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Purity | Quality | Innovation

The Omega3 industry
Process- and technology development

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Content

1. **The omega3 business**
   - Key for success, product segments, supply of fish oils, value chain

2. **Process and Technolgy development**
   - Various starting materials
   - **Purification** of oils
   - **Concentrating** technologies

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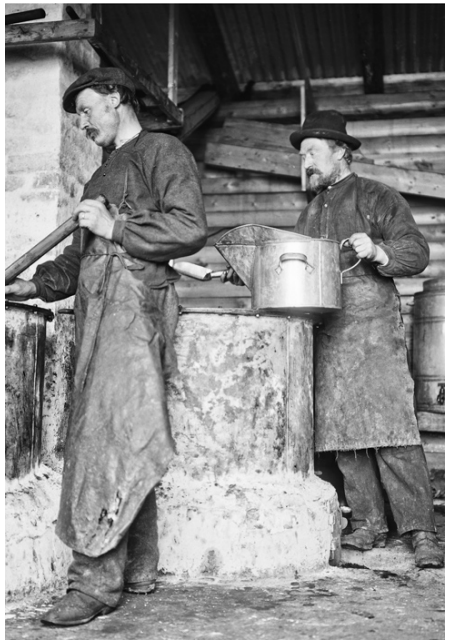
The Omega3 industry



- **A young industry based on long traditions**
  - From cod liver oils: **1800s**
  - Fish body oils: **1980s**
  - Rapid growth – Higher concentrates!
    - ➢ Modern process industry
      - Nutraceuticals
      - Pharmaceuticals
      - Functional food

➢ Most development has not taken place yet!
➢ Exiting future!

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The Omega3 business

- **Key for seccess**
  - **Health!**
  - 20.000 scientific papers and 2.000 klinical studies document the favourable health effects by intake of omega3

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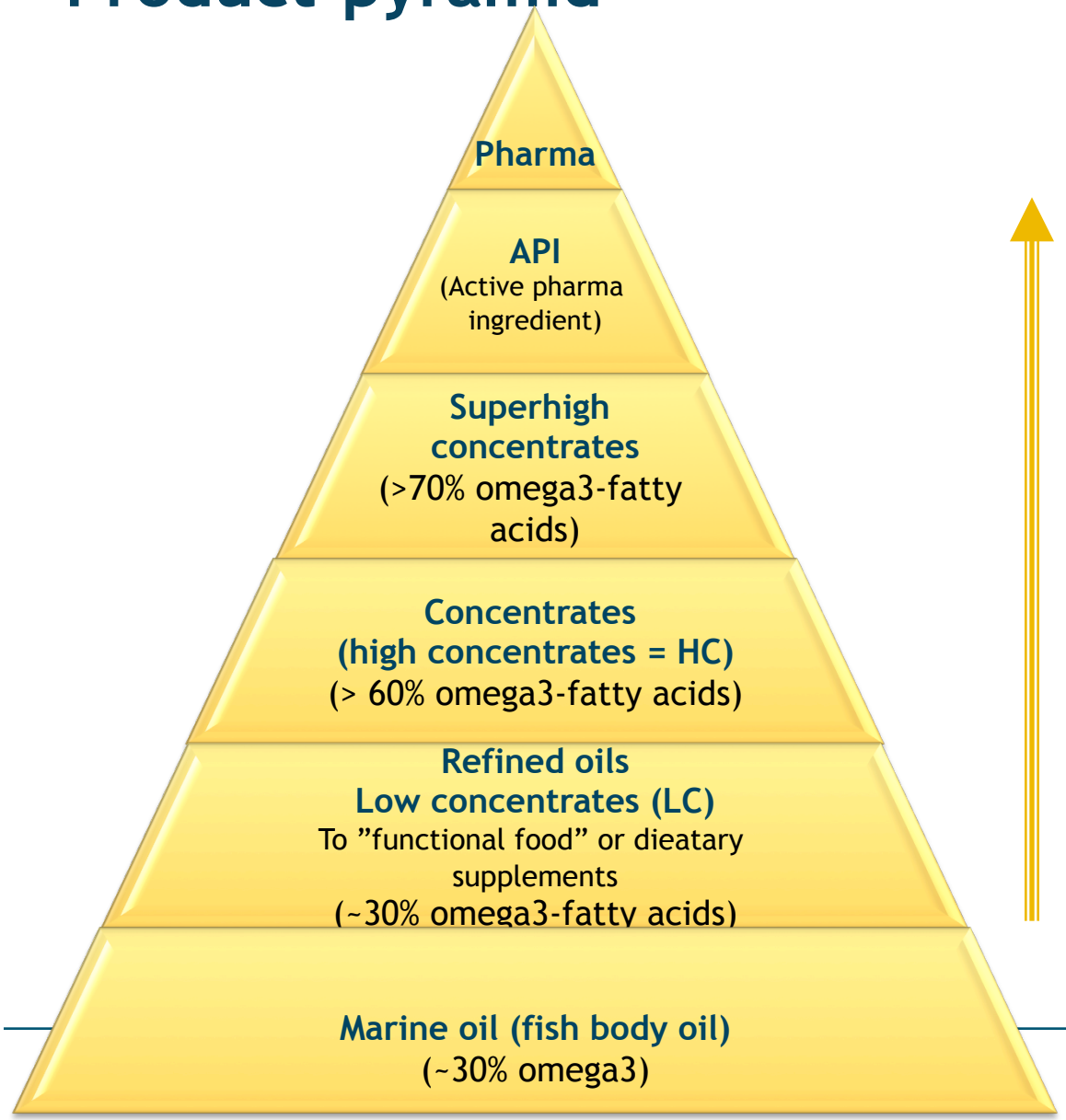
Product-pyramid



Increasing requirement to:

-Equipment

-Processes

-Control- and quality systems

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Fish oil
Food chain for EPA/DHA

- Primary producers of EPA and DHA
  - Marine microalge
  - Micro algae utilise sunlight to convert carbon dioxide and water to fat and other essential nutrients
  - EPA and DHA are formed in this process
- The food chain
  - EPA and DHA accumulates in the food chain
  - Microalgae – zooplankton – crustaceans (krill) – small fish – large fish

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Fish oil
Catch and processing

Meal and oil factory in Chimbote, Peru

Anchovies are caught off the coast and brought to land for processing to meal and oil

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Epax value chain

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Process and technology development

Purity - Quality - Innovation

- Sustainable marine resources
- Environmental friendly processing
- GMP (Good Manufacturing Practice)

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Process and technology development

- **Young advanced processing industry**
- **Busy on development !**

  - Utilize more types of marine oils
  - Develop processes for purification and concentration
    - choose the right ones!
  - Find best **combination** of techniques
  - Find best **order of** unit operations
  - From batch to continous processing

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Starting material – crude oils

- **Various starting material - crude marine oil (Food grade!!)**
  - Anchovy/sardine oils (EPA+DHA ~30%)
  - Other oils: Tuna, Krill, Squid, Cod liver, Menhaden, Salmon, Herring, Mackerel, Micro algaes ++

➢ Variation between fish species
➢ Variation during seasons and from year to year

Species	EPA (%)	DHA (%)	EPA+DHA (%)	Tot Omega3
Anchovy	18	12	30	36
Tuna	6	24	30	36
Sardine	16	9	25	31
Pollock	12	6	18	21
Herring	7	10	17	20
Mackerel	7	14	21	30

Numbers in table are example of values

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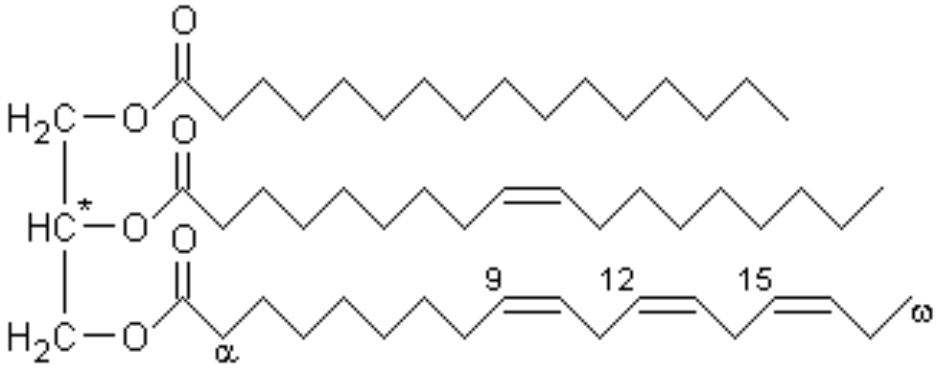
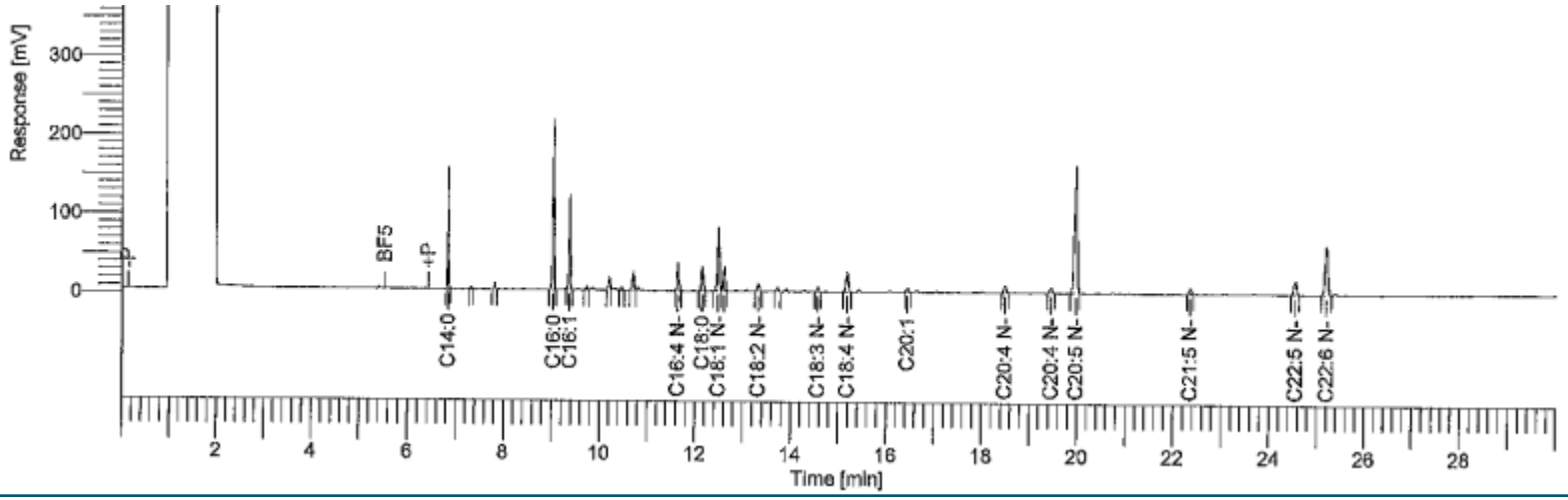
Complexity in fatty acid composition

- Complex fatty acid composition
- High variety in amount and composition - seasonial
- Needs robust and selective processing tools

- More than 30 fatty acids in fish oils
- Distributed «randomly» in Triglycerides





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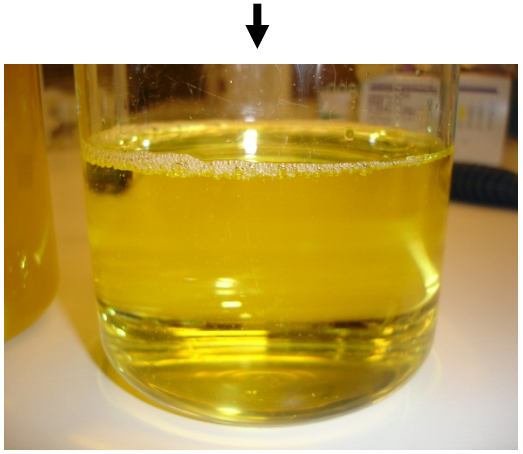
Process operations

The processing has two main goals:

1. Purify the fish oil
2. Concentrate Omega3 (especially EPA and DHA)

1. **Purification:**
   - Removes:
     - Environmental pollutants, heavy metals, proteins, phospholipids, free fatty acids, cholesterol, saturated fatty acids (stearins), color pigments, oxidation products, smell and aroma compounds

2. **Concentrating:**
   - Increase amount of EPA+DHA from 30% to target (60-90%)



Purification of fish oil
- Refining processes and technology

Remove unwanted substances from crude oil

- **De-acidification** – remove free fatty acids
- **Distillation** – remove environmental pollutants
- **Active carbon treatment** - remove PAHs, furans, dioxin
- **Winterization** – remove stearins
- **Bleaching** – remove peroxides, trace metals, dioxins, furans, PAHs
- **Steam deodorization** – remove smell/taste, color

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Purification of fish oil
- Refining processes and technology

- **Order of unit operations**
- **Avoiding oxidation**

- **New technologies**
  - Enzymatic processing
  - More effective absorbents
  - More effective filtration

Key factors:
- **Purity** («no» traces left of impurities, «no« oxidation)
- **Recovery of EPA and DHA** (yield)
- **Capacity**
- **Eco friendly**

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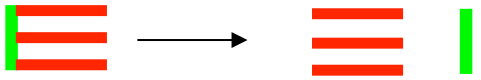
Concentrating omega3 fatty acids

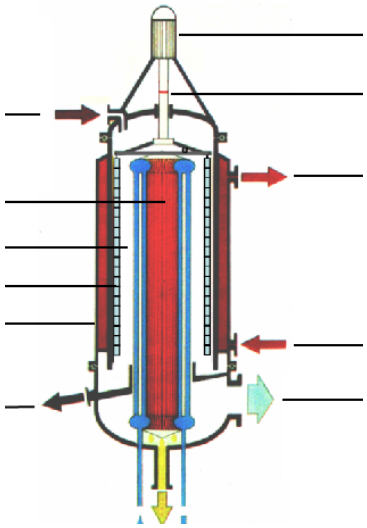
Main goal: Concentrate targeted fatty acids (EPA and DHA)

Pre-treatment:

- Converting from triglycerides to ethyl esters



1. **Molecular distillation** (short path distillation)
2. **Urea precipitation**
3. **Chromatography**
   - SMB (Simulating Moving Beds)
4. **Supercritical fluid extraction/fractionation**
5. **Enzymatic processing**



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Combination of concentrating techniques

1. Selectivity based on **molecular size** (chain length)
   - Distillation

2. Selectivity based on **number of double bonds** and **molecule conformation**
   - Urea precipitation
   - Chromatography
   - Enzymatic processes

Combination of techniques in use:

- Molecular distillation + urea precipitation
- Molecular distillation + chromatography (SMB)
- Molecular distillation + selective enzyme process

Crude oil:	**~30% EPA + DHA**
After distillation:	**~60% EPA + DHA**
After distillation + extra technique:	**~70-90% EPA + DHA**

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Process and technology development

Approx 8-10 unit process operations needed for omega3 concentrates

- Process development and new technologies are wanted!

- **More use of White biotechnology**
  - Enzymes instead of chemicals
- **Secure high EPA and DHA recovery**
  - Smart use of byproducts
- **GMP (Good Manufacturing Practice)**
  - Prepare for a high standard

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Summary

A young processing industry!

- *Most development has not been done yet!!*
- Be able to **utilize marine oils** with variable fatty acid content and composition
- Secure **high purity** by smart combining and development of refining processes
- Secure **high productivity** and **revovery of EPA and DHA** by smart combining of advanced concentrating technologies

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Looking ahead with Epax

A Leader in Omega-3 Concentrates

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