ADVISORY COMMITTEE ON ANIMAL FEEDINGSTUFFS

75th Meeting of ACAF on 15 February 2018

PRESENTATION

Use of Algae as animal feed

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The Use of Algae as Animal Feed

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European Regulatory Affairs Manager

The Advisory Committee for Animal Feed (UK)

Algae

- Algae have been a human food for thousands of years in all parts of the world (Borowitzka, 1998) and in maritime areas of the world as fodder (Volesky, 1970)
- 40000 species of eukaryotic and prokaryotic (cyanobacteria) algae, only a few species are used directly as food or as food supplements at present

<table>
<thead>
<tr>
<th>Algae</th>
<th>Source</th>
<th>Status</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanobacteria (blue-green algae, prokaryotic)</td>
<td>Cultured (U.S., Thailand, China, Taiwan, India, etc.)</td>
<td>Field-collected (Lake)</td>
<td>Jandy (1988); Huisman (1990); Watanabe et al. (1994)</td>
</tr>
<tr>
<td>Zostera marina (seagrass)</td>
<td>Cultured (U.S.A.)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Nannochloropsis sp. (diatom)</td>
<td>Cultured (U.S.A.)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Dunaliella salina (bacterium)</td>
<td>Cultured (Japan)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Chlorella sp. (green algae)</td>
<td>Cultured (U.S.A., China)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Dunaliella tertiolecta</td>
<td>Cultured (U.S.A., China)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Phaeodactylum tricornutum</td>
<td>Cultured (U.S.A., China)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
<tr>
<td>Nannochloropsis sp. (diatom)</td>
<td>Cultured (experimental)</td>
<td>Field-collected (Lake)</td>
<td>Martinez (1990)</td>
</tr>
</tbody>
</table>

Algae – Commercial Uses

- Biogas
- Bioethanol
- Biodiesel
- Biobutanol
- Biofuel
- Cosmetics
- Nutraceuticals
- Pharmaceuticals
- Vitamins
- Food
- Feedstock
- Animal feed
- Fertilizer/nutrients
Algae Foods and Supplements

Is Chlorella a Superfood?

Source of Protein
Mycotoxin binding
Source of DHA/Omega-3; Astaxanthin; β-carotene

Algae as Feed

• Source of Protein
• Mycotoxin binding
• Source of DHA/Omega-3; Astaxanthin; β-carotene

Chlorella Vulgaris

Ochratoxin binding

The addition of Chlorella Vulgaris (CHL) to broiler feed at 0.5, 1 and 2kg/T resulted in 13, 34 and 35% decrease in liver OTA concentration when compared with the control containing no mycotoxin binder.
Algae as sources of Omega-3

- 1980's/1990's
  - Markets for long chain omega-3 fatty acids began to develop in the areas of health supplements and food enrichment and for use in animal feeds to modify the fats of poultry, beef, and pork to a healthier profile for humans (Barclay, 1994)
  - Algae production optimized by companies such as Martek and OmegaTech in the US
- 2000's - Enrichment of meat with omega-3 investigated using different feed sources (Rymer & Givens, 2005, 2010)
- 2010's – Commercial algal products available for enrichment of meat, dairy and eggs. E.g. All-G-Rich and Forplus by Alltech.

Autotrophic Algae Production

- Environmental conditions
- Contamination – Microbial, Chemical, Physical
- Downstream processing
- Inconsistency

Heterotrophic Algae Production

- Closed, controlled system
- Minimized contamination risks
- Higher level of consistency
- Traceable
- Pure
- Capacity, automation and versatility
- Protected by AQS
9 days later...

20 ton harvest

One 1.5ml Cyrovial...

Highly Renewable

An equivalent crop from 6-8 acre of Corn would take 6 months to grow.

6 months later......

Benefits

✓ 100% Plant-Based
✓ Sustainable
✓ Non-GMO
✓ Pure & Traceable
✓ Source of Omega-3/DHA
Omega-3 Fatty Acids

Fatty Acids
- Saturated
- Unsaturated
  - Monounsaturated
  - Polyunsaturated
  - Omega-6
    - Alpha-linolenic Acid (ALA)
  - Omega-3
    - Eicosapentaenoic Acid (EPA)
    - Docosahexaenoic Acid (DHA)

Omega-3/DHA - Clear, Functional Benefits

EFSA Nutrition & Health Claims: O-3 Fatty Acids

"SOURCE OF OMEGA-3 FATTY ACIDS"
A claim that a food is a source of omega-3 fatty acids may only be made where the product contains at least 40 mg of the sum of EPA and DHA per 100 g and per 100 kcal.

"HIGH OMEGA-3 FATTY ACIDS"
A claim that a food is high in omega-3 fatty acids, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 80 mg of the sum of EPA and DHA per 100 g and per 100 kcal.

HEALTH CLAIMS
- DHA and EPA contribute to the maintenance of normal blood pressure (3g)
- DHA and EPA contribute to the maintenance of normal blood triglyceride levels (2g)
- DHA contributes to the maintenance of normal brain function (40mg)
- DHA contributes to the maintenance of normal vision (90mg)
- DHA intake contributes to the normal visual development of infants up to 12 months of age (200mg)
- DHA maternal intake contributes to the normal brain development of the foetus and breastfed infants (200mg)
- DHA maternal intake contributes to the normal development of the eye of the foetus and breastfed infants (200mg)
- EPA and DHA contribute to the normal function of the heart (Source of)
Fish Oil Replacement

- Global fish stocks decreasing due to overfishing
- Global population and demand for food and protein is increasing

...in the year 2050

HOW CAN WE FEED 9 BILLION PEOPLE???

How much protein will we need..?

[Graphs showing trends in fish and meat production]

[Data on protein consumption and demand]

[Altech logo]
Trends in Modern Salmon Feed Formulation

After Tacon & Metian 2008

Global Fish Oil Production

How is it used?
The objective of the study was to evaluate the nutritional and flesh quality impacts and functional activities in commercial Atlantic salmon diets with increasing levels of All-G Rich.

A feeding trial with 4 levels of All-G Rich (0%, 1%, 6% and 15%) was performed.

A total of 480 fish were divided into 4 treatment groups with 3 reps per treatment and 40 fish per tank.

12 week feeding trial

**Trial Design**

- The 6% All-G Rich treatment group had the highest DHA percent in the fillet with the 15% All-G Rich treatment group slightly less.
- The 6% All-G Rich treatment had the highest total of PUFA omega 3 as well as EPA plus DHA.

**Results**
Verification of results from trial 1:
Dietary AA induce statistically significant increase in dress out percentage of salmon.
Trial 2 – Fillet Quality

<table>
<thead>
<tr>
<th></th>
<th>MFM_0_AA</th>
<th>MFM_2.5_AA</th>
<th>MFM_5_AA</th>
<th>LFM_5_AA</th>
<th>LFM_5_AA_BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary FM level (%)</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Dietary AA level (%)</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Liquid loss, %</td>
<td>2.1 ± 0.5</td>
<td>3.0 ± 0.8</td>
<td>2.5 ± 0.6</td>
<td>2.8 ± 0.3</td>
<td>2.2 ± 0.2</td>
</tr>
<tr>
<td>Lightness, L value</td>
<td>78.4 ± 0.3</td>
<td>78.7 ± 0.4</td>
<td>78.9 ± 0.3</td>
<td>78.9 ± 0.2</td>
<td>78.9 ± 0.3</td>
</tr>
<tr>
<td>SalmonFan score</td>
<td>23.0 ± 0.3</td>
<td>27.2 ± 0.2</td>
<td>27.9 ± 0.3</td>
<td>31.9 ± 0.3</td>
<td>27.9 ± 0.3</td>
</tr>
<tr>
<td>Firmness** (N)</td>
<td>1.07 ± 0.06</td>
<td>1.61 ± 0.10</td>
<td>1.61 ± 0.08</td>
<td>1.85 ± 0.08</td>
<td>1.84 ± 0.10</td>
</tr>
<tr>
<td>Gapping* (%)</td>
<td>33.2 ± 2.8*</td>
<td>24.7 ± 2.0*</td>
<td>28.7 ± 2.0*</td>
<td>49 ± 4.0*</td>
<td>6.7 ± 2.0*</td>
</tr>
</tbody>
</table>

Conclusions

- Fish growth rates were high and similar in all treatments.
- FCR was low and similar in all treatments.
- Highest levels of DHA were analyzed in fish fed Alltech Algae Bioplex mineral supplementation in low fish meal diets resulted in significantly improved Omega 3 lipid levels and were similar to medium fish meal diets.
- Gapping was nearly eradicated by the supplementation of Bioplex minerals.

Recently published Alltech research

- Poultry & Egg
- Dairy – milk enrichment and animal performance
- Pigs
- Fertility
Recently published Alltech research

Poultry & Eggs

Poultry Performance

<table>
<thead>
<tr>
<th>Table 1. Effects of dietary treatments on the production performance and body weight of laying hens from wk 6 to wk 10. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Egg production (dL/ hen)</td>
</tr>
<tr>
<td>Feed intake (kg/bird)</td>
</tr>
<tr>
<td>Feed conversion (kg)</td>
</tr>
<tr>
<td>Bodyweight of wk 10 (kg)</td>
</tr>
</tbody>
</table>

1 Dunn’s test of multiple comparisons was used.

Egg Characteristics

<table>
<thead>
<tr>
<th>Table 2. Effects of dietary treatments on egg characteristics. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Egg diameter (mm)</td>
</tr>
<tr>
<td>Egg weight (g)</td>
</tr>
<tr>
<td>Protein (%)</td>
</tr>
<tr>
<td>Fat (%)</td>
</tr>
<tr>
<td>S. Color</td>
</tr>
<tr>
<td>P. Color</td>
</tr>
</tbody>
</table>

1 Dunn’s test of multiple comparisons was used.

Egg characteristics were compared after feeding treatment diets for 22 weeks.

**Note**: The table shows the effects of different dietary treatments on egg characteristics, including egg diameter, weight, protein, fat, and color. The treatments include a control diet, a diet with Mesi-G-ButTM alone, and a diet with Mesi-G-ButTM + Mesi-G-ButTM. The results indicate significant improvements in egg quality with the dietary treatments compared to the control.
Dairy

Dietary supplementation with algae on lactating cows

- Health, productivity and milk composition
- Treatment group - 100 g algae/cow/day (16 g DHA/cow/day)

Results:
- No negative effects on animal health in terms of somatic cell count, haematological and biochemical blood parameters.
- Body condition was marginally improved.
- A tendency towards increased milk production was observed during the final stage of the study (+4.5 kg cow/day on days 78-84).
- The fatty acid profile of milk was improved by supplementation, with significantly lower saturated fatty acids, significantly higher omega-3 fatty acids and an improved omega-3/omega-6 ratio.
- Peak transfer efficiency from feed to milk at day 49 of 8.3%.
- No negative impact on cheese making qualities – casein content, creaming, rennet coagulation.

Pigs

Changes in docosahexaenoic acid (DHA) content in longissimus dorsi and backfat tissue of finishing pigs given diets containing 1% heterotrophically grown algae during the last 28 days. 
Journal of Animal Science, 95 (Supplement 2), 59-59.
Animal Fertility

Dairy Cows*: diet supplemented daily with 100 g/cow of an algae from 27 to 147 days postpartum.

Results:
• Increased resumption of estrous cyclicity (77.6 vs 65.9%) and pregnancy at first AI (47.6 vs 32.8%) in primiparous cows.
• Increased pregnancy per AI in all AI in both primiparous and multiparous cows (41.6 vs 30.7%), which reduced days to pregnancy by 22 days (102 vs 124 days) compared with control cows.

Boars†; supplemented 75g algae daily

Results:
Significant increase in semen volume and total sperm number indicated that the feeding regime described within this study has the potential for increasing the output of boar stud.

* M.P. Boland, S. Fair et al. Theriogenology 90 (2017) 78–87

THANK YOU