Biotechnology Driven Co-product Opportunities

Kalpesh Parekh, Novozymes
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Biofuels Industry Maturation

U.S. corn: Feed and residual use, ethanol, and exports

Billion bushels

Feed and Residual Use

Ethanol

Exports

Noticeable Innovation to Drive Growth

- **Corn Fiber to Ethanol**
  - Insitu & Separate
  - Cellulosic ethanol, higher RINs

- **Co-product Modification**
  - Fractionation and Insitu

- **Technologies to create novel animal feed**
  - Secondary fermentation
Growth in Poultry and Swine

Figure 3.4.2. Growth of meat production by region and meat type
2025 vs 2013-15

Mt (c.w.e. or r.t.c)

- Beef (Developing: 7.67; Developed: 17.13)
- Pork (Developing: 10.77)
- Poultry (Developing: 2.83; Developed: 0.58)
- Beef (Developed: 2.68)
- Pork (Developed: 9.02)
- Sheep (Developed: 0.34)
- Total increase

Note: c.w.e. is carcass weight equivalent, r.t.c. is ready to cook equivalent.

DDGs Inclusion Rate Lowest for Poultry

Avg. of potential DDGS inclusion rates based on field trials (% of daily DM intake)

- Beef: 22%
- Dairy: 8%
- Pigs: 15%
- Poultry: 10%

The lower energy (less starch) and higher fiber content is concern and low fiber digestibility limits the inclusion of DDGS in poultry diets.
Corn Kernel Fiber in DDGS

Cellulose & Hemicellulose

Fiber is a significant component of DDGS (30%)
Takes up space in a monogastric feed ration
  • Dilution of energy in feed
  • Increase in gut fill / viscosity
  • Encapsulation of nutrients (eg: niacin)

Fiber = Low Metabolizable Energy

Idea – create digestible fiber for higher energy, higher inclusion rates and higher value

Cellulase Suite for Corn Fiber Hydrolysis

Non-reducing ends

Reducing ends

CBH

EG

BG

novozymes®
Hemicellulase Suite for Corn Fiber Hydrolysis

Adapted from: Glycan complexity dictates microbial resource allocation in the large intestine. Artur Rogowski et al. Nature Communications 6:7481 doi: 10.1038/ncomms8481 (2015); Published 26 Jun 2015; Updated 5 Feb 2016
Effective blend of enzymatic activities to impact fiber

Novel Enzyme blends can make fiber more digestible - Insitu

Grain Receiving → 
Hammer Mill
Slurry / Mix tank 85 C, pH 4.8-5.8 30 min → 
Liquefaction tanks 85 C, pH 4.8-5.5 90 min → 
Fermentation tanks 32 C, pH 4 – 4.8 48 – 70 hours → 
Beerwell 32 C, pH 4 – 4.5 12 hours
Distillation 110C, pH 4 – 4.5 1 hour → 
Ethanol Storage

Backset → 
Thin Stillage → 
Partially Evaporated Syrup → 
Centrifuge

Evaporators 85C, pH 3.8 – 4.2 30 minutes → 
Distiller’s Corn Oil (DCO)

Syrup Storage → 
Syrup → 
Wetcake → 
Dryer, 220C, 30 minutes

DDGS

DDGs with higher Energy
Increasing Fiber digestibility - Animal trials

40 birds total
Measuring true metabolizable energy (TME) and amino acid digestibility
Impact of novel enzymes on DDGs Energy

Significant decrease in ADF

Significant increase in Energy
Feed Savings in Grower/Finisher Diet

10% AME improvement exceeds $1.5/T Feed savings target with a $20 DDGS premium

Maximum DDGS Inclusion – Control at 10% and Upgraded at 14%
Poultry industry says

- Will Pay more for upgraded DDGS if can impact savings of > $1 per ton feed
- DDG premium structure Market + $X could be acceptable
- Need Proof “beyond reasonable doubt” – Feeding studies, Assays
- Product consistency is as important

- Work consistently with integrators
- Can help develop nutrition equations for upgraded DDGs

- Traceability not an issue – getting easier with technology
To Branch out DDGs from commodity it is imperative to work together

- Feed Integrators
- Ethanol and Co-Product Producers
- Technology Providers
Noticeable Innovation to Drive Growth

Corn Fiber to Ethanol
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cellulosic ethanol, higher RINs

Co-product Modification
Fractionation and Insitu

Technologies to create novel animal feed
Secondary fermentation
Creating a new Co-product – Single Cell Protein
Aqua Feed Market is Growing

Feed Conversion Ratio
Estimated feed required to gain one pound of body mass

<table>
<thead>
<tr>
<th></th>
<th>Farm-raised fish</th>
<th>Broiler chickens</th>
<th>Hogs</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pound</td>
<td>1.1 Pounds</td>
<td>1.7 Pounds</td>
<td>2.9</td>
<td>6.8 Pounds</td>
</tr>
</tbody>
</table>

Health & Sustainability are key drivers

Aquaculture Industry is going through a major shift in the way they acquire ingredients:

**Sustainability and Supply consistency** are major drivers along with **price**

Fishmeal production (FM) = 4.6MM MT

FM like protein need in 2020 = 5-6 MM MT, by 2027 = 8 MM MT

FM production will not go up – alternatives will fill the gap
Filling the protein gap

**Soy based**

SBM – low on protein, high on anti nutritional matter (ANF)

SPC – good on protein, some ANF

Volatile price ($700-$1000/T), maximum inclusion reached (20%)

**Poultry meal, rapeseed & other meals**

Low in protein (50%), inclusion cannot go up much

Europe does not allow animal meal inclusion

**Insect Meal**

Could be a reality someday – scale and economics challenging

Europe started allowing Insect meal in diets this summer
Other Challenges in Aqua industry

Fish, Shrimp are farmed under conditions more stressful than in past
Higher disease and mortality rate

Aquafarming also has opportunity to improve feed digestibility and reduce environmental impact

Novel Biotechnology + Ethanol Industry can meet these needs
## Example Trout diet

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>g/100g Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menhaden Meal</td>
<td>32</td>
</tr>
<tr>
<td>Menhaden Oil</td>
<td>16</td>
</tr>
<tr>
<td>0360 vitamin premix</td>
<td>0.5</td>
</tr>
<tr>
<td>5TSZ Mineral premix</td>
<td>0.1</td>
</tr>
<tr>
<td>Alphacel</td>
<td>6</td>
</tr>
<tr>
<td>Astaxanthin</td>
<td>0.05</td>
</tr>
<tr>
<td>Stay-C (Vitamin C source)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Soy Protein Concentrate</strong></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1</td>
</tr>
<tr>
<td><strong>Chicken by-product meal</strong></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td>Taurine</td>
<td>0.5</td>
</tr>
<tr>
<td>Soy lecithin</td>
<td>0.5</td>
</tr>
<tr>
<td>Lysine HCl</td>
<td>0.35</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.4</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>21</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>100</strong></td>
</tr>
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</table>
**Single Cell Protein**

Single-cell protein (SCP) refers to edible unicellular *microorganisms* from pure or mixed cultures of *algae, yeasts, fungi* or *bacteria* may be used as an ingredient or a substitute for protein-rich foods - *Wikipedia*

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**Single Cell Protein**

Can provide Fish Meal like protein product with similar amino acid balance

Can be designed to provide **health benefits**

SUSTAINABLE, CONSISTENT QUALITY & SUPPLY

*Can help Ethanol and Aqua Industry’s needs*
Flavor for SCP’s potential

Ethanol Industry in NA
   Potential SCP Amount = 2 MM T
   Avg. Price = $1200/T
   SCP revenue > 2 B USD

South America (Chile, Peru)
    Europe (Norway)
    Asia (China, Thailand)
    US

Amount = 4.5MM T
Avg. Price = $1500/T
FM Value = 6.5 B USD

Price
Supply
Sustainability

Technology provider

Single Cell Protein
Single Cell Protein manufacturing

Dextrose

Syrup

Ethanol

CO₂

Bacteria or Yeast
Aerobic or Anaerobic
Protein + Organic acids, antioxidants, colorants
Economic considerations – an example

- **CAPEX 25M**

  **SCP for FM Protein replacement**
  - Produce 15 KT, Revenue ($1200/T) = 18M
  - Margin = 3 MUSD

  - Straightforward
  - Drop in after establishing results

- **SCP for FM Protein replacement + Other benefits (i.e. health)**
  - Produce 15 KT, Revenue ($2500/T) = 38M
  - Margin > 10 MUSD

  - Higher burden of proof for health
  - Establishing “bundling” takes time
Technical Considerations

Physical form of the feed with the SCP – Sink or Swim

Palatability – Do the fish like your feed?

Is it nutritious/digestible? – Feed Conversion Ratio
Commercial Considerations

Partnership with Fish/Shrimp farms and possible feed suppliers
- Running trials that matter – creating product pull

Multiple species, Multiple trials, Multiple metrics
- Salmon, Trout, Tilapia, Shrimp
- Reputable, well connected facilities for trial – e.g. Canada, Norway

Scale, Logistics and Consistency
- Product from multiple plants to same feed integrator
Heard on the floor of aqua conferences

**Novel protein and health benefits are hot topics**

Single Cell Protein being worked on by small and large companies to prove its value and has great potential in providing consistent and sustainable protein to growing Aqua industry