Match Maker/ Sustainable Ingredients/ 3 Feb 2023

High-yield process for natural Astaxanthin production

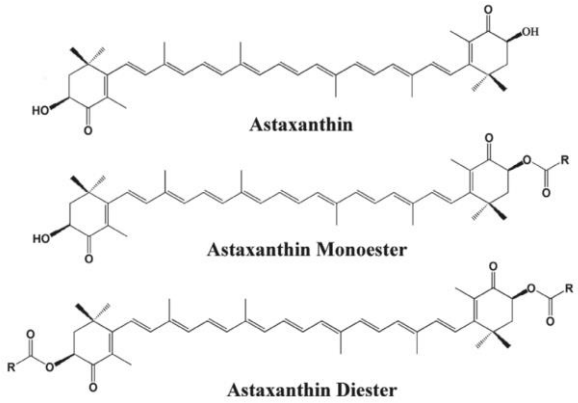
Lead Inventor: Dr Shashi Kumar Rhode

Organization: ICGEB, Delhi

TechEx.in Case Manager: Sharvari Naik (sharvari.naik@venturecenter.co.in)

TechEx.in is a Regional Tech Transfer Office supported by:

Natural Astaxanthin (ASX)



3R,3R: **Free form** (R: Saturated)
from **Petrol/yeast**

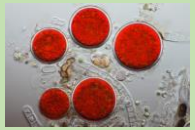
3S, 3S: fat soluble molecules conjugated with polyunsaturated hydrocarbon chain; from **microalgae**

- Astaxanthin ($C_{40}H_{52}O_4$, 3,3′-dihydroxy-β,β′-carotene-4,4′ dione) is a member of carotenoid xanthophyll family like Lutein, Zeaxanthin etc [1]
- **The antioxidant activities of natural astaxanthin are 500 times greater than vitamin E known as super vitamin E** [2]
- Natural ASX makes up only 5%, rest of the market is dominated by synthetic ASX. [3]
- However, synthetic ASX is not approved for human consumption. [6]
- Around 95% of natural ASX is mono- or di-esterified with fatty acid molecules, while synthetic ASX is free

Sources of Astaxanthin

- Animals

  - Crustaceans
  - Crabs & Lobsters
  - Shrimps
  - Prawns & Crawfish
  - Others
- Microalgal



  - *Haematococcus p.*
  - *Chlorococcum spp*.
  - *Chlorella zofingiensis*
  - Yeast/Fungi
  - *Schizochytrium* genus
- Synthetic

  - Petrol products

Natural vs Synthetic Astaxanthin (ASX)

	Synthetic Astaxanthin	Natural Astaxanthin
Stereochemistry	(**3R,3'R**), (3R,3'S), (3S,3'S) optical isomers-1:2:1	(3R,3'R), (3R,3'S), (**3S,3'S**) optical isomers-1:2:22
Structure	**Non-esterified**	**More than 95% molecules are *esterified**
Industrial uses	Aquaculture feed	Food, dietary supplements, cosmetics, nutraceuticals
Production	Petroleum products	Microalgae

*Esterified astaxanthin **has a fatty molecule attached,** while non-esterified astaxanthin is "free."
*Esterified astaxanthin is natural, and non-esterified astaxanthin is largely a synthetic/chemical version

- **Dietary Supplement** - Strong antioxidant and numerous health benefits
- **Fish feed** - Fish pigmentation and gives health benefits to fish making muscles strong
- **Cosmetics (skin care)** - Protects skin against against UV-induced photo-oxidation (used in antitumor therapies and prevention)
- **Food Colouring** - Red colouring and antioxidant properties when added to food, costly cakes



The Opportunity

- The global Astaxanthin market size was valued ~USD 850 million in 2021 and is expected to grow at a compound annual growth rate (CAGR) of around 9% from 2021 to 2032. [8-12]

- Price: **Rs. 10,000 to 1 lakh per kg** for natural astaxanthin (avg 10% astaxanthin content) [13-15]

- Major Global Manufacturers: **Cyanotech** Corporation (USA), Beijing **Ginko** Group (BGG) (China), **Koninklijke DSM** (Netherlands), **ENEOS Holdings** (Japan), **BASF** SE (USA)

- Major Indian Manufacturer: **EID-Parry India** Ltd [13]

Who should be interested and why?

Who?	Why?
Suppliers to Pharmaceutical, Nutraceutical companies	• Demand for antioxidants due to many health benefits • Only natural astaxanthin is approved for human consumption • Protects cells from damage • Higher productivity then existing technology
Suppliers to Cosmetic companies	• Provides protection against UV caused photo-oxidation • Natural Red coloring • Increasing demand for natural colours
Fish feed manufacturers and their suppliers	• Natural Astaxanthin provides red colouring to farmed seafood for health benefits • Addition of a new product in company's portfolio
Suppliers to Food companies	• Only natural astaxanthin is approved for human consumption • Addition of a new product in company's portfolio • Healthy ingredient

About the technology

Technology features:

- Native organism: ***Dysmorphococcus globosus*-HI**
- Highest yield (391 mg/L) of Astaxanthin by the algal strain to be reported.
- Highest ASX content per cell to be reported.
- Low cost aqua media for cultivation
- Non-GMO

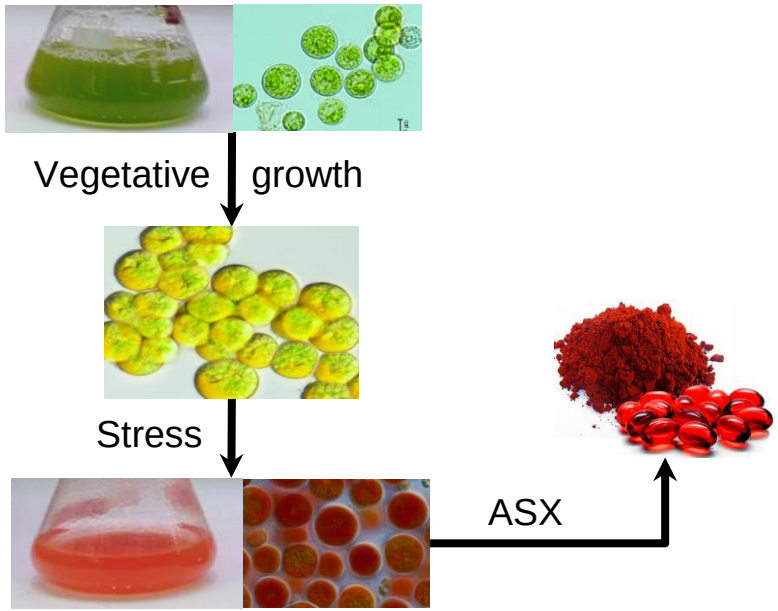


Image Source

Property	*H. pluvialis* (Commercial strain)	*D. globosus* - HI (ICGEB Strain)
Cell biomass	9.00 g/L (30 days)	**0.756 g/L (25 days)**
ASX percentage (CDW basis)	1-5% CDW	**51.01% CDW**
ASX content	7.72 to 174.70 mg/L	**391.00 mg/L**
Doubling Time (hours)	~25	**8-12**

Current status

Technology status:

- The ICGEB team has a new algal strain of producing Astaxanthin, confirmed by TLC and HPLC
- Invitro-growth conditions and media is optimized
- Cultivated at lab scale in 2L-5L flasks
- Sample available for testing

Publication:

- Zohir, W. F., Kapase, V. U., & Kumar, S. (2022). Identification and Characterization of a New Microalga *Dysmorphococcus globosus-HI* from the Himalayan Region as a Potential Source of Natural Astaxanthin. Biology, 11(6), 884. https://doi.org/10.3390/biology11060884

Next Steps

❖ The next steps are to identify an industrial partner for:

- Genetic modification is possible to increase yield double
- Growth media, Stress induction studies with harvesting technology have been optimized
- Extraction process under development
- Scale Up studies at pilot scale 20-100 litre & Techno-economic assessment under development

Seeking:

❖ Industrial partners interested in **sponsoring further technology advancement and scale-up**

❖ Industrial partners interested in raising 3rd party funds for **a collaborative** project.

❖ Industry interested in tapping scientist capabilities as an expert/ **consultant**.

Team and Organization

Lead Scientist:
Dr Shashi Kumar Rhode
Group Leader, Metabolic Engineering, ICGEB, Delhi

*Founding member of **DBT-ICGEB Centre** for Advance BioEnergy Research*
*Availed of **15 grants**, including international funding from NSF-USA and industrial funding from RIL, Aban, CPCL-Chennai and Tata Steel.*

Expertise: Metabolic engineering, Synthetic biology, Genome editing, Chloroplast genome engineering RNAi Technology, Sustainable algae biofuel technology, Carbon capture by genetically modified algae, Drugs biosynthesis in plants

International Centre for Genetic Engineering and Biotechnology

International Centre for Genetic Engineering and Biotechnology, Delhi

- ICGEB is a unique, autonomous, Intergovernmental Organisation, with biotech labs in Italy, India, and Cape Town South Africa.
- Key assets and strengths of the team:
  - 2 patents filed , 1 USA pantent granted.
  - More than 60 publications
  - Well equipped labs and analytical facilities
    - Photobioreactors Facility till 20L-300L scale
    - Mass Spectrometer Facility
    - Flow cytometry
    - High-end microscopy facilities
- Industry project/ tech transfer
    - Collaboration with 3 industries
    - Consultant to 3 industries

Industry Collaboration with the group

Reliance Industries Limited

TATA STEEL

CPCL

Chennai Petroleum Corporation Limited

aban Aban Infrastructure Pvt Ltd (Biotechnology Division)

TechEx.in
Tech Transfer Hub

ICGEB

For more information, contact:

Sharvari Naik
sharvari.naik@venturecenter.co.in
+91-95119-66979

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innovate in India for inclusiveness (i3)

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