ACAF 18/01

ADVISORY COMMITTEE ON ANIMAL FEEDINGSTUFFS

75th Meeting of ACAF on 15 February 2018

PRESENTATION

Use of Algae as animal feed

Gerry Dillon

Alltech Ltd

February 2018

The Use of Algae as Animal Feed

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15th Feb 2018

Presentation for;
The Advisory Committee for Animal Feed (UK)

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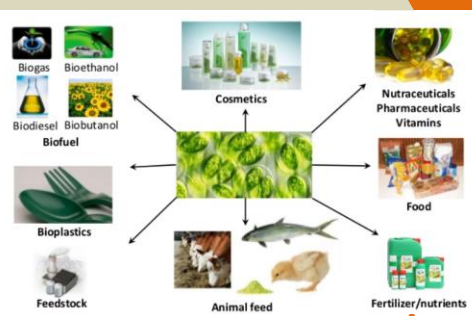
Algae

- Algae have been a human food for thousands of years in all parts of the world (Borowitza, 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

Microalgae currently used (or proposed) for human consumption

Alga	Source	Reference
Cyanobacteria (blue-green algae)		
Spirulina platensis *S. maxima*	Cultured (USA, Thailand, China, Taiwan, India, etc.)	Jassby (1988b); Richmond (1988); Belay *et al.* (1994)
Nostoc commune	Field-collected	Martinez (1988)
Aphanizomenon flos-aquae	Field-collected (Lake Klamath, USA)	
Chlorophyta		
Chlorella spp.	Cultured (Taiwan, Japan)	Soong (1980)
Dunaliella salina (for beta-carotene)	Cultured (Australia, Israel, USA)	Borowitzka & Borowitzka (1989a,b)
Scenedesmus spp.	Cultured (Czech Republic and experimental)	Becker (1988); Grobbelaar *et al.* (1995)
Haematococcus pluvialis (for astaxanthin)	Cultured (experimental only)	Borowitzka (1992)

Algae – Commercial Uses



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Algae Foods and Supplements

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Algae as Feed

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

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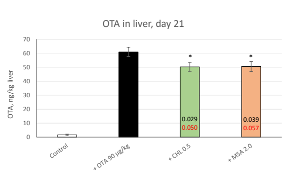
Chlorella Vulgaris

Ochratoxin binding



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

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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.

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Autotrophic Algae Production

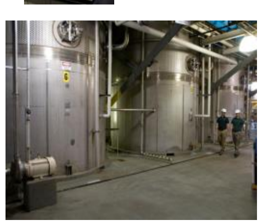
- Environmental conditions
- Contamination
  - Microbial, Chemical, Physical
- Downstream processing
- Inconsistency

Heterotrophic Algae Production

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

Alltech Quality System

Meeting & Exceeding Globally Accepted Standards



Alltech Algae Production Facility

Benefits

Highly Renewable

One 1.5ml Cyrovial...

9 days later...

20 ton harvest

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

6 months later.......

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Benefits

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

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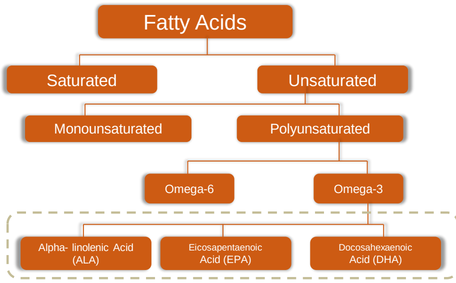
Omega-3 Fatty Acids



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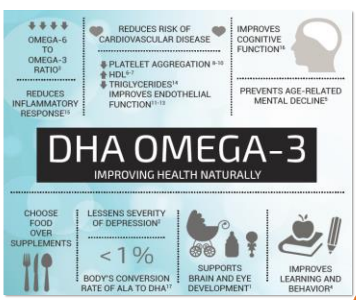
Omega-3/DHA - Clear, Functional Benefits



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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 maintenance of normal brain function (40mg)
DHA contributes to the maintenance of normal vision (40mg)
DHA intake contributes to the normal visual development of infants up to 12 months of age. (100mg)
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)

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Fish Oil Replacement

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

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…in the year 2050

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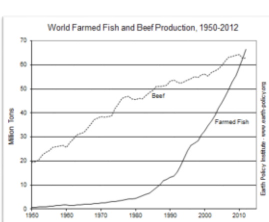
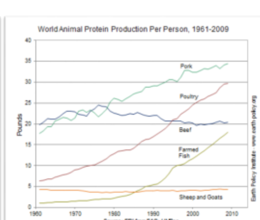
How much protein will we need..?





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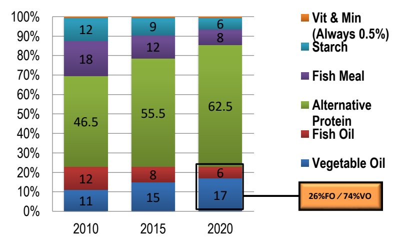
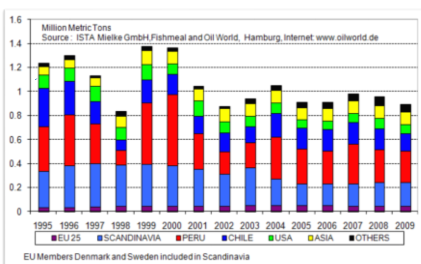
Trends in Modern Salmon Feed Formulation

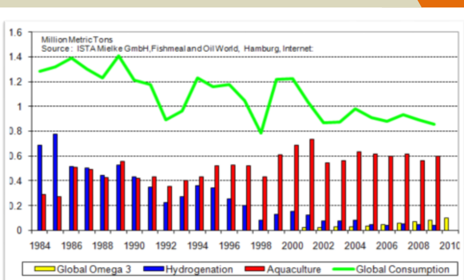


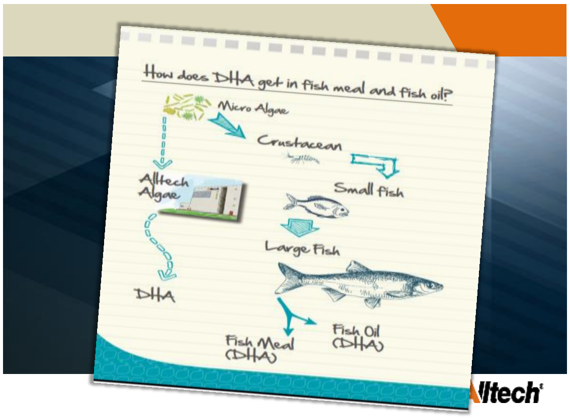
After Tacon & Metian 2008

Global Fish Oil Production



How is it used?





Alltech-Nofima Research Alliance

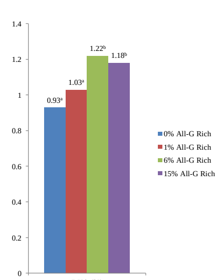
Trial Design

- 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

Alltech-Nofima Research Alliance

Results

- 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.



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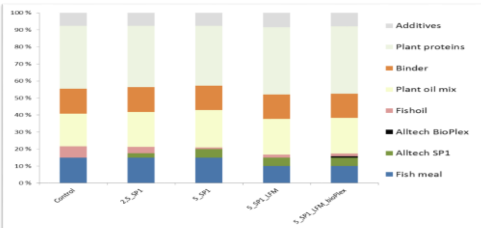
Trial 2 – Diet Design



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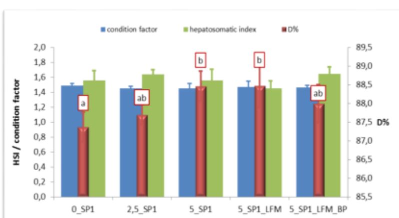
Trial 2 – Biometrics



Verification of results from trial 1:
Dietary AA induce statistically significant increase in dress out percentage of salmon

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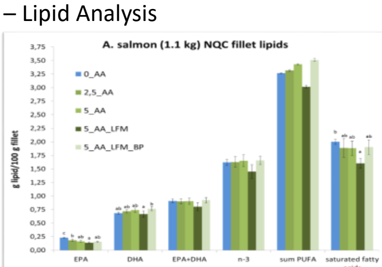
Trial 2 – Lipid Analysis



Alltech-Nofima Research Alliance

Trial 2 – Fillet Quality

	MFM_0_AA	MFM_2.5_AA	MFM_5_AA	LFM_5_AA	LFM_5_AA_BP
Dietary FM level (%)	**15**	**15**	**15**	**10**	**10**
Dietary AA level (%)	**0**	**2.5**	**5**	**5**	**5**
Liquid loss, %	2.1 ± 0.5	3.0 ± 0.2	2.5 ± 0.5	2.8 ± 0.3	2.5 ± 0.4
Lightness, L value	79.4 ± 0.3	79.7 ± 0.4	79.9 ± 0.3	79.1 ± 0.2	80.0 ± 0.5
SalmoFan score	22.0 ± 0.3	21.2 ± 0.2	21.3 ± 0.3	21.9 ± 0.3	21.5 ± 0.3
Firmness** (N)	1.57 ±0.08	1.61 ± 0.10	1.61 ± 0.08	1.55 ± 0.06	1.44 ± 0.10
Gaping* (%)	**33.3 ± 2.5^{ab}**	**26.7 ± 2.5^{b}**	**26.7 ± 2.5^{b}**	**40 ± 4.4^{a}**	**6.7 ± 2.5^{c}**

Alltech-Nofima Research Alliance

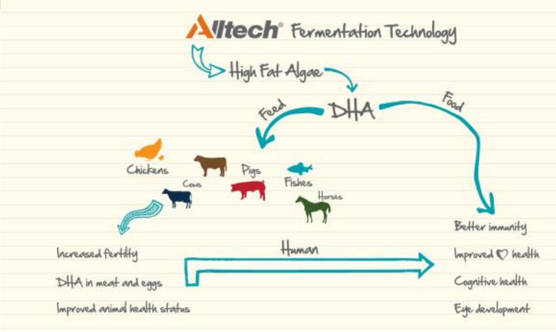
Conclusions

- 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.
- Gaping 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 3. Effects of dietary treatments on the production performance and body weight of laying hens from wk 45 through 77*.

	Diet[1]					
Production parameter	Control	+1%All-G-Rich™	+2%All-G-Rich™	+3%All-G-Rich™	Pooled SEM	P-value
Egg production (HDP,%)	77.6	73.7	78.3	76.5	1.9	0.39
Feed intake (g/hen/d)	116	110	110	113	1.8	0.09
Feed conversion (kg/dz)	1.81	1.80	1.69	1.77	0.06	0.48
Bird weight of wk 65 (kg)	1.80	1.73	1.76	1.77	0.03	0.59
Bird weight of wk 77 (kg)	1.88	1.92	1.77	1.84	0.04	0.10

*Data are means of 6 replicates of 5 hens.
[1]Diet: control = corn-soybean meal basal diet with no All-G-Rich™; +1% All-G-Rich™ = basal diet with 1% All-G-Rich™; +2% All-G-Rich™ = basal diet with 2% All-G-Rich™; +3% All-G-Rich™ = basal diet with 3% All-G-Rich™.

T. Ao, 2015 J. Appl. Poult. Res. 24:394–400
http://dx.doi.org/10.3382/japr/pfv042

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Poultry & Eggs

Egg Characteristics

Table 4. Effects of dietary treatments on egg characteristics.[1]

	Diet[2]					
Egg characteristic	Control	+1%All-G-Rich™	+2%All-G-Rich™	+3%All-G-Rich™	Pooled SEM	P-value
Egg weight (g)	66.3	66.8	66.4	65.8	1.12	0.93
Percent yolk (%)	28.9	29.6	28.4	29.0	0.58	0.55
Percent shell (%)	8.64	8.60	8.35	8.23	0.19	0.38
Haugh unit	74.1	70.7	72.0	74.8	1.83	0.40
L Color	63.9^a	64.0^a	62.7^b	63.0^b	0.24	0.004
a* Color	12.7^b	12.7^b	13.6^a	13.8^a	0.35	0.006
b* Color	59.5	60.7	62.6	62.8	0.97	0.08

[1]Data are means of 6 replicates of 6 eggs sampled after feeding treatment diets for 25 week.
[2]Diet: control = corn-soybean meal basal diet with no All-G-Rich™; +1% All-G-Rich™ = basal diet with 1% All-G-Rich™; +2% All-G-Rich™ = basal diet with 2% All-G-Rich™; +3% All-G-Rich™ = basal diet with 3% All-G-Rich™.
[a,b]Means within a row with no common superscription differ ($P < 0.05$).

T. Ao, 2015 J. Appl. Poult. Res. 24:394–400
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Poultry & Eggs

Egg Enrichment

Table 6. Effects of dietary treatments on the concentration of total lipids and major fatty acids of egg yolk.[1]

Items		Diet[2] Control	+1% All-G-Rich™	+2% All-G-Rich™	+3% All-G-Rich™	Pooled SEM	P-value	Linear contrast
Total lipid,%		30.5	29.3	30.0	29.6	0.51	0.43	
Major fatty acids (mg/100 g of yolk)								
C16:0	Palmitic	7631	7402	7901	8005	172	0.13	ns
C16:1n7	Palmitoleic	563	519	615	611	27	0.11	ns
C18:0	Palmitic	2844	2745	2650	2725	84	0.48	ns
C18:1n7C	Vaccenic	435[a]	404[a]	426[b]	385[c]	5.9	0.01	**
C18:1n9C	Oleic	11503	11064	11255	11304	213	0.57	ns
C18:2n6	Linoleic	5557[a]	5183[a,b]	5066[b]	4555[c]	135	0.01	**
C20:4n6	Arachidonic	608[a]	469[b]	403[c]	336[d]	15	0.00	**
C22:6n3	Docosahexaenoic (DHA)	248[d]	509[c]	717[b]	776[a]	16	0.00	**

[1]Data are means of 6 replicates of one yolk sample pooled from 3 eggs.
[2]Diet: control = corn-soybean meal basal diet with no All-G-Rich™; +1% All-G-Rich™ = basal diet with 1% All-G-Rich™; +2% All-G-Rich™ = basal diet with 2% All-G-Rich™; +3% All-G-Rich™ = basal diet with 3% All-G-Rich™.
[a-d]Means within a row with no common superscription differ ($P < 0.05$).
**significant linear contrast: $P < 0.01$.
ns: not significant linear contrast: $P > 0.05$.

T. Ao, 2015 J. Appl. Poult. Res. 24:394–400
http://dx.doi.org/10.3382/japr/pfv042

Dairy

Dietary supplementation with algae on lactating cows

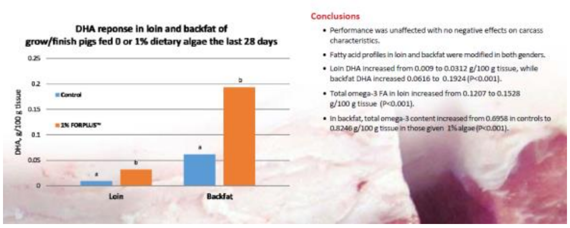
- Health, productivity and milk composition
- Treatment group - 100 g algae/cow/day (16 g DHA/cow/day)

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*

Moran, C.A. J Anim Physiol Anim Nutr. 2017: 1_15
**Moran, C.A. J Anim Feed Sci (in-press)*

Pigs



Moran, C. A., Fusconi, G., Morlacchini, M., & Jacques, K. A. *(2017). 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[ǂ]; 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 studs.

**M.P. Boland, S. Fair et al. Theriogenology 90 (2017) 78-87*
[ǂ]LPD Sinedino, M.P. Boland Reproduction (2017) 153 707–723

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