Microalgal biomass as a sustainable ingredient in salmon feeds

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Algae Biomass Summit 2015
October 1: Track 3
Commercialisation
Market Progress in Algal Products
Global aquaculture production – status of salmon

Values are in million tonnes
Source: FAO

Prediction for 2030
Total production → 101.2
Atlantic salmon → 5.4

2.09
Atlantic salmon
25.5
mariculture
70.2 farmed fish
97.2 total production
Atlantic salmon and trout in Norway - economic value and production volumes

Source: Fisheries.no; DKNVS and NTVA report
Alternatives to use of wild fish in aquafeeds

**FAO Outlook 2014:**

“Increased investment in innovative technologies including those that produce feed sources for aquaculture e.g. marine microalgae and bacteria using sunlight and available carbon”
Why microalgae?

- **Primary producers**
  - Phytoplankton, seaweed

- **Herbivores**
  - Zooplankton, cockles

- **1st level carnivores**
  - Small fish, crustaceans etc.

- **2nd level carnivores**
  - Larger fish

- **3rd level carnivores**
  - Top carnivores

- **Top carnivores**
Microalgae in aquafeeds

- Oil (PUFAs)
- Proteins
- Pigments
- Functional molecules
Earlier trials on Atlantic salmon feeding microalgal biomass

5 & 10% fishmeal protein replacement *Nanofrustulum sp.* (8.7 & 17.4 %) and *Tetraselmis sp.* (3.7 and 7.4%).
US Department of Energy
Sponsored Project

Large-Scale Production of Fuels
and Feed from Marine Microalgae

CORNELL MARINE ALGAE BIOFUELS
CONSORTIUM

https://www.algaeconsortium.com
Defatted biomass of *Desmodesmus* sp. and *Nannochloropsis* sp.

- Atlantic salmon
- Pacific white shrimp
- European seabass
- Red seabream
Atlantic salmon feeding trials

Desmodesmus Lab trial

Nannochloropsis Lab trial

Nannochloropsis Farm trial
Controlled feeding trial with defatted biomass of *Desmodesmus* sp.

- Indoor flow-through seawater rearing system (7°C)
- Oxygen saturation > 90%; 24h daylight regime
- 6 replicate tanks (500L) per feed group; 3 groups
- 25 fish/tank; Initial fish size 167g; 10 week feeding period
Feeds containing *Desmodesmus* biomass

**Specific growth rate**

- Control
- Alga10
- Alga20

**Feed conversion ratio**

- Control
- Alga10
- Alga20

n=6
Nutrient and energy digestibility
Health status

Somatic indices
No differences in hepatosomatic index and visceral somatic index

Antioxidant defense
Similar total antioxidant capacity, catalase activity and superoxide dismutase activity

Expression of antioxidant-related genes
No difference in the mRNA levels of sod and nrf2

n=1
2
Intestinal health – micromorphology of the distal region

n=6
Expression of inflammatory genes in the distal intestine
Expression of genes of antimicrobial peptides in the distal intestine

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**cath1**

![cath1 graph](image)

**cath2**

![cath2 graph](image)
Controlled feeding trial with defatted biomass of *Nannochloropsis* sp.

- Indoor flow-through seawater rearing system (7°C)
- Oxygen saturation > 90%;  24h daylight regime
- 6 replicate tanks (500L) per feed group; 3 groups
- 25 fish/tank; Initial fish size 215g; 12 week feeding period
Atlantic salmon fed *Nannochloropsis*

**Specific growth rate**
- Control
- Alga10
- Alga20

**Feed conversion ratio**
- Control
- Alga10
- Alga20

n=6
Farm trial with defatted biomass of *Nannochloropsis* sp.

- Sea cages 5m$^3$
- Temperature 6.7 °C; DO 9.6 mg/L; Salinity 32.6 ppt
- 4 replicate cages per feed group; 2 groups
- 110 fish/cage; Initial fish size 1 kg; 7 months feeding period
Atlantic salmon fed *Nannochloropsis*

Specific growth rate

Feed conversion ratio

- **Control**
- **Fishmeal**
- **Microalga**
- **Others**

- **Alga12.5**
- **Fishmeal**
- **Microalga**
- **Others**

**n=4**
Pigmentation of salmon fillet

Feed without alga        Feed with alga
Possible inclusion levels of defatted biomass in salmon feeds

- *Desmodesmus* sp. 
  - < 20% inclusion

- *Nannochloropsis* sp. 
  - 10% inclusion
Can microalgae support the salmon industry?

- 1.63 million tonnes of feed
- 1.26 million tonnes of Atlantic salmon
- 0.163 million tonnes of algae in feeds
- 0.58 million tonnes of protein + 0.53 million tonnes of lipid

2012 data
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