Phospholipids and DHA for Brain Nutrition

Alimentacion y Memoria
17 de Mayo de 2012

Dr. Thierry COSTE
And men ought to know that from nothing else but thence [from the brain] come joys, delights, laughter and sports, and sorrows, griefs, despondency, and lamentations. And by this, in an especial manner, we acquire wisdom and knowledge, and see and hear, and know what are foul and what are fair, what are bad and what are good, what are sweet, and what are unsavory... And by the same organ we become mad and delirious, and fears and terrors assail us... All these things we endure from the brain, when it is not healthy... In these ways I am of the opinion that the brain exercises the greatest power in the man.

Hippocrates from the Sacred Disease (IV century before JC)
Evolution of elderly people in France

<table>
<thead>
<tr>
<th></th>
<th>1950</th>
<th>2000</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 75 years</td>
<td>1.56</td>
<td>4.2</td>
<td>11.6</td>
</tr>
<tr>
<td>More than 85 years</td>
<td>0.2</td>
<td>1.2</td>
<td>4.8</td>
</tr>
</tbody>
</table>
Diseases from ageing

INSEE forecasts

Alzheimer disease

Parkinson disease

Part of the population (%)

INSEE forecasts

65+

Part of affected population (%)

>65 years

>75 years

65-69 years

85-89 years
Alzheimer: a complex physiopathology

Hypothetical Alzheimer Cascade: Argument for Pleiotropic Targeting

- Aβ accumulation w/ aging or mutations in PS, ApoE4, APP, CR1 oligomers and plaques
- pTau accumulation
- Oxidative Damage
  - activation or disruption of JNK, cdk5, ERK or GSK3
- Dysfunction in signal transduction Pathways regulating Tau Function
- Tau aggregates
- microtubule destabilization
- Loss of Tau Function
  - Neuron Loss
- Energy Defects Impaired glycanolysis
- Neuroinflammation, increased PLA2 and release of AA increased LOX/COX products
  - Inflammation, increased PLA2 and release of AA increased LOX/COX products
  - Failure Phagocytic Clearance
- Aberrant Sprouting
- Complement activation
- Excitotoxicity
- Synaptic elimination
- Glutamate accumulation
- Cognitive and Neuropsychiatric deficits
  - episodic memory, global cognitive deficits, agitation, depression
- Synaptic Loss
- Neuron Loss
- Synaptic Loss
Alzheimer: implication of tau protein
Alzheimer: implication of APP protein
Alzheimer disease chronology

Clinical phases

Histological lesions
- Synaptic dysfunction
- Inflammation
- Soluble oligomers Aβ

Cognitive decline

Presymptomatic
- Non measurable

MCI
- Mild
- Neuronal death
- Inflammation
- Soluble and fibrillary Aβ

Symptomatic
- Severe
- Cortical atrophy
- Neuritic plaques

Development of preventive approaches?
What is cognitive decline?

➢ A set of troubles associating memory complaints, loss of attention, perception and reasoning.

➢ The general term is MCI for Mild Cognitive Impairment.

➢ Unavoidable consequence of brain ageing?

➢ No scientific link established between ageing and cognitive decline.
Cognitive decline and Alzheimer disease

Proportion of persons with no dementia

Years since the first evaluation

Control group

Cognitive decline group
Some numbers for France

➢ Around 1 million of people affected in France by dementia and in particular Alzheimer disease.

➢ More than 25 millions of people affected in the world.

➢ Around 10 billion of euros for annual expenses in France concerning the medical and medico-social expenses.

➢ The number of patients could double until the year 2040 and so the associated medical expenses.

➢ The number of patients with cognitive decline is more greater and these patients also present a higher risk of mortality.
The study of ageing is a very young science!!!
Impact of alimentation on cognitive decline

- Less cognitive decline for people who consume fishes (rich in DHA & EPA, $\omega$3 fatty acids) over five years follow up (n=210)

- Beneficial effect of coffee consumption (3 cups a day) on cognitive decline over ten years follow up (n=676)

=> Why phosphatidylserine can have an interest in cognitive decline?

=> Why docosahexaenoic acid (DHA) can also have an interest in cognitive decline?
Phosphatidylserine (PS)
## Levels of phosphatidylserine into tissues

<table>
<thead>
<tr>
<th>Tissues (human)</th>
<th>PS in % of total phospholipids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain myelin</td>
<td>21</td>
</tr>
<tr>
<td>Brain white matter</td>
<td>16</td>
</tr>
<tr>
<td>Brain grey matter</td>
<td>13</td>
</tr>
<tr>
<td>Retina</td>
<td>8-16</td>
</tr>
<tr>
<td>Erythrocyte</td>
<td>14</td>
</tr>
<tr>
<td>Platelets</td>
<td>9</td>
</tr>
<tr>
<td>Lung, spleen, amniotic fluid</td>
<td>8</td>
</tr>
<tr>
<td>Liver, heart, skeletal muscle</td>
<td>3</td>
</tr>
<tr>
<td>Kidney</td>
<td>1</td>
</tr>
<tr>
<td>Plasma</td>
<td>Traces</td>
</tr>
</tbody>
</table>
Phosphatidylserine

Polar head (hydrophilic)

Apolar tail (hydrophobic)
Main phospholipids

- Phosphatidic Acid (PA)
- Phosphatidylcholine (PC)
- Phosphatidylethanolamine (PE)
- Phosphatidylserine (PS)
- Phosphatidylglycerol (PG)
- Phosphatidylinositol (PI)
Amphiphilic properties of phospholipids

Polar head (hydrophilic)

Apolar tail (hydrophobic)
Phospholipids into water: structures
From liposome to cell
Cell membrane

[Image: Diagram of the cell membrane with labels for various components such as protein channel, extracellular fluid, carbohydrate, phospholipid bilayer, cytoplasm, hydrophilic heads, phospholipid molecule, hydropobic tails, integral protein, globular protein, filament of cytoskeleton, alpha-helix protein, surface protein, glycoprotein, glycolipid, cholesterol, peripheral protein.]
Membrane phospholipids asymmetry

<table>
<thead>
<tr>
<th>Membrane phospholipid</th>
<th>Percent of total membrane phospholipid</th>
<th>Distribution in membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphatidylethanolamine</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Phosphatidylcholine</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Sphingomyelin</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Phosphatidylserine</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Phosphatidylinositol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphatidylinositol 4-phosphate</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Phosphatidylinositol 4,5-bisphosphate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphatidic acid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Phospholipids levels in food

- Egg yolk: 3.5 g/100 g
- Honey: 30 to 60 g/100 g
- Milk: 30 to 50 mg/100 g
- Fish: 20 to 100 mg/100 g
- Chicken: 100 to 500 mg/100 g
- Vegetables: 20 to 100 mg/100 g
- Beans: 100 to 500 mg/100 g
Dietary intakes comprised between 1 to 3 g daily, decreased because of:
- less use of soy lecithin in the foodstuffs (fear of GMO soybean),
- mad cow disease with a diminished consumption of offal and brain (rich in PS).

Why study the phosphatidylserine (PS)?

- The brain is the tissue the most richest in PS (> 15 %) and contains a big part of total PS in the organism, which suggests an important functional role
  (Sastry PS. Prog Lipid Res 1985, 24 : 69-176)

- There is a decrease of serine incorporation into brain phospholipids of old rats
  (Gatti et al. Neurobiol Aging 1989, 10 : 241-5)

- Beneficial effect on learning and memory in old rats
Firstly, phosphatidylserine was manufactured from cerebral cortex of beef.

=> But the mad cow disease made disappear this source.
Phosphatidylserine manufacturing

- bacteria (less stable during time, microbial toxins?)
- vegetable (cabbage)
Sources to manufacture the PS

Generally, we use soy phospholipids (rich in phosphatidylcholine) as raw material.

But we can use marine sources or egg yolk (because they are also rich in phosphatidylcholine) as raw material and we can obtain phosphatidylserine containing omega 3.
Clinical data with PS
### PS and cognitive decline

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age years</th>
<th>PS dose in mg</th>
<th>Time weeks</th>
<th>Beneficial effects</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>149</td>
<td>50-75</td>
<td>300</td>
<td>12</td>
<td>Amelioration of 3/5 tests in patients and 4/5 among most affected patients</td>
<td>1</td>
</tr>
<tr>
<td>425</td>
<td>65-93</td>
<td>300</td>
<td>26</td>
<td>Amelioration in behaviour and cognitive parameters</td>
<td>2</td>
</tr>
<tr>
<td>120</td>
<td>&gt; 57</td>
<td>300 or 600</td>
<td>12</td>
<td>No significant amelioration</td>
<td>3</td>
</tr>
<tr>
<td>78</td>
<td>50-69</td>
<td>100 or 300</td>
<td>26</td>
<td>Amelioration of memory in patients with memory complaints</td>
<td>4</td>
</tr>
</tbody>
</table>

2) Cenacchi *et al.* Aging 1993, 5: 123-33  
3) Jorissen *et al.* Nutr Neurosci 2001, 4: 121-34  
## PS, Alzheimer and related dementia

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age years</th>
<th>PS dose in mg</th>
<th>Time weeks</th>
<th>Beneficial effects</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>65-91</td>
<td>300</td>
<td>6</td>
<td>2 scores tested: significant amelioration for one and tendency for the other</td>
<td>4</td>
</tr>
<tr>
<td>142</td>
<td>40-80</td>
<td>200</td>
<td>13</td>
<td>9 scores and tests evaluated: significant amelioration for 3 et tendency for 1 among the most affected patients</td>
<td>5</td>
</tr>
<tr>
<td>33</td>
<td>55-75</td>
<td>300</td>
<td>8</td>
<td>Amelioration on global score and electro-encephalogram (EEG)</td>
<td>6</td>
</tr>
<tr>
<td>51</td>
<td>55-85</td>
<td>300</td>
<td>12</td>
<td>Amelioration over some items of 2 tested scores with the best effectiveness among patients less affected</td>
<td>7</td>
</tr>
<tr>
<td>70</td>
<td>48-79</td>
<td>400</td>
<td>26</td>
<td>Amelioration of neuropsychological test, EEG, and glucose use in brain areas affected by Alzheimer (PET)</td>
<td>8, 9</td>
</tr>
</tbody>
</table>

5) Amaducci et al. Psychopharmacol Bull 1988, 24 : 130-4  
Phosphatidylserine is required for an optimal activity of Na,K-ATPase in cell membranes.

Stekhoven et al. 1994, Biochim Biophys Acta 1194: 155-65
Docosahexaenoic acid (DHA)
<table>
<thead>
<tr>
<th>Main omega 3 fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha linolenic acid (ALA, C18:3 ω3)</strong></td>
</tr>
<tr>
<td><img src="image" alt="Chemical structure of ALA" /></td>
</tr>
<tr>
<td><strong>Eicosapentaenoic acid (EPA, C20:5 ω3)</strong></td>
</tr>
<tr>
<td><img src="image" alt="Chemical structure of EPA" /></td>
</tr>
<tr>
<td><strong>Docosahexaenoic acid (DHA, C22:6 ω3)</strong></td>
</tr>
<tr>
<td><img src="image" alt="Chemical structure of DHA" /></td>
</tr>
</tbody>
</table>
Competition between omega 3 and omega 6

18:1 \(\omega 9\) → LA → \(\Delta 12\) DS → 18:2 \(\omega 6\) → \(\Delta 6\) DS → 18:3 \(\omega 3\) → ALA → \(\Delta 15\) DS → 18:4 \(\omega 3\) → EPA

Mammals

Arachidonic acid

Endoplasmic reticulum

Peroxisome

Plants & Invertebrates

Eicosapentaenoic acid

Docosahexaenoic acid

DS = Desaturase
E = Elongase
\(\beta\text{-ox} = \beta\text{-oxidation}\)
Supplementation with DHA* is necessary

Because conversion is not sufficient:
- women ≈ 1 %
- men << 1 %

DS = Desaturase
E = Elongase
β-ox = β-oxidation


* AFSSA recognizes DHA as an indispensable fatty acid in their new RDA for fatty acids (2010)
Omega 3 levels in human tissues

DHA is the omega 3 the more abundant in human cell membranes and especially in retina and brain because this fatty acid is an essential key for the good cell functionality.

Cerveau et DHA

13 à 16 %
Clinical data with omega 3 fatty acids
First data

- EVA study: patients with the highest levels of DHA in erythrocytes => less cognitive decline over 4 years follow up (n=246)
  (Heude *et al.* Am J Clin Nutr 2003, 77 : 803-8)

- Decrease of 47% of risk to develop dementia (*Alzheimer included*) if the plasmatic DHA levels are high
  (Schaefer *et al.* Arch Neurol 2006, 63 : 1545-50)

- Amelioration of short memory and attention in 21 patients with cognitive decline after 3 months of treatment
  (Kotani *et al.* Neurosci Res 2006, 56 : 159-64)

- Amelioration of cognitive functions into a group of patients suffering from mild Alzheimer after 6 months of treatment
  (Freund-Levi *et al.* Arch Neurol 2006, 63 : 1402-8)
### Variable effects of omega 3?

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age years</th>
<th>ω3 dose in g</th>
<th>Time weeks</th>
<th>Beneficial effects</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>302</td>
<td>≥ 65</td>
<td>1.8 or 0.4 EPA&gt;DHA</td>
<td>26</td>
<td>No amelioration of cognitive function</td>
<td>1</td>
</tr>
<tr>
<td>49</td>
<td>60-80</td>
<td>0.8 DHA</td>
<td>18</td>
<td>Amelioration of cognitive performance, better effect if combined with lutein</td>
<td>2</td>
</tr>
<tr>
<td>867</td>
<td>70-79</td>
<td>0.7 EPA&lt;DHA</td>
<td>104</td>
<td>No cognitive decline observed in the control group: not valid study</td>
<td>3</td>
</tr>
<tr>
<td>295</td>
<td>76</td>
<td>2 DHA</td>
<td>78</td>
<td>No amelioration among patients affected by Alzheimer</td>
<td>4</td>
</tr>
<tr>
<td>485</td>
<td>≥ 55</td>
<td>0.9 DHA</td>
<td>24</td>
<td>Amelioration of cognitive performance among patients with cognitive decline</td>
<td>5</td>
</tr>
</tbody>
</table>

1) van de Rest *et al.* Neurology 2008, 71 : 430-8  
2) Johnson *et al.* Nutr Neurosci 2008, 11 : 75-83  
4) Quinn *et al.* JAMA 2010, 304 : 1903-11  
5) Yurko-Mauro *et al.* Alzheimers Dement 2010, 6 : 456-64
Pro-oxidant effect of DHA?

Vericel et al. 2003 J Thromb Haemost 1 : 566-72

42
Inhibition of arachidonic acid by EPA?

- **LA**: 18:2 ω6
- **ALA**: 18:3 ω3
- **18:1 ω9**
- **18:3 ω6**
- **20:3 ω6**
- **20:4 ω3**
- **20:5 ω3**
- **22:4 ω6**
- **22:5 ω6**
- **22:6 ω3**
- **24:4 ω6**
- **24:5 ω3**
- **24:6 ω3**
- **Δ 12 DS**
- **Δ 15 DS**
- **Δ 6 DS**
- **Δ 5 DS**
- **Mammals**
- **Plants & Invertebrates**

**Endoplasmic reticulum**

- **Arachidonic acid**
- **β-ox** = β-oxidation

**Peroxisome**

- **DS** = Desaturase
- **E** = Elongase
- **Eicosapentaenoic acid**
- **Docosahexaenoic acid**

- **EPA**
- **DHA**

- **Inhibition of arachidonic acid by EPA?**

43
Omega 3 levels in human tissues

Human cell membranes present very low levels of ALA and EPA.

DHA is the omega 3 the more abundant in human cell membranes and especially in retina and brain because this fatty acid is an essential key for the good cell functionality.

DHA and erythrocyte deformability

Animal supplementation study

Fatty acid composition of the diets (weight %). Values are means of 4 determinations corresponding to 4 weekly preparations of the diets.

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated</td>
<td>32.6</td>
<td>32.3</td>
<td>31.3</td>
<td>31.0</td>
<td>32.8</td>
</tr>
<tr>
<td>Monounsaturated</td>
<td>58.7</td>
<td>32.7</td>
<td>33.8</td>
<td>33.3</td>
<td>32.0</td>
</tr>
<tr>
<td>(n-6) PUFA</td>
<td>8.1</td>
<td>7.2</td>
<td>7.4</td>
<td>8.2</td>
<td>7.0</td>
</tr>
<tr>
<td>(n-3) PUFA</td>
<td>0.6</td>
<td>27.7</td>
<td>27.5</td>
<td>27.5</td>
<td>28.2</td>
</tr>
<tr>
<td>EPA</td>
<td></td>
<td>26.9</td>
<td>12.7</td>
<td>9.4</td>
<td>1.1</td>
</tr>
<tr>
<td>DHA</td>
<td></td>
<td></td>
<td>9.3</td>
<td>14.5</td>
<td>26.5</td>
</tr>
</tbody>
</table>

Abbreviations: A, reference group; B, eicosapentaenoic acid; C, fish oil; D, mixture of EPA and DHA. E, docosahexaenoic acid; PUFA, polyunsaturated fatty acids.

=> Supplementation with DHA induces an accretion of DHA in erythrocyte membranes resulting in a better deformability, contrary to supplementation with EPA, which can counteract this effect.

Association of PS and DHA?
Strong relationships between PS and DHA

- The brain is a tissue very rich in DHA

- The brain is also a tissue very rich in PS

- More interestingly, DHA is mainly located on the PE (and also PE) in the brain

- A DHA deficiency decrease the levels of PS whereas a supplementation with DHA increase the PS levels

=> It exists a real synergy between these two molecules in the human body
Clinical data on PS-omega 3
## PS-DHA/EPA and cognitive decline

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age years</th>
<th>Dose PS-DHA/EPA in mg</th>
<th>Time weeks</th>
<th>Beneficial effects</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 (pilot study)</td>
<td>≥ 60</td>
<td>300-37.5</td>
<td>6</td>
<td>Amelioration of memory among patients with memory complaints</td>
<td>1</td>
</tr>
<tr>
<td>157</td>
<td>50-90</td>
<td>300-79</td>
<td>15</td>
<td>Amelioration of memory among patients with memory complaints</td>
<td>2</td>
</tr>
</tbody>
</table>

2) Vakhapova et al. Dement Geriatr Cogn Disord 2010, 29 : 467-74
A better bioaccretion into tissue membranes

Animal supplementation study

<table>
<thead>
<tr>
<th>DHA 8mg/kg 40 days in female rats</th>
<th>Plasma µg/ml</th>
<th>Erythrocyte mg/g PL</th>
<th>Hepatic tissue mg/g PL</th>
<th>Adipose tissue mg/g lipids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo (olive oil)</td>
<td>80</td>
<td>12.5</td>
<td>45</td>
<td>4.5</td>
</tr>
<tr>
<td>Phospholipids</td>
<td>150 (+90%)</td>
<td>27.5 (+120%)</td>
<td>90 (+100%)</td>
<td>9 (+100%)</td>
</tr>
<tr>
<td>Triglycerides**</td>
<td>145 (+80%)</td>
<td>22.5 (+80%)</td>
<td>70 (+55%)</td>
<td>7 (+55%)</td>
</tr>
<tr>
<td>Ethyl esters***</td>
<td>150 (+90%)</td>
<td>17.5 (+40%)</td>
<td>40 (-10%)</td>
<td>5 (+10%)</td>
</tr>
</tbody>
</table>

* Not available in the market
** Available as fish or micro-algae oils
*** Available as medical drug (for example Omacor®)

A better bioaccretion into brain

Table 2
Radioactivity content (kBq/g tissue) in rat brain tissues (mean of 3 animals) following a single oral administration of $^{14}$C-DHA-TAG (treatment A), $^{14}$C-DHA-TAG and palmitoyl-oleoyl-PC (treatment A/B) or $^{14}$C-DHA-PC (treatment C) determined by QWBA. Within each age group (2, 4 and 10 weeks), values with a different superscript (A, B) differ at p < 0.05 (no superscripts=no statistical significant differences within this age group). Critical differences (crit. diff.) indicate minimal between treatment differences to reach statistical significance. Hypothalamus and Substantia nigra+VTA could not be quantified in adult brains (n.a.).

<table>
<thead>
<tr>
<th>Brain tissues</th>
<th>Age=2 week</th>
<th>Crit. diff.</th>
<th>Age=4 week</th>
<th>Crit. diff.</th>
<th>Age=10 week</th>
<th>Crit. diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>A/B</td>
<td>C</td>
<td>A</td>
<td>A/B</td>
<td>C</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>13.27</td>
<td>13.82</td>
<td>10.60</td>
<td>5.24</td>
<td>4.81</td>
<td>4.36</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>11.57</td>
<td>11.79</td>
<td>9.78</td>
<td>6.11</td>
<td>3.48</td>
<td>2.95</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>8.18</td>
<td>9.78</td>
<td>8.30</td>
<td>4.55</td>
<td>3.25</td>
<td>2.79</td>
</tr>
<tr>
<td>Inferior colliculus</td>
<td>15.02</td>
<td>14.69</td>
<td>12.80</td>
<td>16.36</td>
<td>6.26</td>
<td>6.20</td>
</tr>
<tr>
<td>Medulla</td>
<td>18.09</td>
<td>19.00</td>
<td>13.35</td>
<td>5.97</td>
<td>4.28</td>
<td>4.07</td>
</tr>
<tr>
<td>Occipital cortex</td>
<td>11.44</td>
<td>11.33</td>
<td>8.41</td>
<td>6.16</td>
<td>4.07</td>
<td>3.45</td>
</tr>
<tr>
<td>Olfactory lobe</td>
<td>11.16</td>
<td>11.32</td>
<td>8.30</td>
<td>7.33</td>
<td>4.72</td>
<td>3.61</td>
</tr>
<tr>
<td>Pineal body</td>
<td>6.37</td>
<td>8.37</td>
<td>5.37</td>
<td>3.45</td>
<td>5.25</td>
<td>4.14</td>
</tr>
<tr>
<td>Pons</td>
<td>17.48</td>
<td>18.57</td>
<td>13.79</td>
<td>7.34</td>
<td>4.69</td>
<td>3.97</td>
</tr>
<tr>
<td>Superior colliculus</td>
<td>9.94</td>
<td>10.89</td>
<td>9.20</td>
<td>6.08</td>
<td>4.49</td>
<td>3.92</td>
</tr>
<tr>
<td>Thalamus</td>
<td>10.69</td>
<td>13.03</td>
<td>9.86</td>
<td>7.32</td>
<td>3.94</td>
<td>2.90</td>
</tr>
</tbody>
</table>

=> Less than 1% of the ingested dose of DHA was found in brain and the phospholipids form permits a two-fold bioaccretion in 10-weeks rats when compared to triglyceride form.

Graf BA et al. 2010, Prostaglandins Leukot Essent Fatty Acids 83: 89-96
A better resistance to oxidation

In vitro study

DHA loss
-97%
-64%
-10%

=> DHA in the form of phospholipids is more resistant to the oxidative degradation than DHA in the form of triglycerides or ethyl esters.

Ilusiones

Querría ya no hacer:
el hogar
la colada
la cocina
Ilusiones

Querría ya no hacer:
el hogar
la colada
la cocina
Deseo realizable

Querría

Envejecer sin decadencia y demencia
Deseo realizable

Querría

Envejecer sin decadencia y demencia

POOF

PS + DHA-PL
Just one more thing…
Free consultation to avoid alcoholic hepatic steatosis

Baboons

Baboons with PC

=> PC with the dose of 2.8 g/1000 kcal, prevents the development of fibrosis and cirrhosis in baboons following a diet with 50% of caloric ration in form of ethanol.

Lieber et al. 1994, Gastroenterology 106: 152-9
Gracias por su atención