B-carotene – a long road to commercial implementation

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CSIR

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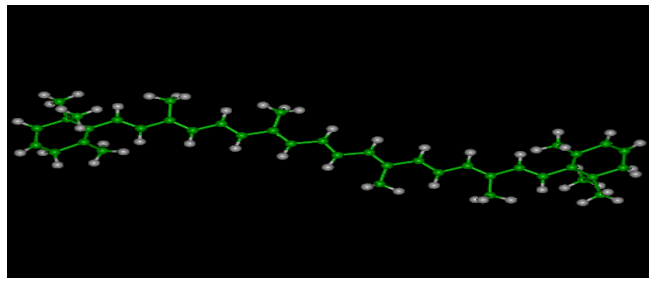
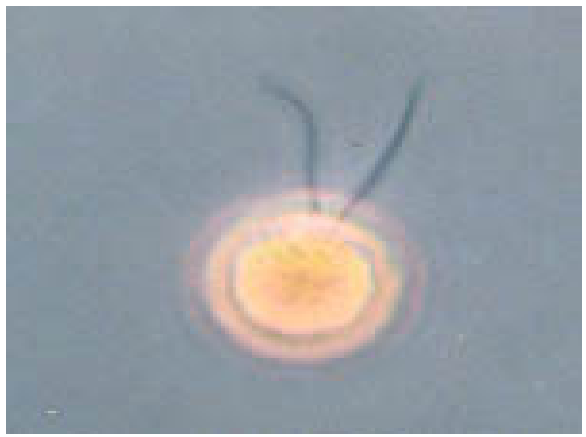
Uses of β-carotene (pro-vitamin A)



- Animal feed supplements
- Food supplements – colorant, Vitamin A supplement
- OTC pharmaceuticals (health supplements) – anti-oxidant, Vitamin A supplement

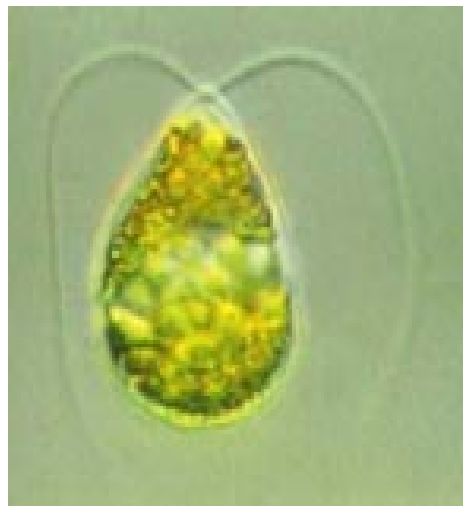
Production

- Chemical synthesis
  - BASF, DSM (formerly Roche)
- Algal production (*Dunaliella salina*)
  - Betatene (Cognis), Koor Foods, NCSA
- Extraction from natural sources (carrots, palm oil)
  - DSM (formerly Roche), Hanson and Darius
- Fungal production (*Blakeslea trispora*)
  - DSM



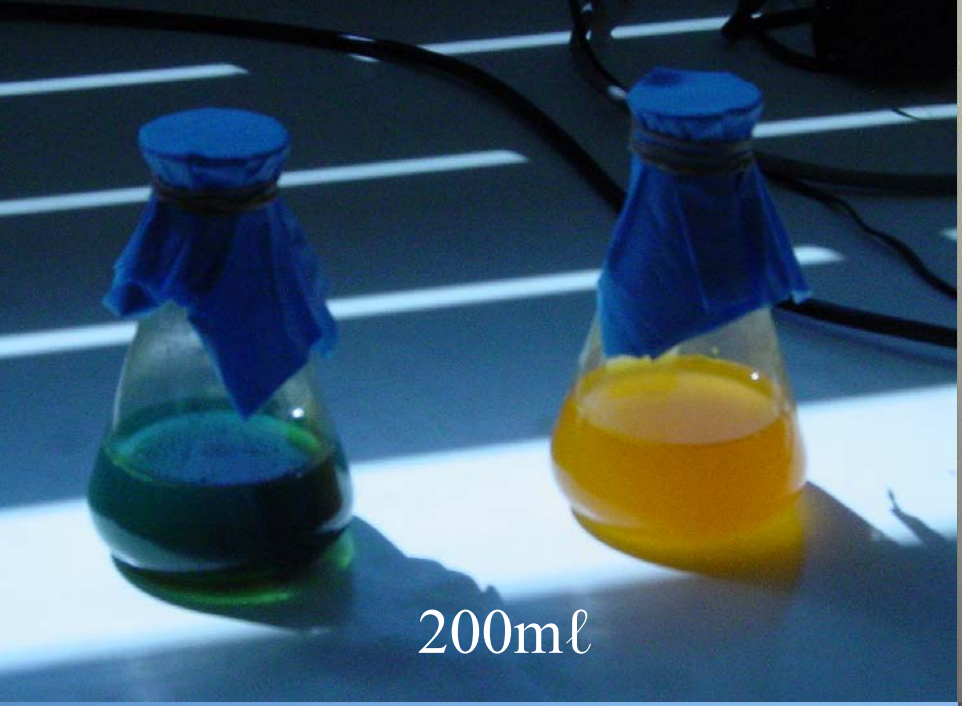
Research and development – algal production

- Growth and stress phases – biomass and carotene production
- "Raceway" pond design selected
- Key parameters:
  - Nutrient optimisation
  - Biomass – balance between productivity and self-shading
  - Growth rate – temperature and light key parameters
  - Light – growth and stressor
  - Temperature - growth
  - Surface area – light intensity
  - Mixing – shading and mass transfer
  - Carotene productivity – stressors (salinity, nutrient limitation, light intensity)



Key challenges

- Many parameters are location specific and require on-site optimisation – pilot plant in Upington
- Transfer of lab research to location specific pilot and production plant
- Integration of upstream and downstream process options
  - Size differentials (250 fold)
  - Upstream process variability - impact of climatic variables
- Scale–up
  - Mixing
  - Optimisation against climatic parameters
  - Recycles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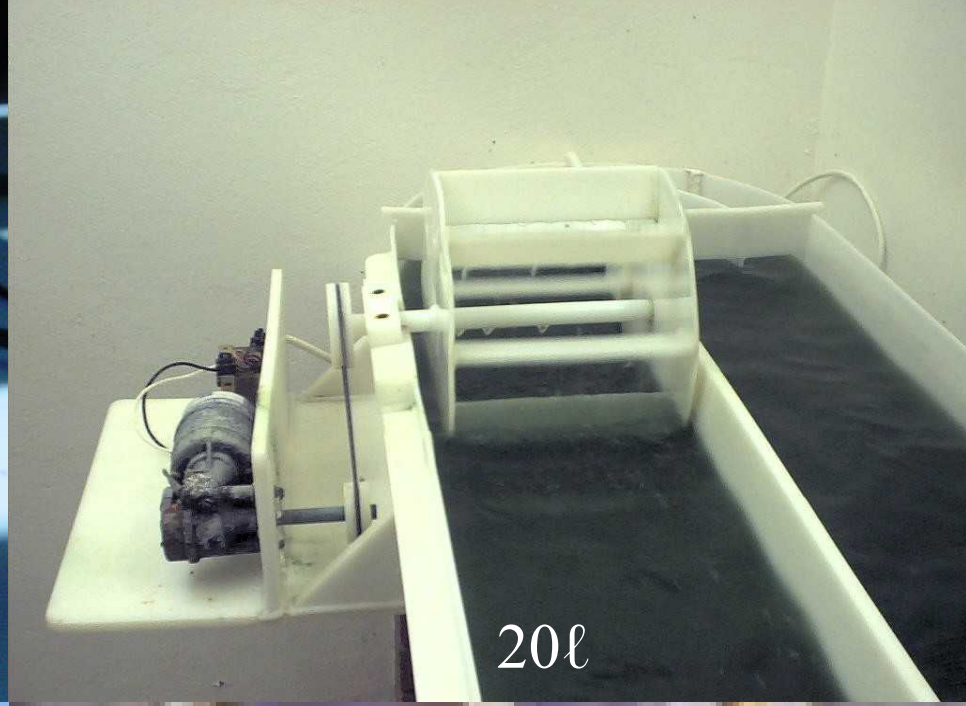
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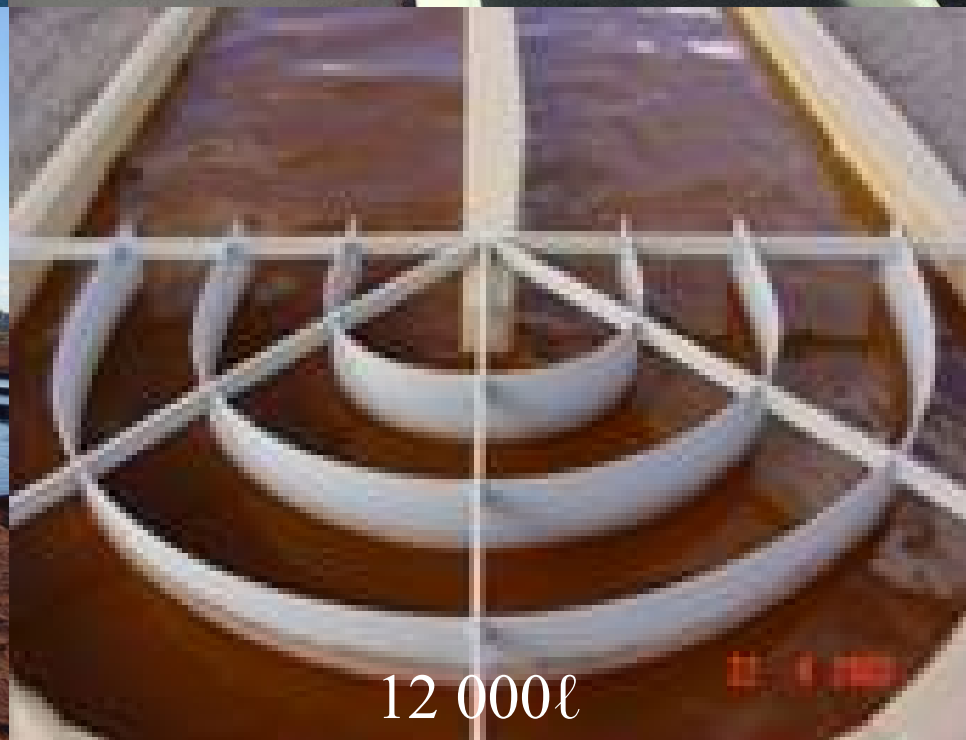
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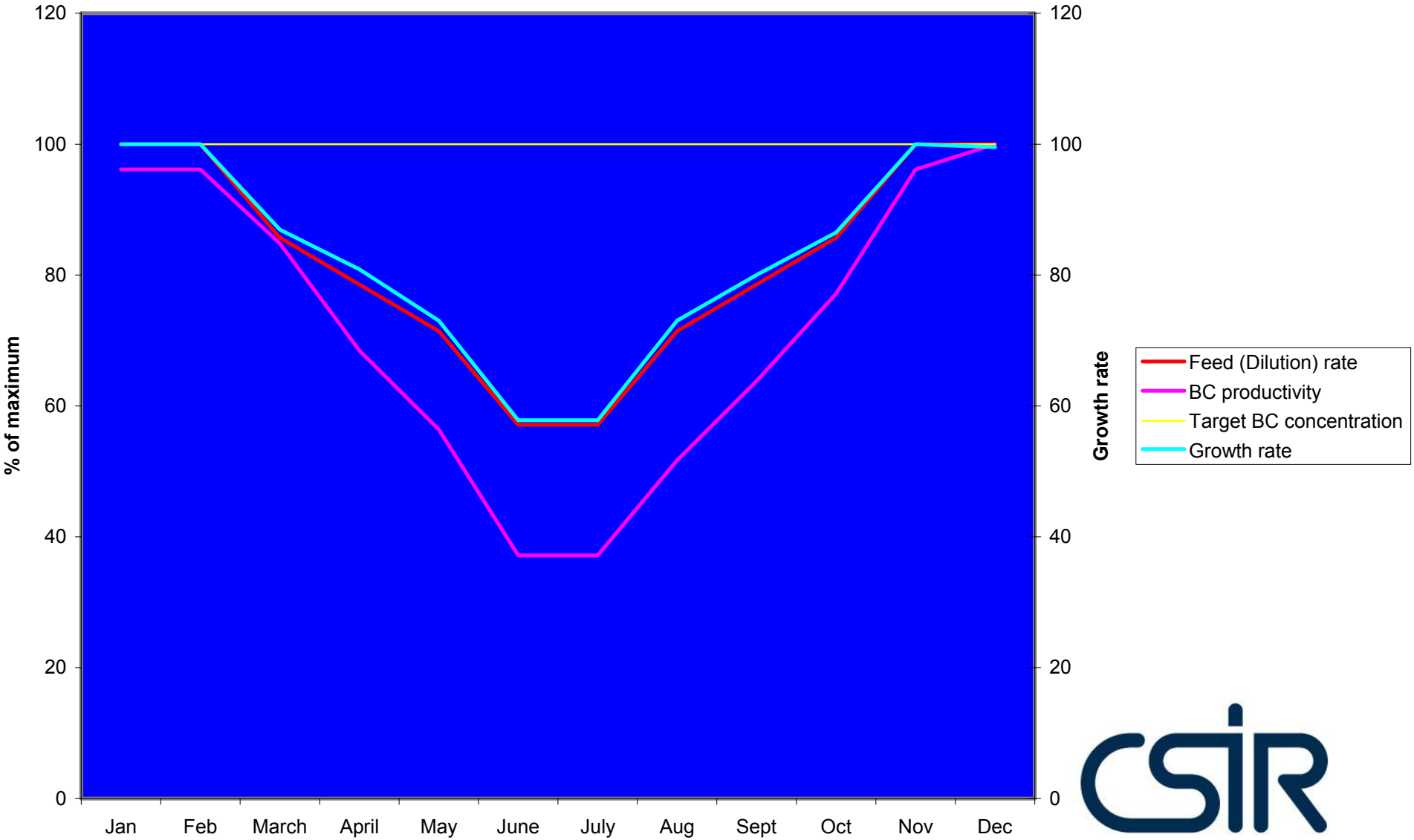
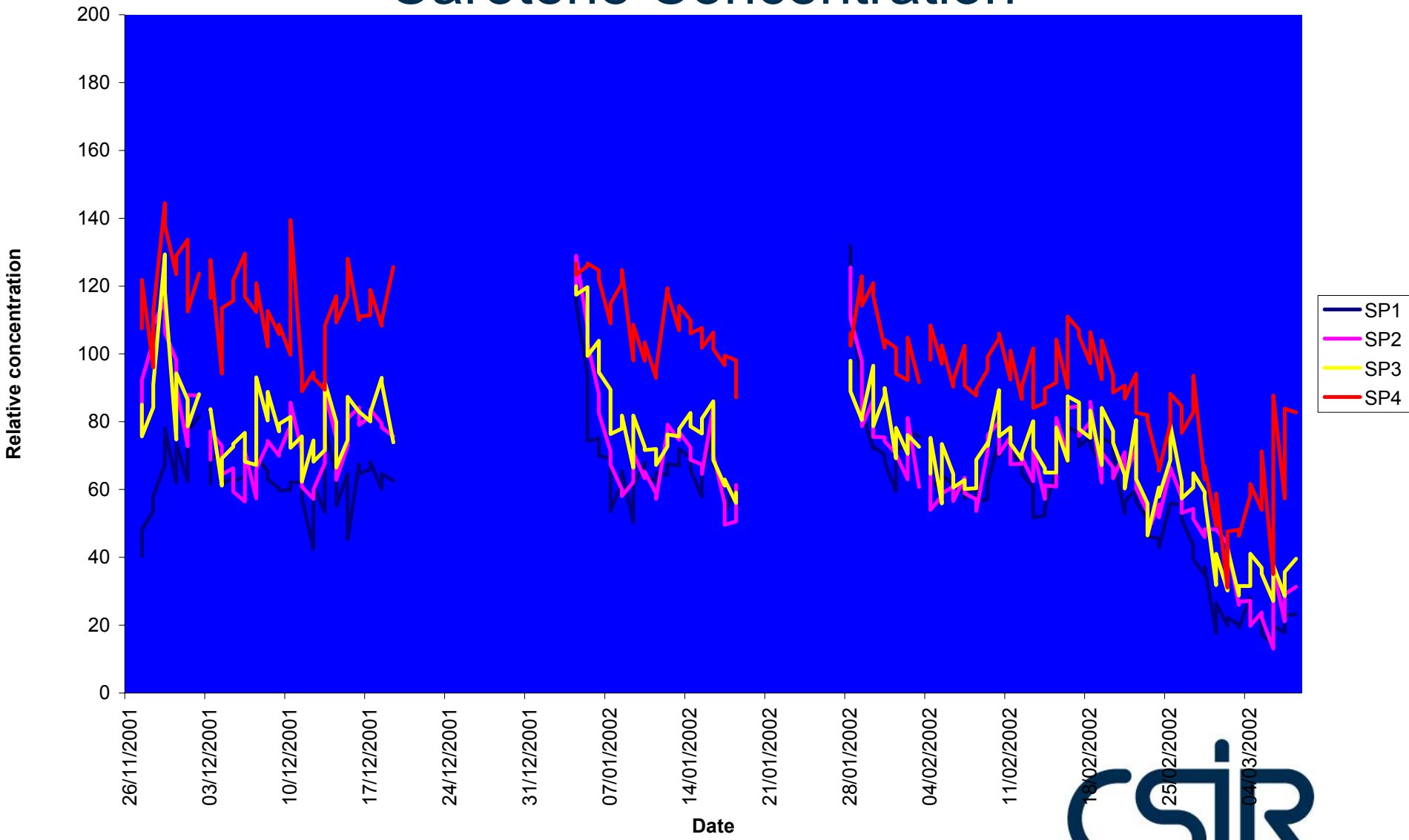
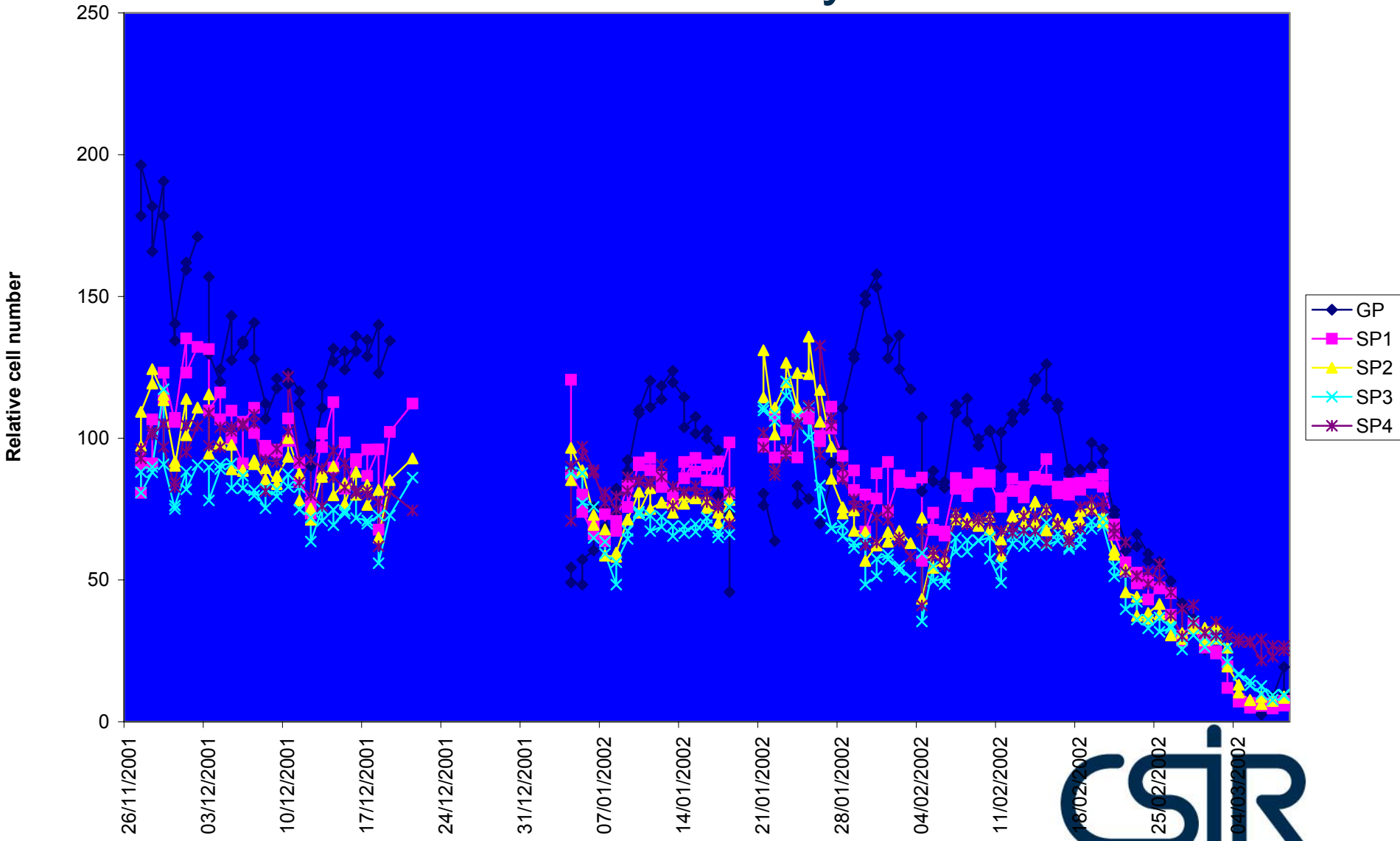
Process strategy



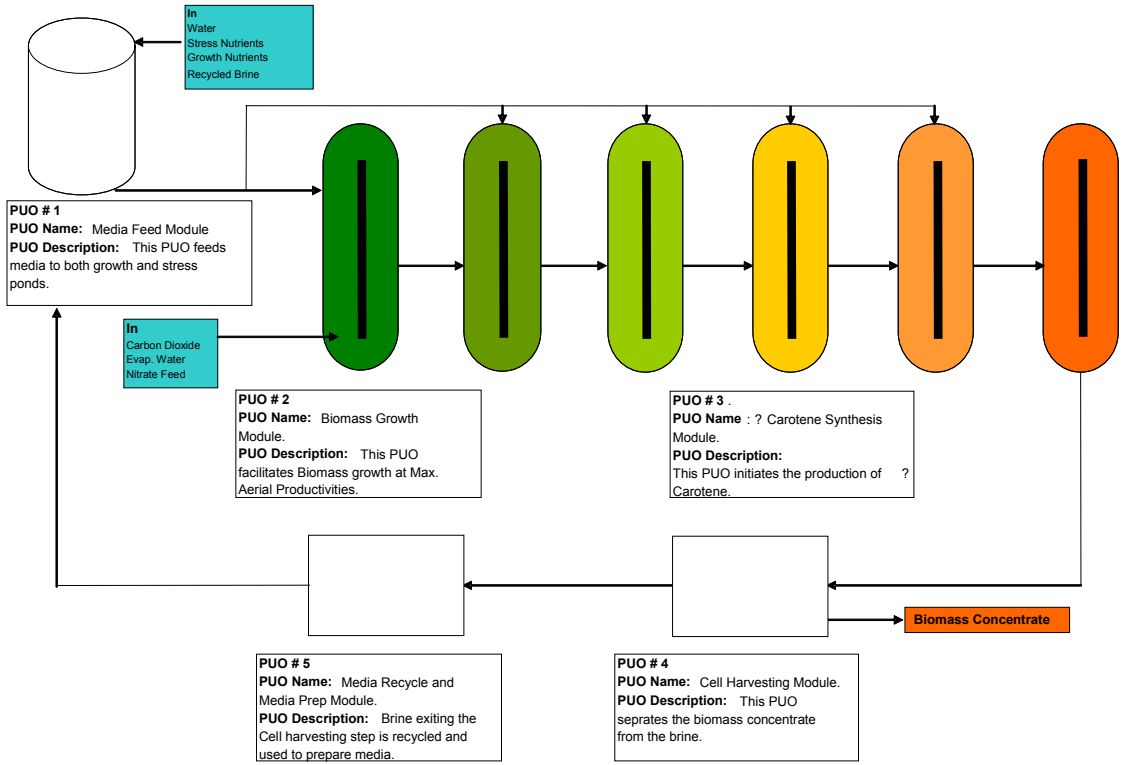
Carotene Concentration



Cell density



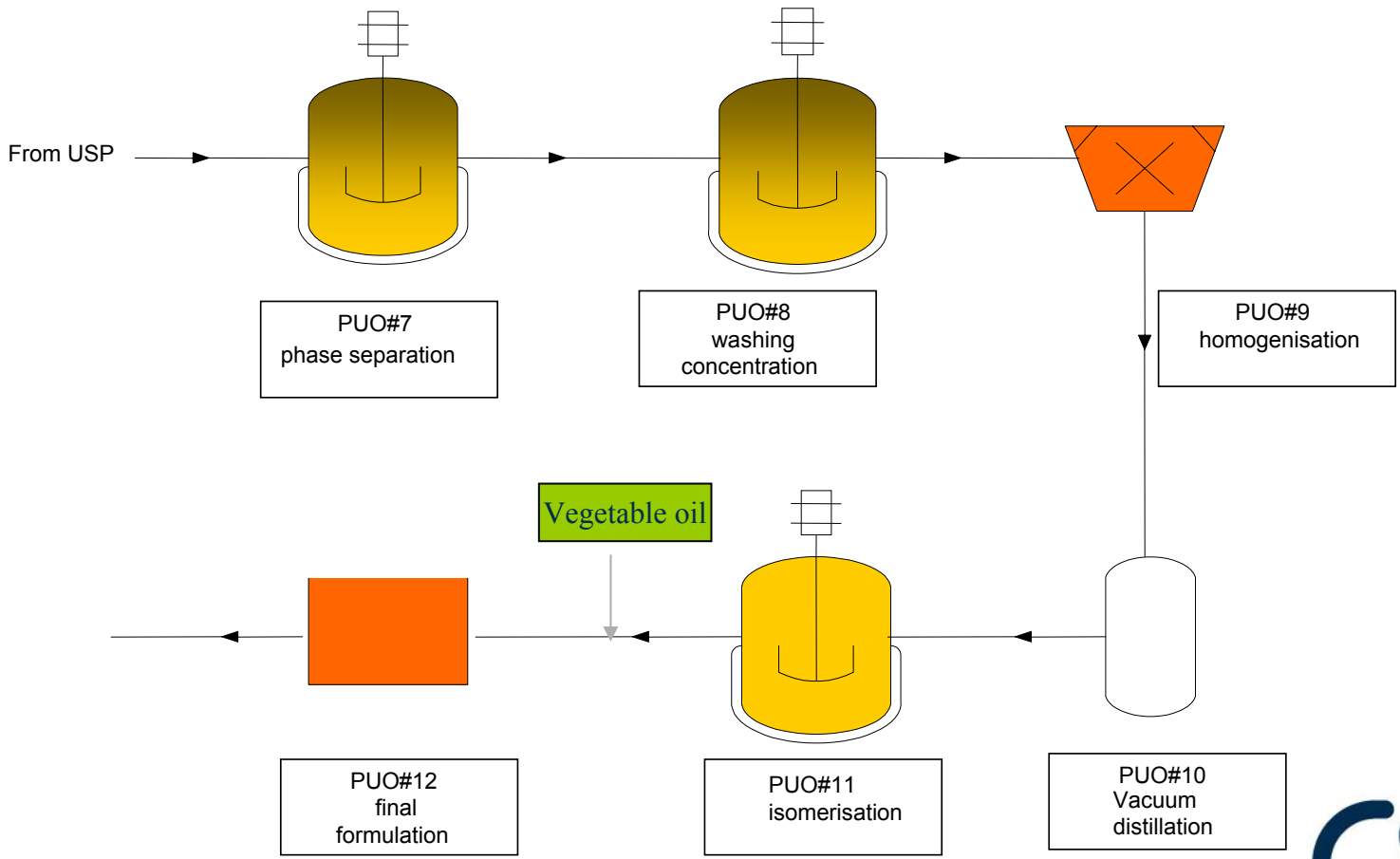
Final upstream process – carotene production



Key R&D challenges – carotene extraction and formulation

- Phase separation
  - 3 layers after solvent extraction
  - “Green layer” containing chlorophyll and mixed carotenoids
  - De-emulsification step introduced
- Solvent removal
  - Product specification < 50ppm food grade solvent
  - Difficult to achieve in two phase product (solid-liquid)
  - Required introduction of homogenisation and additional distillation process step
- Technology integration
  - Process sizing – 250X step down from pond to solvent extraction
  - Impact of algal biomass variability on downstream unit processes
  - Solution implemented is to maintain carotene concentration, fix downstream unit operations and vary downstream capacity utilisation

Final process – carotene extraction and formulation



Challenges in technology implementation

- Product specifications
  - Chemical specs vs in house application specific specifications
  - Introduce new customer specific quality specs (require process tweaking)
- Scale up
  - 25 fold scale up from pilot to commercial ponds
    - Mixing and mass transfer – dead zones
    - Additional process optimisation at large scale
  - Recycle of brine
    - Impurity build up
    - Light penetration
    - Required brine clarification step
- Technology transfer
  - Transfer of research staff for upstream process
  - On site, hands on learning at toll facility

Commercialisation

- Sasol
  - Non-core business
- AECI
  - Exit from fine chemicals business
- NCSA
  - New start up – acquired license to the technology

Key differences between large chemical industry and new start up

- Size/value of new entity
  - R50M – R100M minimum turnover vs ~R10M
- Affordable investment in R&D
  - Large industry will invest far more to reduce technology risk
  - Affordability a key issue for start-up enterprise. More reliant on university/government research and funding
- Appetite for technology risk
  - Large industry will attempt to research/engineer out risk
  - Start-up enterprise will take more risk and continue research phase on to commercial entity
- Implementation strategy
  - Large industry will invest in stand-alone plant
  - Start-up enterprises will innovate to reduce investment requirements
    - Phased roll out
    - Outsourcing

Key challenges to commercialisation

- The right entrepreneurs
- Affordability and appetite for risk
  - Availability of venture capital / angel funding
  - Solution was to reduce investment required :
    - Innovative mix of own plant and toll production by CSIR
    - Phased implementation and investment
- Finance
  - Investment by Cape Biotech Trust and Bioventures
  - Good example of public/private investment
- Market
  - Barriers for new players – availability of market samples from pilot plant
  - Customer specific product specifications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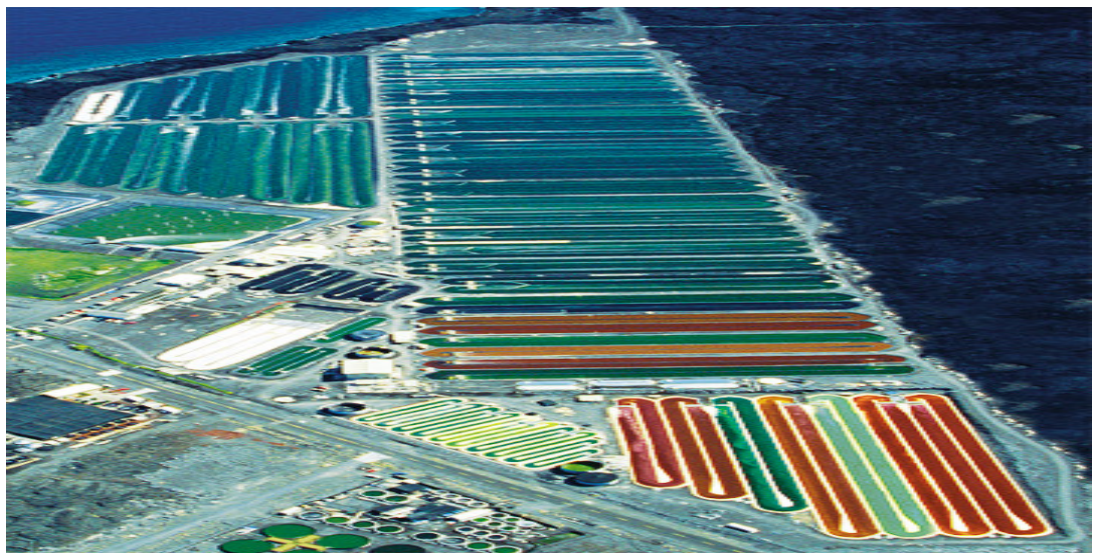
What next ?

- Expansion of carotene production capacity – planning stages
  - Enthusiastic acceptance of product in the market
- Development of Upington “Algal Hub”
  - Astaxanthin (UCT and Cape Biotech Trust)



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Thank you for your attention !!