Growth and metabolic characteristics of polar algae

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Overview

- Background
- Growth of algae in UK
- Polar marine species in laboratory and outside conditions
- Snow algae from Rothera, Antarctica
Species commonly used for bio-economy research and production include *Phaeodactylum tricornutum* (marine diatom) and *Tetraselmis suecica* (marine flagellate).

- **BUT** in northern Europe the growth rate is too low for viable biomass production in the winter months, **optimal temperature for growth is generally 15 to 20 °C**
Comparative growth and metabolic profile study -
Polar species vs a temperate species

Majority of polar algae have an optimal growth temperature of lower than 10 °C

Is it possible to cultivate polar microalgal species during the UK winter months to optimise biomass production?

NERC Impact Acceleration Award

AIM: to characterise growth (biomass) and metabolic (lipids, pigments) traits in polar algae that are favourable for exploitation in bioenergy and high value product industries

Cambridge University:
Department of Plant Sciences: Prof. Alison Smith
Dr. Matthew Davey, Dr. Beatrix Schlarb-Ridley, Dr. Louiza Norman
Department of Biochemistry: Prof. Chris Howe
Department of Engineering: Dr. Stuart Scott

British Antarctic Survey:
Prof. Lloyd Peck, Dr. Kevin Newsham
Dr. Dominic Hodgson, Prof. Peter Convey,
Dr. Melody Clarke
Biomass at 10 °C (flasks, 8 hours light)
Lower Temperatures Required?

Fragilariopsis sp.
10 °C

Fragilariopsis sp.
4 °C
January
• Daytime water temperature **3.5 to 11.5 °C**
• Light intensities generally < 70 µmols m$^{-1}$ s$^{-1}$ (PAR)

February
• Daytime water temperature **5.5 to 12 °C**
• Light intensities often > 80 µmols m$^{-1}$ s$^{-1}$ < 200 µmols m$^{-1}$ s$^{-1}$ (PAR)
Biomass (outside reactors)

Dry Weight g per L

Week No

1

2

3

Phaeodactylum
Fragilariopsis (1023/3)
T. gravida (1085/25)
P. glacialis (1060/10)
Terrestrial species from Antarctica – Snow algae – *Chlamydomonas nivalis*

Dr Simon Morley January 2014 Rothera Point
Red Colour - Astaxanthin

Excellent antioxidant
UV screen
High Value Pigment in food industry

Very difficult to grow in laboratory

What is production in natural environment?

<table>
<thead>
<tr>
<th></th>
<th>Green type</th>
<th>Red type</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.54</td>
<td>7.31</td>
</tr>
<tr>
<td>NO₃ (mg L⁻¹)</td>
<td>2.52</td>
<td>1.46</td>
</tr>
<tr>
<td>NH₄ (mg L⁻¹)</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
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First time a metabolomics study of algae has been carried out in Antarctica

How does it compare to lab grown cultures?

Metabolite extractions in the field, research station, and analysed in the station (FT-IR) or samples brought back to UK.
Terrestrial species from Antarctica – Snow algae – *Chlamydomonas nivalis*
Life Cycle – Snow algae – *Chlamydomonas nivalis* (Chloromonas?)

Light: 500 to 2000 PAR; *Temperature*: -4 °C to +5 °C; *pH*: 4.3 to 9.5

**Encystment (carotogenesis)**

- **ZYGOSPORES FALL**
  - **WINTER**

**SNOW-AIR-LIGHT INTERFACE**

- **GAMETES FUSE FORM ZYGOTES**

- **ZOOSPORES MIGRATE, REPRODUCE ASEXUALLY**

**SUMMER**

- **ZYGOSPORES GERMINATE, PRODUCE ZOOSPORES**

**SNOW-ROCK INTERFACE**
Collect from many sites in the area (per unit volume or area)
Naturally high, single species production
Dry biomass of *C. nivalis* in snow
UV/Vis wavelength scan

\[ \lambda_{\text{max}} \text{ of Asterxanthin} = 475 \text{ nm} \]
Fourier-Transform Infrared (FTIR) spectroscopy

- Infrared (IR) spectroscopy: different molecules absorb specific frequencies (wavenumber) of infrared radiation (14,000 – 10 cm).

- A rapid, direct and non-destructive method for the determination of the lipid, protein, & carbohydrate content in microalgal biomass (see Joshua Mayers work)
FTIR green phase
What next:

• Metabolite analysis on polar species from lab and polytunnel samples
• Temperature acclimation experiments to investigate plasticity of polar species
• Wait for samples to arrive in UK – June 2015
  + Culture of snow algae - how far can we scale up?
• Metabolic profiles of the snow algae, do we see variation between islands?