ACHIEVING OPTIMAL N-3 FATTY ACID STATUS - THE VEGETARIAN’S CHALLENGE

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Sanford School of Medicine
University of South Dakota

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OUTLINE

The Omega-3 Index
What is “normal” and “optimal?”
Are vegetarians n-3 FA deficient?
Vegetarian choices
  Alpha linolenic acid (ALA)
  Stearidonic acid (SDA)
  Non-fish sources of EPA and DHA
    Algae, biotech yeast and plants
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The Omega-3 Index

A measure of the amount of EPA+DHA in red blood cell membranes expressed as the percent of total fatty acids

64 fatty acids in this model membrane, 3 of which are EPA or DHA

\[
\frac{3}{64} = 4.6\%
\]

Omega-3 Index = 4.6%

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Algae, biotech yeast and plants
Age- and Sex-Specific Medians for the Omega-3 Index

Framingham Offspring, Mean=5.6%\textsuperscript{a}

<table>
<thead>
<tr>
<th>Decade</th>
<th>Total</th>
<th>Men</th>
<th>Women</th>
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</thead>
<tbody>
<tr>
<td>10’s</td>
<td>1,153</td>
<td>503</td>
<td>650</td>
</tr>
<tr>
<td>20’s</td>
<td>5,948</td>
<td>2,580</td>
<td>3,368</td>
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<tr>
<td>30’s</td>
<td>14,464</td>
<td>7,017</td>
<td>7,447</td>
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<tr>
<td>40’s</td>
<td>28,545</td>
<td>14,393</td>
<td>14,152</td>
</tr>
<tr>
<td>50’s</td>
<td>39,430</td>
<td>19,368</td>
<td>20,062</td>
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<td>60’s</td>
<td>37,991</td>
<td>18,196</td>
<td>19,795</td>
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<tr>
<td>70’s</td>
<td>22,695</td>
<td>10,442</td>
<td>12,253</td>
</tr>
<tr>
<td>80’s</td>
<td>8,561</td>
<td>3,581</td>
<td>4,980</td>
</tr>
<tr>
<td>90’s+</td>
<td>984</td>
<td>351</td>
<td>633</td>
</tr>
<tr>
<td>Total</td>
<td>159,771</td>
<td>76,431</td>
<td>83,340</td>
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</table>

\(\star\) P=0.005 male vs female

\textsuperscript{a}Harris et al. Atherosclerosis 2012;225:425-431; \textsuperscript{b}Harris et al. PLEFA, 2013
Relative Risk of Sudden Cardiac Death and Blood Omega-3 - Physicians' Health Study

Mean Blood Omega-3 FA (%) by Quartile

- 3.6%
- 4.8%
- 5.6%
- 6.9%

Relative Risk

90% reduction in risk

p for trend = 0.001

Rationale for Selecting Omega-3 Index Targets

Greatest Protection
- GISSI-P: ~9–10%
- CHS: 8.8%
- DART: ~8–9%
- SCIMO: 8.3%
- 5 epi studies: ~8%

Least Protection
- PHS: 3.9%
- SCIMO: 3.4%
- Seattle: 3.3%
- PHS: 7.3%
- Seattle: 6.5%

Omega-3 Index Risk Zones

- **Undesirable**
  - USA/EU: 4%
  - Japan: 8%

- **Intermediate**

- **Desirable**

Percent of EPA+DHA in RBC


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Omega-3 Status in Vegetarians and Vegans

Plasma fatty acids measured in
- 196 meat eaters
- 231 vegetarians
- 232 vegans

Rosell et al. AJCN 2005;82:327-334
RBC Fatty Acids in Dutch Omnivores (n=15) and Vegans (n=12)

<table>
<thead>
<tr>
<th></th>
<th>18:2n-6</th>
<th>20:4n-6</th>
<th>20:5n-3</th>
<th>22:6n-3</th>
<th>O3Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omnivores</td>
<td>9.8%</td>
<td>13.8%</td>
<td>0.55%</td>
<td>3.90%</td>
<td>4.45%</td>
</tr>
<tr>
<td>Vegans</td>
<td>11.6%*</td>
<td>14.2%</td>
<td>0.22%*</td>
<td>2.04%*</td>
<td>2.26%*</td>
</tr>
</tbody>
</table>

*p<0.01

Fokkema et al. PLEFA 2000;63:279-285
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Effects of 8 wks Flax or Fish Oil on RBC EPA and DHA Levels (n=100)

Dewell et al. J Nutr 2011;141;2166-71

*0.7 g+0.5 g; **2.1 g+1.5 g
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Stearidonic Acid Product Concept

Plant soy, canola & flax oils

18:0 D9D 18:1n9 D12D 18:2n6 D15D
stearic acid oleic acid linoleic acid

D6 Desaturase

D6 Desaturase

GLA 18:3n6 SDA 18:4n3

The Delta-6 Desaturase (D6D) in soybeans produces SDA more efficiently than D6D does in humans

SDA is a better “pro-EPA” than is ALA

18:4n3
20:5n3 EPA
22:6n3 DHA
SDA Soybean Oil Composition

*SDA content ranges from 20-30% w/w total fatty acids
Primary Endpoint: Omega 3 Index

Mean (±SEM) for per protocol population of 157 subjects

* p<0.001 compared to soy oil control; SDA and EPA not different p=0.585; ANCOVA
Efficacy of conversion of SDA (as a percent of that achieved with pure EPA feeding) and the approximate EPA dose equivalent (mg/day)
Theoretical Relative Risk Reduction for Sudden Cardiac Death Based on the Increase in the Omega-3 Index Observed after Feeding SDA


To increase Omega-3 sustainability...

Conversion rates based on the EPA content of salmon and SDA’s relative ability to enrich RBC membranes with EPA

Just one acre of Omega-3, SDA- enriched soybeans is equivalent to ~10,000 three ounce servings of salmon

10,000
If you are a food company looking to add omega-3s into your food or beverage products, learn more on this site. Soymega™ makes it easier for food companies to incorporate omega-3s into everyday foods.

Why Soymega?

Omega-3 products grew 42% in 2019 as consumer interest increased in healthy eating.

– Nielsen research, 2010

Health Benefits
Stearidonic (SDA) soybean oil is a source of an omega-3 that helps maintain heart health.

Learn More

Food Applications
Food manufacturers can offer a source of omega-3s to consumers by adding Soymega™ to a variety of foods.

Learn More

Sustainability
Soymega™ is a sustainable plant-based source of omega-3s.

Learn More
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New Harvest EPA-Producing Yeast (Dupont)

Technical Approach
Introduce genes for omega-3 biosynthesis into a GRAS yeast production host that accumulates oil when grown on glucose.

Gillies PJ. Presentation at EB 2010
Effects of Biotech-Yeast EPA vs Algal DHA on Serum N-3 FA in Healthy Subjects

30 subjects per group

Gillies PJ. Presentation at EB 2010
DHA from Plants?

• Genetically-engineered *Brassica napus* (rape)
• Produces oil with 15% DHA
• If commercializable, 1 acre could produce as much DHA as 4000 fish

Effects of DHA on Serum DHA Levels in Vegan men (n=29)

Sanders TAB. PLEFA 2009;81:137-141

200 mg/d DHA for 3 months.
# Omega-3 Supplement Prices

16-Aug-12 (Colorado Springs)

<table>
<thead>
<tr>
<th>Store</th>
<th>Brand</th>
<th>Name</th>
<th>EPA</th>
<th>DHA</th>
<th>Sum</th>
<th>Cap/1g</th>
<th>$/1g</th>
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</thead>
<tbody>
<tr>
<td>Sam's Club</td>
<td>Simply Right</td>
<td>Regular Strength</td>
<td>162</td>
<td>108</td>
<td>270</td>
<td>3.70</td>
<td>$0.11</td>
</tr>
<tr>
<td></td>
<td>Simply Right</td>
<td>Double Strength + Vit D</td>
<td>324</td>
<td>216</td>
<td>540</td>
<td>1.85</td>
<td>$0.12</td>
</tr>
<tr>
<td></td>
<td>Simply Right</td>
<td>Triple Strength</td>
<td>647</td>
<td>253</td>
<td>900</td>
<td>1.11</td>
<td>$0.14</td>
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<tr>
<td>Medicine Shoppe</td>
<td>21st Century</td>
<td>Fish Oil</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>21st Century</td>
<td>Krill Oil</td>
<td>50</td>
<td>24</td>
<td>74</td>
<td>13.51</td>
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<tr>
<td></td>
<td>Metagenics</td>
<td>720</td>
<td>430</td>
<td>290</td>
<td>720</td>
<td>1.39</td>
<td>$0.39</td>
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</table>

**Online Vegan Products**

<table>
<thead>
<tr>
<th>Store</th>
<th>Brand</th>
<th>Name</th>
<th>EPA</th>
<th>DHA</th>
<th>Sum</th>
<th>Cap/1g</th>
<th>$/1g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic Naturals</td>
<td>Algae Omega</td>
<td></td>
<td>90</td>
<td>160</td>
<td>250</td>
<td>4</td>
<td>$1.42</td>
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<tr>
<td>Deva Nutrition</td>
<td>Vegan Omega-3</td>
<td></td>
<td>80</td>
<td>140</td>
<td>220</td>
<td>4.5</td>
<td>$1.26</td>
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<tr>
<td>Nature Made</td>
<td>100% Vegetarian Omega-3</td>
<td></td>
<td>90</td>
<td>180</td>
<td>270</td>
<td>3.7</td>
<td>$1.79</td>
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</table>
CONCLUSIONS

“Optimal n-3 fatty acid status” remains to be defined in both omnivores and vegetarians

Vegetarian choices
1. Alpha linolenic acid: Poor conversion
2. Stearidonic acid: Better conversion than ALA but available? GMO?
3. Non-fish sources of EPA and DHA: algae, biotech yeast and plants may be the long term solution. GMO?
If you can't BE a pescivore, you can at least EAT pescivorous plants!