**Effectiveness of Amino Acids and Sunflower Meal in Replacing Fish Meal in Diets for Eels**

**Objective**
To test two different protein sources (sunflower meal - SFM and meat meal - MM) as alternatives to the commonly used fish meal (FM) in the diet of the European eel (*Anguilla anguilla*).

**Experimental Procedures**
Eels were divided into 18 groups (6 diets x 3 replications) and each group kept in a fiberglass tanks with 385 liters of dechlorinated tap water. The mean initial weight of the eels was 56 g (range 40 to 73 g), the number of eels in each tank was adjusted to represent a total biomass of 2.5 to 3.0 kg.

A photoperiod of 12 h light (8am - 8pm) and 12 h dark was used. The experimental period was 12 weeks long and preceded by an adaptation period of one month.

The experimental diets are found in Table 1. Diets were extruded and pellets (2 mm x 4 mm) were obtained. The protein source of the control diet (CNTRL) was FM. The protein source of the MM50 and MM100 diets were MM replacing 50% and 100% of the FM, respectively. Diets SFM50, SFM100 and SFM100AA used SFM as the alternative protein source replacing 50%, 100% and 100% of the FM in the CNTRL diet. SFM100AA also included the supplemental amino acids: lysine, methionine, histidine and threonine.

Daily food intake was recorded. Eels were fed twice a day to satiation. After waiting 15 to 20 min, pellets remaining at the bottom of the tanks were recovered and discounted from the total amount delivered. Weight increase was determined by individual weights.
### Table 1. Diet Composition

<table>
<thead>
<tr>
<th>Components (g/kg air dry diet)</th>
<th>CNTRL</th>
<th>MM50</th>
<th>MM100</th>
<th>SFM50</th>
<th>SMF100</th>
<th>SFM100 AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitefish meal</td>
<td>359.0</td>
<td>167.0</td>
<td>176.0</td>
<td>346.0</td>
<td>680.0</td>
<td>640.0</td>
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<tr>
<td>Meat Meal</td>
<td>265.0</td>
<td>496.0</td>
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<tr>
<td>Sunflower meal</td>
<td></td>
<td></td>
<td></td>
<td>364.0</td>
<td>660.0</td>
<td>640.0</td>
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<tr>
<td>Essential amino acids+</td>
<td></td>
<td></td>
<td></td>
<td>16.0</td>
<td></td>
<td></td>
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<tr>
<td>Fish oil</td>
<td>37.9</td>
<td>40.3</td>
<td>10.0</td>
<td>54.8</td>
<td>71.0</td>
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<tr>
<td>Maize oil</td>
<td>42.5</td>
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<td>5.0</td>
<td>34.4</td>
<td>27.3</td>
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<tr>
<td>Linseed oil</td>
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<tr>
<td>Manioc meal</td>
<td>371.0</td>
<td>371.0</td>
<td>371.0</td>
<td>236.0</td>
<td>100.0</td>
<td>113.0</td>
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<td>Vitamin premix</td>
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<td>Mineral premix</td>
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<tr>
<td>Chromium III oxide</td>
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<tr>
<td>Sodium alginate</td>
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<tr>
<td>Cellulose (micronized)</td>
<td>72.9</td>
<td>35.0</td>
<td>1.3</td>
<td>36.1</td>
<td>5.0</td>
<td>15.3</td>
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<tr>
<td>Betaine</td>
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</tbody>
</table>

**Composition**

- Moisture (g/kg diet): 81.3, 92.5, 89.4, 78.9, 85.6, 81.5
- Protein (g/kg DM): 290.2, 277.8, 304.0, 287.7, 288.1, 285.1
- Fat (g/kg DM): 118.0, 121.0, 120.2, 130.9, 137.4, 144.1
- Ash (g/kg DM): 126.4, 159.1, 185.9, 113.6, 99.7, 98.5

**Calculated Nutrients (g/kg protein)**

- Aspartic acid: 102, 88, 76, 107, 104, 97
- Threonine: 49, 39, 33, 44, 42, 47
- Serine: 47, 40, 39, 31, 48, 47
- Glutamic acid: 172, 140, 133, 197, 223, 221
- Hydroxy-proline: 47, 73
- Proline: 39, 79, 107, 58, 36, 48
- Glycine: 61, 102, 138, 64, 64, 59
- Alanine: 60, 70, 74, 56, 49, 43
- Valine: 53, 46, 40, 54, 54, 52
- Cysteine: 11, 12, 9, 18, 23, 22
- Methionine: 26, 19, 10, 17, 12, 18
- Isoleucine: 49, 38, 29, 47, 45, 43
- Leucine: 88, 68, 57, 76, 72, 67
- Tyrosine: 31, 26, 22, 28, 26, 24
- Phenylalanine: 48, 40, 33, 48, 51, 50
- Lysine: 80, 62, 47, 59, 44, 53
- Histidine: 25, 21, 16, 26, 27, 32
- Arginine: 60, 65, 64, 72, 80, 77

**Proportion EAA++**

- 0.48, 0.40, 0.33, 0.44, 0.43, 0.44

**EAAI (1)**

- 120.41, 99.18, 78.20, 110.12, 103.23, 111.25

**EAAI (2)**

- 97.01, 79.91, 63.00, 88.72, 83.17, 89.63

**v. Control diet (1)**

- 1.00, 0.82, 0.65, 0.91, 0.86, 0.92

++EAA: essential amino acids; EAAI: essential amino acids index: (1) reference Japanese eel requirements (Nose and Arai, 1972); (2) reference trout egg (Ketola, 1982)
Food intake of the diets containing MM or SFM as the sole protein source was significantly lower than the CONT diet formulated with FM. EAA supplementation significantly improved food intake (see Figure 1).

The growth data (SGR - Specific Growth Rate) suggests FM was the best protein source tested while SFM diets gave intermediate results. Essential AA (EAA) supplementation clearly improved the utilization of the SFM100 diet. The values of Feed Efficiency (FE) displayed a similar trend (see Figure 2).

![Figure 3. Protein Efficiency Ratio](image)

The protein efficiency ratio (PER) is the weight increase (g) divided by the protein intake. FM was the protein source best used for growth according to the PER index. SFM, as the only protein source, produced poorer results, but showed improvement when mixed with FM or supplemented with EAA.

**Conclusion**

SFM can be substituted solely for FM in aquaculture diets for the European eel as long as the diets are supplemented with essential amino acids. This may be an effective way of reducing diet cost.

**Bibliography**