BIOREFINERY OF MICROALGAE

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Microalgae are considered one of the most promising feedstocks for sustainable production of commodities such as food, feed, chemicals, materials and biofuels. Microalgae do not need to be grown in agricultural areas, surface areas not suitable for agriculture can be used as well. They can be grown on seawater in addition to freshwater. They can be grown on residual nutrients. They also have a high areal productivity and via biorefinery the algal biomass can be fractionated into valuable products such as proteins, lipids and carbohydrates.

The technology for production is still immature, but if developed it is expected that biomass can be produced at a commercial scale for a cost price less than 0,68 €/kg of dry biomass[1]. If the different biomass components are collected the total value for commodities in algal biomass is higher than 1.65 €/kg of dry biomass[2].

For the development of an economical business model microalgal biomass should be refined into its different components such as lipids, proteins and carbohydrates. The different components should keep their structural characteristics and therefore biorefinery should be mild. In addition, the technology should be scalable and preferably used as a continuous process to handle large amounts of biomass.

To make microalgae really interesting as a source of biofuels the cost price for production needs to be reduced and the scale of production needs to be increased significantly. Technically this will be feasible. However, the development to a commercial process will at least take 10 years[3].

Our research program on the production of microalgae is well developed, both at laboratory scale and at pilot scale. AlgaePARC is a pilot facility with which we intend to bridge the gap between basic research and demonstration projects. In AlgaePARC we will compare state-of-the-art technologies and develop new reactor concepts and production strategies to achieve lower production costs and energy requirements as well as to gain knowledge for the design and process control of large-scale microalgae facilities.

To date, an optimal photobioreactor design for algal bulk products has not been available. Nevertheless, in AlgaePARC pilot units are presently being developed based on the available state-of-the-art technology in order to obtain direct practical experience. The pilot photobioreactors chosen for AlgaePARC reflect the present development of several reactor concepts used by different research groups and companies and will enable a rigorous comparison between systems, the selection and ultimately the development of an improved system. AlgaePARC initially comprises four large (24 m^2) and three small (2.4 m^2) outdoor pilots: a raceway pond, two horizontal tubular photobioreactors, two vertically stacked horizontal tubular photobioreactors and two flat panel reactors. All reactors are fully automated and flexible in order to allow a fast change in photobioreactor type, layout and process control strategies. Productivities in photobioreactors outdoors are expressed per ground surface. At AlgaePARC the large systems have the same ground surface (24 m^2) and receive thus the same amount of light but the volume differs.

The four types of reactor systems at AlgaePARC (left to right, top to bottom): open raceway pond, horizontal tubular reactor, vertically stacked tubular reactor and flat panel reactor. Photos: AlgaePARC

The large systems will allow comparison of different designs and study of the most important fundamental aspects for the successful operation and scale-up of photobioreactors, i.e. light regime, mass transfer and photosynthetic efficiency. They will serve as the basis to build up the knowledge required for the development of new, more competitive systems and strategies for scaling up. The smaller systems will be used to screen species, to test different feedstocks and to gain insight on reactor control and operation. If promising results are obtained in the small systems, we would then be able to scale up these systems immediately to a larger scale (24 m^2).

AlgaePARC is unique because it is an independent research center covering the whole production chain of microalgal products: systems biology, photobioreactor and production strategy development, biorefinery, scale-up, chain development and systems analysis, thus bridging the gap between fundamental research and industrial applications. AlgaePARC also has a direct link to fundamental research programs at Wageningen UR as well as a wide industrial network: 18 companies participate in this initiative. AlgaePARC is fast in development of technology because of the large critical mass generated in its technology platforms, from which dedicated product platforms can be shaped. AlgaePARC determines its research focus after analysis of the economy and sustainability of the whole production chain.

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2. Wijffels, R.H. et al. 2010. *Microalgae for production of bulk chemicals and biofuels.* Biofuels, Bioproducts and Biorefining 4
3. Wijffels, R.H.& Barbosa, M.J. 2010. *An .outlook on microalgal biofuels*. Science 329.