Microalgae Production and Their Use in Animal Feeds
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
Spirulina Production Flow Chart

Culture Ponds

Culture Media Reservoir

CO₂

Nutrients

Make-up Water

Culture Media and Wash Water

Clarified

Vacuum Filter

Wash Water

Wash Water

Dryer

Dewatered, Washed, Spirulina Slurry

Dried Spirulina Powder

Blender

Packaging

QC Testing
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-Chantrans). 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

Inoculation System
Closed Photobioreactors
0.25 to 20 liters

Vegetative Growth
Closed Photobioreactors
400 to 30,000 liters

Air, CO2, & Nutrients

Dryer

Harvest System
“Reddening System”
Open Ponds
500,000 liters

Cracking Mill

NatuRose Product Storage
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.

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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 blended into oils and used to topcoat feeds.
NatuRose Carotenoids

- Astaxanthin monoester: 70%
- Astaxanthin diester: 10%
- Astaxanthin free: 5%
- Lutein: 4%
- Canthaxanthin: 5%
- Beta-carotene: 6%
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
- Ornamental
  - 5 Studies
- Poultry
  - 3 Studies
- Dogs
  - "Secret ingredient"
Atlantic Salmon
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%