Finding Farmers: Opportunities and Challenges for Algae Feed and Fertilizer

Martin Sabarsky, CEO
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Outline of Presentation

1. (Brief) introduction to Cellana
2. Mega-trends for algae-based feeds (and foods)
   A. The looming protein crisis / gap (WSJ article from December 2015)
   B. The rise of alternative protein / meat sources (Impossible Foods, New Wave, Beyond Meat, Hampton Creek, Soylent, Modern Meadow, etc.)
   C. “Peak Fish” and the explosion of aquaculture
      i. Farmed fish no longer as good a source of Omega-3s because of the increasing trend to reduce the fishmeal % in feed and replace with grain products (generally with lower protein and no/low Omega-3s and no/low pigments)
   D. Increasing consumer attention to sustainability (needs to be credible)
3. Recent (successful) feed trials with Cellana’s ReNew Feed™ algae meal
4. Emerging value proposition for algae-based feeds
Intensive, Efficient Algae Production at the Kona Demonstration Facility (KDF) in Hawaii

- 6-acre (2.5 ha) site in Kona, Hawaii
- ~$20MM facility; ~1MM liter cultivation capacity
- Produced over 15,000 kg of microalgae since 2010 for testing/large-scale feed trials
- 10+ novel strains grown at industrial scale to date; focus on high-Omega-3 strains (for $10+/kg applications)
- Commercial biomass yields achieved with Omega-3 producing strains in 2015/2016

- Whole algae enriched with Omega-3s
- Protein-rich algal meal (w/ some Omega-3s)

Aerial View of KDF

Omega-3 oil

Biocrude oil
Cellana’s Multi-Product Business Model: up to 4 Products From Each Strain Via ALDUO™ + “Conventional” Upstream/Downstream Processes

• “Off-the-shelf” ag inputs + sunlight + CO₂ + ALDUO™ =

• Existing or new & improved separation/extraction techniques =

- Whole algae for Omega-3 extraction
- Aquaculture hatchery feed

~70% tot. vol. (post-extraction)
Opportunity for Algae Meal to Replace Fishmeal in Aquafeeds and Soymeal in Livestock Feeds

Fishmeal trades at 3x - 4x the price of soymeal historically

Aquaculture growing rapidly & needs more protein; Fish capture peaked in 1996 & is now flat / in decline

Source: FAO, “THE STATE OF WORLD FISHERIES AND AQUACULTURE 2016”

Source: prices for fishmeal and soymeal from http://www.indexmundi.com
How to Satisfy the World’s Surging Appetite for Meat

by Jacob Bunge

The race is on to breed better birds as chicken emerges as the protein of the masses

by Jacob Bunge
“How to Satisfy the World’s Surging Appetite for Meat”
by Jacob Bunge

World Meat Production
By type, in millions of metric tons

*includes chicken and turkey

Source: UN Food and Agricultural Organization
“How to Satisfy the World’s Surging Appetite for Meat”

“Food producers face a monumental task. At current consumption rates, the world would need to generate 455 million metric tons of meat annually by 2050, when the global population is expected to reach 9.7 billion, from 7.3 billion today. Given today’s agricultural productivity, growing the crops to feed all of that poultry, beef and other livestock would require every acre of the planet’s cropland, according to research firm FarmEcon LLC — leaving no room for raising the grains, fruits and vegetables that humans also need.”

“Rising household incomes among rapidly growing populations of developing countries are expected to whet the world’s appetite for meat. Global meat production nearly quadrupled over the past 50 years, while the population only slightly more than doubled. Over the next 35 years the world will need to increase meat production by another two-thirds as global GDP roughly doubles, according to United Nations projections.”

“Environmentalists and consumers who share their concerns are pressuring companies over water use: Crop and livestock production accounts for nearly 70% of the global total.”

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water Footprint (Liters)</th>
<th>Emissions (kg CO$_2$e)</th>
<th>Land Use (m$^2$)</th>
<th>Grain for Feed (kg)</th>
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<td>BEEF</td>
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<td>7.9</td>
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<td>ALGAE (ReNew)</td>
<td>&lt;500</td>
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<td>&lt;0.25</td>
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Sources: Water footprints: [www.waterfootprint.org/?page=files/productgallery](http://www.waterfootprint.org/?page=files/productgallery); emissions and land use: UK DEFRA (2006), [http://goo.gl/T12.ho](http://goo.gl/T12.ho); grain: National Geographic, [http://goo.gl/4CgFB](http://goo.gl/4CgFB); Algae, Cellana estimates <0.25 CCU.
Lowest Carbon, Land, Water Footprints Compared to Other Sources of Protein/Feed and Fuels

- Lower Carbon Footprint
- Lower Arable Land Footprint
- Lower Fresh Water Footprint

- Carbon Footprint of Conventional Feeds & Fuels <10%
- Arable Land Footprint of Conventional Feeds & Fuels <10%
- Fresh Water Footprint of Conventional Feeds & Fuels <20%
Algae is Key to Sustainable Omega-3 Production
Algae Meal Co-Product Can Replace Fishmeal Too!

Fish Oil / Omega-3 Food Chain

Sustainable Omega-3 Production Direct from Algae

Cellana “Cuts Out the Middle-Fish”™
Vegetarian, Low-Cost, Sustainable Omega-3s
without Mercury, Dioxins, or PCBs from Fish

Marine microalgae
Zoo-plankton
Herbivorous/planktivorous fish
Smaller carnivorous fish
Larger carnivorous fish (e.g., Salmon)
Fish Oil with Omega-3 + Mercury, Dioxins, & PCBs
Marine microalgae
Algae Oil with Omega-3s
Multiple successful, large-scale feed trials

- **Broiler Chicks**: Cellana’s ReNew™ Feed could substitute for 7.5% of soybean meal alone, or in combination with corn, in diets for broiler chicks when appropriate amino acids are added.

  *Potential and Limitation of a New Defatted Diatom Microalgal Biomass in Replacing Soybean Meal and Corn in Diets for Broiler Chickens*, Xin Gen Lei (Cornell) et al., J. of Agricultural & Food Chemistry, 61(30), pp. 7341-8 (2013)

- **Broiler Chicks and Weaning Pigs**: Broilers fed 15% Cellana’s ReNew™ Feed had 16% greater gain/feed efficiency than the control diet over the 42-day period.

  *Nutritional and Metabolic Impacts of a Defatted Green Marine Microalgal (Desmodesmus sp.) Biomass in Diets for Weanling Pigs and Broiler Chickens*, Xin Gen Lei (Cornell) et al., J. of Agricultural & Food Chemistry, 62 (40), pp. 9783–9791 (2014)

- **Broiler Chicks**: Broilers fed 16% Cellana’s ReNew™ Feed had up to 60x greater Omega-3 content than those fed the control diet.


- **Salmon and Shrimp**: Cellana’s high-Omega-3 ReNew Feed was acceptable for salmon and shrimp at up to 12.5% to 15% inclusion; *Publication pending, 2016/2017*

- **Salmon**: Cellana’s high-protein ReNew Feed was acceptable for Atlantic salmon at up to 20% inclusion; Fishmeal reduced by 26%, fish oil reduced by 15%

Validation in salmon and shrimp (inclusion up to 12.5%, 15%)

Enhanced pigmentation of salmon fillet with Cellana algae meal (Omega-3 strain, 2015)

Improved pigmentation with algae feeding based on SalmoFan™ values (visual analysis) below.
1. Protein content vs. fishmeal, soy/soymeal, wheat, DDGs, others
2. Specific amino acid profile vs. other protein sources
3. Residual Omega-3 content in algal meal (post-extraction)
4. Residual pigments in algal meal (post-extraction)
5. Less/No allergenicity vs. other protein sources (e.g., wheat, soy)
6. No estrogen-mimetic compounds (phytoestrogens) vs. soy/soymeal
7. Unparalleled sustainability vs. other protein sources
Thank you

For more information, visit www.cellana.com