Readily Available Sources of Long-chain Omega-3 Oils: Is Farmed Australian Seafood a Better Source of the Good Oil Than Wild-Caught Seafood?

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LC Omega-3 Oils: Coverage today includes

- **Health** – Nutritional need for and inadequate intake of LC Omega-3

- **Supply** – LC Omega-3 resource (environment) issue
  - Alternate sources needed, including for aquaculture
  - Profiles of representative Australian Fish Oil capsules

- **Aquaculture status** – farmed fish results past & present
  - R&D occurring to obtain & increase LC Omega-3 yields in commercial crops (S. Singh, AAOS)
  - CSIRO consumer research on LC Omega-3 in commercial crops and their use in feeding fish
Essential Fatty Acid Families

**ω6 family**
- **18:2 ω6**
  - Linoleic (LA)
    - Corn Oil
    - Safflower Oil
    - Sunflower Oil
- **20:4 ω6**
  - Arachidonic AA
    - Meat, Eggs, Brains

**ω3 family**
- **18:3 ω3**
  - α-Linolenic (ALA)
    - Flaxseed Oil
    - Canola Oil
    - Soybean Oil
- **20:5 ω3**
  - Eicosapentaenoic EPA
- **22:6 ω3**
  - Docosahexaenoic DHA

**Thrombotic**
- Inflammatory

**Anti-thrombotic**
- Anti-inflammatory

**LC Omega-3 Oils:** ≥C20, two or more double bonds
How Much \textit{LC Omega-3} Do We need?

Average intake - \textbf{EPA + DHA} in Australia:
- \textbf{30 mg/day} (Bureau of Statistics 1995);
- \textbf{175 mg/day} (Howe et al. 2006)

\begin{tabular}{|l|}
\hline
\textbf{2006 – NHMRC: Suggested Dietary Targets:}  \\
\textbullet \textbf{610 mg/day - men, 430mg/day - women}  \\
\textbullet \textbf{1000-2000 mg/day for CHD patients}  \\
\hline
\end{tabular}

Most fish oil supplements - \textbf{18\% EPA + 12\% DHA}

\textbf{2 g fish oil supplies the SDT for EPA + DHA}
Australian Seafood - “The Good Oil I & II”

Two “Guides” for consumers/industry
By-product / by-catch included
Results available for marketing seafood
Results also in “Aust. Seafood Handbook”

<table>
<thead>
<tr>
<th>LC Omega-3 oils (mg per 100g)</th>
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<tbody>
<tr>
<td>Fish</td>
</tr>
<tr>
<td>235</td>
</tr>
<tr>
<td>Oysters</td>
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<tr>
<td>150</td>
</tr>
<tr>
<td>Prawns</td>
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<td>130</td>
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<td>Veal</td>
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Nichols et al. 1998,2002
Omega-3 polyunsaturated fatty acids in Australian seafood

- fish high in omega-3
  - slender tuna
  - swordfish
  - banded morwong
  - alfonsino
  - whitebait

- common fish
  - blue eye
  - gummy shark
  - southern bluefin tuna
  - tiger flathead
  - king snapper

- fish average
  - banana prawn
  - southern rock lobster
  - blue mussel
  - Pacific oyster
  - southern calamari

- farmed fish
  - Atlantic salmon
  - barramundi
  - jade perch
  - silver perch
  - Murray cod

mg/100g flesh

Nichols et al. 1998,2002
Fish Oil Capsules

Three Product Groups
Cost (pa, 500 mg/day)

18/12 oils $20-80

Enriched oils $90-140

Other oils $130-2000

Cost per Annum to Supply 500 mg/day EPA+DHA

mg of EPA & DHA per Capsule

Enriched products

18 / 12 Oils

Other Oils
Aquaculture - Has the Good Oil gone missing?

July 2002, INFORM, AOCS:
“warned that some species of farm-raised fish may have little or no omega-3 fatty acids......”
(Stoll, Harvard Med. School)

Farm fish fail omega-3 trial

Emma Ross

The health benefit of eating oily fish such as salmon and mackerel seems to depend on what the fish are fed, new research has revealed. Also, adding vegetable oil to feed pellets appears to dilute the potential heart disease fighting effect.

Fatty fish such as salmon, tuna, mackerel, sardines and herring are rich in omega-3 fatty acids, the healthy fat that scientists believe raises the good HDL cholesterol, lowers unhealthy triglycerides and slows the growth of plaque, protecting the heart from disease.

However, in modern fish farming, the fish are usually fed pellets that contain a mixture of natural fish oil and vegetable oil.

In a study presented at the annual meeting of the European Society of Cardiology, Norwegian scientists showed that people who ate salmon fed on pure vegetable oil, or on 50 percent fish oil and 50 percent vegetable oil, did not get the same nutritional improvement in the relevant blood tests.

The research involved 28 people with heart disease in Oslo, Norway. The fish was farmed in northwest Norway, colour-coded according to the pellets they were fed and shipped to a central kitchen in Oslo where they were transformed into meals and served.

One-third of the volunteers were fed salmon that had been given pellets of fish oil; another third got fish fed on a 50-50 mix of fish oil and repressed oil; and the last group got salmon reared on pure repressed oil pellets. Each volunteer ate 35g of the fish per week, for six weeks.

The scientists, led by Dr Harold Arnesen of Ullevaal University Hospital in Norway, examined the blood of the volunteers at the beginning and the end of the six-week period to see the concentrations of omega-3 fatty acids and track changes in blood chemicals linked to heart disease.

“Triglycerides are the chemical form in which most fat exists in food and in the body. Everybody’s cholesterol dropped, but that was probably because they were eating fish instead of meat, which is high in saturated fat, the scientists concluded. Nobody lost weight during the study, which means the results could not have been due to differences in weight loss, Arnesen said.

“Only two percent of the market today is wild salmon. The farmed salmon market today is very close to 80-85 percent of the total. This is what we have in Norway and it is more or less the same all over the world,” Arnesen said. “The findings underline the importance of eating the salmon with heart protective properties.”
Global Fisheries – are there enough fish anyway - ?

We estimate that large predatory fish biomass today is only about 10% of pre-industrial levels.

“...and there are few in the North Sea, the Baltic Sea, and the Northeast Pacific...”

Letters to Nature
Rapid worldwide depletion of predatory fish communities
Ransom A. Myers & Boris Worm
Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1

We estimate that large predatory fish biomass today is only about 10% of pre-industrial levels.

Loved to death: our fish stocks in crisis
Australian Farmed Fish – Good Oil (2002-13)

Global fish catches static or declining
  • Fish oil used in aquaculture – replaced by other oils

LC Omega-3 oils have decreased cf 2002
  • $\omega_3/\omega_6$ ratio $<1$ in 2012-13
  • Content decreased by 10-50+% in 2010-13

![Graph showing Farmed Atlantic salmon - Omega-3/Omega-6 Ratio from 2002 to 2013](chart.png)
Changing diets:

- EPA+DHA are decreasing
- LA increasing
Tasmanian farmed Atlantic salmon – LC Omega-3 content

(mg/100 g)

Average 2010-13

mg/100 g

2500
2000
1500
1000
500
0

2002 Winter
2010 Autumn
2010 Spring
2011 Autumn
2011 Summer
2012 Autumn
2012 Spring
2013 Autumn

2010 Autumn
2011 Autumn
2011 Summer
2012 Autumn
2012 Spring
2013 Autumn

Average 2010-13
Atlantic salmon smolt: effect of changing diet and DHA/EPA ratio

- FO and three mixed diets
- EPA+DHA ‘spared’

- Higher DHA/EPA diet $\rightarrow$ higher LC Omega-3 content in flesh

Codabaccus et al. Aquaculture 2012
Comparison farmed Tasmanian and NZ salmon:

**EPA + DHA** content (mg/100 g)

NZ King salmon data – c/o Matt Miller, Plant & Food Res.
**Barramundi – LC Omega-3 content (mg/100 g)**

Nichols et al. 1998a&amp;b, 2002; Unpublished data
Food Futures Flagship: **LC Omega-3 Oils**

- LC Omega-3 oils essential for human & marine fish health
- Global fish catches static or declining
- Microalgae biosynthesize the LC omega-3 oils that fish consume & store. *Fish do not make EPA+DHA*

**CSIRO-wide project**

Goal: Isolate omega-3 genes from microalgae & transfer them to crop plants to sustainably produce **LC omega-3 oils**
DHA synthesis in oil seeds – application to aquafeeds
A large proportion of the population are accepting of GM land plant LC omega-3 oil that:

• Provides a health benefit,
• Was supported by health claims from a trusted source,
• Was indirectly consumed (e.g. food for farming fish)

(Cox et al. 2007, 2008, 2010)
Summary

• Seafood remains an excellent source of LC Omega-3 for Australian and NZ consumers
  – *Farmed seafood* in Australia and NZ generally contains higher LC Omega-3 content than wild harvest seafood
  – LC Omega-3 content in *farmed fish* is decreasing, as is the previously high omega-3 / omega-6 ratio

• Alternate sources LC Omega-3 are required for future aquaculture application, e.g. krill, yeast, precursors such as SDA, new land plants.
  – Excellent progress with new land plants (DHA-Canola, CSIRO-Nuseed-GRDC; *S. Singh et al. AAOCS-O3C*)
Thank you

CSIRO Food Futures Flagship
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