Let them eat insects: evaluating the potential of manure-raised housefly larvae (*Musca domestica*) as a feed ingredient in the diet of rainbow trout (*Oncorhynchus mykiss*).

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Introduction

Historically, fishmeal has been an excellent, although unsustainable, source of protein for farm- and hatchery-raised fish. To reduce feed costs and improve the sustainability of aquaculture and hatchery operations, alternative sources of high-quality protein must be developed. Housefly larva meal (LM) is a particularly promising alternative to aquaculture and hatchery operations, alternative sources of high-quality protein.

Methods

Historically, fishmeal has been an excellent, although unsustainable, source of protein for farm- and hatchery-raised fish. To reduce feed costs and improve the sustainability of aquaculture and hatchery operations, alternative sources of high-quality protein must be developed. Housefly larva meal (LM) is a particularly promising alternative to aquaculture and hatchery operations, alternative sources of high-quality protein.

Raw Diet Design

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Control Diet</th>
<th>5% Larvameal</th>
<th>10% Larva Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Larva meal</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Soy protein concentrate</td>
<td>20.7</td>
<td>15.8</td>
<td>0</td>
</tr>
<tr>
<td>Corn gluten meal</td>
<td>20.7</td>
<td>20.7</td>
<td>12.29</td>
</tr>
<tr>
<td>Wheat gluten</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>20.4</td>
<td>20.4</td>
<td>20.4</td>
</tr>
<tr>
<td>Fish oil</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Soybean Oil</td>
<td>5.9</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Minerals/Vitamin Mixture</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Diets were designed following the standard developed by Lee and Hardy (2015), which is meant to be representative of a modern commercial diet for Rainbow trout. High mortality was observed in the 5% LM diet (~20% after 8 weeks). Mortalities were examined but no clear cause was identified. This is a statistically significant difference (p<0.01, Kaplan-Meyer).

Feeding Trial

<table>
<thead>
<tr>
<th>Group</th>
<th>Diet Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Standard diet</td>
</tr>
<tr>
<td>Group 2</td>
<td>5% LM diet</td>
</tr>
<tr>
<td>Group 3</td>
<td>30% LM diet</td>
</tr>
<tr>
<td>Group 4</td>
<td>Standard diet</td>
</tr>
<tr>
<td>Group 5</td>
<td>30% LM diet</td>
</tr>
</tbody>
</table>

n = 6 aquaria per group, 14 fish per aquaria, 84 fish per group

Conclusions

- Even with with minimal processing, housefly LM compares favorably to leading modern fishmeal substitutes as an aquafeed ingredient.
- Housefly LM may have immune stimulatory properties which could increase its value as an ingredient in functional feeds.
- Housefly larvae can be produced at low cost by utilizing existing waste streams and the resulting LM is suitable as a feed ingredient for Rainbow Trout. This may one day improve the profitability and sustainability of dairy and aquaculture/hatchery operations, mitigate environmental impacts, and reduce reliance on fishmeal.

Future Directions

- Conduct follow-up experiments using LM to directly replace fishmeal
- Work with local farmers to develop ways to upscale LM production
- Investigate immune-stimulatory potential of LM with a focus on how the diet of the larvae might impact these properties

Acknowledgements

- Kelly Sams and Doug Haner provided expert technical assistance with fish care
- Rod Getchell gave advice on experiment design and diagnostic consultations
- The rest of the Marquis lab offered input, support, and occasional weekend fish feeding
- Françoise Vermayer of the Cornell Statistical Consulting Unit helped with the statistical analysis of mortality data.
- Funding for this project is provided by NE SARE and the Cornell Department of Food Science.

Literature Cited

5. Sams et al. (2015) Diet Design
7. Sealey et al. (2015) Diet Design
9. Work with local farmers to develop ways to upscale LM production
10. Literature Cited

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