Microalgae production in Greenhouse Horticulture

WUR Algae symposium 18 February 2016, Wageningen
Silke Hemming, Wageningen UR Greenhouse Horticulture

Why microalgae production in Dutch horticulture?

- Innovative sector
- New business model
- Greenhouse is solar collector
- Growth factors highly controllable
- Available infrastructure in greenhouse
- Entrepreneurship of growers, experience with food supply chains

Focus on high-quality and high-value, reproducibly end-product

Microalgae and horticultural crops

- energy
- Light (PAR)
- water / nutrients
- temperature
- CO₂
- pest and diseases
- hygiene
- labour
- running costs
- value end product
- investment

Control of light

Source: Dermoun et al., 1992

Fotos: WUR Bleiswijk, 2012
Control of temperature

![Graph showing growth rate vs temperature](image)

Source: Dauta et al., 1990

Control of CO₂, O₂, pH, nutrients

![Graph showing CO₂, O₂, and pH levels](image)

Source: measurements bioreactors WUR, Bleiswijk, 2013

Production facility in greenhouse Bleiswijk

![Production facility image](image)

Gem-tube® photobioreactors

- 6 Gem-tube á 450l
- Two-phase PBR
- In fully controlled greenhouse
Production facility in greenhouse Bleiswijk

Climate chamber in Bleiswijk – Starting material cultivation

Climate chamber in Bleiswijk

Expertise @WUR Greenhouse Horticulture

- Multidisciplinary
- Fundamental research → Applied research
- Breeding → starting material → production → market
- Expertise: crop physiology, plant nutrition, water technology, sustainable molecular science, phytopathology, entomology, (micro)biology...
  → Systems engineering, physics, mathematics, electronics, mechatronics, artificial intelligence, economics...
Activities @WUR Greenhouse Horticulture

- Physical modelling
  - Light raytracing
  - Dynamic climate
- Economic modelling
- Biosystems engineering
- Collection key figures algae production
- Monitor algae systems at growers
- Knowledge exchange growers
- Set up new business cases for high-value products e.g. astaxanthin

PPS Astaxanthine 2.0 Project goal

- Realisation of a proof-of-principle chain for the production of astaxanthin as oleoresin from microalgae (*Haematococcus pluvialis* strains) in photobioreactors in Dutch greenhouses.

PPS Astaxanthine 2.0 workpackages

WP 1: Starting material
Selection *Haematococcus* strains incl. strain mutagenesis for production in Dutch greenhouses

WP 2: Optimisation production process
Cultivation starting material, optimisation green and red phase, growing period, amount of astaxanthin, xanthophyll, hygienic protocol

WP 3: End product
Harvesting, stabilisation, and formulation following market demands, new markets in food products

Team

Team @Wageningen UR Greenhouse Horticulture: Wim Voogt, Marta Streminska, Aat van Winkel, Jim van Ruijven, Piet Koorneef, Kees Scheffers etc.
Design of a greenhouse with: (a) integrated production of a tomato crop and microalgae in different greenhouse compartments, and (b) with separated production of a tomato crop and algae in available resources of greenhouse enterprises, such as controlled algae PBR in a 1 ha greenhouse with and without a tomato crop (Fig. 1).

The goal of this study was to assess the productivity and the economic feasibility of the combined tomato and algae production in Dutch greenhouses. A combined production of algae and tomato improves efficient use of available resources and support of this research.

Table 1. Cost price of 8 different reactor designs

<table>
<thead>
<tr>
<th>Reactor Design</th>
<th>Number tubes total</th>
<th>Volume [m3]</th>
<th>Area algae production [m2]</th>
<th>€ m-2 y-1</th>
<th>€ kg-1 dry matter</th>
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</thead>
<tbody>
<tr>
<td>Small scale</td>
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<td>In under crop</td>
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<td>Large system</td>
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The combined production of algae and tomato in a Dutch greenhouse is interesting "new crop" for Dutch greenhouse producers. In greenhouses, the indoor climate conditions can be controlled. This offers the opportunity to produce high quality microalgae year-round. The advantage of algae production in a greenhouse facility is that the algae can be protected against pests and the indoor climate can be controlled. Furthermore, algae can be grown in a separate greenhouse that can be used for horticultural crops.

Several MSc students and several MSc students other chair groups?
- Bioprocess technology
- Biomass refinery
- Environmental technology
- Aquaculture
- Etc. etc.

Joint phd students?
Joint future projects?