Can Feeding Defatted Microalgae Produce Healthier Animal Foods?
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The Desirable Fats—EPA and DHA
- ω-3 FA have human health benefits
- ω-6:ω-3 < 4    PUFA:SFA > 0.4
- Deposited in cell membranes
- All synthesized from ALA (18:3n-3)
- De novo FA synthesis is very low in mammals
- Primary source of deposition into muscle is uptake from the diet
(Chow, 2008)

Roles and Synthesis of EPA/DHA
- Increased EPA and DHA has been linked to Decreased:
  - Production of platelet aggregators and vasoconstrictors
  - Production of inflammatory inducers

Omega-3 Fatty Acids (n3)
- C18:3n-3
  - A-Linolenic acid (ALA)
  - Eicosapentaenoic acid (EPA)
  - Docosahexaenoic acid (DHA)
  - Fish oils
  - Eicosanoids:
    - Anti-inflammatory

Human Nutrition of EPA/DHA
- The western diet is “deficient” in ω-3 fatty acids
- Ideal ω6:ω3 Ratio is 1
  - US consumption is ~15-20 : 1
- Recommended intake is 400 mg EPA+DHA/day
  - US consumption ~100 mg EPA+DHA/day
  - > 5 times less in non-fish eaters

What can we do about this deficiency?
(Simopoulos, A. P., 2002; Smet, 2012)
Omega-3 Fatty Acid Enrichment

- Humans have low synthesis of PUFAs
  - Must supply through the diet
- Terrestrial meat is low in PUFA, but is the primary source for non-fish eaters
- Average American consumes:
  - 40 kg broiler chicken/year
  - 250 chicken eggs/year
  - Relatively high in ω-6 and low in ω-3 fatty acids

Effects of Flaxseed/Canola

- High in ALA (53.3%)
- Pros:
  - Increases ω-3 content
- Cons:
  - Negative effects on egg production with high levels of supplementation (>10%)
  - Easily oxidized
  - Low conversion of ALA to EPA/DHA

Effects of ALA Supplementation

- Consumption of ALA is ~2 g/day
- 15-35% of ALA is catabolized to CO₂ for energy
  - High dietary ALA increases its oxidation
- < 1% of dietary ALA is converted to DHA
- DPA → DHA is rate limiting step

Can we supplement EPA and DHA?

Effects of Marine Sources

- Fishmeal or Fish Oil
- Pros:
  - High EPA and DHA contents
- Cons:
  - Easily oxidized
  - “Fishy” taste
**Effects of Microalgae**

- Laying hens fed microalgae:
  - Increased egg ω-3 fatty acids
  - Including EPA and DHA
- Broiler chickens fed microalgae
  - Increased breast muscle ω-3 content
  - Improved ω6:ω3 ratio

(Mooney et al., 1998; Abril et al., 1999; Fredriksson et al., 2006)

**Marine Microalgal Biomass**

- Defatted biomass (DFA) from biofuel production research
  - Residual long chain n3 fatty acids
  - High protein content (38.2%)
- Moderate levels of inclusion have no effect on growth performance and digestibility
  (Austic et al., 2013, Gatrell et al., 2014)

**Experimental Design**

- Hatchling Ross broiler chicks (n = 6 pens, 6 chicks/pen)
  - Inclusion of 0 (Control), 2, 4, 8 or 16% DFA
- 6 wk trial
- Food and water provided *ad libitum* access
- Blood and tissues collected at wk 3 and 6
- Fatty acid analysis
  - Fatty acids extracted according to Ichihara et al (1996)
  - Agilent 6890N

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Summary of Broiler Study

- Omega-3 content and n6:n3 ratios were improved at all levels of microalgal biomass inclusion
- Consuming 200g of chicken breast/day can supplement up to 35 mg of EPA/DHA to the average American diet

Experimental Protocol

- DFA fed at 0, 2.85, 5.75, 11.5, and 23% for 6 wk
- 10 birds/diet = 50 hens
- Growth, feed intake, and egg production was monitored weekly
- At 6 weeks 5 birds/diet were sampled for compositional and gene expression analyses
Summary of Laying Hen Study

• DFA can enrich egg yolks with EPA and DHA
• Breast, Thigh, and Liver also had increased levels of EPA and DHA
• Chickens had increased expression of key genes involved in fatty acid synthesis when fed DFA

Acknowledgements

• Cellana, Kailua-Kona, HI
• USDA/DOE Biomass R&D Initiative Grant
• Hatch grant
• Cornell University CALS