

Microalgae Production and Their Use in Animal Feeds

Cyanotech

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Cyanotech

- Specializing in Microalgae Technology
- Operating since 1984
- 75 Employees
- ISO 9001:2000 Certified
- GMP Certified by NPA
- Non-GMO, environmentally friendly products
- Public Company:
NASDAQ:CYAN



Keahole Point, Hawaii

Cyanotech's Production Facility



- 90 acre facility in Kona, Hawaii.
- Consistent sun and temperature year-round
- Separate production facilities for *Spirulina* and *Haematococcus*
- Major Spirulina production capacity
- Astaxanthin production is consistent and can be expanded to meet growing markets.
- Focus on high-value human nutrition products

Microalgae Production In Kona, Hawaii

- Ideal Climate
 - Warm year round
 - High solar insolation
 - Low rain fall
 - Unique resource
 - Cold deep seawater
- High Costs
 - Land Clearing (hard lava)
 - US\$ 80,000/acre
 - CO₂
 - US\$ 440/mt
 - Power
 - US\$ 0.35/Kwh

Spirulina Production

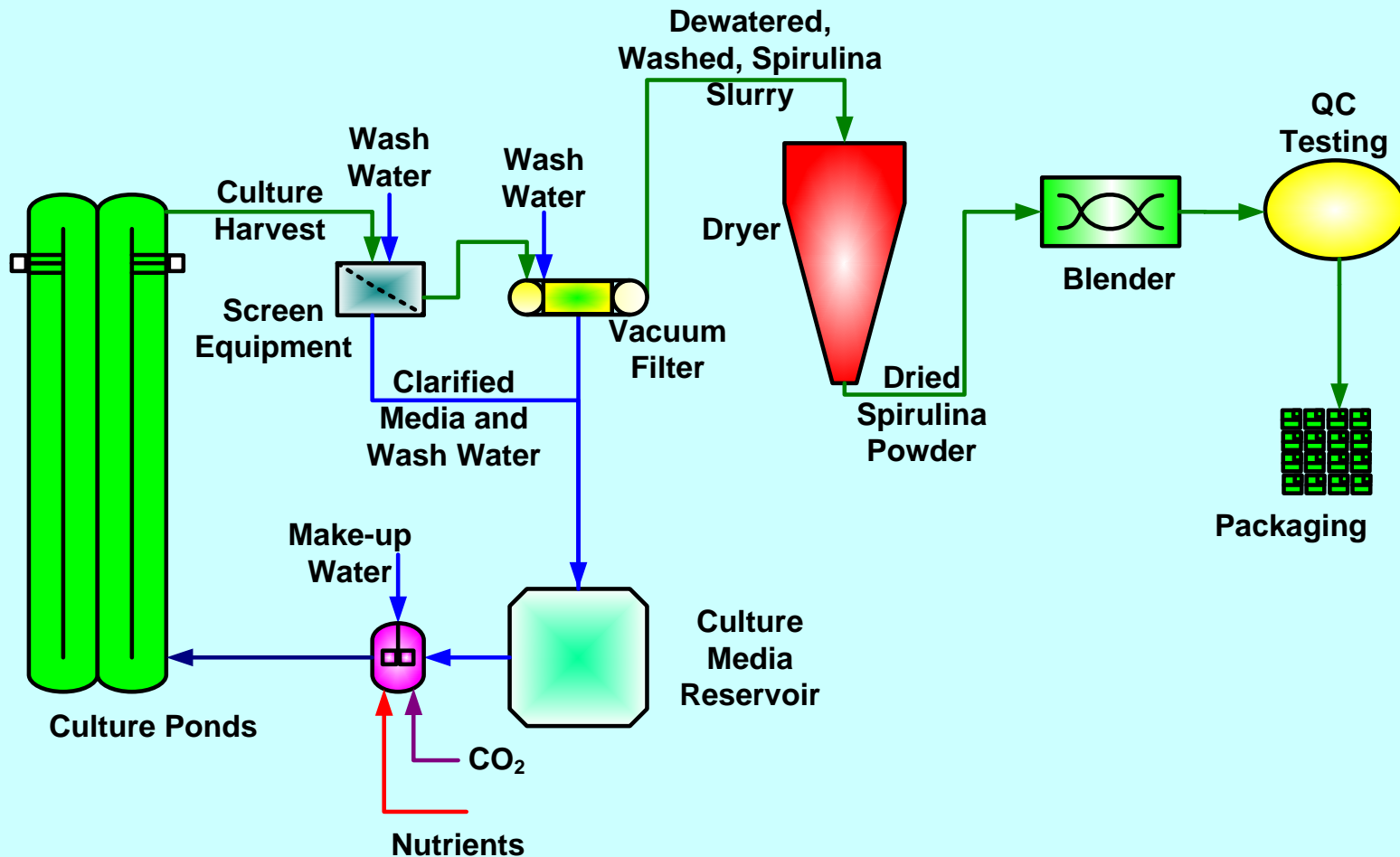


- 40 Culture ponds
- Average size
2,900 sq meters
- Total area
29 acres



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Spirulina Production Flow Chart



Spirulina-High Nutritional Value

- 60% Protein
- Rich in carotenoids
 - Beta Carotene
 - Zeaxanthin
- Phycocyanin
 - Liver and Kidney protection
- Immune stimulating compounds
- Antiviral compounds

Spirulina Feeding Studies

Yellowtail—0.5% Spirulina Diet

- 20,000 fish
 - 10,000 on Spirulina diet
- 37% Increase in growth rate
- 14% Increase in survival rates
- 30% reduction in medication
- Improved coloration and quality

Spirulina Feeding Studies

Salmon—2.5% Spirulina Diet

- 23% Increase in growth rate
- Improved coloration and quality
- Improved coloration also for:
 - Sea Bream
 - Mackerel
 - Koi
 - Other tropical aquarium fish

Haematococcus (Astaxanthin) Production

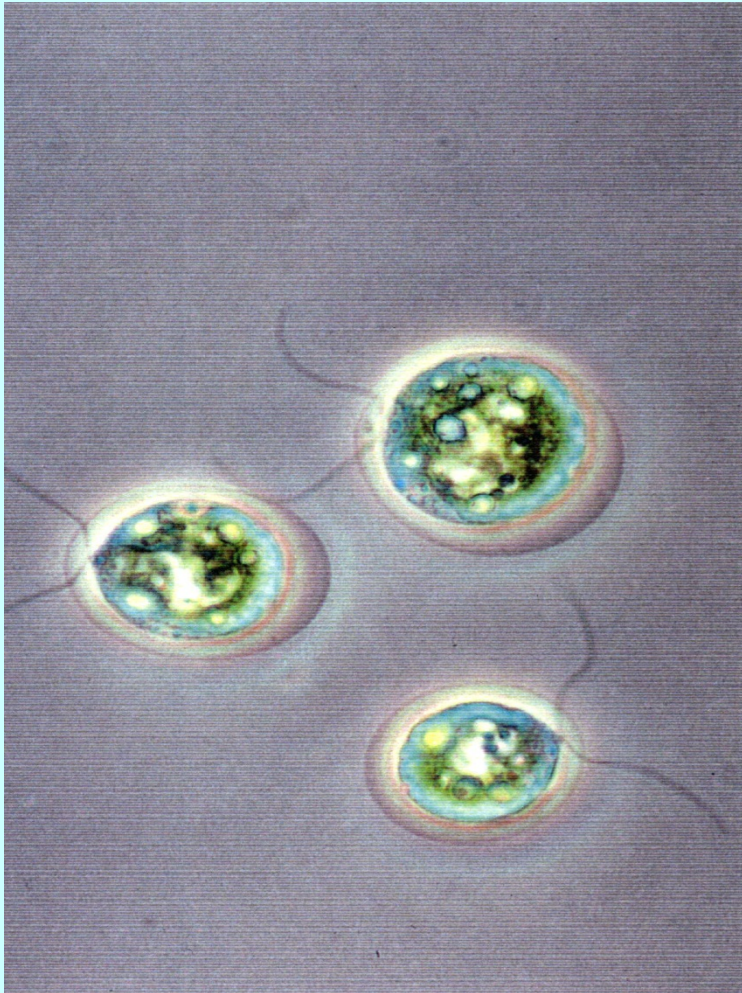


- 20 Culture ponds
- Average size
2,800 sq meters
- Total area
14 acres

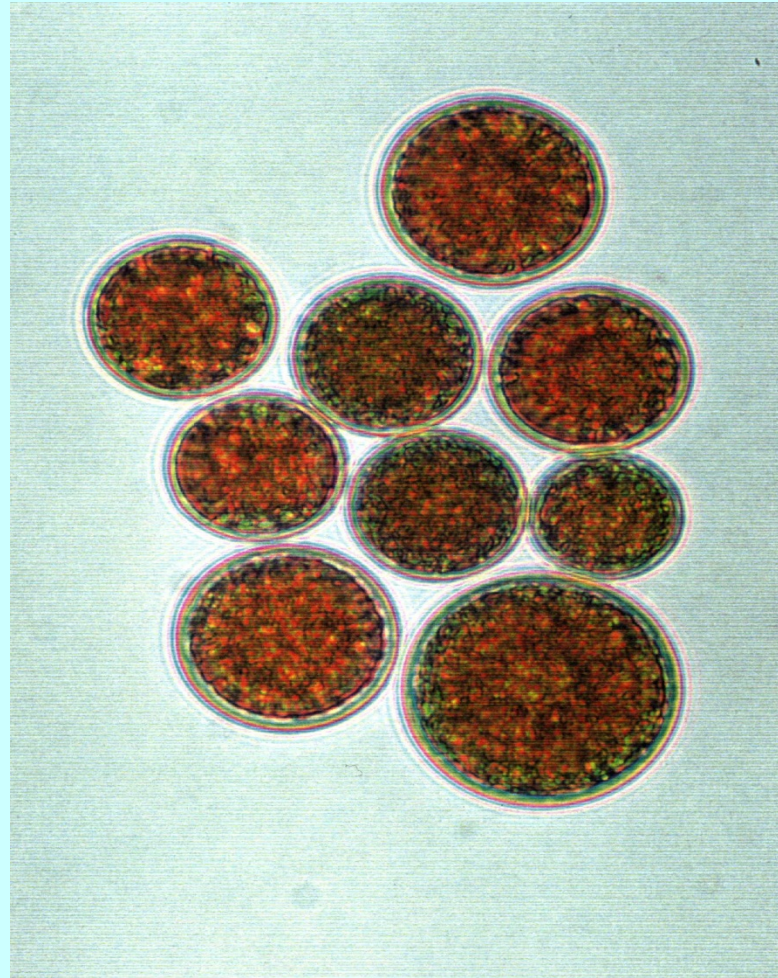
What is Haematococcus?

- *Haematococcus* is a green algae, Chlorophyta.
- Found in pools of fresh water throughout the world.
- Studied since 1797 (Girod-Chantrons). Astaxanthin correctly identified as red pigment in 1944 (Tisher).
- Produces the highest concentration of natural astaxanthin (50,000 ppm. Wild type *Phaffia* produces 200 ppm astaxanthin, Krill or crawfish oils up to 1200 ppm.
- Green cells have flagella to provide motility to seek new nutrient sources.
- When stressed, cells lose flagella, encyst and produce intracellular astaxanthin for protection against oxygen radicals and UV light.

Haematococcus Cells

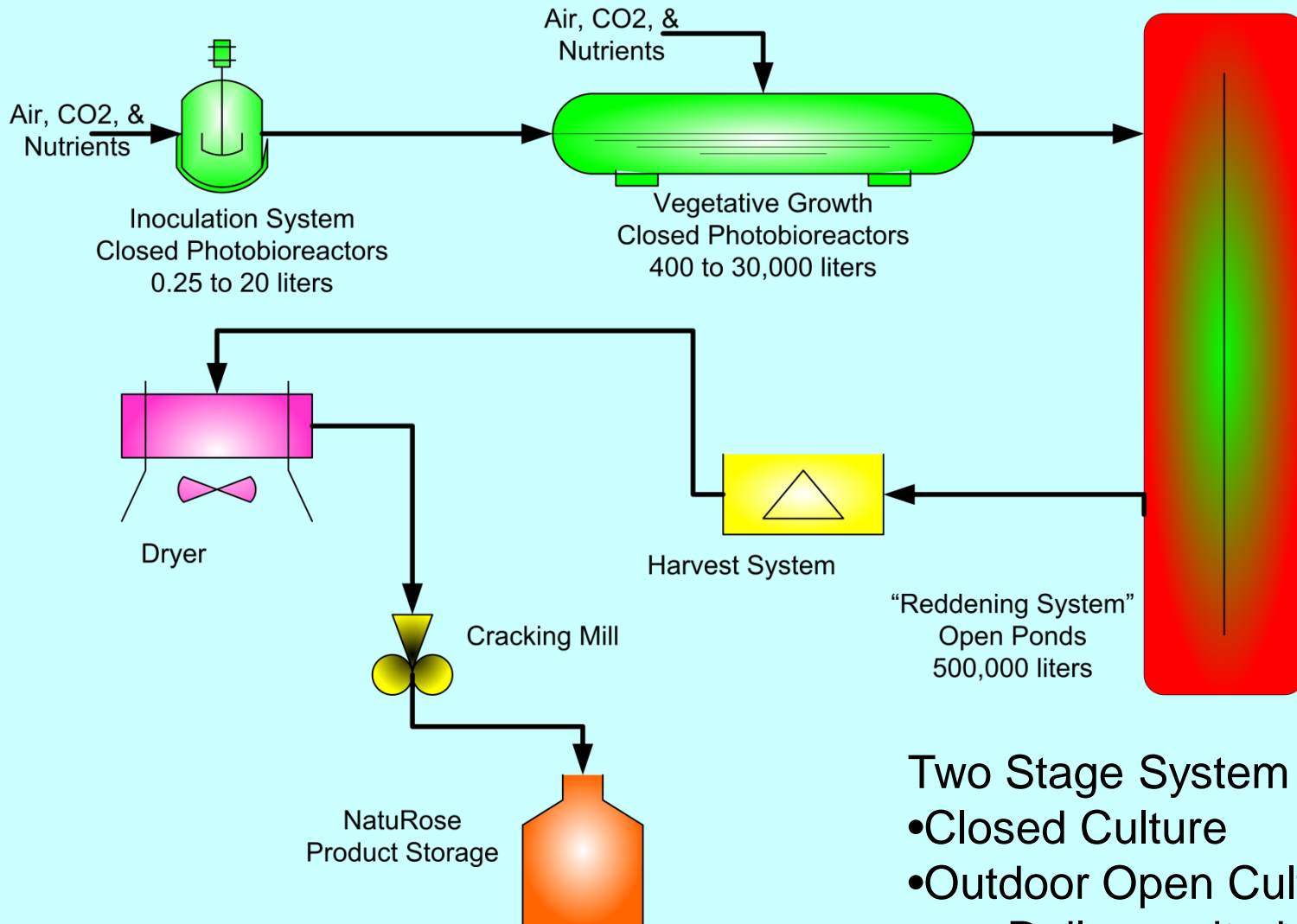


Motile, green
Haematococcus
cells



Encysted cells produce massive
amounts of astaxanthin (400x
magnification)

Productions of Haematococcus



Two Stage System

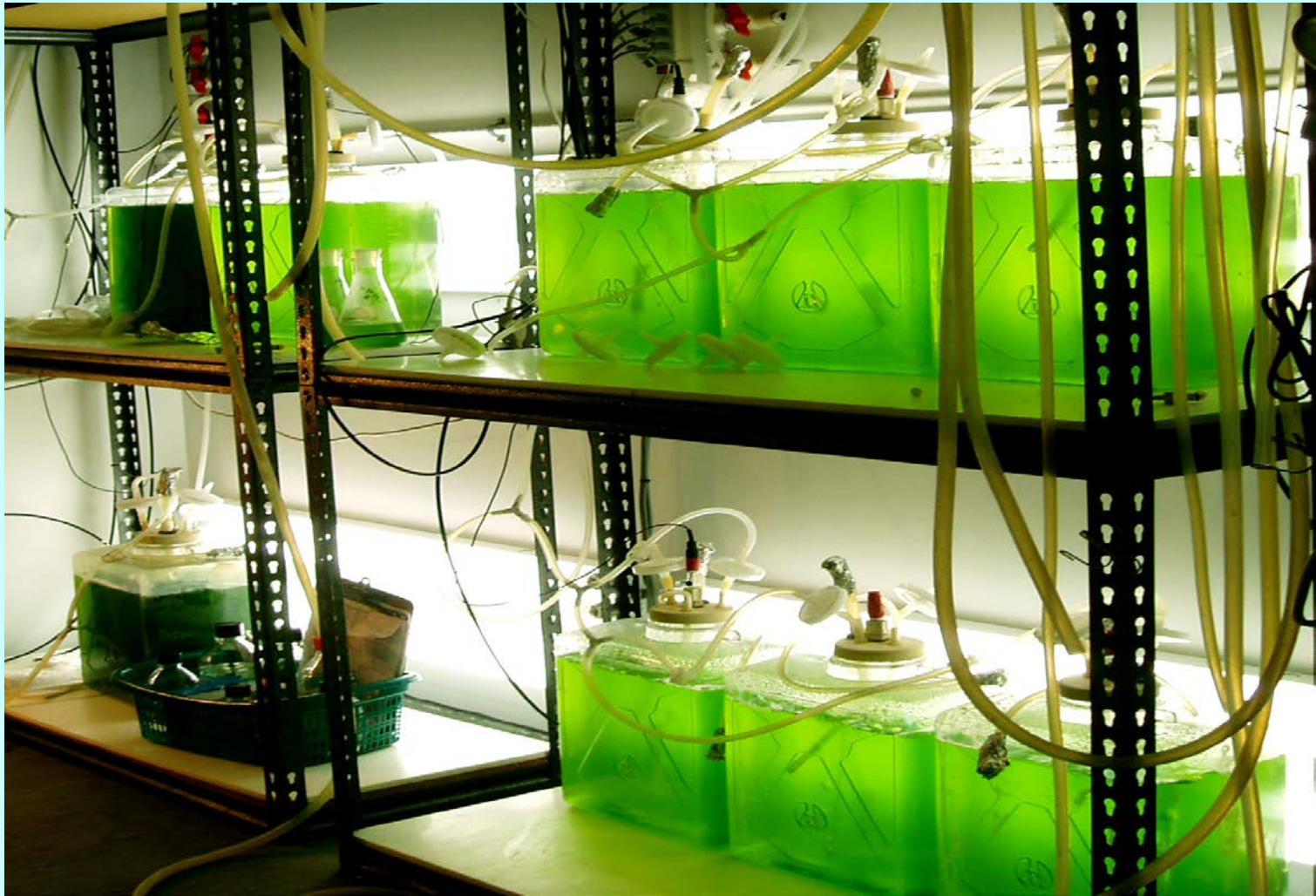
- Closed Culture
- Outdoor Open Culture
 - Daily monitoring of open cultures

Productions of Haematococcus



250 ml Shake Flask Cultures

Productions of Haematococcus



20 Liter Carboy Culture System

Productions of Haematococcus



400 Liter Column Closed Culture System

Astaxanthin formation in Haematococcus cultures

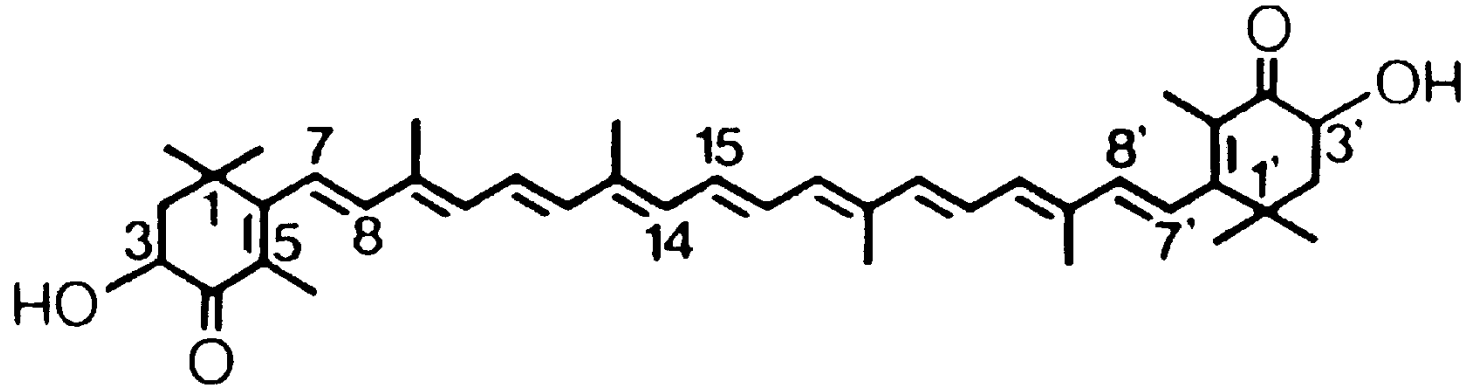


Final Production in Reddening Ponds



The final stage *Haematococcus* production is in 500,000 liter ponds where high concentrations of astaxanthin accumulate in cells.

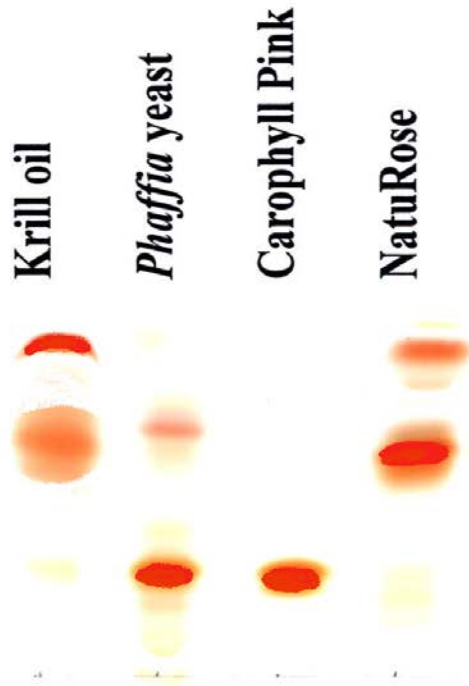
Astaxanthin Chemistry



- Astaxanthin is a carotenoid similar to beta-carotene, lutein and lycopene.
- Carotenoids are sensitive to heat, light and oxygen.
- Conjugated double bonds 'chromophore' elicits red color.
- The 3-hydroxyl and 4-keto groups bind to muscle flesh of salmonid flesh. Astaxanthin is lipid soluble (lipophilic).
- Hydroxyl groups can be esterified to fatty acids, creating mono and diesters.

Carotenoid analysis

Thin-layer chromatography shows NatuRose is most similar to krill, a natural source of astaxanthin for wild salmon.



← Astaxanthin diesters

← Astaxanthin monoesters

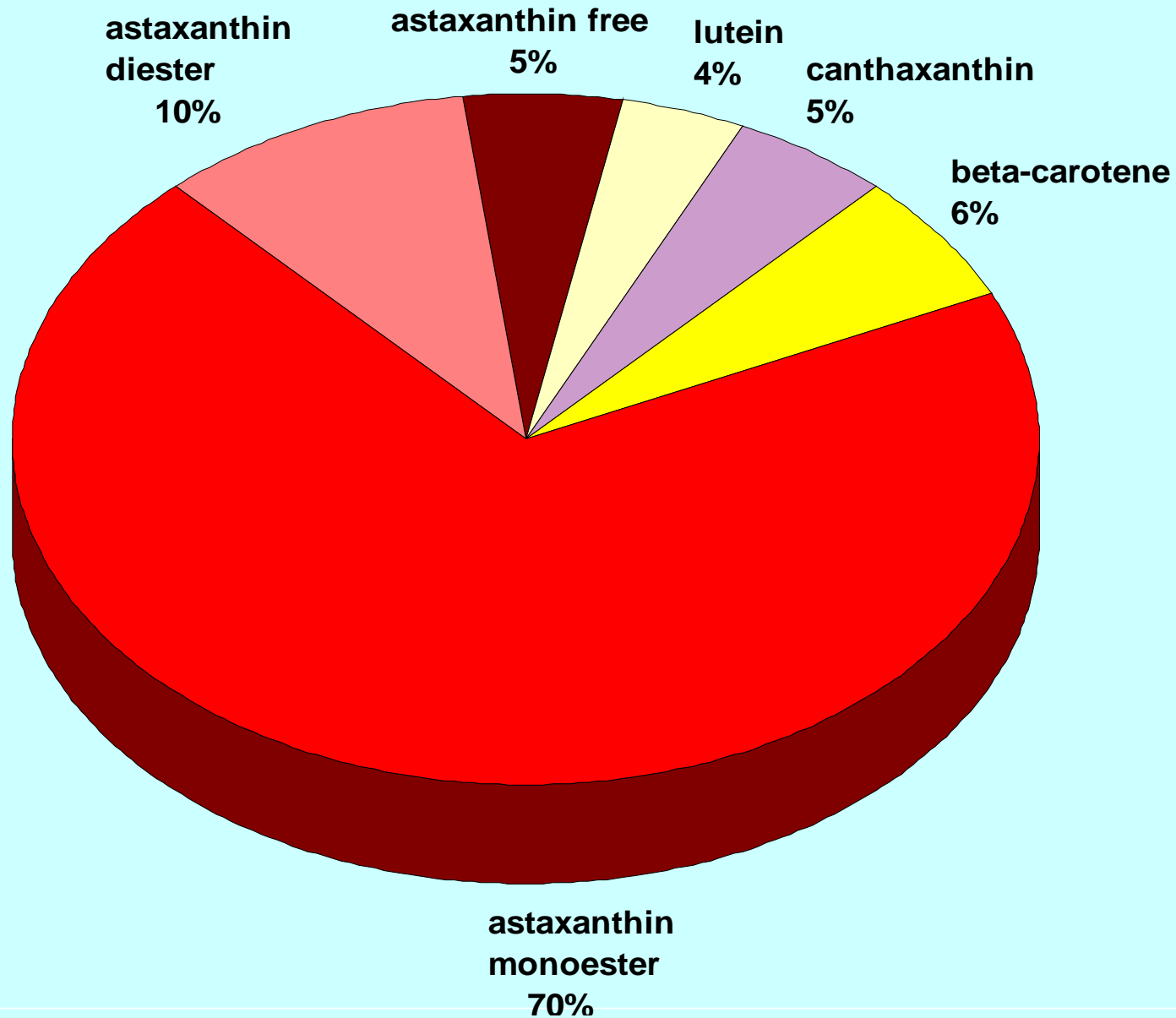
← Free astaxanthin

What is NatuRose?

- NatuRose™ is a natural source of astaxanthin from non-GMO *Haematococcus pluvialis*. NatuRose is milled to crack cells, and spray-dried into a dark red powder.
- Consistent concentration: *Standardized* to contain 2.0% (20,000 ppm) astaxanthin, plus beta-carotene, canthaxanthin and lutein.
- Whole algae is used: lipids, proteins and carbohydrates
- Packaged in vacuum-sealed, foil laminate bags.
- Added to feeds as a premix or can be blended into oils and used to topcoat feeds.



NatuRose Carotenoids



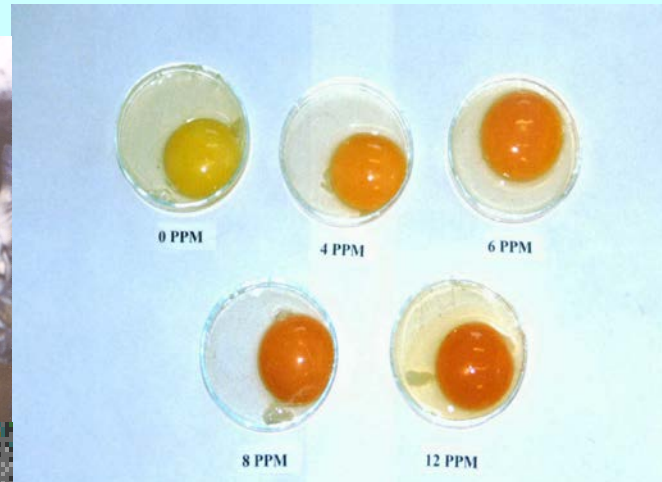
NatuRose Approvals



- Approved by US FDA for salmonids (21 CFR 73.185).
- Approved by Canada CFIA for salmonids (Reg. # 990535).
- Approved in Japan for all animal feeds.
- Organic approval New Zealand.

NatuRose Applications

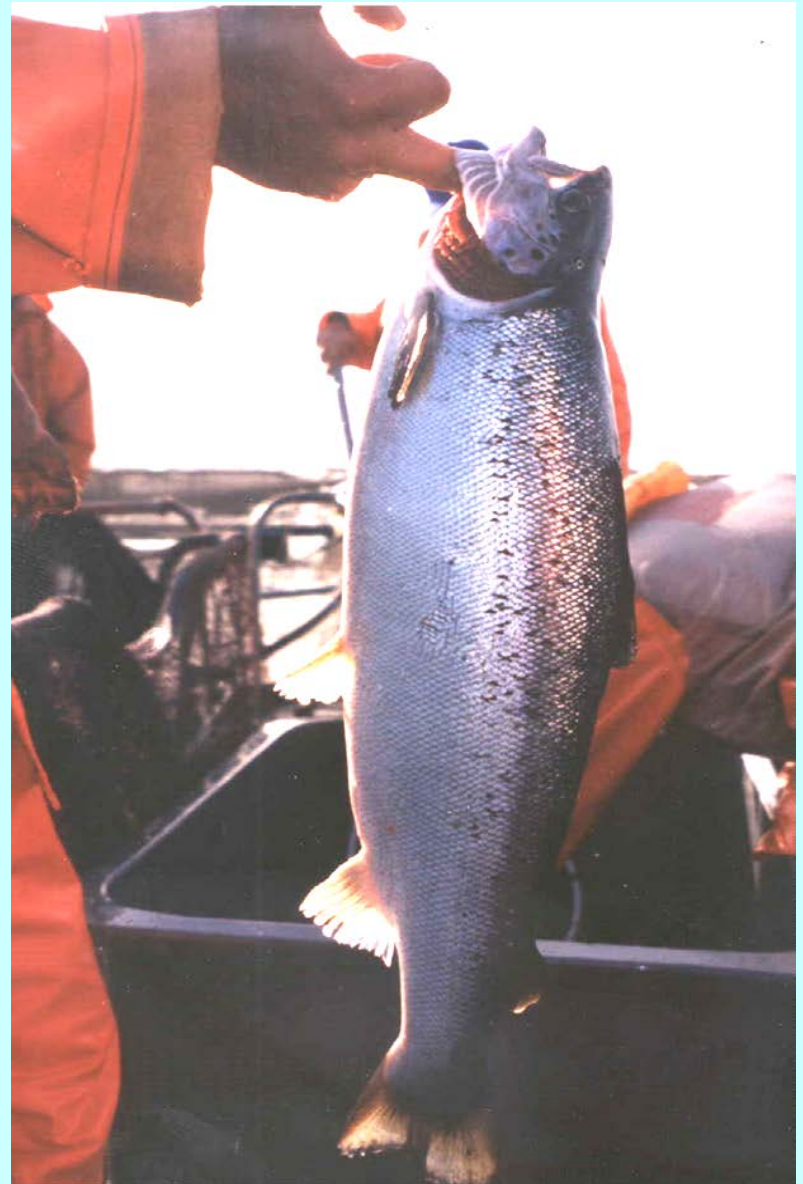
NatuRose was used worldwide to pigment shrimp, trout, Coho, Atlantic salmon, red sea bream, tropical fish, and egg yolks.



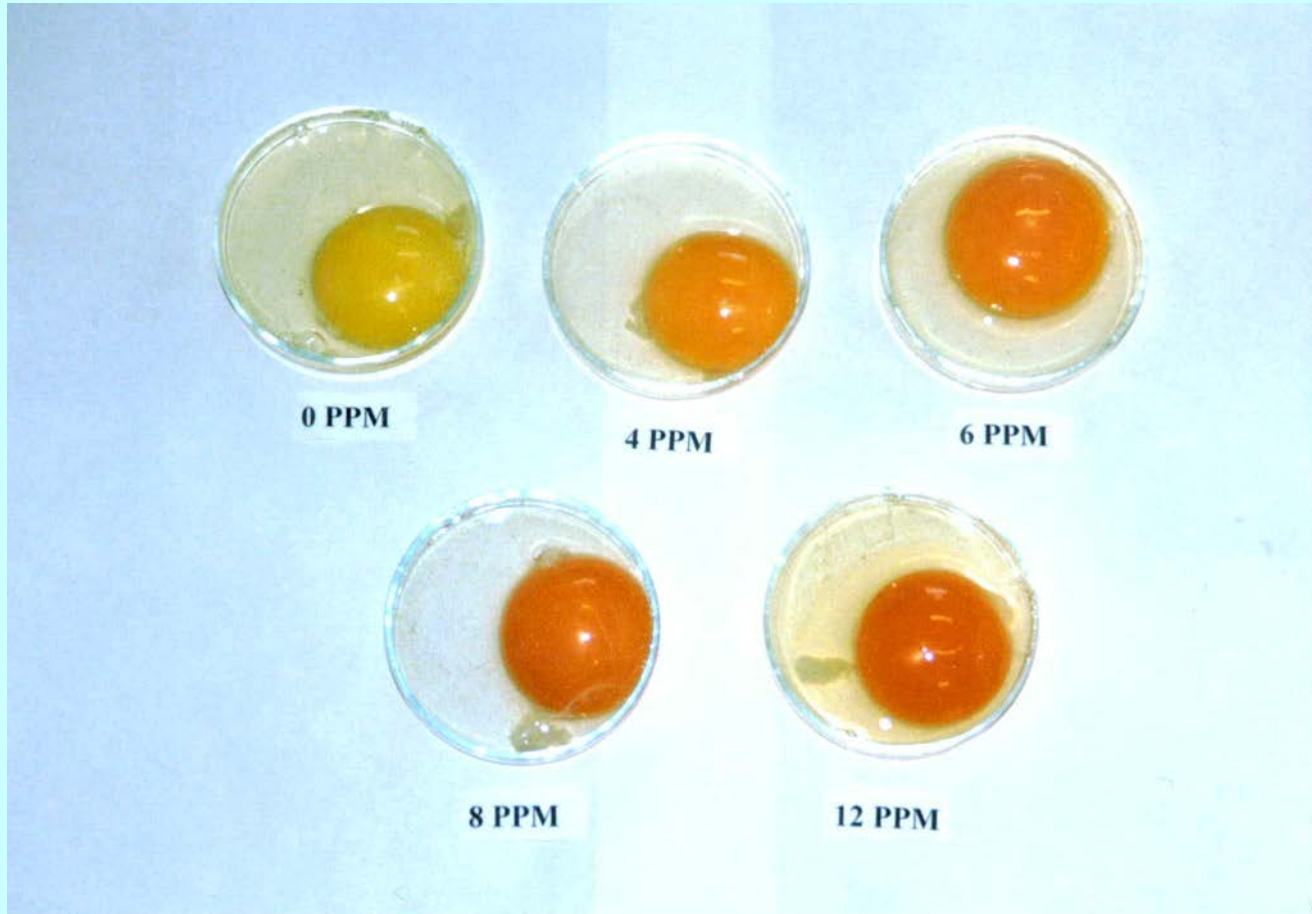
NatuRose Feeding Studies

- Trout
 - 3 Studies
- Salmon
 - 4 Studies
- Shrimp
 - 6 Studies
- Yellowtail
- Sea Bream
- Ornamentals
 - 5 Studies
- Poultry
 - 3 Studies
- Dogs
 - “Secret ingredient”

Atlantic Salmon



Poultry



NatuRose coloration of egg yolks,
University of New England

NatuRose Safety



- 48 NatuRose Customers in 15 Different Countries
 - Commercial aquaculture—Salmon, trout, sea bream, yellow tail
 - Ornamental fish feeds
 - Poultry
 - Dogs
- Discontinued NatuRose Sales in late 2007
 - High demand in human supplement market, BioAstin
 - 97% sales increase first 6 months of 2011
 - Expanding production by 33%

Cyanotech Corporation

