Effect of plant feedstuffs on nutritional physiology and gut histology of tilapia – Preliminary results

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Outline

- Introduction
  - Overview about gut health
  - Hypotheses and objectives
  - Soybean meal in salmon
  - Soybean meal in carp
  - Tilapia???
- Materials and methods
- Preliminary Results
- Conclusions
Introduction – gut health is vital in gut health and maintaining general health of fish (Jutfelt, 2011, Sundhøl, 2009)

Gut barrier function is vital in exchange of materials between gut lumen and body.

Level 1: Inside the gut

Level 2: The gut wall (Epithelium cells)

Level 3: Immune system

Impairment

Exchange of materials between gut lumen and body

Stressors

Dietary composition

Environmental challenges

Transcellular through transcytosis

Paracellular through tight junction

WAGENINGEN UR
For quality of life
Fish are fed 20% of the dietary fishmeal replaced by soybean meal. The intestinal disorders were more severe in salmon reared at 12\textdegree C compared to those reared at 8\textdegree C. (Urán, 2008)

Fish fed the control diet

After 7 days of soybean meal feeding

After 20 days of soybean meal feeding
Introduction – enteritis is recovered on carp

**Common carp**

Fish are fed 20% of the dietary fishmeal replaced by soybean meal. The enteritis in the hindgut were present in week 1 and more severe in week 3. Common carp start to recover from 4 – 5 week (Urán, 2008)

*SNV: supranuclear vacuoles; GC: goblet cells; BG: basophilic granulocytes, LP: lamina propria.*
Introduction... On tilapia

- Tilapia have a acid stomach and very long gut compared to other fish. Good for digestion, but maybe a bigger risk for pathogens.
- Many bacteria/virus pathogens in tilapia try to penetrate the gut barrier.
- Plant ingredients may affect gut barrier function in some fish species.
- What are dietary and environmental factors of importance in tilapia?

The digestive tract of Nile tilapia has thin walls and is very long (6x body length) for efficient absorption of nutrients.

Stomach pH<2
Introduction – Hypothesis and objectives

**Overall Hypothesis**

Dietary changes (fish meal → plant protein meal)

"Less" stressor

Digestion and intestinal health

"More" stressors

Environmental changes

**Overall Objectives**

1. The effect of plant feedstuffs on digestibility and gut histology of tilapia

2. The effect of environmental and dietary changes on digestibility and intestinal health

3. Gut health promoters that prevent intestinal health disorder induced by environmental or dietary challenges
First experiment: Key questions to answer

1. Does dietary composition affect the apparent digestibility coefficients in time?

2. Does dietary composition (plant ingredient) alter histological intestine in time?
Experimental diets

7 types of raw ingredients. Diet 1 is basal diet. Diet 2 – 7 are made of 70% basal diet + 30% of particular raw material

Diet 1: Basal diet
Diet 2: 70% basal diet + 30% feather meal
Diet 3: 70% basal diet + 30% soybean meal
Diet 4: 70% basal diet + 30% rice bran
Diet 5: 70% basal diet + 30% canola meal
Diet 6: 70% basal diet + 30% sunflower meal
Diet 7: 70% basal diet + 30% DDGS *(dried distillers drains with soluble)*

0.02 % yttrium oxide as marker

<table>
<thead>
<tr>
<th>No.</th>
<th>Ingredients</th>
<th>%</th>
<th>Nutrition Composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fish meal</td>
<td>48.35</td>
<td>Gross energy (kJ/g)</td>
<td>18.4</td>
</tr>
<tr>
<td>2</td>
<td>Wheat meal</td>
<td>35.65</td>
<td>Crude protein</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>Wheat bran</td>
<td>10</td>
<td>Crude lipid</td>
<td>9.4</td>
</tr>
<tr>
<td>4</td>
<td>Fish oil</td>
<td>2</td>
<td>NFE</td>
<td>32.3</td>
</tr>
<tr>
<td>5</td>
<td>Soya oil</td>
<td>2</td>
<td>Ash</td>
<td>10.4</td>
</tr>
<tr>
<td>6</td>
<td>Vitamin Premix</td>
<td>1</td>
<td>Moisture</td>
<td>9.9</td>
</tr>
<tr>
<td>7</td>
<td>Mineral Premix</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Yttrium oxide</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Composition of basal diet used to test digestibility
Experimental facilities

Non-sex reversed Nile tilapia (*Oreochromis niloticus*): ± 10 g

7 diets, three replicate. 35 fish/ tank

21 tanks of 120 L

Separate faeces settling unit

Faecal collection bottle is kept in ice → to avoid bacterial degradation of nutrients

Hand feed to 3% body weight per day, twice daily
Timeline for sampling

Week 0
- Collecting feces
- Sampling

Week 1
- Collecting feces

Week 2
- Collecting feces

Week 3
- Collecting feces

Week 4
- Collecting feces

Week 5
- Collecting feces

Week 6
- Collecting feces

Feeding:
- Fish meal
- Soybean meal
- Canola meal (rape seed meal)
- Feather meal
- Sunflower meal
- Rice bran
- DDGS
Measurement of gut histology

- Lamina propria thickness
- Goblet cell count/surface area
- Submucosal epithelium thickness
# Results

## Apparent digestibility coefficients

### Table: Digestibility at week 6

<table>
<thead>
<tr>
<th>ADC&lt;sub&gt;diet&lt;/sub&gt; of nutrients</th>
<th>Basal diet (Fish diet)</th>
<th>+ 30% Feather meal</th>
<th>+ 30% Soybean meal</th>
<th>+ 30% Rice bran meal</th>
<th>+ 30% Canola meal</th>
<th>+ 30% Sunflower meal</th>
<th>+ 30% DDGS meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>80.18 ± 0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>78.15 ± 0.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>78.31 ± 1.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>71.34 ± 0.81&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>71.31 ± 0.56&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>69.86 ± 3.35&lt;sup&gt;c&lt;/sup&gt;</td>
<td>73.66 ± 0.82&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>92.29 ± 0.49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.44 ± 0.47&lt;sup&gt;d&lt;/sup&gt;</td>
<td>92.14 ± 0.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88.99 ± 0.86&lt;sup&gt;c&lt;/sup&gt;</td>
<td>88.68 ± 0.40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>90.87 ± 0.75&lt;sup&gt;b&lt;/sup&gt;</td>
<td>89.90 ± 0.76&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crude Fat</td>
<td>94.11 ± 0.91&lt;sup&gt;a&lt;/sup&gt;</td>
<td>84.78 ± 2.30&lt;sup&gt;d&lt;/sup&gt;</td>
<td>93.47 ± 0.64&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>86.85 ± 1.35&lt;sup&gt;d&lt;/sup&gt;</td>
<td>90.39 ± 0.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>91.44 ± 0.82&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>92.93 ± 0.85&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>56.36 ± 2.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.76 ± 0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.83 ± 5.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.72 ± 1.70&lt;sup&gt;c&lt;/sup&gt;</td>
<td>46.16 ± 5.30&lt;sup&gt;d&lt;/sup&gt;</td>
<td>48.82 ± 4.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>60.09 ± 3.50&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ash</td>
<td>47.05 ± 2.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38.34 ± 4.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50.73 ± 0.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.84 ± 1.30&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.75 ± 1.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.15 ± 7.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50.57 ± 2.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Energy</td>
<td>85.14 ± 0.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.64 ± 0.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>83.39 ± 0.64&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>70.70 ± 1.14&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>76.82 ± 0.75&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>74.85 ± 2.57&lt;sup&gt;d&lt;/sup&gt;</td>
<td>77.99 ± 0.97&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Results - SM increases for both diets

**Submucosal epithelial thickness FM vs Soy**

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 3</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>Soy</td>
<td>FM</td>
</tr>
<tr>
<td>50 µm</td>
<td>50 µm</td>
<td>50 µm</td>
</tr>
</tbody>
</table>

**SOY Week 1**

**SOY Week 3**

**SOY Week 6**
Results – LP increase in week 6 at SBM feeding

Lamina Propria  FM vs Soy (Average)

SOY Week 1

SOY Week 6

SOY Week 3
Results – Goblet cell go up and down at SBM feeding

Relative goblet cell counts (per pixel)

<table>
<thead>
<tr>
<th>Diet</th>
<th>Week 1</th>
<th>Week 3</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>2.00E-04</td>
<td>3.00E-04</td>
<td>1.00E-04</td>
</tr>
<tr>
<td>Soy</td>
<td>4.00E-04</td>
<td>5.00E-04</td>
<td>3.00E-04</td>
</tr>
</tbody>
</table>

Average per week per diet

SOY Week 1

SOY Week 3

SOY Week 6
Conclusions

1. Crude protein digestibility around 90% for all diets except feather and canola meal. Tilapia seem to adapt plant protein diets quite well. Soybean meal did not reduce crude fat digestibility as reported in salmon.

2. Tilapia change to diet with 30% soybean meal did not develop a severe enteritis as reported in salmon.

3. There was a trend of minor changes in gut histology of tilapia fed soybean meal:
   - Sub mucosal had increased size for both fish and soybean meal diet.
   - Lamina propria increased after 6 weeks for soybean meal diet.
   - Goblet cell count increased up till week 3. At week 6, that symptom returned back to normal for soybean meal diet.

4. The Goblet cell count may indicate that the intestine of tilapia can adapt to soybean meal feeding as reported in common carp.
Thank you