Tunicates: A new marine biomass for animal feed and cellulose production
Aquaculture feed sources

Table 1  Use of plant ingredients vs. fish ingredients over the past 20 years in Norwegian aquaculture (% used of total feed sold from three feed companies*).

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>63.8</td>
<td>37.5</td>
<td>25.6</td>
</tr>
<tr>
<td>Plant protein (various sources)</td>
<td>0</td>
<td>15.4</td>
<td>36.9</td>
</tr>
<tr>
<td>Starch (mainly wheat)</td>
<td>10.3</td>
<td>10.9</td>
<td>9.4</td>
</tr>
<tr>
<td>Fish oil</td>
<td>23.4</td>
<td>30.7</td>
<td>17.0</td>
</tr>
<tr>
<td>Plant oil</td>
<td>0</td>
<td>0.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

*Microingredients such as vitamins, minerals and amino acids are excluded

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total industrial aquaculture feed production</td>
<td>30,000,000</td>
<td>71,000,000</td>
</tr>
</tbody>
</table>

-41,000,000

FAO-564, 2011
Easy mariculture (2,500 – 10,000 ind/m²)

200-450 kg WW per m²

260 kg DW biomass per surface m²

Rapid and extended seasonal growth
Established pilot farm

- Scalable trials and tests
- Product documentation
- Harvesting technology
- Processing tests
- Large scale growth capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (tonn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.5</td>
</tr>
<tr>
<td>2011</td>
<td>3</td>
</tr>
<tr>
<td>2012</td>
<td>7</td>
</tr>
<tr>
<td>2013</td>
<td>150</td>
</tr>
<tr>
<td>2014</td>
<td>300</td>
</tr>
<tr>
<td>2016</td>
<td>1000</td>
</tr>
</tbody>
</table>
## Tunicate chemical composition

![Image of a tunicate](image)

### Ciona intestinalis composition analysis (g/100 g DM)

<table>
<thead>
<tr>
<th></th>
<th>Raw Biomass (g/100g DM)</th>
<th>Inner Animal (g/100g DM)</th>
<th>Mantle (g/100g DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASH</strong></td>
<td>40.9 ± 0.1</td>
<td>18.9 ± 0.1</td>
<td>6.5 ± 1.4</td>
</tr>
<tr>
<td><strong>Protein</strong>*</td>
<td>50.1 ± 2.6</td>
<td>61.7 ± 3.5</td>
<td>49.1 ± 4.3</td>
</tr>
<tr>
<td><strong>Carbohydrates</strong>*</td>
<td>15.3 ± 3.0</td>
<td>6.5 ± 1.0</td>
<td>31.5 ± 3.3</td>
</tr>
<tr>
<td><strong>Lipids</strong>*</td>
<td>13.7 ± 1.5</td>
<td>19.8 ± 3.4</td>
<td>3.9 ± 0.8</td>
</tr>
</tbody>
</table>

*Ash free
Tunicate Product Opportunities

- Biomedical
- Electronics
- Absorptive
- Composites
- Paint and coatings

Animal feed
Opticom-gründer Hans Gude Gudesens comeback

Bruker all tid og penger på sitt livs prosjekt

Dette er Gudesens nye kjempeprosjekt

Opticom-gründer Hans Gude Gudesen (67) gjør comeback i norsk næringsliv. Nå bruker han all energi på sitt livs prosjekt.
Collaborative & Partnership Network

Concepts/R&D

- University of Bergen
- Uni Research
- BTO
- NOFIMA
- SINTEF
- IMR
- ILAB
- IRIS
- NIFES
- NMBU

Universities/Institutes

- KTH (Royal Institute of Technology)
- Linköping University
- Innventia
- Swerea IVF
- MoRe Research
- Zhejiang University
- Bristol University
- University of South Florida
- University of Oregon

Companies

- TuniChor
- Scalpro
- Yara Int
- EWOS Innovation
- Ølke Industrier
- Stord Process
- Hansen Mekaniske
- Borregaard
- Sperre
- Freudenberg household products
- LinkoCare
- Ocean IPR
- Ocean M
- Kramer Machines
- AkzoNobel
- Flottweg
Thank you