Sustainable and cost-efficient replacement of fish meal by animal and plant protein in feeds for Atlantic salmon salmo salar

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Objectives

Replace the fish meal in salmon diets by *plant protein* and *avian by-products* to investigate effects on

1. Growth and feed utilisation
2. Cost efficiency
3. Fish in / fish out
4. Productivity
Feedstuffs

Protein sources:
• Fish meal (FM)
• Shrimp meal
• Poultry by-products meal
• Feather meal
• Corn gluten meal
• Wheat gluten
• Soybean meal
• Lupin kernel meal

Other:
• Fish oil
• Wheat meal
• Vit + min premix
• Phosphorus
• Lysine HCl
Test diets - composition

<table>
<thead>
<tr>
<th></th>
<th>5% FM</th>
<th>10% FM</th>
<th>20% FM</th>
<th>36% FM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>41.0</td>
<td>41.2</td>
<td>40.7</td>
<td>41.4</td>
</tr>
<tr>
<td>Lipid, %</td>
<td>29.8</td>
<td>29.9</td>
<td>30.1</td>
<td>30.2</td>
</tr>
<tr>
<td>Ash, %</td>
<td>5.1</td>
<td>5.9</td>
<td>5.9</td>
<td>7.1</td>
</tr>
<tr>
<td>USD / tonn*</td>
<td>620</td>
<td>663</td>
<td>772</td>
<td>860</td>
</tr>
</tbody>
</table>

*Prices on Chiloe Island in July 2006
Test diets – 36% vs. 5% fish meal
Ingredient cost and use of marine protein in the diets

<table>
<thead>
<tr>
<th>Ingredient cost, USD / ton feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>2000</td>
</tr>
<tr>
<td>3000</td>
</tr>
<tr>
<td>4000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use of marine protein, kg / ton feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>2000</td>
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<td>3000</td>
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</table>

% FM in the diet vs USD / ton feed and kg / ton feed.
Fish and experimental details

- Location: Salmofood’s model sea farm at Liucura (Chiloe, Chile)
- Fish: Atlantic salmon; IBW = 721 g
  1500 fish / pen
- Pens: 12 7 x 7 x 7 m
- Replication: 3 pens / treatment
- Saltwater (11 -13 °C)
- 116 feeding days
Weight gain

% FM in the diet

Initial BW  Gain

5  1467  1546  1675  1731
10  1500  1546  1675  1731
20  1500  1546  1675  1731
36  1500  1546  1675  1731

5.8.2009 Aquaculture Europe 2009, Trondheim
Growth (TGC x 1000)

- Days 1-35
- Days 36-116

$R^2 = 0.99; P < 0.0001$

$R^2 = 0.60; P = 0.24$
FCR (feed intake / gain)

\[ R^2 = 0.95; P = 0.0001 \]

\[ R^2 = 0.70; P = 0.03 \]
The aim of productivity is maximum efficient utilisation of resources

- **Increased** net fish production
  (fish in / fish out < 1)
Ingredient cost and use of marine protein per ton salmon produced

- **Ingredient cost, USD / ton fish produced**
- **Use of marine protein / ton fish produced**

**Graph:**
- Y-axis: USD / ton fish
- X-axis: % FM in the diet

**Data Points:**
- Ingredient cost: 0, 300, 500, 600 USD / ton fish
- Use of marine protein: 0, 100, 200, 300 kg / ton fish

**Note:**
- 15.8.2009 Aquaculture Europe 2009, Trondheim SR
Wild fish caught for fish meal production / ton salmon produced

\[
\begin{align*}
\text{kg wild caught fish} & = 1500 \\
\% \text{FM in the diet} & = 0
\end{align*}
\]
Ton edible salmon produced / ton edible fish caught for fish meal production
Unit produced / unit spent marine protein

Net production

% FM in the diet
5 10 20 36
Conclusions

Reducing the dietary FM from 36 to 5%

- Only marginally affected growth
- Increased the FCR by 8.5%
- Reduced raw material costs by 31%
- Reduced marine protein use by 76%
- Made Atlantic salmon a net producer of marine protein, producing 2.5 times as much as it consumed
Perspectives

• Further growth in aquaculture requires efficient use of marine feedstuffs
• Production and processing of grains offers a wide variety of protein sources
• Animal and aquaculture by products may be “re-circulated” into excellent protein sources for fish
• Salmon farming may become independent of fish meal
Future fish feeds contains little fish!

Thank you.