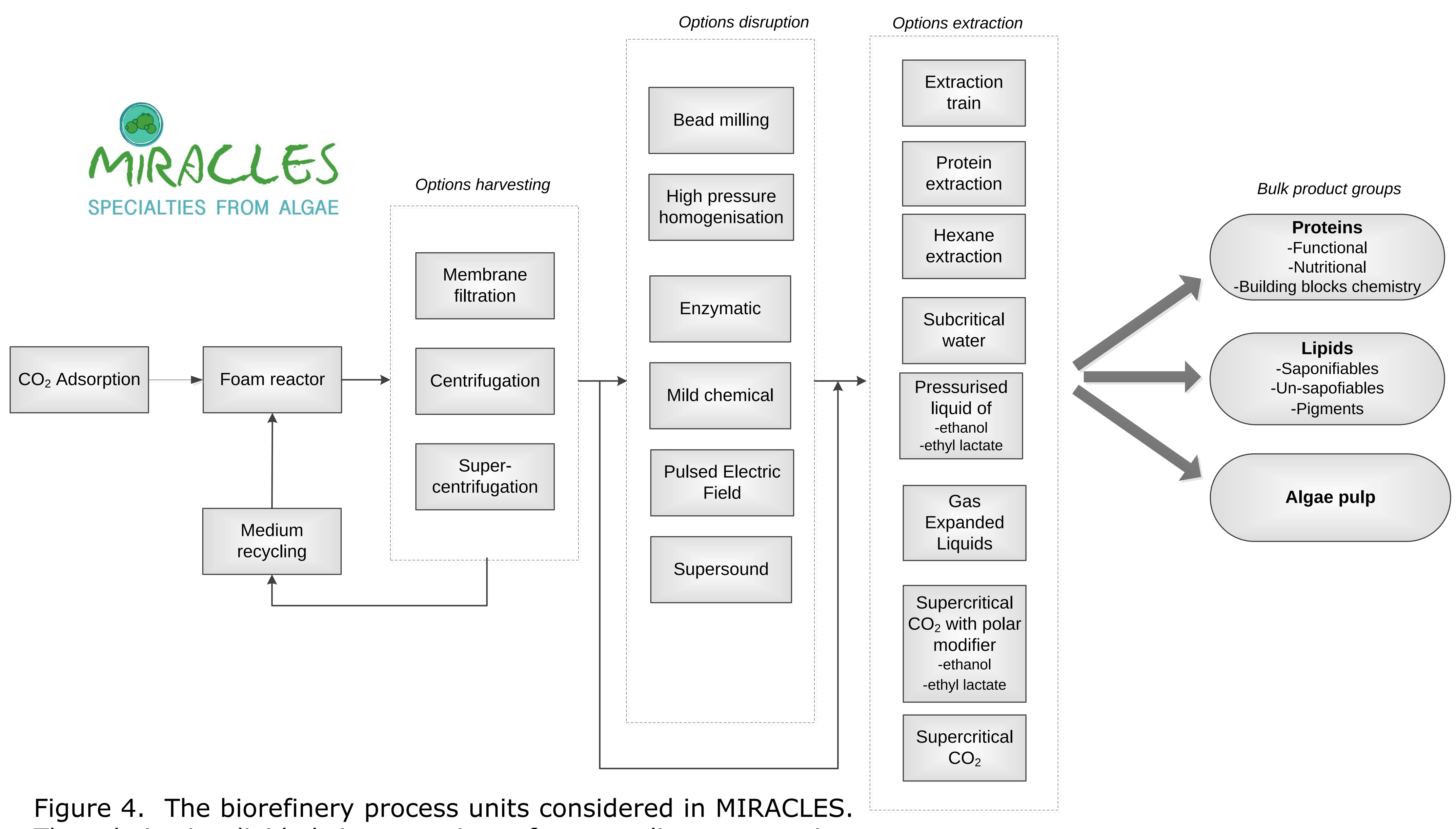

Figure 4. The biorefinery process units considered in MIRACLES. The chain is divided in a series of succeeding steps; i.e. harvesting, dewatering, cell disruption, extraction and fractionation.

Summary

The approach allows to 1) quantify the performance of new process technologies within a biorefinery chain, 2) identify and study critical points in the biorefinery chains, 3) identify knowledge gaps, 4) evaluate how to connect the initial results to data-intensive techno-economic and life cycle assessments

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Wageningen University
Biobased Chemistry and Technology
P.O. Box 17
6707 AA Wageningen
Contact: ellen.slegers@wur.nl
T + 31 (0)317 48 49 52
www.wageningenUR.nl/bct

AlgaePARC MIRACLES SPECIALTIES FROM ALGAE

Reference

Slegers PM, Koetzier BJ, Fasaei F, Wijffels RH, van Straten G, van Boxtel AJB. A model-based combinatorial optimisation approach for energy-efficient processing of microalgae. Algal Research. 2014;5:140-57.