Oils and fats from southern countries for oleochemistry

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At the beginning was the soap

Oleochemistry is everywhere

Triglycerides as versatile raw materials

Seed oil market, non-food uses and southern countries

Focus on oleochemistry of tropical oils and castor oil

Next challenges for seed oils and oleochemistry

Conclusions
At the beginning was the soap...

The word “sapo” is very likely of Gaulish or Germanic origin and was first mentioned by Pliny the Elder (23-79 AD) in its Natural History.

*BABYLON* ≈ 2800 BC

Soap-like material in clay cylinders - First evidence of soap making

*EGYPT* ≈ 1500 BC

Soap-like material for washing or treatment of and skin deseases

*EUROPE* 467 AD

Fall of the Roman Empire, the act of bath is condemned by the clergy

*EUROPE* 17th cent.

South Europe is the center of soap making from olive oil

*FRANCE* 18th-19th cent.

Soda ash from NaCl (Leblanc) - Fat & soap chemistry (Chevreul)

*BELGIUM* 1861

The Solvay Process (Na$_2$CO$_3$ from NaCl and ammonia)

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Oleochemistry is everywhere

“Oleochemistry: physico-chemical (enzymatic) transformation of fats and oils of animal and plant origins”

Oils and Fats

Bulk chemicals
Intermediaries
High added-value molecules

Food, surfactants, lubricants, cosmetics, pharmaceuticals, biodiesels, polymers…
Triglycerides as versatile raw materials

...but also renewable, biodegradable...

ESTER FUNCTION

Hydrolysis
Transesterification
Halogenation
Reduction
Amidation...

DOUBLE BOND

Hydrogenation
Ozonolysis
Metathesis
Halogenation
Epoxidation
Polymerization...

SIDE FUNCTIONS

Dehydration
Pyrolysis
Halogenation
Esterification
Urethane formation...

FA (free, salt, chloride),
Glycerides, Esters, Glycerol
Alcohols
Amides/Amines (salts)

Paraffins/olefins
Diacids, Functionalized oils
Polymers...

Functionalized oils
Polyurethanes
Sebacic, undecylenic ac.
Alkyl/Alkylaryl esters...
9 Major Vegetable Oils – Global production 2011 (million tons - Mt)

- Olive: 3.0 Mt
- Coconut: 3.7 Mt
- Peanut: 5.0 Mt
- Cotton: 5.0 Mt
- Palm kernel: 5.6 Mt
- Sunflower: 11.3 Mt
- Rape: 22.6 Mt
- Soybean: 42.1 Mt
- Palm: 48.0 Mt

Total: 152.4 Mt

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
9 Major Vegetable Oils – Global production 2011 (million tons - Mt)

<table>
<thead>
<tr>
<th>Oil</th>
<th>Production (Mt)</th>
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<tbody>
<tr>
<td>Olive</td>
<td>3.0</td>
</tr>
<tr>
<td>Coconut</td>
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</tr>
<tr>
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</tr>
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<td>Palm kernel</td>
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</table>

**Total: 152.4 Mt**

Significant growth of oilseed industry with a growth rate of prod. & consump. (≈5% pa) higher than that of the wheat market (1.8% pa)

**Strong growth in human food consumption**
- Westernisation of diets in developing nations
- Replacement of animal fats with vegetable oils in the developed world

**Strong growth in industrial consumption**
- Tremendous growth of the biodiesel industry

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
Share of Southern Countries (SC) in the global seed oil production

Palm, palm kernel (PK) and coconut oils are exclusively produced in SC vs 42% for soybean oil and 23% for the 4 other vegetable oils (excluding olive)

SC account for almost 60% of the global seed oil production

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
**Global Seed Oil Market**

Vegetable oil production of SC – Allocation by area and commodities

**Palm, coconut palm kernel**
- Indonesia: 84%
- Malaysia: 5%
- Other: 4%

**Soybean**
- Argentina: 82%
- Brazil: 12%
- Other: 3%

**Cottonseed, sunflower, peanut, rapeseed**
- India: 48%
- Other: 21%
- Argentina: 17%
- Brazil: 6%

**Limited production from Africa**

**Major southern areas of production:**
- Asia (Indonesia, Malaysia, India) and South America (Argentina, Brazil)

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
Global Seed Oil Market

Domestic Consumption of vegetable oils of majors producers from SC

- **Palm, PK, coconut**
  - Production (Mt): 7
  - Cons. Food uses (Mt): 8
  - Cons. Non-food uses (Mt): 5
  - Indonesia/Malaysia (Domestic Consumption): 54%

- **Soybean**
  - Production (Mt): 4
  - Cons. Food uses (Mt): 5
  - Cons. Non-food uses (Mt): 6
  - Argentina/Brazil (Domestic Consumption): 15%

- **Cotton, sunflower, peanut, rape**
  - Production (Mt): 6
  - Cons. Food uses (Mt): 0
  - Cons. Non-food uses (Mt): 5
  - India (Domestic Consumption): 5%

**Export level**
- Indonesia/Malaysia: High (75%)
- Argentina/Brazil: Medium (38%)
- India: negligible

**Non-food uses (%)**
- Indonesia/Malaysia: 54%
- Argentina/Brazil: 59%
- India: negligible

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
Global Seed Oil Market

Non-food uses of vegetable oils from Southern Countries (SC)

<table>
<thead>
<tr>
<th>Non-food uses</th>
<th>Palm oil</th>
<th>Coconut oil</th>
<th>Rapeseed oil</th>
<th>6 oils (soybean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiesel Burning (E) Chemicals</td>
<td>low medium high</td>
<td>low very high</td>
<td>very high - low</td>
<td>(very high) - (high)</td>
</tr>
</tbody>
</table>

Increase (%) during the last decade

- 12% → 24% (+12)
- 16% → 26% (+10)
- 36% → 46% (+10)
- 9% → 32% (+23)
- 7% → 19% (+12)

Data: USDA-FAS Circular series – FOP 11-12 – December 2011
**Focus on oleochemistry of tropical oils and castor oil oil**

<table>
<thead>
<tr>
<th>LAURIC oils</th>
<th>PALM oil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coconut oil</strong></td>
<td><strong>Palm kernel oil</strong></td>
</tr>
<tr>
<td>C8-14 79%</td>
<td>70%</td>
</tr>
<tr>
<td>C16-C18 11%</td>
<td>12%</td>
</tr>
<tr>
<td>(P)UFA 11%</td>
<td>18%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Palm stearin</strong></th>
<th><strong>Palm olein</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2% 1-2%</td>
<td>50-80% 39-45%</td>
</tr>
<tr>
<td>50-80% 18-45%</td>
<td>54-60%</td>
</tr>
</tbody>
</table>

- **Fatty acids**
  - flavours and fragrances
  - softeners, plasticizers
  - candles
  - cosmetics from C14-C18
  - Soaps

- **Partial glycerides**
  - solvents,
  - humectants
  - stabilisers,
  - lubricant, anti-freeze, etc

- **Polymers**
  - Polyurethanes, polyacrylates

- **Fatty esters**
  - High quality soaps
  - surfactants (sulphonated form)
  - Biodiesels

- **Fatty alcohols derivatives**
  - Surfactants (sulfates, ethoxylates…)

- **Fatty nitrogen compounds**
  - Surface actives compounds (imidazolines )
  - Softeners (esterquats)

- **Epoxidized palm oil (EPO)**
Focus on oleochemistry of tropical oils and castor oil

CASTOR oil (CO)

Production: 0.54 Mt
India: 0.38 Mt (70%)

- C16-C18: ≈ 2%
- C18:1 – C18:2: ≈ 6-8%
- Ricinoleic acid (RA): ≈ 85-90%

Only source of natural hydroxy fatty acids at industrial scale

Castor Oil

- decanedioic acid (sebacic)
- octanoic acid
- 2-octanol
- methyl undecylenate
- undecylenic acid
- methyl oleate/linoleate
- heptanoic acid
- 2-heptaldehyde
- 12-hydroxy-stearic acid

Cosmetics
Perfumes
Flavors
Pharmaceuticals
Pesticides
Polymers
Plasticizers
Lubricants
...

FOCUS ON OLEOCHEMISTRY OF TROPICAL OILS AND CASTOR OIL
**Next challenges for seed oils & oleochemistry**

- Increase of World population from 7 to 9 billion in 2050
- Westernisation of diet in emerging countries (China, India..)
- Depletion of fossil resources and need of sustainable alternatives

Tremendous increase of food and industrial demands in oils and fats with Competition for land uses, food/non-food uses and between non-food uses

?!?

Increase areas  Increase yields  Reduce wastes  Control prices  Step up ecological practices

How to ensure the development of oleochemistry?

- Shift from FAME-based biodiesels to the 2\textsuperscript{nd} generation biofuels
  - Ethanol and biogases from lignocellulosics
- Favor new and non-edible crops in water-limited areas/degraded lands
  - Jatropha, *cuphea*, *vernonia*, black mustard...
- Improve processes and products
  - Biorefinery, green chem., white biotech...
- Multi-scale innovations
  - Genetic, agronomy, (bio)chemistry
CONCLUSIONS

ROLE OF SOUTHERN COUNTRIES IN OLEOCHEMISTRY AND NON-FOOD USES OF VEGETABLE OILS

- Account for 60% of the vegetable oil production
  - 100% of palm, palm, kernel and coconut oils (Indonesia, Malaysia)
  - 42% of soybean oil (Argentina, Brazil)
  - 23% of rapeseed, cottonseed, peanut, sunflower oils (India)
  - modest contribution of Africa

- Contrasted situations of domestic consumption (vs production)
  - Indonesia & Malaysia: 72% export, 15% non-food uses (Energy > Chemicals)
  - Argentina & Brazil: 40% export, 33% non-food uses (Biodiesel >> Chemicals)
  - India: total consumption of its edible oils but main producer/supplier of Castor oil

OLEOCHEMISTRY, PRESENT AND FUTURE

- Key sector of global economy covering feed, energy, chemicals, materials....
- Excluding biodiesels, applications depend on oil type (Sat/Unsat, long/medium chains)
- Essentially based on edible oils and linked to their market and availability

- It will have to face challenges of competition for vegetable oils uses
- It will have diversify its applications and sources of raw materials
- Innovation for green processes and new products of enhanced properties will be crucial
THANK YOU FOR YOUR ATTENTION